IMPACTS OF HIV/AIDS MORTALITY ON FOOD SECURITY AND NATURAL RESOURCE UTILISATION IN RURAL SOUTH AFRICA

Julia Mambo

A thesis submitted to the Faculty of Science, University of the Witwatersrand, Johannesburg, in fulfilment of the requirements for the degree of Doctor of Philosophy

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DECLARATION

I declare that this thesis is entirely my own work, except where otherwise stated in the text. It is being submitted for the Degree of Doctor of Philosophy in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree of examination by any other university.

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(Signature of Candidate)

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ABSTRACT

AIDS mortality, its linkages as a determinant and consequence of food security and its impact on natural resource utilisation by mainly rural populations, has not been well researched, especially their effects on rural livelihoods. With the high epidemic prevalence and persistent food insecurity, natural resources are and will continue to play a key role as a buffer against stresses and shocks in rural livelihoods. Determining linkages between household food security, adult AIDS mortality, and how these affect natural resource utilisation at the village level was the objective of this research. The overarching goal of sustainable natural resource utilisation in Agincourt Demographic Surveillance Site (DSS) was determined through three research questions outlined as follows; What is the status of food security, AIDS mortality and Natural resource utilisation in Agincourt?; What is the relationship between dependence on natural resources as a source of food and or livelihood to resource degradation?; and What are the household and community drivers of household food security? Statistical analysis was used to evaluate the prevalence of food insecurity and the reliance on natural resources while remote sensing was used to assess resource availability and identification of possible natural resource degradation hotspots. More than half of the population in the DSS is food-secure, in 2004, with an even smaller hungry population in 2007. HIV/AIDS and non-HIV/AIDS adult mortality, analysed at village level are underlying drivers and determinants, affecting availability of income which is a direct driver of food insecurity. Availability of income, through social grants, remittances or wages, and delay or non-receipt of this income results in food insecurity in some households. Food production, affected and constrained by climate variability, is a less stable and less popular means of attaining food. More than half of the Agincourt population utilises natural resources to supplement dietary diversity and household income, although there is a significant reduction in households using natural resources in 2007 compared to 2004. Resource degradation is noted in the village commons especially between the highly food-insecure villages and are identified as environmental degradation hot spots. The identification of synergies among these factors in policy design and for interventions is essential for poverty alleviation, improved health and sustainable utilisation of natural resources and rural livelihoods.

Glory be to GOD for making this work possible

"Commit your work to the Lord and then your plans will succeed"

(Proverbs 16:3)

"Material poverty doesn't necessarily lead to a lack of capacity for creativeness and Inventiveness. Poor people survival by their wits and have much more to contribute to address complex problems than we tend to credit them with."

Dr. Maphela Ramphele (Destiny Magazine, 2010)

PREFACE AND ACKNOWLEDGEMENTS

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My research interest in land and environmental degradation issues and how it impacts on livelihoods stemmed from my involvement in the Save Catchment Rehabilitation Project when I was employed by the Zimbabwe Forestry Commission. The Save is a big river catchment in Zimbabwe which, due to land degradation and siltation, affected approximately a quarter of the country's agricultural potential and population, including the commercial and small scale irrigation schemes that depended upon it. While the study area for this research thesis does not include river catchments, the dependence of rural populations on natural resources is threatened by degradation of resources upon which rural livelihoods depend, affecting in turn their food security. Thus, combining issues of food security and natural resource degradation with the aim of improving natural resource management and sustainability of utilisation for rural livelihoods did not only make sense but become a necessity given the magnitude of these two phenomena in sub-Saharan Africa. The HIV and AIDS epidemic to me only served to exacerbate the situation of an already suffering region both in terms of food insecurity and resource degradation.

While the linkages between these three phenomena seemed clear in my understanding, through my research my perception of the causes and effect of these linkages became challenged. The realisation that many drivers influencing environmental change,

resource degradation, and a myriad of food insecurity causes existed and occurred concurrently, changed the level of analysis and previously-assumed perceptions for this research. Through it all, natural resource management in rural areas was persistently lacking endangering the ecosystems' services and functions of which degradation is a threat. The availability of data on utilisation of natural resource by households in the Agincourt DSS allowed for an in-depth look at how much natural resources contribute to livelihoods especially for the generation of or saving of household income. Poverty or the unavailability of income or capital has emerged in this thesis as one of the underlying drivers of both food insecurity and utilisation of natural resources which are used by all rural households and not just the most vulnerable households.

My gratitude goes to the Agincourt Demographic surveillance site whose rich database was one of main sources of the data used and without which this study would not have been possible. Without the assistance of Dr. Wayne Twine and his wife Rhian, my field work and research would not have been possible. I would like to thank them for their hospitality, assistance and the time they gave up to assist me during my stay at Wits Rural and in my research. I would like express my sincere gratitude to my field guide Sinah, whose rich detailed and historic knowledge of the study area and familiarity with the study area and its people made the field work fun and exciting. I am further grateful to the University of the Witwatersrand/Medical Research Council Rural Public Health and Health Transitions Research Unit (Wits/MRC Agincourt Unit) for their support with logistics, data, administration and advice. At the Agincourt office, my sincere gratitude goes to Ben Clark, Mark Collinson and Afolabi Suliman who responded to all my email requests and numerous questions for clarifications without complaining and always willing to assist.

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GLOSSARY OF KEY TERMS AND CONCEPTS

Analysis: Understanding something by dividing into smaller parts, and studying each part separately

Change detection: Change detection for GIS is a process that measures how the attributes of a particular area have changed between two or more time periods. Change detection often involves comparing aerial photographs or satellite imagery of the area taken at different times. The process is most frequently associated with environmental monitoring, natural resource management, or measuring urban development.

Change Vector Analysis: An automated method of conducting change detection analysis

Dependent variable: A statistical term for whatever measure you are trying to predict.

Dietary Diversity: Refers to the sum of foods consumed by an individual over a specific period of time

Descriptive statistics: Figures which summarize or describe a data set, without making any inferences or generalizations. All measures listed on this page are descriptive statistics. In contrast, inferential statistics make inferences about the data - such as using a sample to make estimate about a population.

Economic Structural Adjustment Programme: Structural adjustment is a term used to describe the policy changes implemented by various governments at the recommendation the International Monetary Fund (IMF) and the World Bank 'Bretton Woods Institute' in developing countries. These policy changes are conditions (Conditionalities) for getting new loans from the IMF or World Bank, or for obtaining lower interest rates on existing loans.

Globalisation: The transition from national and regional economies to global economies

Grant market: These are one day markets set up on the day of social grants pay outs in most rural areas on South Africa. Different products including fresh food, vegetables fruit and meat are sold during these markets.

Green Revolution: refers to a series of research, development, and technology transfer initiatives, occurring between 1943 and the late 1970s, that increased industrialized agriculture production in India; however, the yield increase has also occurred worldwide. The initiatives involved the development of high-yielding varieties of cereal grains, expansion of irrigation infrastructure, and distribution of hybridized seeds, synthetic fertilizers, and pesticides to farmers.

Household coping strategy: Methods and resources used by households to cope with or supplement food insecurity and or household income

Indicators: An indirect measure of a broad concept which can't be measured directly

Independent variable: One of a set of measures which is used to predict a dependent variable

Land capability: The quality of soil resources for agricultural which shows the suitability of soils for most kinds of field crops. Soils are grouped according to their limitations when they are used to grow field crops, the risk of damage when they are used, and the way they respond to treatment. Capability classes, the broadest groups, are designated by Roman numerals I through VIII, with I being the best soils and VIII being the poorest.

Livelihood Strategies: Livelihood strategies are the combination of activities that people choose to undertake in order to achieve their livelihood goals. They include productive activities, investment strategies and reproductive choices. Livelihoods approaches try to understand the strategies pursued and the factors behind people's decisions; to reinforce the positive aspects of these strategies and mitigate against constraints.

Malnutrition: A state of poor nutrition; can result from insufficient or excessive or unbalanced diet or from inability to absorb foods

Neo-Malthusian: A belief that the world is characterized by scarcity and competition in which too many people fight for too few resources. Named after Thomas Malthus, who predicted a dismal cycle of misery, vice, and starvation as a result of human overpopulation

Political Ecology: Is the study of the relationships between political, economic and social factors with environmental issues and changes. Political ecology differs from apolitical ecological studies by politicizing environmental issues and phenomena

Prevalence: In epidemiology, this is the percentage of the population who at a particular time have the disease being studied. The prevalence of a disease is its times the average duration. This is not limited to epidemiology alone but to many disciplines.

Proxy Indicator: A proxy is a type of indicator, used when you can't measure the real thing. In other words, not a very reliable indicator, but better than nothing For example, if you are comparing innovation levels in different countries, the number of patents issued per million people per year is a proxy indicator.

Regression: A statistical method which tries to predict a dependent variable (result) by combining a number of independent variables (measures).

Stakeholder: Any person, group of people, or organization affected by or affecting the system being studied.

Unsupervised classification: Unsupervised classification is a method which examines a large number of unknown pixels and divides into a number of classed based on natural groupings present in the image values. Unsupervised classification does not require analyst-specified training data.

ACRONYMS

AIDS:	Acquired Immune Deficiency Syndrome
ARC:	Agricultural Research Council
AGIS:	Agricultural Geographic Information System
AHFSI:	Aggregate Household Food Security Index
CIFOR:	Centre for International Forestry Research
CVA:	Change Vector Analysis
DOA:	Department of Agriculture
DSS:	Demographic Surveillance Site
ESAP:	Economic Structural Adjustment Programme
FAO:	Food and Agriculture Organisation
FARA:	Forum for Agricultural Research in Africa
FBSA:	Food Bank of South Africa
FIVIMS:	Food Insecurity and Vulnerability Information Mapping System
GDP:	Gross Domestic Product
GHPWG:	Global HIV Prevention Working Group
GIS:	Geographic Information System
HDI:	Human Development Index
HDDS:	Household Dietary Diversity Score
HIV:	Human Immunodeficiency Virus
IDDS:	Individual Dietary Diversity Score
IFPRI:	International Food and Policy Research Institute
IFSS:	Integrated Food Security Strategy (South Africa)
IMF:	International Monetary Fund
ISRDP:	Integrated Sustainable Rural Development Programme
MDG:	Millennium Development Goals
NDVI:	Normalized Difference Vegetation Index
NEPAD:	The New Partnership for Africa's Development
NFRA:	National Food Reserve Agency (Malawi)
NGO:	Non-governmental Organisation
NLC:	National Land Cover
NRM:	Natural Resource Management

NTFP:	Non-Timber Forest Products
NVF:	New Variant Famine
PCA:	Principal Component Analysis
RDP:	Rural Development Programme
RS:	Remote Sensing
SADC:	Southern Africa Development Community
SGR:	Strategic Grain Reserve
UNAIDS:	The Joint United Nations Programme on HIV/AIDS
UNDP:	United National Development Programme
UNGASS:	United Nations General Assembly
WFP:	World Food Programme
WTO:	World Trade Organisation
WWF:	World Wildlife Fund

PART ONE

INTRODUCTION, CONTEXT AND RESEACH DESIGN

This research thesis is divided into three parts. Part One provides an introduction to the research and a literature review of both context and methods. Part one also provides the research questions and an overview of methods and data used to answer these questions, including an introduction to the study area. Part one also presents the theoretical and geographical contexts for Parts two and three.

CHAPTER ONE

INTRODUCTION

1.1 Background

HIV and AIDS are devastating African societies and economies, threatening the hard-earned human development gains of the past several decades (Topouzis and de Guerny, 1999; Hammarskjöld, 2003). The epidemic has evolved from being merely a health issue into a broader developmental problem (Loevinsohn and Gillespie, 2003; UNAIDS, 2008). HIV and AIDS have resulted in the biggest reversal of human development in history, leading to a reduction in life expectancy by up to 20 years in the worst affected countries. The epidemic is undermining national systems, affecting country demographics, weakening institutional capacity and slowing economic growth (UNDP, 2009). HIV and AIDS have also resulted in intensified poverty for various vulnerable households and communities. Virtually unknown 27 years ago, the epidemic has escalated into a health problem of unparalleled dimensions, with an estimated 25 million deaths (UNAIDS, 2007; UNAIDS, 2008). The epidemic has been described as multi-dimensional and ongoing, with the impacts to be felt for decades to come (Hammarskjöld, 2003; Gillespie, 2006).

Sub-Saharan Africa (SSA), with the highest HIV prevalence rates in the world, is the region where the epidemic has hit hardest, with southern Africa being the worst affected (Figure 1.1). The region is bearing the disproportionate share of the global burden of the epidemic with 35% of new HIV infections and 38% of the AIDS deaths in 2007 (UNAIDS, 2008). Within the sub region, rural livelihoods and rural development are areas where its impacts are increasingly felt, threatening the stability of whole societies (Loevinsohn and Gillespie 2003). Within rural households, HIV and AIDS results in loss of labour, lower levels of agricultural production, lower incomes and increased expenditure (for medical care, medicines and funerals); and in areas where the epidemic is extensive, it also leads to the weakening of social structures with considerable repercussions on all sectors (Hammarskjöld, 2003).

The epidemic is increasingly intertwined with availability and access to the most basic livelihood needs, for example food security (de Waal and Whiteside, 2003; Loevinsohn and Gillespie 2003; Ansell *et al.*, 2009; Arrehag *et al.*, 2009). The devastating nature of the HIV and AIDS epidemic has highlighted the plight of food insecurity in Sub-Saharan Africa and in southern Africa in particular. Despite the focus of the Millennium Development Goals on the eradication of extreme hunger and poverty, food security has remained elusive in the region.

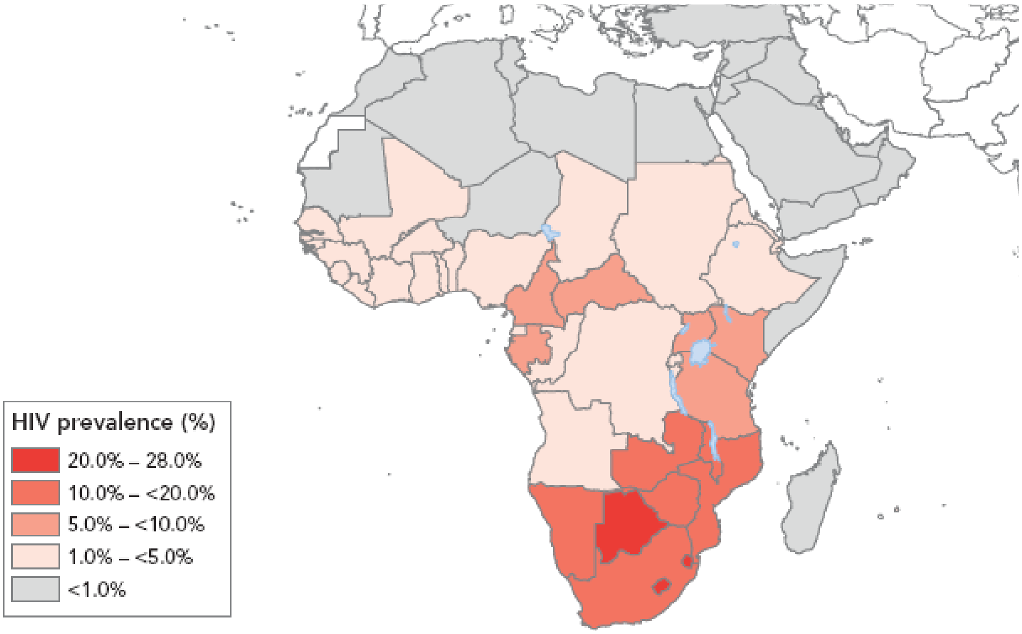

Figure 1.1: Adult HIV/AIDS prevalence SSA in 2008 (www.unaids.org, 2008)

The contribution of the HIV and AIDS epidemic to the current developmental crisis in southern Africa is contentious, premised on the interactions of the epidemic with other factors such as chronic poverty (Hammarskjöld, 2003). This has raised debates about the causes of the crisis and to what extent this may be attributed to HIV and AIDS. While the debate on whether the epidemic should be considered an emergency rages on (Harvey, 2004), its adverse impacts on regional, national and household food security are self evident. The '*New Variant Famine'* hypothesis has placed HIV and AIDS at the centre of its argument. It highlights in particular the inability of affected households to cope with internal stressors such as the death of a breadwinner or external stressors such as drought (de Waal, 2005; Arrehag *et al.*, 2009; Ansell *et al.*, 2009).

Approximately 67% of the world's HIV and AIDS affected people are living in the SSA region, where the high mortality of prime-aged adults is manifested in more vulnerable groups, among them children and the elderly. According to UNAIDS (2006, UNAIDS, 2008), there were an estimated 12 million AIDS orphans in SSA in 2005. The majority of these orphans, as well as their sick parents, are under the care of the elderly who have cited food security as the biggest challenge faced (Dayton and Ainsworth, 2002; Nhongo, 2004; UNAIDS, 2006).

With more than 35% of the population in the region chronically malnourished in 2001-2003, and given the increase in the number of under-nourished people from 169 million between 1990 and 1992 to 206 million between 2001 and 2003, hunger in the region has remained as persistent as it is widespread (FAO, 2005). It has therefore become essential for strategies aimed at the sustainable improvement of food security and poverty reduction, to integrate strategies for mitigating the exposure and impacts of HIV and AIDS. Such integration requires a good understanding of the interactions between HIV and AIDS, food insecurity and poverty reduction among target communities. Further, it is well known that the rural poor in SSA largely depend on the exploitation of natural resources for their livelihood and in particular for food security (Hunter and Twine, 2005; Scoones *et al.*, 2005). Increased vulnerability to food insecurity, attributed to HIV and AIDS among other exacerbating factors, may lead to increased reliance on the natural resource base.

The importance of the environment or natural resources in food security is noted in the new emerging literature on health and agriculture and food security. According to Hawkes and Ruel (2006) and Lang (2006), the natural environment is one the factors mediating a relationship between agriculture and health. Natural resource constraints, which are a pre-existing problem and environmental degradation, brought about the globalisation among other things, affect agricultural systems, consequently affecting food security and in turn human health. As noted by Nugent and Drescher (2006) agricultural production, depends on environmental services to produce convert raw resources into nutritious and diverse food products people can depend on. However, poor agricultural choices and environmental pollution from livestock waste for example (Catelo, 2006), have resulted in the contamination of the natural resources with dire consequences for biodiversity and human health (Nugent and Drescher, 2006). Biodiversity is cited as providing essential components for a healthy environment and sustainable livelihoods (Johns *et al.*, 2006). The emerging literature goes further to propose for synergies between these different aspects to address food security and human health.

1.2 South Africa

In a country that produces enough food to feed its people, such as South Africa, food security should not be considered an issue (DOA, 2002; de Klerk *et al.*, 2004; Machethe, 2004). However, the failure of livelihoods to provide sufficient food at household level becomes more evident, coupled with the regional food shortages which further impact availability of food at a local level (Devereux and Maxwell, 2001; de Klerk *et al.*, 2004). Despite a strong agricultural economy and being an exporter of cereals such as maize, South Africa had approximately more than 14 million food-insecure people and 1.5 million children suffering from malnutrition in 2004 (de Klerk *et al.*, 2004; Machethe, 2004; Chopra *et al.*, 2009). Both of these groups are on the increase, with the latest figures of over 19 million people[1], 40% of the population being predicted to be food insecure in 2009 by the Food Bank of South Africa (FBSA, 2009). Furthermore, South Africa has one of the highest burdens of HIV infected people. Despite notable strides in the treatment of the disease in the country (UNAIDS, 2006; UNAIDS, 2008), it is projected that by 2010, 65% of deaths in provinces like Limpopo will be attributed to AIDS (Hunter and Twine, 2005). The disease is increasingly acknowledged as a rural as much as an urban problem.

[1] This figure should be treated with caution as no references were given on the website

An estimated 70% of the country's poorest households reside in rural areas (de Klerk *et al.*, 2004). A large proportion of this rural population are net consumers of purchased food (Vogel and Smith, 2002; Roberts, 2004), as they are unable to produce adequate food to feed themselves. This has been attributed to the apartheid policy of "betterment and development" which resulted in overcrowding of the homelands, with limited access to land and resources as well the estrangement of people from their land, for provision of labour in the mines and other economic activities (DOA, 2002; Francis, 2006; Clark *et al.*, 2007). Due the limited livelihood options for the rural population, many households thus rely primarily on social protection schemes such as the government grants, remittances and wage labour to maintain rural livelihoods. Further, non-farm activities are used to supplement household economies and food security, through harvesting for resale and/or consumption of natural resource products (Dovie *et al.*, 2003; Hunter and Twine, 2005; Shackleton *et al.*, 2008).

Urban-rural migration due to job retrenchments and the return by AIDS-infected people to their rural homes puts further pressure on already strained rural livelihood systems and natural resources (Collinson *et al.*, 2004, Dovie *et al.*, 2004; Clark *et al.*, 2007, Shackleton *et al*, 2008). Evidently, an increase in the reliance on natural resources has been noted in most South African rural areas. This is attributed to the deterioration of the socio-economic environment, high AIDS mortality and better social and economic returns gained from natural resources products compared to formal employment (Shackleton *et al.*, 2008).

Despite the crucial role of natural resources acting as a buffer against poverty and household stresses, the environmental dimensions of HIV and AIDS remain little explored (Hunter and Twine, 2005; Hunter, 2006). Thus a better understanding of the effects of HIV and AIDS on natural resource management (NRM) and *vice versa* would offer very important insights into the dynamics between HIV and AIDS and sustainable food security (Topouzis and de Guerny, 1999; Hammarskjöld, 2003; Harvey, 2004; Torell *et al.,* 2006). It has been suggested that poverty is an assumed driver of vulnerability to both HIV and AIDS and unsustainable resource utilisation, thus the reduction of poverty will have immense benefits for both HIV and AIDS and sustainable resource utilisation (Hunter, 2006).

1.3 Statement of the Problem

The lack of adequate understanding of the effects of HIV and AIDS on food insecurity, poverty and natural resources management has been observed. Of particular concern is the management and sustainable utilisation of natural resources in common property areas by affected households, as noted by Thaxton (2004), Hunter and Twine (2005) and Ansell *et al.,* 2009). The absence of forums to discuss public health, in particular HIV and AIDS and the environment, except within the context of food security have served to exacerbate the understating of these phenomena (Hunter 1996; Hunter and Twine, 2005; Gillespie, 2006). While food security is important, it is only one of the dimensions of the epidemic’s impact on the environment, given that natural resource shortages could intensify vulnerability to HIV and AIDS, worsen poverty and jeopardise the viability of household livelihoods choices (Hunter and Twine, 2005; Hunter 2006). This is particularly relevant in areas characterised by high levels of resource dependency, where adult mortality would increase pressure on the natural resources (Hunter, 2006).

Despite aforementioned limited research on these interactions, a few early studies have shown that public health, HIV and AIDS, environmental policy and advocacy can benefit from each other, by providing a beneficial mutual understanding of the impacts and linkages between these phenomena (Hunter, 2006). Organisations such as WWF have realised the importance of these interactions, aiming within their programmes to promote HIV and AIDS awareness in local communities as well as providing livelihood options to alleviate pressure on the environment (WWF, 2008). Further, over-exploitation of resources as demand increases among the affected communities should be investigated to ascertain the complex interactions and feedbacks between HIV and AIDS and natural resources (CIFOR, 2006). Recently, emerging literature on health, agriculture and food interactions further emphasise the need for a holistic approach to issues of health, food security and natural resources (Benson, 2006, Bos, 2006).

The hypothesis in this research is that natural resource utilisation provides a critical 'safety net' particularly for AIDS affected households faced by both chronic and transitory hunger, as a short and long term coping strategy. As indicated by Hunter and Twine (2005), Twine and Hunter (2008) and Giannechinni *et al*. (2008) most households in the study area depend on the natural environment as a source of food and income, suggesting high utilisation and dependency. The death, especially of a breadwinner, and in the absence of social protection benefits, exposes vulnerable households to food insecurity. The affected households therefore may tend to rely on natural resources (e.g. firewood, wild fruit, herbs, vegetables and bush meat) to supplement household food and income. Further, these households may be less likely to cope with physical and social stressors due the depletion of household assets which would have been sold to care of the sick.

Natural resource utilisation by the rural poor may be through harvesting of survival foods such as herbs and wild fruits, the gathering of fuelwood and medicinal plants for either own consumption or commercially, for sale in urban markets. The magnitude of HIV and AIDS in the region and country of study will result in increased mortality of the prime-age adults. Consequently this may lead to increased vulnerability for the affected households and increased reliance on the natural resource base. Natural resource utilisation may escalate, leading to over exploitation of these essential resources, leading to possible degradation. This would have adverse effects on natural resources upon which people depend, making the people more vulnerable.

The main aim of this research is therefore to contribute to the enhanced understanding of the nexus between HIV and AIDS and natural resource utilisation, by analyzing the interactions between HIV and AIDS, food insecurity and natural resource utilisation among the vulnerable groups in a typically rural South African context. This research has been conducted in the Agincourt Demographic Surveillance Site (DSS) in Bushbuckridge municipality in Mpumalanga province. This research recognises the importance of including the impacts of HIV and AIDS in planning for environmental and/or natural resource management as well as planning for poverty alleviation, rural livelihoods and the attainment of food security. This thesis will discuss issues of food security, AIDS mortality impacts and natural resource use, with the results presented in chapters five, six and seven. A synthesis of the research is done in chapter eight with the new chapter nine concluding the thesis. Key bodies of literature to engage with include political ecology, the general literature of food security, HIV/AIDS epidemic and natural resources and most importantly the recently emerging literature specifically on health/agriculture and food interactions

1.3.1 Research Objectives

The overall objective of this research is to better understand **the dynamics and interactions, in rural livelihoods, between natural resources utilisation, the HIV and AIDS epidemic, in particular, HIV/AIDS related mortality and sustainable food security** through the analysis of socio-economic and bio-physical data, in Bushbuckridge, South Africa. Sustainable food security in this context refers to food acquired without degrading or endangering the natural environment.

The research has two objectives:

> **Firstly,** to investigate the role of natural resource assets as household coping strategies, in dealing with the combined stress of food insecurity and the HIV and AIDS epidemic. Research here is divided into two parts, the shorter term and the longer term, e.g. the epidemic's long-term indirect effects on livelihood assets;
>
> **Secondly**, to assess the interactions of food security and HIV and AIDS in the Agincourt Demographic Surveillance Site (DSS) by developing indicators of all known drivers and determinants of food security from the DSS database.

This research will provide insight into, and better understanding of the dynamic linkages between HIV and AIDS, natural resource utilisation, land use and land cover change, environmental degradation and sustainable food security.

Specific objectives are to:-

- Assess food security in the Agincourt DSS using the food security indicators developed from the DSS database;
- Determine the role played by natural resources in supplementing household food and income in the face of HIV and AIDS;
- To determine the extent to which HIV and AIDS are drivers of food insecurity;
- Analyse the linkages between food insecurity, land use change and resource degradation, analysed at village level;
- Assess what, if any, spatial patterns of food insecurity exist between vulnerable villages and other drivers of food security such as agro-climatic zones, land cover change and proximity to urban areas;
- Monitor the difference in food security in the DSS between 2004 and 2008[2].

The following research questions will be answered:-

- What is the status of household food insecurity, AIDS mortality and natural resource utilisation in the DSS?

- What is the relationship between dependence on natural resources as a source of food and/or livelihood to resource/land degradation?

- What are the household and community drivers of household food insecurity?

[2] The first food security module was run in 2004 and the second module was run in 2008.

1.4 Thesis Structure

1.4.1 Part I: Chapter One to Four

- **Chapter Two** reviews the literature on the background of food security and the environment, including the political ecology of food security, and debates about food security and the environment. The conceptualisation of food security and the causes of food insecurity in SSA and southern Africa are also discussed;
- **Chapter Three** describes the physical, economic and social characteristics of the study area and country of study, including the food security status and HIV and AIDS prevalence;
- **Chapter Four** outlines the methodologies utilised in the study, to analyse land use and land cover change and related demography.

1.4.2 Part 2: Chapter Five to Seven

This part of the thesis presents the results of both the land use/land cover change and the related demographic analysis.

- **Chapter Five** presents the results of research question 1, relating to the demographic data analysis from the DSS database. The indicators of food insecurity derived from the DSS database are presented. The food security, HIV and AIDS status, as well natural resource utilisation are presented, including the factors influencing food security in the DSS;
- **Chapter Six** presents the results of research question two, pertaining to the land use and cover change in the DSS as well the analysis of what if any relationship exist between natural resource availability, utilisation and resource degradation. Land use and land cover change analysis based on land cover maps for the years 1990, 2001 and 2005 and natural resource availability at village level are presented;

- **Chapter Seven** is based on the results for research question three, analysing other bio-physical and socio-economic factors that might be influencing food security in the DSS.

1.4.3 Part 3: Chapter Eight

This part of the thesis synthesises the research conducted and the results presented.

- **Chapter Eight** presents the synthesis of the research, including the results from chapters Five, Six and Seven, relating to the research objectives. The conclusion of the research is also presented, especially the findings on the relationship between the HIV and AIDS epidemic, food security and natural resources. The ways in which this research thesis sheds light on such issues as well as the way forward are reported;
- **Chapter Nine** concludes the thesis, setting the research in the context of emerging research agendas on agriculture, health and food interaction**.**

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

Issues of food insecurity among the rural poor have long been of concern. With most of the rural poor settled in marginal areas, their quest for food security is usually strongly coupled to the environment and, in particular, on the state of the natural environment. A degraded environment is one that is often viewed as having limited ability to sustain activities that may provide resources (e.g. food). Views of the state of the environment and the role and influence of humans (including population pressure) have been the basis for a long and contested discourse. The degradation concerns, for example, are usually based on the methods of utilisation and on ignorance of the rural poor on sustainable utilisation of the resources at their disposal, especially common property resources. The resource degradation narrative has also been based on population growth with two notions explored; namely that population and the environment are in conflict and, secondly, that population and the environment are complimentary. These two notions are then used in constructing the debate on population and the environment.

Food security issues among the rural poor are, however, not only driven and shaped by the natural environment in a simple cause and effect way, but are influenced by other factors that complicate this relationship such as poverty. As this thesis suggests, food security can also be exacerbated by HIV and AIDS, that increases the vulnerability to food insecurity among the affected households and in turn increases the dependency on natural resources (de Waal and Tumushabe, 2003; Hunter and Twine, 2005; Ansell *et al.*, 2009). The simple unidirectional cause and effect relationship between people and pressure on the environment is therefore far more complicated than documented (Hunter *et al.*, 2005). Given the myriad of impacts the epidemic has on food security and livelihoods, it has become one of the biggest developmental challenges. Further, Sen's (1981) food entitlement theory changed people‘s perception about food security, shifting the focus from availability to access and institutions that govern access to food and resources, which in turn also influence food security. The cascading influence of various drivers of change, operating at various scales, also further clouds simple cause and effect interactions. The food security situation in South Africa, for example, can intensify the food security situation in the SADC region, with detrimental consequences for the local rural population. With increased food insecurity and vulnerability of the rural poor, there is the chance for increased dependence on natural resources, thereby re-enforcing population, food security and environmental degradation dynamics.

The aim of this chapter is to introduce the paradigms of the interactions between people and their environment and how these interactions in turn shape food security, HIV and AIDS and natural resource utilisation. Various frameworks and approaches will be discussed that delve into the 'messy reality' of causal drivers shaping food security, for example, the Neo-Malthusian theory. Such approaches can, on the one hand, yield the well known 'degradational narratives', usually propounding compelling claims between people and natural resources. On the other hand, several scholars such as Ostrom (1990) and Leach and Mearns (1996), have contested such notions by drawing attention to more nuanced causes of land-use change, particularly focussing on the role of degradational myths in explaining the nexus between population and the environment in Africa and elsewhere.

In this chapter, several of the paradigms on population and the environment are described through discussion of four main bodies of literature. The first highlights the common debates of population as a possible driver of environmental change and degradation; the second is the conceptualisation of food security and paradigm shift in the perception of and vulnerability to food insecurity (including causes of food insecurity in SADC). Thirdly**,** given its impact on food security and rural livelihoods, the extent and impacts of the HIV and AIDS epidemic are discussed and analysed. Lastly, the literature examines the combination of food insecurity and HIV and AIDS and how these drive natural resource utilisation (Figure 2.1) in rural areas. The epidemic is not only acknowledged as a driver of food insecurity but as a driver of environmental or land-use and land-cover change in rural livelihoods.

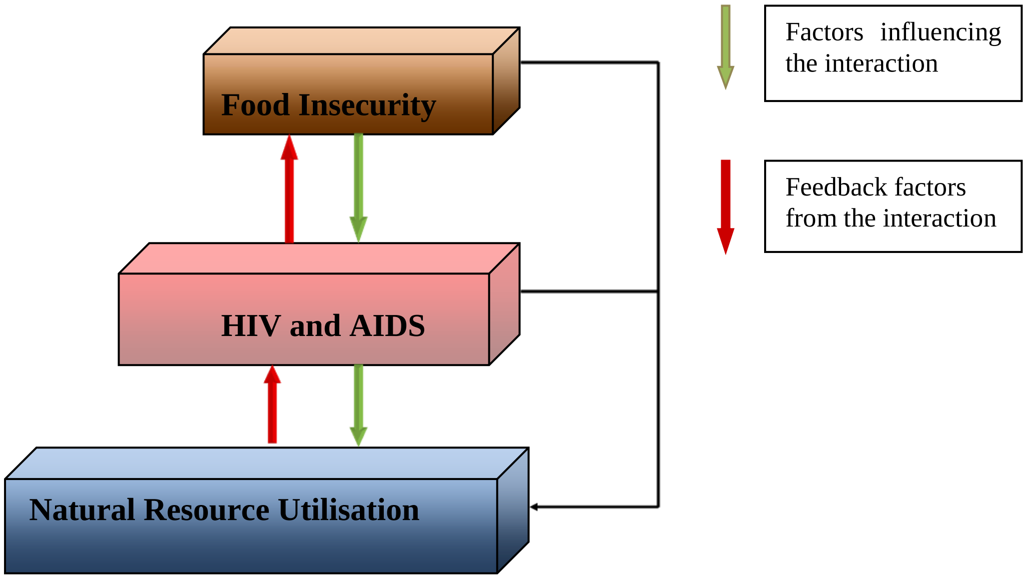

Figure 2.1: The interaction of food insecurity, HIV and AIDS and natural resource utilisation

2.2 Population and the Environment Debate

As previously stated, several notions have assisted in the construction of the population and environment debate, starting with the political ecology that frames the debate in social, economic and physical constructs. These notions are further explored based on the two theories shaping population and the environment discussions. This discussion will include the role of poverty as a driver of land-use and land-cover change as well as environmental degradation, and the management of common property resources. Both positive and negative theories on population and the environment and the poverty debate will be considered, leading to the discussion on environmental degradation. Environmental degradation, especially the clearing of land for agriculture has been cited for the decline in African rural livelihoods. The discussion will conclude by exploring the concept of sustainable development and sustainability of natural resource use.

2.2.1 Political Ecology

As remarked above, political ecology frames the debate on population and the environment. Political ecology[3] is broadly defined by Blaikie and Brookfield (1987) as concerning the impact of people and their productive activities on ongoing changes within society at global and local level. While not entirely inspired by isolated rural communities political ecology was inspired by peasant and agrarian communities struggling on the midst of capitalism (Peet and Watts, 1996). Political ecology makes three assumptions; interactive, contradictory and dialectical, implying that society and land based resources mutually act together such that poverty can induce environmental degradation, deepening poverty (Blaikie and Brookfield, 1987). The second assumption is the regional or spatial accounts of degradation where local level studies are subsumed within multi-layered analyses, pitched at regional scales. The third assumption is that land management is framed by external structures such as the role of the state (Blaikie and Brookfield, 1987).

Political ecology made possible a platform for discussions about how nature and environmental problems are framed and how discursive formations shape policy and practice (Peet and Watts, 1996). It views environmental problems in the developing world as a result of local social, economic and political constructs, governing how people utilise natural resources. This construct does not acknowledge ignorance, mismanagement or overpopulation as sole drivers of environmental change (Peet and Watts, 1996; Devereux and Maxwell, 2001). Hunger and famine in marginal areas is premised on changes in the economic, social and political systems and not only on environmental limits. These changes impact on entitlements to food and natural resources. Land tenure systems, such as utilisation of and access to common property resources, is primarily determined by political governance, leading to power struggles within the communities (Moorehead and Wolmer, 2001), impacting on livelihoods and food security. Further, incentive structures such as security of tenure, property relations and institutional arrangements determine how people use their natural resources to

[3] Political ecology refers to the a body of literature which combines the conventional concerns of ecology and with the political economy, in an attempt to integrate physical and ecological elements, with social, economic and political processes (Moorehead and Wolmer 2003)

achieve food security and are central to political ecology (Peet and Watts, 1996; Devereux and Maxwell, 2001).

The political ecology body of knowledge assisted in challenging the revised wisdom about population as a driver of environmental/ecological degradation, highlighting instead the role of poverty as a proximate cause of ecological deterioration (Peet and Watts, 1996). This changed the mindsets of how people viewed nature and society relations. However, political ecology has some weaknesses, for example the emphasis on poverty over issues of capital, while the focus on poverty did result in a bias towards the rural, agrarian and third world issues (Peet and Watts, 1996). Further, Blaikie and Brookfield (1987) do admit that the poverty-centred analysis reveal only part of the story or broader picture.

2.2.2 Theories framing Population and the Environment Debate

While the political ecology notion stated above does not consider over population as a main driver of change, population is the basis of the two narratives, both positive and negative which will be discussed in this section. The negative impact of people on the environment has been captured in the degradation narratives which views the rural poor (peasants, pastoralists and hunters) as destroyers of their own environment (Geist, 2006).

The dominance of these degradation narratives has overlooked the understanding of land-change dynamics and has usually been at the expense of investigating the actual complexities and opportunities for conservation that exist and often ignore local human-environment conditions (Geist, 2006). There are two main opposing narratives about food security and the environment, the Malthusian and the Boserupian narratives.

The Malthusian[4] view is based on:-Population growth and the environment being in variance, with climate change and environmental degradation, posing huge challenges for food security;

- The quest for food security, as population increases will have negative inevitable environmental costs, while environmental protection policies can negatively affect food security.

The Malthusian theory, which is regarded as a negative degradation narrative, is based on population growth growing geometrically and food production growing arithmetically resulting in population growth exceeding food supply (Malthus, 1798). The Neo-Malthusian theory based on the works of Malthus, predicted hyper-exponential population growth that will eventually outstrip growth in economic and food production unless measures to control population growth are implemented. Food security for a growing population will, according to Malthus, ultimately lead to an escalation in land degradation, a decline in agricultural productivity and greater food insecurity (Malthus, 1798). According to Malthus, the world would run out of food unless drastic preventative and positive checks on population growth are taken, as well as steps to protect the environment from people (Hardin, 1968; Binns, 1997; Moorehead and Wolmer, 2001). The Neo-Malthusian approach regards food security and the environment as separate entities. The second narrative is the Boserupian theory.

The Boserupian view states that:-

- Population and income growth will drive technological inventions to solve food production constraints thus achieving environmental and economical sustainability (Boserup, 1965);

[4] Thomas Malthus – an English political economist and demographer – viewed the potential rapid growth of population to be faster than the food supply available to them. This view is also referred to as the "Malthusian catastrophe".(Malthus, 1798 - www.espn.org, 1998)

- Given that population growth is gradual, rural populations will over time adapt their environment and cultivation strategies, increasing crop yields without significant degradation of the resource base (Binns, 1997);

- Food security and the environment are complimentary and interdependent, with a healthy natural resource base providing food security.

Boserup[5] supports this hypothesis, believing that when faced with food shortages, farmers will adopt intensification methods which will saturate land with more labour to boost food production by frequent cultivation and careful husbandry (Boserup, 1965; Abernethy, 2005). Boserup revealed that population determines agricultural methods, increasing production to meet the increased demand for food needs. Boserup's key point on the population and agriculture debate was that necessity was the mother of invention (Boserup, 1965, Abernethy, 2005). Food security and a healthy natural resource base are thus viewed as inter dependent and mutually reinforcing for the positive gain to both. The Boserupian view gained popularity, given that the empirical research revealed the considerable capacity of indigenous people to increase the productivity of their farming systems (Binns, 1997).

The Machakos study is a case in point on the complementary nature of population growth, food security and the environment. In Machakos, despite a six fold increase in population, there was an increase in productivity, whilst controlling and still reversing land and natural resource degradation. Agricultural output per head increased four times. While the success of Machakos has been accredited to financial aid and investments, traditional conservation practices such as terracing were made compulsory for agriculture, first by the government then by the farmers themselves (Leach and Mearns, 1996). Agricultural intensification occurred in the areas of high population and high potential land productivity, proving that population growth does not necessarily jeopardize the environment. The reverse was experienced for sparcely populated and

[5] Ester Böserup - was an economist and studied agricultural growth, believing in "agricultural intensification" to boost production Her book "*The Conditions of Agricultural Growth: The Economics of Agrarian Change under Population Pressure*" published in 1965 was her most notable work

low potential land (Leach and Mearns, 1996; Moorehead and Wolmer, 2001). Consequently, population growth and poverty alone are not the only or the major underlying drivers of environmental or land-cover change, but rather peoples' responses to economic opportunities and institutional arrangements drive land cover change (Lambin *et al*., 2001).

The debate on the relationship between people and their environment has been shaped by the two aforementioned narratives, including the way in which policies that influence resource use, are made and implemented. This relationship is a complex and long-running debate, portraying humans as both victims of the harsh environments in which they reside and depend, as well as agents of change and/or degradation of these environments (Binns, 1997; Geist, 2006). People, especially the rural poor, have been blamed for misusing the resources at their disposal for short-term gains, with intensive agriculture and over grazing being responsible for degradation, pollution and other deleterious impacts (Binns, 1997; Moorehead and Wolmer, 2001; Geist, 2006). With suggestions that rapidly growing rural populations are responsible for environmental degradation and desertification, poverty has played a major role in this degradation narrative (Binns, 1997; Geist, 2006).

Poverty is regarded both as a potential cause and effect of land-use and land-cover change. A lack of economic resources may hinder investment in environmental conservation by the rural poor, resulting in failure to maintain the natural resource base. In addition the immediate need for survival may supersede the need for conservation with short sighted decisions made on natural resource use and management (Geist, 2006). The narrative of poverty-induced environmental degradation has been contentious; both in terms of the short-term decisions taken by the rural poor and sustainable land management. The arguments have been, firstly, that the rural poor are more often concerned about long-term sustainability of their livelihoods and, secondly, that sustainable land management is not a capital intensive process, with cultural ecologists arguing that traditional land management is neither inefficient nor destructive (Geist, 2006).

While studies have shown that poverty and population growth may result in more pressure for food and other resources (Booth *et al.*, 1996; Dixon *et al*., 2001; Kangalawe and Lyimo, 2010), the contribution of the rural poor to degradation, in particular the claims of their ignorance, has been contested (Leach and Mearns, 1996; Binns 1997; Leach *et al.,* 1997). According to Leach and Mearns (1996), research has revealed the presence of 'indigenous' ecological knowledge and organisation in natural resource management by African farmers and herders, with a better understanding of their own land use practices (Leach and Mearns, 1996; Bins, 1997; Geist, 2006). Further, Moorehead and Wolmer (2001) argue that the poor are aware of the consequences of their actions; they are however forced to adopt short-term solutions to meet their immediate needs (Binns, 1997; Thaxton, 2004).

Of particular concern are the coping strategies engaged in during times of distress, such as deforestation for charcoal production, over exploitation of wild fruits, overgrazing of grasslands and expansion of agriculture into marginal areas (Devereux and Maxwell, 2001; Kangalawe and Lyimo, 2010). These strategies may affect mainly common properties resources. Such debates have brought about questions about the validity of scientific baselines such as climax vegetation community or static concepts such as carrying capacity (Leach and Mearns, 1996).

The Neo-Malthusian theory assumes that agro-ecological zones have limited carrying capacities and are not able to sustain huge populations. The theory disregards the potential of economic development within sustainable environments such as the green revolution which boosted food production (Leach *et al.,* 1997; Moorehead and Wolmer, 2001). This theory has, however, been contested, especially the growth and distribution of population and the management of common property resources (Boserup, 1965; Moorehead and Wolmer, 2001).

Most closely associated with the carrying capacity theory is the management of common property resources. The degradation of common property resources is based on the poor management and lack of ownership of the resources as outlined in the "Tragedy of the Commons" (Hardin, 1968). The common property resources tenure system has been cited as exacerbating utilisation of common property resources, leading to over utilisation and degradation (Hardin, 1968; Moorehead and Wolmer, 2001). Coping strategies for food shortages are cited to have further deleterious effects on the natural environment:

> *"when the viability of the household as a productive and reproductive unit is threatened by food shortage, farmers often must employ strategies that increase immediate income sources and subsistence levels, but have detrimental consequences for the natural environment"* (Frankenberger and Goldstein, 1990, p21, cited in Moorehead and Wolmer, 2001)

Scholars such as Ostrom (1990) have, however, challenged the conventional wisdom of degradation and management of common property resources. According to Ostrom (1990), common property resources such as fisheries, groundwater resources and pastures have been long subjected to over exploitation by individuals. However, the development of sophisticated systems to enforce rules for handling conflicts of interest and for decision-making by the resource users promotes successful outcomes (Ostrom, 1990). Consequently, common property resources will then be successfully managed by the resource users, as noted in the Swiss grazing pastures case study. In Torbel, a village in the Swiss Alps, common property boundaries were clearly set and access to these resources was limited to the citizens. Overuse of the grazing lands was an offence subjected to financial penalties, which were enforced by a selected member of the community (Ostrom, 1990). Overgrazing was avoided by strict access control and rules and regulations set by the community. Torbel has maintained its productivity for centuries and has been improved due to investment by the community in maintaining the pastures (Ostrom, 1990). Additionally, long-term sustainable resource use is maintained by interactions between people and ecosystems, with institutional arrangements being made to manage the commons and avoiding ecosystem collapse (Ostrom, 1990).

As has been illustrated by the Machakos case study, poor rural populations do not necessarily cause natural resource degradation. In Machakos, the availability of knowledge and technologies on soil and water conservation methods acquired through agricultural extension made sustainable natural resource use achievable (Mortimer *et al*., 1994). However, Zaal and Oosterndorp (2004) among others have considered Machakos an unusual case which cannot now be replicated, in particular the conducive market conditions, infrastructure and government support that existed at that time. The inability to replicate the success of Machakos in terms of conservation and reversal of land and resource degradation leaves the rural poor worse off in the environmental degradation nexus, especially in their quest for food security due to the inability to invest in their land and resources.

2.2.3 Degraded Environments

While the debate about population and the environment continues, rural livelihoods continue to depend on the natural resource base, as a source of income and as a coping strategy in the face of food insecurity. Further, natural resources provide a buffer for rural households against shocks, providing ways of generating much needed income and supplementing dietary food needs (Hunter *et al.*, 2007). Accordingly, the rural poor are usually the most vulnerable to all kinds of shocks to the natural system that sustains them, such as climatic variability and progressive degradation (Binns, 1997; Vogel, 2005; Kangalawe and Lyimo, 2010). In southern Africa, the highest concentrations of rural people are settled in areas prone to degradation, in semi-arid and arid lands, largely due to a legacy of colonial era policies (Moyo *et al.*, 1991; Booth *et al.*, 1996; Ansell *et al*., 2009; Le Roux and van Huyssteen, 2010). It is therefore essential to understand the coping strategies undertaken to combat and tolerate hunger and malnutrition. The strategies could be physiological, biochemical or behavioural but with acknowledgement that coping mechanisms for long-term climatic cycles and for short-term food security shocks are different (Maxwell and Frankenberger, 1992; Moorehead and Wolmer, 2001). These strategies are mainly dependent on natural resource availability for subsistence farming and rural livelihoods.

Approximately 80% of the world's most hungry people are based in rural areas and depend largely on the exploitation of natural resources for their livelihoods (FAO, 2005). They rely on soil and water resources for subsistence farming (crops and livestock); economic activities such as fishing, processing and marketing of agricultural products; and forest and biodiversity resources for timber and non-timber products including wildlife (FAO, 2005; Scoones *et al.*, 2005; Kangalawe and Lyimo, 2010).

Substantial tracts of tropical and indigenous forest as well as grassland are for example, cleared annually for agriculture and other land uses. In poor countries this may lead to the overexploitation of the available resources, with negative effects on food production (Booth *et al.*, 1996; FAO, 2005; Kangalawe, and Lyimo; 2010). In Africa, an estimated 50 000 ha of forest and 60 000 ha of grassland are lost to agriculture annually (Henao and Baanante, 2006). Another estimated 600 000 ha of indigenous forests in the sub-humid zones is cleared every year for various land uses (Blay *et al.*, 2004)[6]. Such behavior supports the Neo-Malthusian hypothesis of a growing world population unable to feed itself, and a world desperate to meet its food needs through exploitation of natural resources (Devereux and Maxwell, 2001; Blay *et al.*, 2004; Henao and Baanante, 2006; Ansell *et al*., 2009).

One factor singled out among all the environmental factors is land degradation, cited in the progressive decline of African livelihoods (Chapman, 1995; Dregne, 1998). Land degradation is defined as a temporary or permanent decline in the productivity of land. Its effects are worst in SSA, manifest in the decline in forest products and wild foods, worsening levels of poverty and malnutrition (Blay *et al.*, 2004; FAO, 2009). Anthropogenic factors such as clearing of woodlands for agricultural expansion, logging, firewood collection and charcoal production, lead to deforestation, a component of land degradation (Blay *et al.*, 2004).

Land degradation processes such as soil erosion by wind and water may result in the loss of essential soil nutrients which could reduce agricultural yields from an estimated 17% to 30% by 2020 (Henao and Baanante, 2006). The consequence will be a vast decrease

[6] These figures should be treated with caution; the data may not always be accurate.

in the yield of cereals by as much as 10 m t, tubers and roots by 15 m t and pulses by 1 m t (Henao and Baanante, 2006). SSA alone will be importing approximately 34 m t of cereals by 2020 if the current poor agricultural land management is maintained (Henao and Baanante, 2006). Land degradation has further been cited as a factor responsible for increased pollution of water resources, with undesirable consequences for Africa's growing population (Dregne, 1998). The predicted population growth may result in more pressure for food. FAO (2005), for example, reports that the highest rates of deforestation occurred in areas where hunger was prevalent and where access to water and sanitation were lowest. This could represent most of the southern Africa rural areas.

Although deforestation has been blamed for the land degradation in Africa, Binns (1997) cites some areas where tree cover has greatly improved over the last two decades. The initial clearance of woodland or forest for agriculture is followed by planting of trees and shrubs that are beneficial for the settlers. Various initiatives focussing on rehabilitation of degraded lands and forests have been under way especially in SSA and other parts of the world (Blay *et al.*, 2004; FAO, 2009).

2.2.4 Sustainable Environments

The two degradation narratives on population and the environment outlined above have influenced how policies for the management of the environment and consequently natural resources are made and implemented, with population and the environment usually being treated separately. The concept of sustainable development in the 1980s resulted in people and the environment being considered more as inter-dependent entities, especially for populations that are dependent on the natural resource base for food security and livelihood. This brought about the concept of sustainable livelihoods and sustainability, including food security and in particular:

> *" people's capacity to meet food security needs without compromising that of future generations to do so – that is without degrading the natural resource"* (Devereux and Maxwell, 2001 p94).

Consequently, sustainability has become more about the tradeoffs between the environmental, economic and social dimensions of food security (Moorehead and Wolmer, 2001; Kangalawe and Lyimo, 2010). Sustainable development summarises the reduction of vulnerabilities, poverty and welfare issues, social justice and environmental protection while embracing economic growth and equitable distribution of its gains, which can be analysed through the sustainable livelihoods framework (Moorehead and Wolmer, 2001; Kangalawe and Lyimo, 2010).

The issues of food security and environmental sustainability have been addressed at a global and local level. Questions raised are whether livelihood activities maintain and enhance or deplete and degrade the natural resource base. It has been noted that livelihoods may contribute to degradation, desertification, deforestation, erosion and other negative impacts (Devereux and Maxwell, 2001; Kangalawe and Lyimo, 2010). On the other hand, livelihoods may also improve the productivity of renewable resources such as air, water, soil and organic soil fertility and trees. People who are vulnerable to environmental shocks and are less able to cope with change have, however received less attention in the environmental arena. As a result, environmental vulnerability has not been closely associated with poverty but rather with food security (Moorehead and Wolmer, 2001). Despite less attention given to environmentally vulnerable people, their dependence on natural resources continues, supplementing household income and food.

2.3 The Role of Natural Resources in Rural Livelihoods

The previous discussion has delved into some of the long and complex population and environment narratives, looking in particular at the dependence on natural resources as a driver of environmental change. The focus now turns to examine the importance of natural resources in rural livelihoods, including the role played by natural resources in the livelihoods of those affected by the HIV and AIDS epidemic.

The reliance of the rural poor on natural resources, particularly common property resources, is not a new phenomenon and neither is it only associated with the HIV and AIDS epidemic (Hunter and Twine, 2005). The exploitation of wild foods, also termed survival foods, in times of stress, be it physical, economic or social, has been documented since the 1970s. More than 30% of the calorific intake is derived from these survival foods (Maxwell and Frankenberger, 1992). The reduction in these resources may indicate food security shortages. Consequently, women are usually the worst affected by shortages or degradation of these resources, being the main resource collectors responsible for feeding the household (Maxwell and Frankenberger, 1992; Dovie *et al.*, 2003; Hunter and Twine 2005).

Conditions of natural resources directly relate to three key aspects of poverty, namely livelihoods, health and vulnerability (Carney, 1999; Adelzadeh, 2003). Land-based livelihoods, including natural resource harvesting, are highly susceptible to the impacts of environmental degradation (Hammarskjöld, 2003; Hunter and Twine, 2005). Biomass is the most important natural resource asset with various uses including energy, construction and implements (Dovie *et al.*, 2003; Dovie *et al*., 2007). The reliance of rural people on biomass is mainly associated with natural resource degradation and access to food, with fuel wood sufficiency pertinent to food security (Kangalawe and Lyimo, 2010). The availability or lack of biomass may influence the shift to foods that require less energy to prepare despite being of less nutritional value. Where biomass shortages are experienced, the food and nutrition security of the affected population may occur (Emery and MacLain, 2001). Shortage of biomass may result in more time spent looking for fuel wood, compromising agricultural activities. This is compounded by the utilisation of alternative fuels such as dung and crop residue which could be used to fertilise the fields for better yields and to improve soil conditions (Devereux and Maxwell, 2001). Further, high demands for biomass energy have led to deforestation and environmental degradation (Kangalawe, and Lyimo; 2010).

An even greater role is played by non-timber forest products (NTFP) (Dovie *et al.*, 2003; Shackleton and Shackleton, 2004; Dovie *et al*., 2007). According to Shackleton and

Shackleton (2004), an average of 95.6% of households consumed wild vegetables, 88.2% wild fruits, 53.5% insects such as locusts, and 51.6% consumed bushmeat in rural South Africa. Cumulatively, these households consume 58.2 kg of wild vegetables annually, with the common species consumed as much as twice a day. Traditional medicines, mostly derived from the forest, form the basis of primary health care, regularly used by traditional healers as a complimentary form of health care. These are essential as modern medicine is inaccessible for the rural poor and as the prevalence of HIV and AIDS and other diseases increase (Emery and McLain, 2001; Konz, 2007). Commercial harvesting for markets in cities could possibly lead to unsustainable harvesting of medicinal plants, leading to biodiversity loss (Botha *et al.*, 2004; Dovie *et al.*, 2007).

Wildlife, wild fruits and foods are also recognized for their crucial role in supplementing household food and nutrition as well as household income during normal, drought and famine periods and to supplement household income. When faced with economic hardships, natural resources provide inexpensive alternatives to commercial goods, offering households opportunities to generate income from trade of natural products (Dovie *et al.*, 2004; Shackleton and Shackleton, 2004). Thus, wild fruits and food, including honey, are recognized as a means of coping with shocks such as droughts (Shackleton *et al.*, 1999; Dovie *et al.*, 2003; Dovie *et al.*, 2007). Other natural resource assets harvested are reeds used for making furniture and thatch grass, all of which are gathered and sold by the rural people, fodder and biomass for feeding animals and for composting (Emery and McLain, 2001).

The overall condition of the natural resource base may thus impact greatly on the resilience of households to withstand any changes in household food insecurity and household income, especially for vulnerable households such as those affected by the death of a breadwinner due to AIDS (Hunter, 2006). In turn, the epidemic is presumed to also have detrimental impacts on the sustainable utilisation of natural resources due to increased dependence on the resource. As more prime-aged adults, for example, succumb to the epidemic, the knowledge of proper utilisation of natural resources is lost thereby impacting on the possible sustainability of effective natural resource utilisation (Hammarskjöld, 2003; Thaxton, 2004; Torell *et al.*, 2006) .

The importance of the natural environment is further acknowledged in the new emerging literature on agriculture, food security and health. Agriculture production, which is pertinent for human health, depends on environmental services to convert raw materials into various nutritional foods (Nugent and Drescher, 2006). However, poor and careless agricultural practices may contaminate natural resources with detrimental impacts for human health, resulting in direct health implications or through a reduction in food security (Nugent and Drescher, 2006). Agricultural practices such as land clearing and use are cited in the various problems associated with soil loss, erosion and sodicity to mention a few, resulting in loss of active agricultural farming land (Nugent and Drescher, 2006). Land clearing also results in loss of, and declining biodiversity, especially of medicinal plants leading to many ecosystem service challenges, given that biodiversity is important for a healthy environment and sustainable livelihoods (John *et al*., 2006). The implementation of agricultural practices with positive environmental and health impacts could promote positive agriculture, environment and health synergies (Nugent and Drescher, Benson, 2006).

2.4 Food Security

Having discussed the importance of natural resources in rural livelihoods and in HIV/AIDS impacted households and some of the nuanced complex debates, attention now turns to examine food security in greater detail, which has been noted above as one of the key drivers that compounds simplistic interpretations of changes in natural resource utilisation. Natural resource utilisation, as a major component of livelihoods, has mainly been associated with the need to fulfill household food security needs and household income for mainly rural populations. As previously mentioned, natural resources can also act as a buffer for households faced with internal or external shocks and stressors, such as death or drought (Hunter and Twine, 2005).

The food security paradigm has evolved in recent decades with shifts in the perception of food security. Historic debates on the perception of food security and how it is attained have shaped the way polices were made and implemented. These debates have centered on the relationship between food security and the environment, with two main opposing views, which have already been discussed. The next section discusses the food entitlement approach, which has been influential in the paradigm shift on the perception of and conceptualisation of food insecurity by shifting the focus from people to the institutional arrangements that influence how food is attained and accessed. The conceptualisation of food security and vulnerability to food insecurity is also discussed, alluding to the complexities involved in the food security paradigm.

2.4.1. Food Entitlement

The entitlement theory is the basis of much of the discourse on food security and famine. Based on the works of Sen, 'Poverty and Famines' in 1981, the concept of entitlement[7] is premised upon the acquisition and exchange of property in social systems. The entitlement approach is based on three conceptual categories, the endowment set, the entitlement set and the entitlement mapping (Nayak, 2000).

According to Sen (1981), an individual's exchange entitlement is dependent on the initial endowment or inherited property rights and the method in which the endowments are shaped, referred to as entitlement mapping. Four ways of obtaining food are recognized, production (production entitlement), buying (trade base entitlement), working for food (own labour entitlement) and being given (transfer based entitlement).
The endowment set is the combination of resources legally owned by an individual, conforming to established norms and practices and these resources include both tangible assets, such as land, equipment, animals and intangibles such as knowledge and skill, labour power, or membership of a particular community (Nayak, 2000). The entitlement set is the possible combinations of goods and services that can be legally obtained by a

[7] Entitlements are defined as the set of all commodity bundles over which a person can establish command given the legal, political, economic and social arrangements of the community in which they live

person, using the resources of his/her endowment set, and this use of these resources may be either in the form of production, exchange or transfer. The resources are used to obtain final goods and services (Nayak, 2000). The entitlement mapping, also referred to as E-mapping, describes the relationship between the endowment set and the entitlement set. E-mapping refers to the rate at which the resources of the endowment set can be converted into goods and services included in the entitlement set (Nayak, 2000). Thus, food shortage is due to the entitlement failure, especially if the entitlement set of an individual does not contain enough food and in the absence of non-entitlement transfers, for example charity. Entitlement failure results in two types of famine, one is due to changes in entitlement and the other due to changes in entitlement mapping (Nayak, 2000).

The entitlement theory places emphasis on food accessibility rather than food availability as a cause of food insecurity (Sen, 1981; Devereux, 2001a). This paradigm shift in food security since the 1970s made local household level the unit of analysis, instead of global and national level (Maxwell, 2001; Baro and Deubel, 2006).

Politics or lack of political commitment, cited by the FAO (2006) as one of the deterrents towards achieving millennium development goal one[8], is also pinpointed in Sen's entitlement theory as a cause of food insecurity. Politics even at the local level bring out issues of power struggles that affect the food security of communities (Sen, 1981; Devereux, 2001; Baro and Deubel, 2006).

There has been some criticism leveled at Sen's entitlement theory, due to its narrow description and explanation of famine and the assumption that famines occur in functional societies. Further, famine is not classified as a discrete event set off by external causes but as caused by long-term socio-economic processes that accelerate impoverishment and makes people vulnerable (Baro and Deubel, 2006, cited in Ansell *et al.*, 2009). According to Devereux (2001a), by placing an emphasis on entitlement through legal ways, Sen failed to cross-examine the social realm in which claims over food are exercised within households and communities. The next section discusses the

[8] Millennium Development Goal one is the eradication of extreme hunger and poverty by 2015

conceptualization of food security and vulnerability including the definitions used. The conceptualisation of food security has been largely influenced by the food entitlement approach.

2.4.2 Conceptualising Food Security and Vulnerability to Food Security

There are a myriad of definitions of food security, most of them dependent on organisations' and peoples' perceptions. The most widely used definition is derived from the World Food Summit (1996), which defines food security as being

> "*achieved when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food, to meet their dietary needs and food preferences for an active and healthy life.*" (FAO, 2006 p1)

Therefore ***food insecurity*** exists when an individual or population group does not have access to enough food, either through lack of availability or poor utilisation. There are two types of food insecurity: chronic and transitory. Chronic food insecurity is defined as a continuously inadequate diet as a result of the inability to acquire food, affecting households that continually cannot either buy or produce their own food to meet their dietary requirements (FAO, 2003). On the other hand, transitory food insecurity is temporary, usually occurring just before the next harvest or induced by crop failure in a season. Food security is classified into three distinct categories, food availability, food accessibility and food utilisation, occurring on three levels; national, household and individual (Figure 2.3).

Food availability at national level is determined primarily by agricultural production and food supply, including imports of grain where shortages are envisaged (FAO, 2006). Local food production is determined by access to arable land and the size of the land holdings for subsistence farming by the rural populations and the farm labourers. Other factors such as rainfall, temperature, soil condition and soil degradation influence the yields of staple foods such as maize. This is compounded by the lack of agricultural infrastructure such as irrigation and farming equipment and lack of access to finance to invest in subsistence agriculture (DOA, 2002).

Food access is defined as access by individuals to adequate resources - entitlements, (see Entitlement above) for acquiring appropriate foods for a nutritious diet (FAO, 2006). Access to food is mainly dependent on sources of income, which are in turn influenced by employment or unemployment. Accessibility is further affected by infrastructure in terms of roads to reach the markets to buy food or access to markets to derive livelihoods as a source of income, particularly in remote rural areas. While poverty levels are utilised in measuring household accessibility, international and local grain markets play an important role, determining the prices of staple grains. Increases in food prices, affect the working class and poor populations (DOA, 2002; Von Braun, 2008). Food access for the poor is additionally influenced by safety nets for the poor provided by the government such as pension and other social grants.

The availability of food at national and household level does not guarantee individual food security. This is determined by **food utilisation**, which in turn depends on the health of the individual. Diseases such as AIDS affect all dimensions of food security; availability, stability, access and utilisation, resulting in food insecurity as an outcome and exacerbating vulnerability to food insecurity where its prevalence is high (DOA, 2002; FAO, 2006). Access to clean water and sanitation, reduces the chances of diarrhoea diseases thus improving food security among the affected population groups.

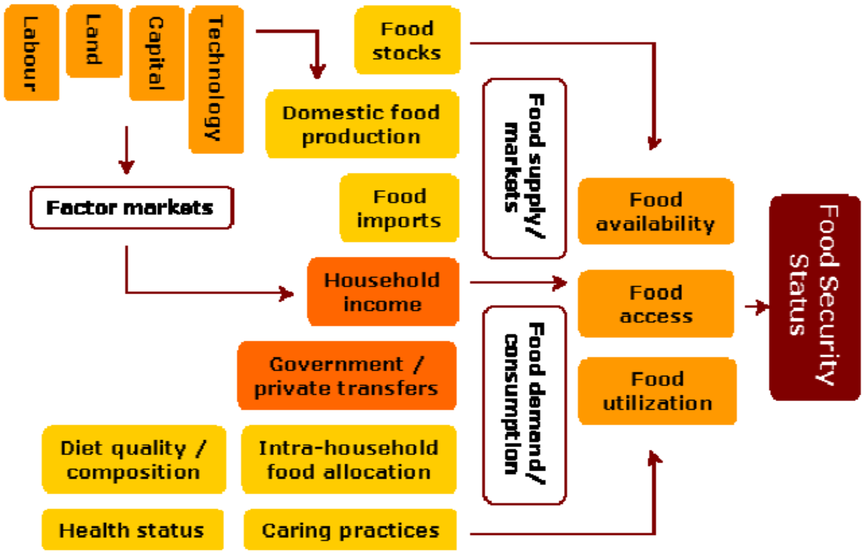

Figure 2.3: Conceptual Framework of Food security and vulnerability (Bangladeshi Food Security Atlas, 2004).

2.4.3 Vulnerability to Food Insecurity

While the above section has discussed the definition and conceptualisation of food insecurity, vulnerability to food insecurity is conceptualised differently with the concerned populations likely to become food insecure due to their physical, economic and or social conditions. Vulnerability is defined as a condition of exposure and sensitivity to stress or shocks and the ability of the affected population to cope or recover from these shocks (Devereux and Maxwell, 2001). Vulnerability refers to the various factors that place people at the risk of being food insecure, as a result of their exposure to risk factors and their ability to cope with or withstand stressful situations. Vulnerability affects groups of people and places differently and occurs at different levels. Vulnerability is further classified as internal (pertaining to shocks or hazards) and/or external, relating to the capacity of affected households to cope with those shocks (SEI, 2004).

Food insecurity is classified as a form of vulnerability, in other instances it is classified as an outcome of vulnerability. Organisations such as FAO do however differentiate between the two, classifying vulnerable people as having a high probability of becoming food insecure and the food insecure being those who already cannot meet their minimum food requirements (FAO, 2006). Poverty is also considered as a form of vulnerability, affecting a community's ability to cope with the different stressors, shocks and hazards. On the other hand poverty can also be an outcome of the different factors acting concurrently on a community.

The questions of vulnerability are based on social, economic, demographic and political frameworks (see Figure 2.3). Spatially, regions or areas may be vulnerable to climatic elements such as drought or socio-economic factors such as violence and crime; however, the most vulnerable people may not be in vulnerable areas and *vice versa* (SEI, 2004). Due to the complexity of vulnerability, it is essential when mapping vulnerability to consider the above mentioned economic, social and environmental factors. It should be noted nonetheless that some overlaps may occur between food insecurity and vulnerability.

2.5. Persistent Food Insecurity in Southern Africa

The entitlement approach and the conceptualisation of food security and vulnerability to food insecurity have laid the foundation for the understanding of food security mainly at a local household level. At the national level, different factors influence food security, mainly food availability. As previously mentioned in the introduction to this chapter, economic, political and social activities in the SADC region affect local food insecurity. This next section focuses on food security in SADC and some of the causes of this food insecurity.

Despite concerted efforts at international, regional and national levels by international organisations, non-governmental organisations (NGOs) and national governments, both food insecurity and poverty continue to challenge the SSA region. The World Food Summit (1996) and the Millennium Summit (2000) brought forth the 10 millennium development goals (MDGs) of which the first is the eradication of extreme hunger and poverty. Further, the first millennium development goal pledged to halve the number of undernourished people in the world by 2015.

The MDGs were initiated after two decades of food insecurity in SSA (Devereux and Maxwell, 2001). The consensus around the MDGs propelled the eradication of extreme hunger and poverty to the top of the development agenda in southern Africa and other developing regions (FAO, 2005). While most developing regions have shown improvements in their food security status, SSA continues to face widespread chronic food insecurity and persistent famines (Devereux, 2001b; Vogel and Smith 2002; Drimie and Misselhorn, 2005; FAO, 2009). Despite making this a priority, the past three decades have seen an increases in the number of malnourished and undernourished, accounting for 13% and 25% of the total population, respectively, with one third suffering from chronic hunger (Figure 2.4) (FAO, 2006, 2009). The number of malnourished children in the sub region also continues to increase (IFPRI, 2004, 2005).

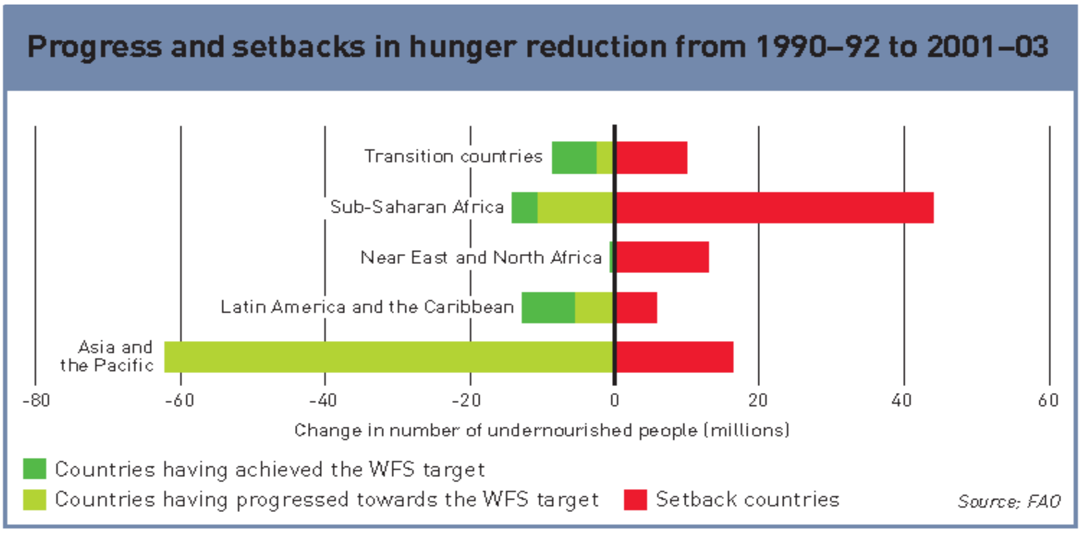

Figure 2.4: Progress and setbacks in hunger reduction from 1990-92 to 2001-03 (www.fao.org).

There has been virtually no progress towards the attainment of this goal within the last ten years, neither globally nor regionally. The FAO projections in 2006 highlighted a 10% reduction in the number of hungry people by 2015, from 1990-1992. Nevertheless, the global target for the reduction of undernourished people will not be met, with 1.02

billion people undernourished in 2009, instead of the World Food Summit target of 412 million (FAO, 2006, 2009). This has been attributed to the previous and current global food and economic crisis (FAO, 2009). To this, SSA contributes 265 million people, an increase of 11.85% from 2008 (Figure 2.5). Further, the number of hungry people was on the rise even before the economic crisis (FAO, 2009). While some progress in the reduction of the undernourished population was noted in several countries in 2006, with a 3% drop from 35% to 32% over an eleven year period, as 2015 draws near, it is becoming increasingly clear that SSA will not attain the first MDG, unless dramatically innovative interventions are taken on a large scale (FAO, 2006, 2009).

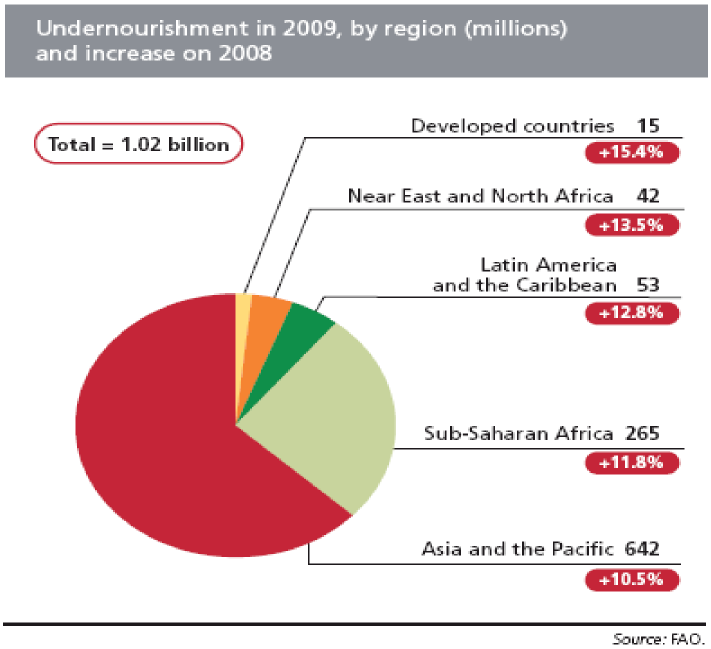

Figure 2.5: Undernourished global estimates 2009 (www.fao.org).

Regardless of the world being richer and more food being available than 10 years ago, and despite improved knowledge and resources in fighting hunger, political will and commitment to mobilise these resources for the poor, especially in the face of current food and economic crisis[9] has been lacking and remains a challenge (FAO, 2006, 2009; Von Braun, 2008). The global decline in agricultural investment, conflicts and other

[9] The increase in food insecurity is because high domestic food prices, lower incomes and increasing unemployment reducing access to food by the poor.

forms of natural disasters, as well a fragile agricultural resource base and meagre economic development, has worsened the food security situation. This has been exacerbated by high rates of population growth, especially for agro-economic dependent countries (FAO, 2009).

The rural poor are the worst affected by food insecurity, leading to rural-urban migration in some cases, as a means of escape from rural livelihood depravation, and in turn making urban food security a new developmental challenge (FAO, 2006, 2009). The scourge of the HIV and AIDS epidemic between 1997 and 2007 (Figure 2.10) exacerbated an already vulnerable region, plunging SSA, southern Africa especially, into a humanitarian crisis of unparalleled dimensions. While the debates about the making of this humanitarian crisis rage on, the increased suffering and vulnerability of this region continues unabated.

The World Food Summit Plan of Action (Figure 2.6) was adopted as a way to combat the spread of hunger. The main thrust within the commitments of the plan of action underline the importance of sustainability in achieving food security. While the importance of agriculture in meeting food security and eradication of poverty in rural livelihoods is emphasised, commitment three and six acknowledges the presence of other non-agricultural livelihoods (natural resources). These include fisheries and forestry systems (FAO, 2006).

The World Food Summit Plan of Action

Commitments

1 We will ensure an enabling political, social, and economic environment designed to create the best conditions for the eradication of poverty and for durable peace, based on full and equal participation of women and men, which is most conducive to achieving sustainable food security for all.

2 We will implement policies aimed at eradicating poverty and inequality and improving physical and economic access by all, at all times, to sufficient, nutritionally adequate and safe food and its effective utilization.

3 We will pursue participatory and sustainable food, agriculture, fisheries, forestry and rural development policies and practices in high and low potential areas, which are essential to adequate and reliable food supplies at the household, national, regional and global levels, and combat pests, drought and desertification, considering the multifunctional character of agriculture.

4 We will strive to ensure that food, agricultural trade and overall trade policies are conducive to fostering food security for all through a fair and market-oriented world trade system.

5 We will endeavour to prevent and be prepared for natural disasters and man-made emergencies and to meet transitory and emergency food requirements in ways that encourage recovery, rehabilitation, development and a capacity to satisfy future needs.

6 We will promote optimal allocation and use of public and private investments to foster human resources, sustainable food, agriculture, fisheries and forestry systems, and rural development, in high and low potential areas.

7 We will implement, monitor, and follow-up this Plan of Action at all levels in cooperation with the international community.

Figure 2.6: The World Food Action Plan (www.fao.org)

2.6 Causes of Food Insecurity in Sub-Saharan Africa

The persistent food insecurity in southern Africa has been attributed to the failure of the African Green revolution, revealing the complex nature and the different actors involved in the making of the food crisis (Scoones *et al.*, 2005). The following section discusses the multifaceted causes of food insecurity with a focus on the SADC region.

2.6.1 Decline in Agricultural Production and Productivity

As an essential economic activity, agriculture contributes more than 30 percent of GDP (gross domestic product) of most African countries. In addition, agriculture provides employment and income to 75% of the African population (Devereux and Maxwell, 2001; Henao and Baanante, 2006; World Bank, 2007). Despite its importance, agricultural productivity in the region is declining, this attributed to a number of reasons. The decline in agricultural production has been further exacerbated by the HIV and AIDS epidemic. This has adversely affected the availability of farm labour through sickness and death of the most productive segment of the population (15-49 years) (Drinkwater, 2005). Labour has further been diverted from farming to caring for the sick (de Guerny, 2000; Ansell *et al.*, 2009; Arrehag *et al.*, 2009). Qualitative data from Mutangadura (1998), for example, shows that AIDS can limit productivity of maize farming by up to 60%. Increased trends in rural-urban migration further limit the availability of labour to till the land (Bruce *et al.*, 2007), while the tendency to abandoned agriculture for cash based livelihoods further compounds the dilemma of agricultural productivity (Bryceson, 1999).

The poor performance of the agricultural sector has contributed to the slow progress of the reduction of poverty and hunger in Africa. The growth in per capita agricultural output has lagged far behind other developing regions and has barely kept up with population growth rates (FARA, 2006). In order to meet the first MDG, the agricultural sector needs accelerated growth and to maintain annual growth rates of approximately 6.2%. Some countries will require even higher growth rates, given the many years of agricultural neglect (FARA, 2006).

However, the focus on agriculture has also been cited as resulting in a neglect of other non-agricultural rural livelihood strategies (Scoones, 1998; Devereux and Maxwell, 2001) and other factors contributing to food insecurity (Harvey, 2004; Misselhorn, 2005; FAO, 2006). Such strategies would include harvesting of natural resource products. While it is acknowledged that increased agricultural production may solve the current food crises, only 6% of arable land in the region is irrigated, mainly in South Africa. With 60–80% of the region dependent on rain-fed agriculture, southern Africa remains vulnerable to climate variability (Ziervogel *et al*., 2006; Boko *et al*., 2007).

2.6.2 Climate Variability and Food security

As previously mentioned, southern Africa is vulnerable to climate variability. Climate variability may result in increased occurrences and intensity of extreme natural events, such as drought, floods and cyclones as well gradual changes in rainfall and temperature (Vogel, 2005; Ziervogel *et al*., 2006; Boko *et al*., 2007; Brown and Crawford, 2009). The impacts and losses resulting from these extreme events are immense, due to poverty and weakened competence to cope and recover from them (Oxfam, 2008). SSA is expected to bear the brunt of the adverse effects of climate change and variability, both in terms of intensity and magnitude (Vogel, 2005; Boko *et al*., 2007).

The impacts of climate variability are already being felt particularly by the rural poor and possibly some subsistence farmers who rely on rain-fed agriculture (Vogel, 2005; Ziervogel *et al*., 2006; Boko *et al*., 2007). For example, while not the sole causes, droughts, floods and frost, triggered the 2002-2003 food crisis in the region (Vogel, 2005; Ansell *et al*., 2009; Brown and Crawford, 2009). Climate variability affects both irrigated and commercial agriculture and rain-fed subsistence agriculture (Vogel, 2005; Ziervogel *et al*., 2006).

For countries that depend on agriculture, losses due to floods or drought will negatively impact on the GDP, including losses in farm labour and livelihoods. The 1991-1992 drought is reported to have reduced maize production in Southern Africa by 10 m t, costing an estimated US$500m to import and transport cereals to affected countries (Vogel, 2005). Flooding in Mozambique reduced economic growth from 8 to 2% (Brown and Crawford, 2009). Further, hail and frost attributed to the food crisis in Lesotho. Thus a combination of slow climatic changes and increased occurrences of sudden shocks may result in larger and frequent poor harvests of which countries would not be able to cope or recover (Vogel, 2005; Oxfam, 2008; Brown and Crawford, 2009).

Climate change and variability may also alter agro-climatic zones, affecting the length of growing seasons, and consequently affecting food production (Devereux and Maxwell, 2001; Fischer *et al.*, 2002). Some agro-ecological zones will gain in agricultural land but substantial losses are expected for sub Saharan Africa (Fischer *et al.,* 2002). Climate modeling has projected the potential increase in global food production, with the increases in local average temperature over a range of 1 to 3^{o}C. It is therefore argued that global food production will be maintained despite the effects of climate change (Boko *et al*., 2007; Brown and Crawford, 2009). However, the distribution of hunger will not change as a result of climate change, although climate and socio-economic changes will have negative effects on sub-Saharan Africa (Devereux and Maxwell, 2001; Boko *et al*., 2007).

Inter-annual climatic variability or poor and erratic rainfall has been persistent in southern Africa over the past 40 years, resulting in intense and wide spread droughts and consequently, resulting in a continuous decline in food production (Mudimu, 2003; Brown and Crawford, 2009). The inability of countries to cope and or respond adequately to the drought of 2002 for example, despite early warning indications, compounded the famine which became a major humanitarian crisis (Mudimu, 2003). For example, Zimbabwe had previously struggled to recover from the effects of cyclone Eline during 1999-2000, followed by dry spells in 2000-2001, combined with the years of economic decline and balance of payments. All these factors resulted in a reduction in food production and the inability to produce surplus commodities for export to earn foreign currency, transforming a food surplus country into a food deficit country (Mudimu, 2003). While international Non-Governmental Organisations such as World Vision have cited economic and political instability as well as governance issues as the causes of the humanitarian crisis (www.worldvision.org, 2009), climate variability has played and continues to play a key although not solitary role in triggering and perpetuating the food and humanitarian crisis.

While the causal linkages and feedbacks within and between natural and social systems are under scrutiny, it has been acknowledged that climate change and/or variability may act together with other existing stressors such as HIV and AIDS, compounding the vulnerability of the affected communities (Oxfam, 2008). It is therefore important to understand these linkages and interactions in order to urgently and adequately respond to these extreme events. Strategies for response include building resilience and preparedness among the target communities and reducing sources of vulnerability, while complementing traditional efforts (Oxfam, 2008). Previously, the failure, mainly by governments, to adequately respond to these extreme climatic events has jeopardised rural livelihoods that consist mainly of subsistence farmers (Drimie, 2004).

Further, government economic policies such as economic liberalisation exacerbated the food security crisis in the region.

2.6.3 Adverse Effects of Economic Liberalisation on southern African Agriculture and Globalisation

The removal of agricultural subsidies through economic liberalisation, for example, adversely impacted most countries' economies (Drimie, 2004; IFPRI, 2004). Market functionality is central to the ability of individuals, household and communities to access food (Vogel and Smith, 2002). The assumption that markets would fill the gap of supplying agricultural inputs, as well marketing the produce, failed to perform to expectation. The failure of markets resulted in agricultural inputs being out of reach of many farmers (Rosegrant *et al.,* 2006). This led to a decline in agricultural production and agricultural exports, farmers unable to reinvest in their livelihood and the poor unable to purchase food. Similar trends of erosion of livelihoods and economic liberalisation have been noted in other countries in the sub region (Jooma, 2005).

The lack of agricultural support, especially for smallholder farmers, resulted in a substantial decline in maize production and other economically viable crops (Drimie, 2003). While overall the food production in southern Africa increased by 2.7% per annum between 1990 and 1997, it failed to keep the pace with population growth at 3% per annum (Gibbon, 2000; Misselhorn, 2005). Food dumping by developed countries at uncompetitive prices resulted in market inaccessibility and poor production prices for the regional and local agricultural sector. Mbaya (2003) argued that the stringent agricultural reforms undertaken under the Economic Structural Adjustment Programmes (ESAP) in the region, under the direction of the International Monetary Fund (IMF), only served to augment food insecurity (Mbaya, 2003).

Whilst there has been a boom in global trade particularly for small upcoming economies, the boom has benefited only a few in Africa with negative impacts in SSA in particular (Drimie, 2004; IFPRI, 2005). This is attributed to trade protectionist policies by developed countries that have resulted in unequal economic integration (Devereux and

Maxwell, 2001; Drimie, 2004; IFPRI, 2005; Jooma, 2005). Despite initiatives such as NEPAD, whose aim is to integrate African agriculture into the global market and despite African agriculture being amongst the world's most globalised, issues of food insecurity in the continent persist (Von Braun, 2004).

Countries like South Africa and Kenya benefited from globalisation especially in horticulture, targeting mainly international export markets. However, increasingly stringent requirements and control by the overseas markets and buyers has resulted in the sidelining of smaller growers, even in these countries (Dolan *et al.*, 1999). This, for instance, led to restructuring of the citrus exports in South Africa with various winners and losers noted (Mather and Greenberg, 2003). It has also been recognised that in those countries where globalisation has succeeded, only a few have benefited (Dolan *et al.*, 1999; Mather and Greenberg, 2003). The removal of agricultural subsidies through globalization may have further contributed to the decline or erosion of livelihoods, adversely impacting most countries' economies noted in other countries in the sub region (Drimie, 2004; IFPRI, 2005; Jooma, 2005).

Globalisation has led to the improvement of average annual incomes in southern Africa but it also increased inequality between the rich and poor. The success of globalisation is much dependent on the ability of the population to participate in global markets, leading to economic growth (Watkins and Von Braun, 2003). However, in southern Africa, this had negative effects particularly on the small producers due to the rigid terms of international trade set by the World Trade Organisation (WTO), leaving the poorer countries less able to protect their local markets from the subsidised agricultural products (Misselhorn, 2005). This undermined local smallholder farmers and markets, with high tariffs on products manufactured from raw materials restricting opportunities for agricultural diversification and industrialisation. The reduction and or removal of government subsidies and controls, lead to poor quality products which could not compete on the global markets, exacerbating economic growth (Watkins and Von Braun, 2003; IFPRI, 2004; Misselhorn, 2005).

As a result of globalisation, food security policies moved beyond local production and consumption, into the hands of the large conglomerates that control the global food supply chain (Maxwell and Slater, 2003). Consequently, the recent increases on global food prices and increases on fuel have fuelled hyper inflation resulting in high food prices (Von Braun 2008). These price increases have affected the poor who are living below the poverty line, while pushing more families into food insecurity (Von Braun, 2008; FAO, 2009). The high food prices compromise the health and nutrition status of poor families, with irreversible consequences. The demand for production of biofuels may have further worsened an already dire situation, possibly affecting an already vulnerable population (Von Braun, 2008).

In recognition of the severity of the current food crises the G8[10] leaders issued a statement on global food security, pledging interventions that aimed to reverse the overall decrease in agricultural investment and increase support for initiatives in developing countries (Von Braun, 2008). Despite this and other pledges aimed at combating the global food crises, no political or financial commitments were made. While the good intentions to assist the poor and vulnerable countries are recognised, timely actions on global, regional and local level are pertinent including the merging of the food security and climate change agendas (Von Braun, 2008).

The picture on globalisation painted above seems very negative but Dozier (2010) argues that developing countries can benefit from globalisation. By increasing trade between nations and as civil liberties are recognised, trade and access to goods is increased there by creating income and wealth (Gurría, 2007; Dozier, 2010). The assumption is that more goods at lower prices will be available increasing food accessibility and thus the standard of life (Dozier, 2010). The potential for agro-economic based poorer countries to complete in the global food market is recognised and supported by organisations such as the World Bank (Dozier, 2010). While it has been pointed out that some countries will get richer at the expense of poorer ones, globalisation may be viewed as part of the solution to the persistent economic decline

[10] G8 - is an international forum for the governments of Canada, France, Germany, Italy, Japan, Russia, the United Kingdom, the United States and the European Union

in the southern Africa region, to reduce poverty and lack of availability of products (Gurría, 2007; Dozier, 2010).

2.6.4 National Governance in SSA region

As discussed in the previous section, climate variability and poor economic policies have worsened the food security in the region. This has been further exacerbated by poor governance by national governments. Increasingly recognized as one of the key factors exacerbating food insecurity, governance is cited as a major contributor to the food crisis of 2002-2003, particularly in Malawi and Zimbabwe (Vogel and Smith, 2002; Mbaya, 2003; UN, 2003). Some government policies notably on trade, pricing of inputs, lack of access to credit and limited funding for agricultural research and extension are cited. Furthermore, the instability of prices and the removal of price controls adversely impacted on smallholder agricultural production and access to food by the poor (Drimie, 2003; IFPRI; 2004).

The food crisis in Malawi in 2001-2 is a case in point. Previous events such as poor harvest, bad information, a depleted grain reserve, import bottlenecks, and unaffordable high food prices all contributed to the food crisis of 2001-1 (Stevens *et al*., 2002). In addition, Malawi, on the advice of the IMF (International Monetary Fund) sold its Strategic Grain Reserve (SGR), firstly to recycle old stock and secondly to repay a debt owed by the National Food Reserve Agency[11] (NFRA) (Vogel and Smith, 2002). The intention was to reduce the grain reserve from 165,000 t to 60,000 t with the anticipated looming harvest which turned out to be an overestimate (Stevens *et al*., 2002). In addition the relationships between the donor agencies and the government were strained, because of concerns about SGR profiteering and various governance issues. Thus when the famine occurred the government was unable to implement food distribution programmes and the donor response was delayed until civil society brought the food crisis to international attention (Stevens *et al*., 2002). The food crisis in Malawi led to thousands of hunger-related deaths, exceeding any famine in living memory.

[11] A Quasi government organisation dealing with grain

Approximately one third of the population was dependent on food aid by the peak of the famine in 2003 (Stevens *et al*., 2002; Devereux, 2003).

The ongoing food security crisis in Zimbabwe, on the other hand has been attributed to the poorly organised land reform, which resulted in the disruption of both commercial and non-commercial agricultural activities. The redistributed land has been under-utilised due to lack of finance to invest in agricultural inputs by the resettled farmers. In addition, the lack of training or knowledge on commercial farming, and the wide spread severe environmental degradation in the country, as a result of the land reform programme has led to low production levels (Maguwu, 2008). This together with the deteriorating international relations has contributed to severe food shortages (Maguwu, 2008). Zimbabwe has been dependent on imported and donated food for the past seven years, meaning that the refusal the by the government to appeal for food aid despite being advised to do so exacerbated food insecurity (Maguwu, 2008).

A recently hypothesis offered by the UN (2003) as an explanation of the humanitarian crisis in SSA, '*the triple effect'* cites governance as a major contributor, combined with other multiple stressors of poverty, chronic and recurrent food insecurity, principally drought and HIV and AIDS (Devereux and Maxwell, 2001; UN, 2003; Drimie, 2004).

2.6.5 Migration and Urbanisation

The failure by some governments to adequately respond to extreme climatic events and poor governance endangered rural livelihoods leading to migration as one of the coping strategies by affected farmers and communities. This is more prevalent in SADC countries, for example Zimbabwe. The ripple effect for the Zimbabwean crisis has affected the SADC region in form of migration by desperate Zimbabweans to neighbouring countries such as Mozambique, Botswana, Namibia and South Africa (Brown and Crawford, 2009; Kiwanuka and Monson, 2009). The remittances sent by migrants to sustain their families have become an essential and important economic activity for many Zimbabweans (Bracking and Sachikonye, 2006). This has nonetheless caused major challenges in the receiving countries, where resources are already limited for the local poor population, with no adequate systems and facilities to cope with the huge influx of refugees crossing borders on a daily basis (Kok *et al.*, 2006; Brown and Crawford, 2009).

While migration is not a new phenomenon, the magnitude of the current migration trend, not only from refugees and asylum seekers but from black professionals as well (Kok *et al.*, 2006; Kiwanuka and Monson, 2009), pose a lot of unforeseen challenges. This is prevalent in urban areas, where shortages of food, shelter, health and education are severely affected (Kok *et al.*, 2006).

While country to country migration is noted as a challenge as explained above, internal country migration, especially rural to urban is on the rise. More and more people are leaving their rural homes in search of employment in neighbouring towns, farms and mines. This results in a lack of labour to farm the land for subsistence, consequently leading to food insecurity (Collinson *et al.*, 2003; Kok *et al.*, 2006). Migration has been attributed to a lack of livelihood options in rural areas and the need for a cash based income which cannot be obtained from subsistence agriculture (Bryceson, 1999; Brown and Crawford, 2009). Access to basic services such as water and sanitation, health and wellbeing has further been cited as other reasons for migration especially within South Africa (Roux and van Tonder, 2006).

Rapid urbanisation (Figure 2.7) has resulted in rapid expansion of informal settlements, which bring about a whole set of social, economic and environmental problems (Brown and Crawford, 2009). The growth of informal settlements has resulted in overcrowding and spread of diseases as well high rates of food insecurity within the urban poor (Kok *et al.*, 2006). It is acknowledged that not all migration is permanent and this alleviates the pressure on urban resources. Nonetheless remittances gained by rural population as a result of migration play an important role in rural economies and should be acknowledged as such (Collinson *et al.*, 2003; Stats SA, 2006).

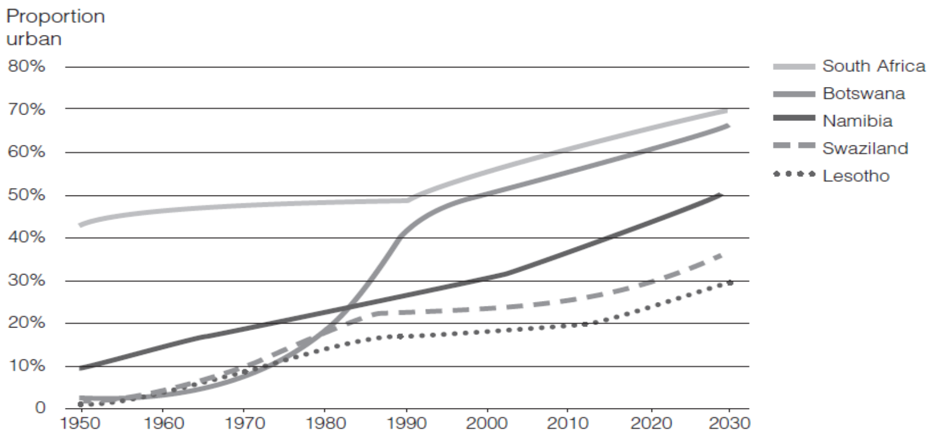

Figure 2.7 Urban population growth trends (UN, 2004; Kok *et al.*, 2006)

2.6.6 Poverty and Food Insecurity: A sub region under siege

The eradication of poverty, as in the case of the eradication of hunger, is facing severe challenges. The number of people in the region living in extreme poverty has doubled from an estimated 164 million in 1981 to 314 million in 2005 (Devereux and Maxwell, 2001; Jooma, 2005).

According to the Forum for Agricultural Research in Africa (FARA) (2006), to mitigate the increase in the number of SSA people slipping into poverty and consequently food insecurity (Figure 2.8), countries need to sustain increased agricultural productivity growth rates. Such growth rates have sadly eluded most countries in the region, with agricultural productivity on the decline.

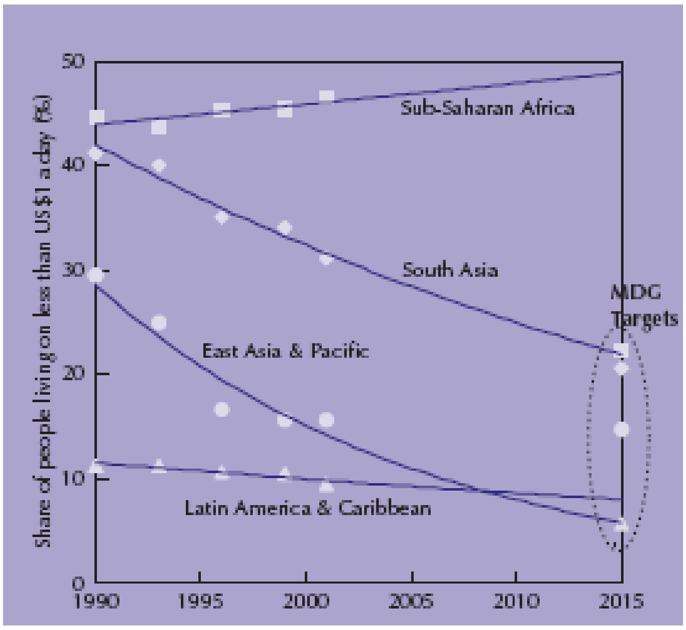

Figure 2.8: Progress in attaining MDG1 by 2015 (Rosegrant *et al.*, 2006: 20).

As discussed above, the food security situation in the region is brought about by a complex mix of factors, both external and internal occurring together or separately, resulting in what Jooma (2005) calls the '*entangling crises'* (Vogel and Smith, 2002). Even so, most of the external and internal shocks facing the sub region are neither new nor unpredicted. In spite of the dramatic improvements in early warning systems, technologically advanced agricultural productivity, transport and communications infrastructure and international humanitarianism, chronic food insecurity and hunger in the region persist (Devereux and Maxwell, 2001). Holloway (2004 p5) describes the prevailing situation as an illustration of disaster risk where:

> *"the risk has been driven upwards by the often silent but intensifying conditions of political, socio-economic and environmental vulnerability"*.

These conditions are then further aggravated by a physical shock, for example, drought or social shock such as HIV and AIDS (Vogel, 2005). The current food insecurity crisis has been described by Jooma (2005) and others as a failure of livelihoods to ensure access to sufficient food at household level (Devereux and Maxwell, 2001).

This is the basis for numerous calls for a paradigm shift in analyzing and assessing vulnerability to, and responses to, food insecurity. The proposed shift is for the adoption of a livelihoods approach (Maxwell, 2001; Swift and Hamilton, 2001; O'Donnell, 2004), and for greater participation by households and communities in the research and analysis, programme design and implementation of food security strategies (UN, 2003). As HIV and AIDS takes centre stage in the food insecurity debate in SSA a deeper understanding of the linkages between these two factors is essential for the formulation of food security strategies. Such understanding would be obtained through a comprehensive and multi-sectoral analysis of the HI virus and the AIDS epidemic (Loevinsohn and Gillespie, 2003).

2.7 The HIV and AIDS Epidemic in Sub-Saharan Africa

The myriad of factors contributing to the food security crisis in the region has been discussed in the previous section, including the key role played by natural resources in rural livelihoods and the complex food security paradigm. Attention now focuses on the HIV and AIDS epidemic which as previously mentioned has become a huge developmental challenge associated with food insecurity and natural resource utilisation. The following section discusses the prevalence and contribution of the HIV and AIDS epidemic to the food insecurity debate which had led to a humanitarian crisis in the region. The focus will also be on the impacts of HIV and AIDS on livelihoods and the vulnerable groups, as well as a discussion on the '*new variant hypotheses'*.

Increasingly associated with the death of prime-aged adults is the HIV and AIDS epidemic, with detrimental implications for household food and income for the affected households. The postulation is that the affected households become vulnerable to food insecurity, natural resources will begin and or continue to play a pertinent role in the survival of affected households as a livelihood strategy. The HIV and AIDS epidemic has been cited both as a driver of food insecurity and vulnerability to food insecurity, while food security has been cited in the major response towards the epidemic and vulnerability to HIV and AIDS infection.

Described as a disease of hunger, poverty and inequality, the HIV and AIDS epidemic is probably the biggest challenge facing development, poverty reduction and food security in SSA (FAO, 2005). As mentioned earlier, the statistics for HIV and AIDS infections and mortality in the region, as well as the prevalence rates are staggering, with an estimated 1.9 m new infections in 2007. In countries with high prevalence, the epidemic is the main killer of children and life expectancy has dropped drastically (UNAIDS, 2008). An estimated 55 m Africans will succumb to the disease by 2020, according to UNAIDS estimates (Whiteside, 2004). Assuming that maximum efforts are made in terms of mitigation, treatment and care of the disease, the effects of the epidemic and related mortality will still be felt for the next two decades (de Waal and Tumushabe, 2003; Hammarskjöld, 2003; UNAIDS, 2006, 2009). When aggregated to national and regional level, the economic, social, political and environmental impacts of the epidemic are critical.

In recognition of the global magnitude and multifaceted nature of HIV and AIDS, world leaders, through the United Nations General Assembly (UNGASS) in 2001, pledged through the Millennium Development Goal 6, *Declaration of Commitment on HIV AND AIDS*[12] to halt and begin to reverse the global HIV epidemic by 2015. The declaration included time-binding commitments for measurable action and progress towards AIDS response and towards universal access to HIV prevention, treatment, care and support by 2010. HIV response was made an overriding international priority. The financial commitments to the declaration are beginning to bear fruit, with an annual global reduction in the number of AIDS deaths. This has been attributed to substantial improvement in the access to HIV treatment (UNAIDS, 2008). Sexual behavioural change in some of the worst affected African countries has resulted in a decline in the number of new infections, and together with education and the

[12] Declaration of Commitment on HIV and AIDS – UN Member States endorsed by to strengthen HIV and AIDS response and included time bound pledges to generate measurable action and concrete progress in the AIDS response in 2001.

availability of medication, has led to a stabilisation of the epidemic (UNAIDS, 2008). While behaviour change has worked in some regions, the Global HIV Prevention Working Group (GHPWG) (2008) notes that in Southern Africa, behaviour change alone will not result in the desired reduction of prevalence rates. Changes in social and cultural norms about sexual relationship and gender equality are essential.

In the countries where the epidemic has stabilised, it has done so at very high prevalence rates. While some of the worst affected countries, such as Kenya, Rwanda, Uganda and Zimbabwe have experienced a stabilisation in the prevalence of the epidemic, other countries are experiencing a reverse of this trend. Further, there is no clear indication of decline in other countries such as Botswana, Namibia and Swaziland although, the epidemic seems to be stabilising in South Africa (UNAIDS, 2006, 2008).

Two years before the 2010 target for universal access to treatment, prevention, care and support, some countries are not on target, with infections on the rise in countries such as Mozambique (UNAIDS, 2008). While access to treatment has drastically improved, the need for access to treatment for a large number of infected population remains (UNAIDS, 2008, 2009).

2.7.1 Sub-Saharan Africa

Sub-Saharan Africa remains the region worst affected, bearing the brunt of the epidemic. With the highest prevalence rates in the world (see Figure 2.8) the region is home to approximately 67% (22 m) of the global population living with the HI virus, 75% of AIDS deaths in 2007 and approximately 60% of infections in women (UNAIDS, 2008).

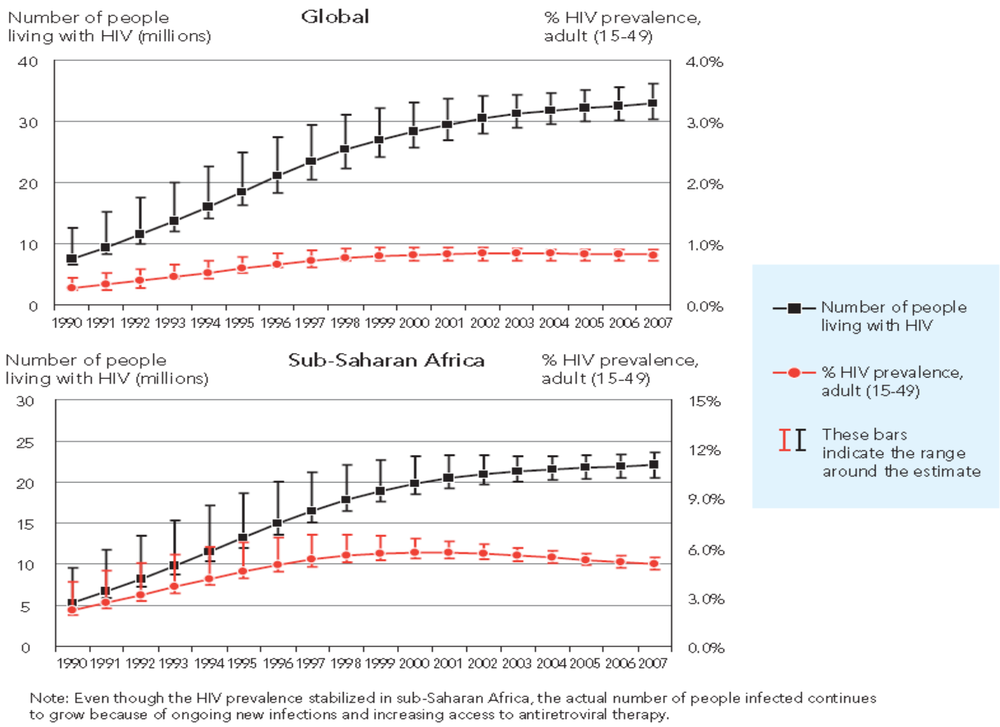

Figure 2.9: Comparison of Global HIV epidemic and Sub-Saharan Africa HIV epidemic 1990–2007 www.unaids.org.

Within the sub region, the magnitude of the epidemic varies between countries in scale and scope (Figure 2.9)

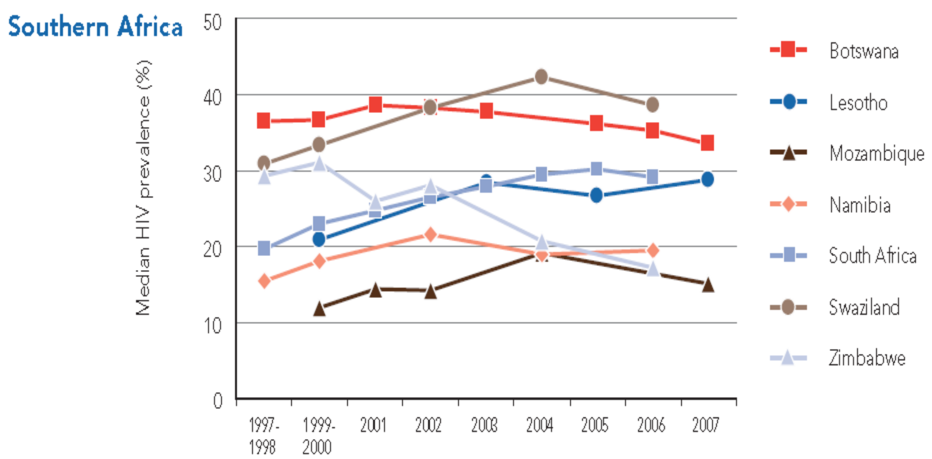

Figure 2.10: HIV prevalence (%) among pregnant women attending antenatal clinics in sub-Saharan Africa, 1997-2008.

The epidemic is most prevalent among adults, the most economically productive segment of the population. It adversely impacts on the transfer of knowledge from one generation to the next, with consequences for livelihoods (UNAIDS, 2008). Further, HIV and AIDS affect all sectors of development from agriculture, education, health, industry to security services. The negative economic impacts of the epidemic have, however been contested, with some of the worst affected countries such as Botswana and South Africa, experiencing economic growth while in the depth of an HIV and AIDS epidemic (UNAIDS, 2008). It has been argued that the epidemic has merely exacerbated the developmental crisis attributed to among other things, economic and political strife, globalisation and other humanitarian crises, making it difficult to measure the direct impacts of the epidemic on the economies of affected countries. For example, countries such as South Africa and Zimbabwe have not only experienced HIV and AIDS, but social and economic changes in the previous two decades (UNAIDS 2008). Nevertheless, the loss of human capital due to AIDS is accompanied by immense lasting trauma for the affected households.

2.7.2 Impacts of the epidemic in Southern Africa

Understanding the impacts and mitigation responses of the epidemic is complicated and difficult to grasp, due to the impacts being often multiple, interlinked and very context specific (Gillespie, 2006). Neither have the hypothesised macro level effects such as collapse of economies and national governments been experienced. While there is growing research on the impacts of the epidemic, the documentation and thorough study of potential strategies for mitigating the epidemic's adverse effects remain limited (UNAIDS, 2008).

Conversely, besides the loss of lives, for the majority of southern Africans the worst impact of the epidemic is evident in increased vulnerability to shocks and reduced ability to recover from them; i.e. resilience (de Waal, 2005). This is despite a high degree of resourcefulness and resilience noted in some of the worst affected communities. While the affected communities and households give the impression of coping with the effects of the epidemic, it is argued that struggling is not coping and many affected household are struggling (Gillespie *et al.*, 2007). Apart from the loss of household income, the affected communities have to deal with the profound individual and collective trauma, which in itself cannot be measured and is inadequately understood (Gillespie *et al.*, 2007; UNAIDS, 2008). The loss of household income and the long-acting, slow-burning nature of AIDS restricts the resilience and increases vulnerability of the affected households to other shocks and increases inequalities (Gillespie *et al.*, 2007; UNAIDS, 2008).

With agriculture as the primary livelihood for many affected by the epidemic, detrimental effects on food security especially in the high prevalence countries have been noted, with reductions in agricultural production. However, the predicted shift towards subsistence crops has not been thoroughly studied or well documented (Jayne *et al.*, 2004: UNAIDS, 2008). In addition, the epidemic has impacted on the demographic profiles of affected countries, in particular, the age and gender distribution, resulting in fewer adults and fewer adult females, which are the groups worst affected by AIDS (de Waal and Whiteside, 2003). As mentioned earlier, increased vulnerability to food insecurity attributed to multiple stressors including HIV and AIDS may lead to over exploitation of the natural resource base.

Gillespie and Kadiyala (2005) make a number of recommendations in order to alleviate the epidemic's unfavorable outcome for agricultural sectors, food security and the natural resource base, namely

- initiatives to protect and improve the livelihoods of rural households through farm and non-farm activities (including use of natural resources);

- social protection policies to provide financial and nutritional assistance where appropriate;

- focused nutrition programmes for key populations at higher risk (e.g. girls and women);

- improvement in the development, implementation and accountability of policy making in the agricultural sector (Gillespie and Kadiyala, 2005).

Calls to declare the epidemic an emergency, given the extent of its effects in SSA have been controversial. Some donor organisations argue that the impact of HIV and AIDS is being overstated and given undue attention. This is done at the expense of addressing other diseases such as malaria and other issues such as governance (Harvey, 2004). The argument further suggests that the fragile economies of some of the worst-affected countries and the epidemic mutually reinforce each other, making separation of the impacts of each an intractable task (Drimie, 2004; Harvey, 2004). Donor agencies have alluded to the exploitation of HIV and AIDS by governments as a means to attract continued humanitarian support (Harvey, 2004). Despite this scepticism, information on the impacts of the disease has been available for more than a decade. In spite of the cautionary notes regarding the devastating impacts of HIV and AIDS, its adverse consequences on economic development, livelihoods and increasingly on food security at regional, national and household level in southern Africa are self-evident.

2.7.3 HIV and AIDS and Household Food Security

As has been shown in this chapter, several factors including health and natural resource utilisation configure food security across varying temporal and spatial scales. One area which is clearly at a crisis is the HIV and AIDS epidemic and food security. It has been argued for example that the emphasis on food security might have undermined other important aspects of the humanitarian crisis in the region (Harvey, 2004). However, linkages between household food insecurity (be it rural or urban) and HIV and AIDS are progressively being acknowledged (Topouzis and de Guerny, 1999; FAO, 2003; Loevinsohn and Gillespie, 2003). Livelihoods-based studies have revealed the epidemic's impacts to be systematic, impacting on all aspects of rural livelihoods and requiring context-specific analysis by area or social group (SADC FANR VAC, 2003; Drimie 2004; Crush *et al*., 2006). This is echoed by Harvey (2004) who describes the impacts of the HIV and AIDS epidemic as negative, complex, wide ranging and gender specific, resulting in high adult mortality, creating new vulnerable population groups and killing more men than women. However, as this thesis will show, not all households affected by HIV/AIDS mortality are food insecure or utilise natural resources, while conversely some households not affected by mortality depend on natural resources to generate and supplement income and food.

The disease undermines the household's ability to meet its daily basic needs, eroding the capabilities of individuals, families and communities as well as social networks. HIV and AIDS, and food and nutrition insecurity may become increasingly entwined in a vicious cycle, where one causes or perpetuates the other (Loevinsohn and Gillespie, 2003; Crush *et al*., 2006), in what Drimie (2004) and O'Donnell (2004) have classified as a '*bi-directional relationship'.* Additionally, it is recognised that malnutrition increases the susceptibility of HIV and AIDS infected people to opportunistic infections, whilst increasing the mother to child transmission (Hunter, 2006). Consequently, food insecurity heightens susceptibility to HIV exposure and infection and HIV and AIDS in turn heightens vulnerability to food insecurity. Malnutrition may in addition, reduce the effectiveness of anti-retroviral and other HIV and AIDS treatments, as noted in Singapore (Crush *et al*., 2006; Hunter, 2006). In response, improving food and nutrition security is cited as a key element in the three pillars of response to the disease, namely prevention, care and mitigation (Gillespie, 2004; Harvey, 2004; FAO, 2005).

As mentioned earlier, some of the recognised aspects of food security and agricultural production associated with HIV and AIDS and consequently with food insecurity include:

- high mortality and morbidity resulting in loss of human capital;
- loss of farm and non-farm income;
- diversion of resources from agricultural activities;
- more time spent caring for the sick, not engaging in an economic activity;
- declining health for the surviving members of the affected family;

- loss of knowledge on livelihoods skills (Toupozis and de Guerny, 1998).

The decline in food production has been noted in some southern African countries, with big reductions in cereal production noted between 1999 and 2002 in countries such as Lesotho and Malawi (de Waal and Whiteside, 2003). At a household scale, the reduction in maize output was noted to be 61% compared to 45% from other forms of mortality (de Waal and Whiteside, 2003). Households affected by the epidemic tend to favour growing less labour intensive crops such as cassava instead of maize due to a lack of labour and financial input, in terms of agricultural supplies such as fertiliser (de Guerny, 2002). Ultimately the disease contributes to an increase in poverty, compromising food and nutrition security for the vulnerable groups (FAO, 2003; IFPRI, 2004 Jooma, 2005; Crush *et al*., 2006). The gender bias of the epidemic, killing more women, means that the care-giving capacities are also continually being eroded (de Waal and Whiteside, 2003; UNAIDS, 2008).

2.7.4 HIV and AIDS and Natural Resources Based Livelihoods

The premature death of prime-aged adults who are knowledgeable regarding the sustainable harvesting of these mostly common property resources may severely impact their utilisation and sustainability. Surviving members, due to a lack of indigenous knowledge and the need for survival may engage in unsustainable utilisation, regarding both the method and frequency of harvesting of these resources as noted in Tanzania and Malawi (Hammarskjöld, 2003; Thaxton, 2004; Torell *et al.*, 2006). The effects of HIV and AIDS on natural resources would then be premised on the assumption of increased and unsustainable harvesting of the forest and natural resource products to meet daily dietary and energy needs as well as household income. The increased number of deaths from the HIV and AIDS epidemic has further increased demand for coffins and fuel wood used at the funerals, as noted in Limpopo (Thaxton, 2004).

The HIV and AIDS, natural resource and environment dynamic is highlighted in Figure 2.2.

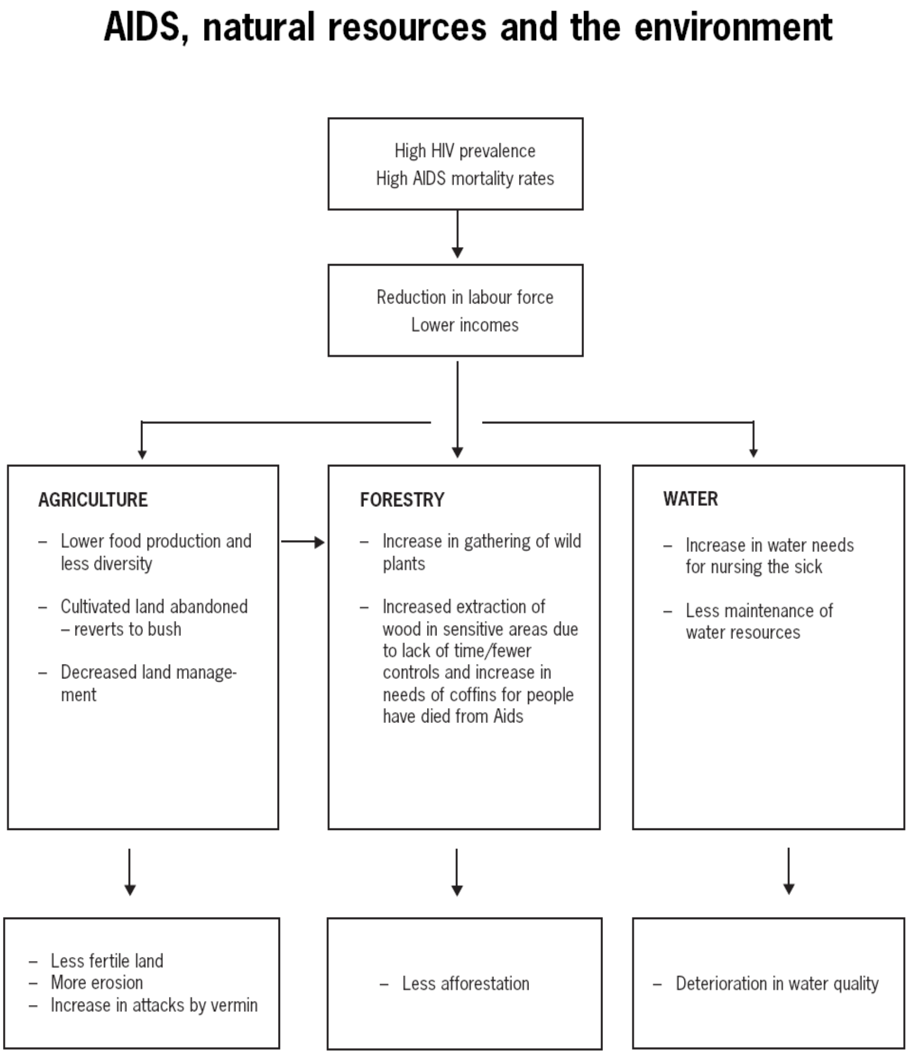

Figure 2.2: AIDS, Natural Resources and the Environment (Hammarskjöld, 2003)

As is shown in Figure 2.2 above, the stresses and interactions are shown to be in one direction only. As this thesis suggests, however, such interactions are exceedingly more complicated and 'messy' with a number of feedback loops often required. For example, the effects of agriculture, forestry and water on the livelihoods of the affected communities and households and the centrality of food security in this construct are excluded. Also excluded from Figure 2.2, the negative impacts of the interactions of natural resources and food security for rural livelihoods are not only restricted to HIV and AIDS alone. The reduction in labour indicated in the figure may further be attributed to migration and not only AIDS related mortality. On the other hand, the fallowing (temporary abandonment) of land might be beneficial for the recovery of over utilised land resources. As this thesis will show, food security, HIV/AIDS and poverty, manifesting in unavailability of money or income, are a complex set of drivers that influence how rural communities utilise their natural resources to supplement household food and income.

The effects of HIV/AIDS on the local use of the environment and natural resources is complicated by other stressors occurring concurrently in rural areas (Hammarskjöld, 2003, Crush *et al*., 2006; Gillespie, 2006). As highlighted in Figure 2.2, agriculture is but one sector of the environment affected by the epidemic, which in turn impacts on food security of the households and communities. This additional co-stressor requires further discussion, particularly given the importance of food security on affected and inflicted household and communities. The attention will now focus on food security, from its conceptualisation to its definition and factors that affect it.

2.7.5 New Variant Famine (NVF)

All the above mentioned factors can be viewed as part of a discourse on food security. Nonetheless, some critiquing suppositions are bringing in a new dimension for example the new variant famine. A hypothesis proposed by de Waal and Whiteside (2003), the '*new variant famine'* highlights the inability of afflicted families to cope with the death of breadwinners (Ansell *et al*., 2009). According to the hypothesis, there are three main features relating to food insecurity: wide spread vulnerability of household including in drought affected areas; a quick onset of household impoverishment; and household failure rate to recover (de Waal and Whiteside, 2003). These are as a result of AIDS interactions increasing vulnerability of households such as unfavourable changes in dependency due to adult mortality and morbidity, loss of assets and skills due to high adult mortality, increased burden of caring for the sick adult and orphaned children and the vicious interaction between malnutrition and AIDS (de Waal and Whiteside, 2003). This affects mainly agrarian households, which would be both susceptible and less resilient to external shocks such as droughts. This may result in increased mortality among the HIV and AIDS infected and the rest of the household from food insecurity related and other diseases (Arrehag *et al.*, 2009; Ansell *et al.*, 2009). Instead of the usual famine victims, such as the elderly and young children, HIV and AIDS targets adults of productive ages, killing more women than men. Women are highly susceptible to infection either through their partners, or transactional sex. The economic impacts of HIV and AIDS are increasing the risk of infection of younger girls (de Waal and Tumushabe, 2003; Jooma, 2005; Arrehag *et al.*, 2009; Ansell *et al*., 2009).

The epidemic is also altering the agricultural profile of affected countries, especially the availability of labour for both commercial and subsistence farming. Labour-intensive crops such as maize are being substituted for by less labour-intensive albeit less nutritional crops like cassava[13] for some households affected by a shortage of labour. Further, there has been a reduction in area farmed due to a lack of labour and intensive agricultural management practices such as soil and water conservation are neglected, leading to an acceleration of land degradation (de Guerny, 2002; de Waal and Whiteside, 2003; Arrehag *et al*., 2009). The preservation of indigenous knowledge on farming techniques and biodiversity has been affected as adults who possess this knowledge may die prematurely before passing it on to their children. The epidemic may weaken institutional capacity, as noted in conservation and community based natural resource management programmes, with staff invested in, such as leader and managers succumbing to the epidemic (WWF, 2008). In terms of commercial agriculture, migrant labour may be severely affected, given their mobility, accommodation conditions and lack of access to health care making them highly susceptible to the HI virus (Jooma, 2005; Ansell *et al.*, 2009).

The coping mechanisms employed by the affected households (Figure 2.11), reflect the erosion of resilience of the rural livelihoods, premised upon labour availability, skill and experience (de Waal and Whiteside, 2003; Arrehag *et al*., 2009). These losses will impact the younger population who are not knowledgeable on how to utilise effectively and efficiently the resources at their disposal for survival (Thaxton, 2004).

[13] The dependence on rain sensitive maize has been debated, with preferences for less sensitive crops such as cassava.

Furthermore, the burden of caring for the sick and orphans, exacerbated by malnutrition, severely puts pressure on households, and on communities to a lesser extent (de Waal and Whiteside, 2003; Arrehag *et al*., 2009).

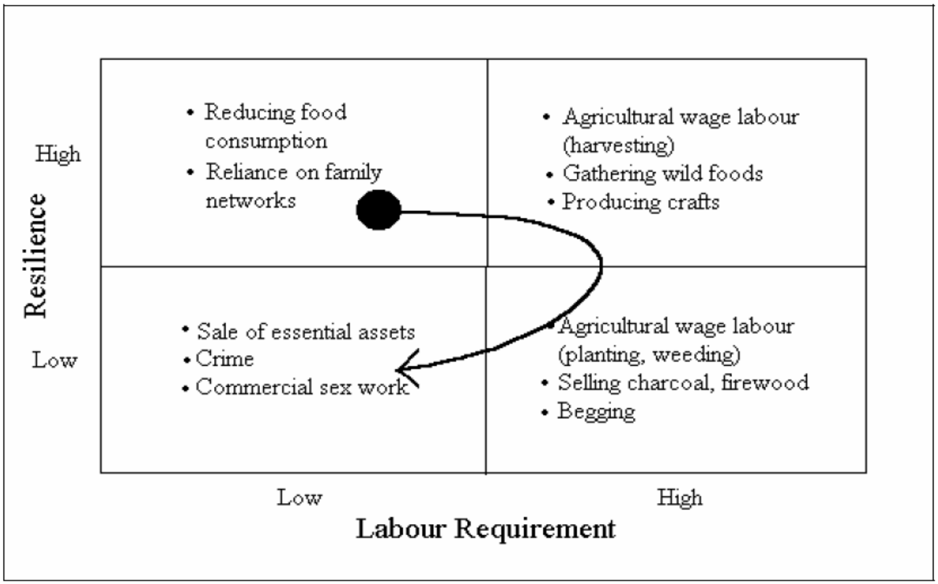

Figure 2.11: Livelihood coping strategies (de Waal and Whiteside, 2008).

The hypothesis does, however, acknowledge and mention the contribution of other factors in the making of this new famine, such as the effects of drought on food production and poverty as driver of both food insecurity and HIV and AIDS infection (Harvey, 2004; de Waal, 2005). The fact that there is no elaboration of the contribution of these other factors has been a source of criticism of the hypothesis (Ansell *et al*., 2009). In addition, not all southern African countries with high HIV prevalence have experienced food insecurity, questioning the influence of AIDS relative to other factors ((Ansell *et al*., 2009). Other criticism levelled against the hypothesis include the lack of evidence on the decline in food production due to AIDS, neither has the evidence of NVF occurring in sub Saharan Africa been substantiated, despite small scale studies in countries like Malawi which have recorded strong negative links between the two (Ansell *et al*., 2009). Debates about the validity and the terms used in the definition only serve to polarize the hypothesis, without pointing out its key points or basis.

Some of the concerns cited are the use of the word ‘famine’ when there was no occurrence of a famine in southern Africa *per se* and that the hypothesis should be based on the future impacts rather than on explaining the current crisis (Ansell *et al*., 2009). Consequently, it may be said that although there is a link between HIV and AIDS and food insecurity, HIV and AIDS does not cause food insecurity but rather exacerbates it (Drimie, 2004; Ansell *et al*., 2009; Arrehag *et al*., 2009).

2.8 Summary - HIV and AIDS, Food Security and Natural Resources

This chapter has provided a detailed discussion on the interactions between food security, the HIV/AIDS epidemic and the utilisation of natural resources as a livelihood strategy. The complex issues of food insecurity have further been analysed through the discussion on the causes of food insecurity in the southern African region. The extent of food insecurity and the HIV/AIDS epidemic in SSA and southern Africa has highlighted the magnitude of the epidemic. This included the adverse impacts of the epidemic on food security and livelihoods for the affected vulnerable populations, indicating the multifaceted nature of these factors. The discussion has also provided the global and regional context of these complex issues highlighting the need for an integrated approach among the myriad of actors at regional level. This is essential to begin to address food insecurity and vulnerability to food insecurity in the region, as well the role of natural resources in rural livelihoods.

The contribution of the HIV/AIDS epidemic to the current humanitarian and food insecurity crisis, natural resource utilisation and on rural livelihoods, though debatable, has been acknowledged and is self evident as has been discussed in this chapter. The impacts of the interactions between food security and the epidemic on sustainable natural resources use would need to be addressed through mainstreaming HIV/AIDS in all humanitarian and developmental programmes. This would mean inclusion in early warning systems as a means of mitigating the impacts of the deadly virus. In responding to the epidemic, prevention and treatment of HIV/AIDS also needs to be considered. As will be highlighted in this thesis, in Chapter 5, understanding the complex ways in which the epidemic affects livelihoods (farm and non-farm) and food security as well natural resource utilisation is essential for effective, multi-sectoral and comprehensive responses to the humanitarian crises.

The historic debate on population and the environment has highlighted how these two entities and the policies guiding their utilisation were influenced by the perception of population and the environment. The paradigm shift in the perception of food insecurity and the discussion of food inaccessibility through the entitlement approach, reiterated the versatile nature of food security and the importance of the environment in the attainment of food security for the rural poor. While sustainable agriculture is still a major consideration, most of the debates on food security and the environment, have raised concerns about population growth, climate change and environmental degradation and their effects on rural livelihoods. As will be highlighted in Chapter 6 of this thesis, issue of environmental resource degradation will be explored in relation to resource availability and food security, while the population interactions will be analysed in Chapter 5.

The importance of the food security and natural resources will be further highlighted in the description and discussion of the study area (Chapter 3) where most of the above mentioned factors are prevalent. Set in a rural background, Agincourt has faced a myriad of challenges in terms of sustainable livelihoods and food security which is being exacerbated by the HIV/AIDS epidemic. Thus, the next chapter will give a detailed outline of the area of study; the country, municipality and Agincourt DSS. Issues of poverty, food insecurity, resource utilisation and HIV and AIDS in the municipality and local area of study will be discussed as well, setting the scene for the basis of the research.

CHAPTER THREE

CASE STUDY AREA: SOUTH AFRICA

3.1 Introduction

The previous chapter has discussed in detail the complex issues of food security, HIV/AIDS as well as the role played by natural resources in rural livelihoods. The discussion included the historic debates on population and the environment as well as the intricate issues of food security. These include how food security has been defined, including assessments of how food security and vulnerability to food stresses are shaped at various levels from regional and national scales to household and individual, including the regional causes of food insecurity. The discussion then focussed on the extent and detrimental impacts of the HIV/AIDS epidemic at regional, national and local level.

As illustrated in Figure 2.2., there are overwhelmingly simplistic notions on the interactions of natural resource use, HIV and AIDS, food security. The interactions among the three entities have been illustrated as unidirectional, excluding any other forms of livelihoods except for those that are natural resource based. In addition, how the conditions of agriculture, forestry and water affect households or communities affected by the epidemic are not illustrated. Neither is food security included in the illustration as a possible driver of both natural resource use, forestry resource use and the importance of water to the affected communities. All these feedbacks are essential for a comprehensive understanding of the interaction of not only the HIV and AIDS epidemic, natural resources and the environment but interactions with food security and livelihoods as well.

The attention in this chapter now turns to the study area, laying out the background and the basis of food insecurity, HIV and AIDS and utilisation of natural resources within the country of study South Africa, within the province of Mpumalanga, the municipality of Bushbuckridge and the study area of Agincourt.

3.2 South Africa

Located in Southern Africa (Figure 3.1), South Africa is considered an economy in transition. The midyear population estimate for 2009 was 49.32 million people, 52% (25.45 million) of which is female (Stats SA, 2009). The current life expectancy is estimated at 53.3 years for males and 57.2 years for females, an improvement from the previous 43 years for males and 53 for females in 2006 (Stats SA, 2006, 2009). The infant mortality rate is approximately 45.7 per 1000 live births (Stats SA, 2009; World Bank, 2009).

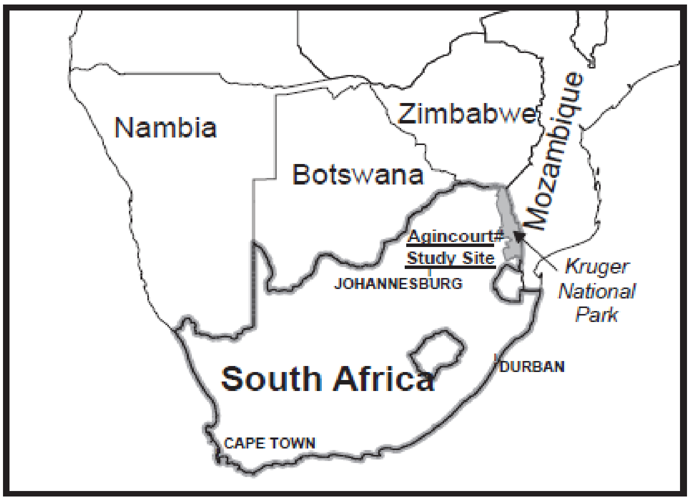

Figure 3.1: The location of South Africa in Southern Africa (Kahn *et al.*, 2007)

The eastern and northern parts of the country are the most populated. Other large concentrations of population are located in coastal belts, while the lowest population densities are in the western half of the country (Stats SA 2009; Le Roux and Van Huyssteen, 2010). Other highly populated areas include Bushbuckridge (the study area) and settlements such as Nelspruit (Le Roux and van Huyssteen (2010). Urbanisation, rural-urban migration as well as continued expansion of the urban areas, major settlements and towns on major access routes and movement corridors is attributed to the growth trends in the country during the last decade (Le Roux and van Huyssteen, 2010).

Former Bantustan areas are also experiencing population growth, even though these areas are already densely populated. These areas are however not economically viable urban centres, often lacking in infrastructure and governance capacity (Le Roux and van Huyssteen, 2009). Increases in population pressure are further exacerbated by the high numbers of people living in poverty, especially in urban and former Bantustan areas (Stats SA, 2009; World Bank 2009; Le Roux and van Huyssteen, 2010). With the exception of the former Lebowa and parts of former Bophuthatswana, most of the densely populated rural areas are located in comparatively favourable natural resource environments (Lahiff, 2003; Seekings, 2007; Kepe, 2009; Le Roux and van Huyssteen, 2010).

It is estimated that 42.7% (19 m people) of the population are rural survivalists, still practising traditional agricultural practises. At least 15 m of this rural population still resides in poverty, with food insecurity, low income and poor access to basic services such as education and housing (Backeberg, 2009). While subsistence farming contributes 6–12% of total income, rural livelihoods are mainly dependent on remittances, wages, pensions and social grants (Backeberg, 2009; Chopra *et al*., 2009; Jacobs, 2009). Despite the high levels of poverty and under nourishment noted, land resources in rural areas are hugely under utilised (Backeberg, 2009). Nonetheless, organisations such as the World Bank have supported land and agricultural reform as fundamental to prevail over the racially based distortions of the past (Kepe, 2009), albeit with a revamp of the structural, ownership and operation of the agricultural sector (Lahiff, 2000; Backeberg, 2009; Kepe, 2009). Meanwhile, the rural poor rely on non-farming activities such as natural resource harvesting to meet their household food and income needs and are net consumers of purchased food (Machethe, 2004; Chopra *et al*., 2009; Jacobs, 2009).

South Africa is not overwhelmingly dependent on agriculture. It is agriculturally technologically advanced, is rated as food secure and exports cereals e.g. maize and other agricultural products (de Klerk *et al.*, 2004; www.southafrica.info, 2009). In 2000, the agricultural industry accounted for 3.2% of GDP and 7% of exports, and supported directly or indirectly 15% of the population (DOA, 2002; de Klerk *et al*., 2004). By 2009, this figure decreased to 2.6% of the GDP and the number of people supported was nearly 9%. Economically, the agro-industry sector still contributes an estimated 15% to the GDP, with 8% of export over the last five years (www.southafrica.info, 2009). South Africa is also one of the few sub-Saharan African countries to benefit from economic liberalisation and globalisation (DOA, 2002).

South Africa accounts for most of the irrigated land in southern Africa, despite limitations imposed by uneven distribution and availability of rain (DOA, 2002; www.southafrica.info, 2009). There are two sectors of agriculture, a highly successful commercial farming sector and rural based subsistence farming. Approximately 13% of the country's land area is agriculturally viable with 22% of this located and classified as high potential land (www.southafrica.info, 2009). Given the above factors, South Africa produces enough food to feed its population. However the assumption that all South Africans, including the rural poor have access to enough food, especially in the face of the HIV and AIDS epidemic is naïve (de Klerk *et al.*, 2004; Chopra *et al*., 2009).

South Africa, like its southern African neighbours, is battling with a high HIV and AIDS prevalence rate, resulting in a high burden of HIV infected people, in all major services including the health sector. Despite notable strides towards the treatment of the disease in the country (UNAIDS, 2006), it is projected that by 2010, 65% of deaths in provinces like Limpopo will be attributed to AIDS (Hunter and Twine, 2005). Adequate and affordable nutrition becomes essential for the HIV and AIDS infected population. The disease is exacerbating food insecurity and increasing vulnerability among affected communities.

While agriculture has been advanced as the answer to food insecurity in South Africa, its role in eradiating household level hunger and poverty in rural areas has been contentious (Machethe, 2004; Jacobs, 2009; Kepe, 2009). The argument has been based on most of the rural populations depending on agriculture for subsistence and income.

Unfortunately, agrarian and land reform has not had much impact in rural areas, leaving rural dwellers vulnerable to food insecurity. Furthermore, Francis (2006) alludes to approximately 900 000 households in the former homelands who lack access to arable land. This raises debates about the contribution of agrarian reform towards the eradication of household food insecurity and poverty in rural South Africa (Kepe, 2009).

3.3 Food Security in South Africa

The government's commitment as stated in Section 27 of the Constitution's Bill of Rights specifies four essential elements of well-being one of which is section (b) *"the right to food and water".* The government pledges to take legislative and other measures, within its available resources, to achieve this right to sufficient food and water. As a result, the National Department of Agriculture's Integrated Food Security Strategy (DOA, 2002) was adopted as its guiding strategy for the improvement and achievement of physical, social and economic access to sufficient, safe and nutritious food for all South Africans (DOA, 2002; Drimie and Verdujun, 2004; Jacobs, 2009). As interpreted by the IFSS, food security is influenced by infrastructure and commodity markets to allow access to markets and income to purchase food (DOA, 2002; Drimie and Verdujun, 2004; Jacobs, 2009).

The overarching goal of the strategy was to eradicate hunger, malnutrition and food insecurity by 2015 (DOA, 2002: Jacobs, 2009). Despite a strong agricultural economy, commitment by government and all government initiatives, food insecurity and malnutrition are on the increase. According the Food Bank of South Africa (2009), over 19 m people (40%) are food-insecure. At least one out of two households (51.6%) at national level experienced hunger and one out of three households were at risk of experiencing hunger (Chopra *et al*., 2009). Provincially, Eastern and Northern Cape, and Limpopo are the worst affected. High hunger prevalence is mainly associated with informal dwellings, with low monthly income, low spending on food and low literacy levels for the mothers (Chopra *et al*., 2009). Poverty and food insecurity are endemic in urban areas but the rural areas are the worst affected (Food Bank, 2009).

Food insecurity in the country is still prevalent despite the government’s commitment to reduce the percentage of underweight children to 4.7% by 2015 (MDG1) (Machethe, 2004, Roberts, 2004). The prevalence rate of malnutrition rose from 9.3 to 10.3% during the 1990s. Stunting, another measure of food insecurity also rose from 22.9 to 23.3% in children between the ages of 1 to 6 years in 1994. Primary health care and nutritional programmes initiated in the last decade have yielded little results, with stunting and underweight still the most common nutritional disorders affecting 1 in 5 and 1 in 10 children, respectively (Chopra *et al*., 2009). Given the above stated facts, insufficient and unstable food supplies have been cited as the main contributors to food insecurity, in particular micro-nutrient deficiency, to which most South Africans are highly susceptible (DOA, 2002; Chopra *et al*., 2009). Food security has thus remained an imperative developmental challenge in South Africa (Jacobs, 2009; Kepe, 2009).

Access and entitlement of individuals and households to food, instead of availability, becomes a key issue in addressing food insecurity (Archer, 2004). Entitlement failure, may consequently lead to some households experiencing hunger. In South Africa, increases in food prices, especially of staple foods such as maize escalate vulnerability to food insecurity especially for female headed households and pensioners (Chopra *et al*., 2009; Jacobs, 2009). The price of maize meal doubled in 2002 and the food price index rose to 16.7%[14] (DOA, 2002; Watson and Makgetla, 2002). Price hikes on food and maize meal increased food insecurity, not only for the working class who spend more than a third of their income on food, but also for the poor. The poor, two thirds of whom reside in rural areas, spend up to 50% of their income on food, 20% on maize alone (Watson and Makgetla, 2002; Chopra *et al*., 2009). This figure is assumed to reach 80%, this attributed to the current global food crisis which has resulted in an escalation of basic food prices globally and locally (Von Bruin, 2008; Chopra *et al*., 2009). The recently conducted Income and Expenditure survey revealed that population in deciles 1, 2 and 3 (1 being the poorest), each representing 10% of the total population, spend 80%, 45% and 36% of their incomes on food respectively (IRIN, 2008). This great reliance on purchased food, instead of production of own food exposes households to adverse

[14] Consumer Prize Index figures should be used with caution.

effects of market and price fluctuations which impacts on household food security (Drimie and Verdujun, 2004; (Backeberg, 2009; Chopra *et al*., 2009).

With international and regional calls for a paradigm shift in the analysis of food insecurity from agricultural production to a livelihoods approach and from national to household level (Swift and Hamilton, 2001), livelihoods begin to play an important role in enabling access to food and reducing vulnerability of households to food insecurity (Chopra *et al*., 2009). While it is generally agreed that natural resources play an important part in the livelihoods of many rural populations in Africa, quantifying the value of natural resources in rural livelihoods and issues of access to these resources has remained an intractable task (Dovie *et al.*, 2003).

South Africa as a country has some challenges in terms of food security which include:

- To ensure that enough food is available for all South Africans;
- To match the incomes of people to the ever escalating food prices to ensure accessibility;
- To empower South Africans in terms of nutritional and safe food choices;
- To provide adequate safety nets for the poor to enable them to meet their food requirements and to mitigate the effects of natural disasters;
- To have information systems for long-term monitoring and evaluation of impacts of food security programmes on target populations (DOA, 2002; Chopra *et al*., 2009).

In response to these food security challenges, and through the IFSS, FIVIMS – ZA was set up to assist in the identification of the food insecure, where they were located and the nature of their vulnerability to food insecurity, in order to devise target specific interventions (DOA, 2002; Drimie and Verdujun, 2004).

3.4. Apartheid and Food Security in South Africa

While striving for industrial development, apartheid managed to profoundly undermine African agriculture, destroying rural wealth, farming and entrepreneurial skills and experience (DOA, 2002; Seekings, 2007; Kepe, 2009). Industrial development, which resulted in the majority of the black population being used as wage labour in the mines and farms, was the driving force behind present-day poverty and food insecurity for the black population (DOA, 2002; Seekings, 2007, Kepe, 2009).

Apartheid's discriminatory and migration policies contributed to the estrangement of people from their land and resources, resulting in:

1. Inefficient resource use;
2. Inequitable access to environmental services;
3. Unjust land use practices;
4. Environmental degradation (Adelzadeh, 2003; Francis 2006; Kepe, 2009).

In addition, corrupt land allocation and administration restricted access to natural resources essential for sustaining livelihoods and promoting economic development. Environmental degradation, which affects agricultural production, has also been attributed to apartheid (DOA, 2002; Adelzadeh, 2003; Francis, 2006; Seekings, 2007; Kepe, 2009).

3.4.1 Poverty and Inequality

Issues of food security in South Africa are inextricably linked to poverty and inequality (Machethe, 2004; Francis, 2006; Chopra *et al*., 2009). Despite being one of the world's 50 wealthiest countries, South Africa has one of the most skewed income and wealth distributions (Adelzadeh, 2003; Francis, 2006; Seekings, 2007; Chopra *et al*., 2009). The income and wealth inequality, a legacy of apartheid, has contributed to an increase in poverty, possibly leading to disturbances in the utilisation of society's resources. Further, this could have caused disturbance in the country's growth potential and jeopardising the wellness of the environment (Kepe, 2009). With an estimated 21.9 m people (48.5%), living below the poverty line in 2003, poverty, income inequality and distribution remains high, and continues to display strong spatial and racial biases (Lahiff, 2000; Chopra *et al*., 2009; Le roux and van Huyssteen, 2010).

Poverty and inequality challenges, especially in urban areas resulted in poor living standards with limited access to economic opportunities, and lack of basic services, social security and health care (Seekings, 2007; Le Roux and van Huyssteen, 2010). As a result of apartheid, these inequalities are often spatially embedded and despite significant progress being made towards addressing these imbalances, service delivery especially in urban areas remains an challenging task (Le Roux and van Huyssteen, 2010). This is supported by Seekings (2007) who notes an increase in poverty and inequality in post-apartheid South Africa in the 1990s, despite slight reductions in the 2000s.

South Africa's Human Development Index (HDI) rating has worsened from 121st out of 177 countries in 2005 to 129th out of 182 countries in 2007 (see Table 3.1). The Gini coefficient[15] for the country rose from 0.65 to 0.69 between 1995 and 2000, with an increase in the Gini coefficient for the black population from 0.56 in 1995 to 0.61 in 2000 (UNDP, 2007). The Human Development Index[16] (HDI) has also declined from 0.73 in 1995 to 0.67 in 2003 and 2005 and to 0.683 in 2007. The human development index assists in identifying sustainable developmental challenges and measures the country's achievements, in three aspects of human development:

- longevity, which is measured by life expectancy at birth;
- knowledge, which is measured by adult literacy rates as well school and tertiary enrolment rates ;
- the standard of living, which is measured by purchasing power reflected by the national GDP (UNDP, 2007).

It does not however measure sub-national income distribution (Misselhorn, 2005).

[15] Gini coefficient- a measure of income inequality ranging from 0 (perfect equality) to 1 (perfect inequality) www.agtrade.org/glossary_search.cfm

[16] Human Development Index - a measurement of human progress introduced UNDP based on purchasing power, education, and health www.photius.com/countries/brazil/glossary/

Table 3.1: South Africa's human development index 2007 (www.undp.org 2007).

HDI value	**Life expectancy at birth (years)**	**Adult literacy rate (% ages 15 and above)**	**Combined gross enrolment ratio (%)**	**GDP per capita (PPP US$)**
1. Norway (0.971)	1. Japan (82.7)	1. Georgia (100.0)	1. Australia (114.2)	1. Liechtenstein (85,382)
127. Tajikistan (0.688)	156. Malawi (52.4)	78. Saint Vincent and the Grenadines (88.1)	75. Saint Lucia (77.2)	76. Lebanon (10,109)
128. Namibia (0.686)	157. Uganda (51.9)	79. Dominica (88.0)	76. Mauritius (76.9)	77. Saint Lucia (9,786)
129. South Africa (0.683)	158. South Africa (51.5)	80. South Africa (88.0)	77. South Africa (76.8)	78. South Africa (9,757)
130. Morocco (0.654)	159. Cameroon (50.9)	81. Namibia (88.0)	78. Georgia (76.7)	79. Brazil (9,567)
131. Sao Tome and Principe (0.651)	160. Niger (50.8)	82. Sao Tome and Principe (87.9)	79. Egypt (76.4)	80. The former Yugoslav Republic of Macedonia (9,096)
182. Niger (0.340)	176. Afghanistan (43.6)	151. Mali (26.2)	177. Djibouti (25.5)	181. Congo (Democratic Republic of the) (298)

3.4.2 Land Tenure

Spatially and racially, the majority of the black population resides in the former homelands. An approximate 67% of black households, heavily concentrated in these former homelands, lived/live below the poverty datum line, with female headed households worse off (Lahiff, 2000, Francis, 2006; Le Roux and van Huyssteen, 2010). Land use planning or betterment under apartheid, which was deemed to have failed in its supposed objective of protecting the environment while promoting homeland agriculture, has been attributed to the environmental degradation in these areas (Lahiff, 2000; DOA, 2002; Adelzadeh, 2003; Francis, 2006; Seekings, 2007, Kepe, 2009).

Land was divided into three categories, arable, grazing and residential, and those without rights to land were allocated small plots with no access to grazing or arable land, and were expected to survive on wages (Lahiff, 2000; Seekings 2007; Kepe, 2009). Those who were newly settled in the homelands had to compete with the existing residents for the already scarce resources, exerting undue pressure on the environment, employment, 'hard pressed welfare', health and educational services (Seekings, 2007; Kepe, 2009). Another issue has been the growth of informal urbanisation within the homelands. Due to landlessness and poverty, rural to urban migration accelerated, mainly around the homeland capitals and or nearby farming areas and towns (Lahiff, 2000; Francis, 2006; Seekings, 2007; Kepe, 2009).

3.4.3 Subsistence Agriculture

In former homeland areas such as Lebowa, studies revealed that 45.6% of households had rights to arable land and a further 20% had access to grazing land. In Gazankulu, more than 50% of the households had no access to arable land and these figures increase up to 85% in other former homelands (Francis, 2006). Agricultural production in these areas was further compounded by poorly developed commercial cooperatives. This restricted access to formal credit and consequently access to inputs such as seeds and fertiliser. Poorly developed transport services and critical shortages of tractors for tilling the land exacerbated the situation (Lahiff, 2000; Kepe, 2009). The over reliance on maize has further intensified food insecurity because of the small size of the holding and the low yields due to poor quality seed and land. While inaccessibility to financial capital is acknowledged, the poor state of agriculture has been cited to have been further exacerbated by a shortage in human (labour) and physical capital (Lahiff, 2000; Kepe, 2009).

Given the high unemployment among the population in the homelands, shortage of labour should not be an issue, but this has resulted in under-utilisation of resources, purchased inputs and a weak integration into the produce markets (Lahiff, 2000; Backeberg, 2009). A shortage of labour at household level during the labour intensive periods of the agricultural cycle particularly ploughing and weeding reduces crop yields. Whilst agriculture in the homelands is regarded as a household activity, it is mainly carried out by women, children and the elderly to a lesser extent (Lahiff, 2000; Andrew *et al.*, 2003; Kepe, 2009). The participation of men is usually restricted mainly to ploughing. Methods of promoting soil fertility which are labour intensive are abandoned, while methods such as crop rotation and fallowing are restricted due to the small size of household plots. Intercropping, which is widely used in the homelands has also been attributed to the low yields (Lahiff, 2000; Francis, 2006; Kepe, 2009). Further, the lack of transport and distance to markets, weakened by the integration into the formal produce markets exacerbates food security (Lahiff, 2000; Andrew *et al.*, 2003; Baiphethi and Jacobs, 2009). Whilst the government views subsistence agriculture as essential for addressing poverty and food insecurity, the stalling or lack of progress in the land redistribution raises doubts about its success (Kepe, 2009).

3.4.4 Livestock

In terms of livestock, herds are inclined to be small and the majority of households do not own any livestock. Livestock per hectare is between 20–100% higher than in white areas of the same eco-climate. Homelands are believed to own one-third of the country’s cattle, half of the goats and over one-tenth of the country’s sheep (Lahiff, 2000; Andrew *et al.*, 2003). While the main studies were predominantly for the homelands in coastal regions, similar trends have been noted in the inland homelands, with the number of livestock being less and the percentage of households owning livestock being even smaller (Andrew *et al.*, 2003). Furthermore, in semi-arid areas where arable farming is severely restricted, numbers of livestock per household remain low with a sizeable number of households without any livestock.

For those households with livestock, access to formal markets to sell is restricted again by lack of infrastructure; distance to these markets and a lack of transportation (Lahiff, 2000; De Klerk *et al.*, 2004). For an estimated third of farmers who did sell their livestock, it was due to pressing financial problems and this is usually done through informal private sales locally. Pressing financial problems could range from school fees, motor repairs and basic survival during periods of unemployment (Lahiff, 2000; Andrew *et al.*, 2003; Baiphethi and Jacobs, 2009). Thus the value of livestock, even the small herds, is important to poor households in these areas. While not considered as important as cropping, livestock does play a role in rural livelihoods in some areas, by supplying food, draught power, bridal wealth, and as a form of savings (Andrew *et al.*, 2003; Baiphethi and Jacobs, 2009).

3.4.5 Livelihoods and Income

Income from agriculture consists of a relatively small percentage of the overall household income but this varies from household to household (Baiphethi and Jacobs, 2009; Jacobs, 2009). Agriculture is usually the only source of livelihood for food consumption and household income mainly for the poor households (Andrew *et al.*, 2003; Kepe, 2009, Seekings, 2009). For other households, it is supplementary in case of a disturbance such as death, unemployment, or illness. Whilst agriculture provides a significant livelihood, it is usually supported by other sources of income such as wages, pensions or grants (Lahiff, 2000; Andrew *et al.*, 2003; Chopra *et al*., 2009). Access to land, even small plots and access to shared communal grazing enables households to maintain a diversified livelihood, which may include wages and income, with agriculture for consumption and livestock for investment (Lahiff, 2000; Andrew *et al.*, 2003; Jacobs, 2009; Kepe, 2009).

Agriculture does and continues to play an important role in rural livelihoods, particularly in the crowded rural, former homeland areas, which supported at least 47% (17.4 m) of the South African population in 1991. While the black population in the former homelands doubled between 1970 and 1995, the increase in land holdings was not reciprocal, at a mere 10%. Despite the post-apartheid land reform and redistribution programme, access to land in the rural and former homelands remains a major challenge (Seekings, 2007; Kepe, 2009). Over and above this, land in the homelands is held under communal tenure (Lahiff, 2002). Studies have shown, however, that households in the homelands tend to rely on various sources of income, of which agriculture plays a role, particularly for those without access to wages and pensions and acts as a safety net in times of need (Baiphethi and Jacobs, 2009; Jacobs, 2009; Kepe, 2009).

While it is noted that households in the homelands rely on various forms of income, wages, migrant and non-migrant are the most important forms of income (60–80%), a third of this obtained from migrant remittances (De Klerk *et al*. 2004; Francis, 2006; Chopra *et al*., 2009; Jacobs, 2009). Pensions are the next important source of cash income providing between 10–20% of household income. Approximation of agricultural income, with regards to income and consumption shows a lot of variation, but is estimated between 10–20% (Lahiff, 2000). Other activities include brewing beer and making clothing.

Another source of household income, closely linked to this thesis, is from those livelihoods that depend on natural resources, in form of home-based activities such as production of crafts, like floor mats and brooms. This includes an increase in South African households engaged in cash based informal sector including the trade in natural resources products such as marula beer and jam (Dovie *et al*., 2003; Giannecchini *et al*., 2008; Baiphethi and Jacobs, 2009). This is discussed in more detail in the later chapters.

3.5 Food Security Status in South Africa

As remarked above, rural livelihoods in the former homeland areas tend to rely on a myriad of activities for household food and income, including social grants, pensions, remittances and informal trade in natural resources and other products. The next section shifts the discussion to the food security situation in the country of study, this analysed using the different categories of food security.

3.5.1 Food Availability

Food production is determined mainly by rainfall. Approximately 60% of the country receives less than 600 mm, while approximately one fifth of the country receives less than 200 mm annually, and the rest of the country receives summer rain. Approximately 80% of South Africa is considered arid, with only 18% sub-humid to humid (Figure 3.2).

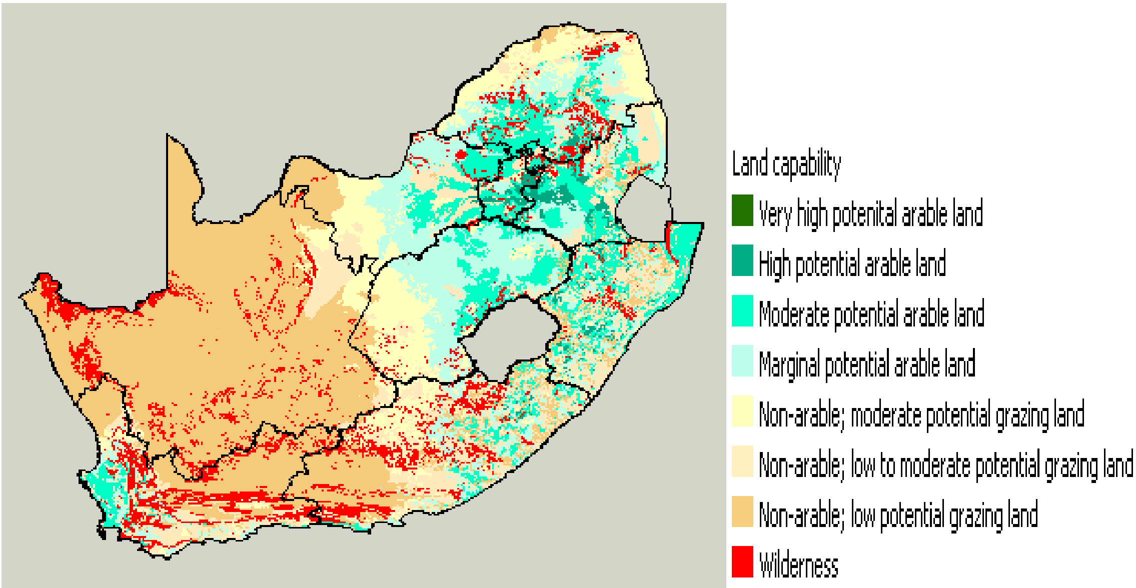

Figure 3.2: Land Capability of South Africa (AGIS – FIVIMS – ZA)

Other physical factors to consider include extreme weather events such as droughts, floods and frost. In terms of land capability, which measures physical characteristics of areas including soils, erosion potential and climate, 98% of the area in South Africa is shown to have severe limitations with respect to climate (rainfall), terrain and soils. The arable land area covers only 12.4% and the other 11% is covered by marginal land (AGIS, 2008).

3.5.2. Food Accessibility

Food access is ensured when a household or an individual has enough resources to purchase or acquire appropriate food for a nutritious diet. Such access would depend on the distribution of income and prices of food (Chopra *et al*., 2009; Jacobs, 2009). In South Africa access to food is hindered by various factors such as prevalence of poverty and inequality (Francis, 2006; Kepe; 2009). Livelihood profiles of the poor have suggested strong linkages and correlation between vulnerability and chronic poverty, hunger, nutrition and poverty (Coates *et al.*, 2006; Francis, 2006; Chopra *et al*., 2009). Most households in the country face incidences of poverty or are susceptible to falling into poverty. An estimated 19 m people live in the poorest 40% of the households, earning below R360 per adult per month (Watson and Makgetla, 2002). Despite the massive injection of finance into social security programmes and the increase of beneficiaries from 2.6 m to 7.9 m by 2007, more than 55% of households still earn below R1000 a month, with urban informal settlements recording households with no income (Chopra *et al*., 2009).

Poverty and vulnerability reinforce each other to exacerbate vulnerability to food insecurity. Access refers to the ability of people to acquire sufficient food but in areas where livelihood opportunities are low, people are generally poor. Poverty normally leads to poor sanitation, poor nutrition and poor access to food (De Klerk *et al.*, 2004). Households which are below the poverty line usually have no assets with which to act as a buffer against food insecurity, and thus are more vulnerable to shocks and stresses (Chopra *et al*., 2009; Jacobs, 2009).

While the difference between vulnerability and poverty is acknowledged (Du Toit and Ziervogel, 2004), in terms of the vulnerable populations, there is likely to be an overlap between the chronically food insecure, who constantly cannot acquire sufficient food and the vulnerable to food security, classified as food secure but stand a good chance of becoming food insecure during parts of the year. Further, while mapping accessibility has been mainly about poverty, the presence or absence of safety nets for the poor through government grants or social security programmes also affects accessibility to food (DOA, 2002).

3.5.3 Food Utilisation

Food security is also determined by utilisation, which is in turn influenced by a variety of factors, primarily human health, accessibility to clean and safe water, and sanitation facilities, as well as access to health facilities regarded in terms of distance and infrastructure (De Klerk *et al.*, 2004; Chopra *et al*., 2009). While this area is relatively not that well researched, food utilisation in the household is further dependent to a greater extent on knowledge about food storage and processing techniques, basic principles of nutrition and child care, and handling of illnesses. Improper utilisation would usually result in higher prevalence of malnourishment, Infant Mortality Rate (IMR) and the less than five years mortality (Coates *et al.*, 2006). Prevalence of other diseases such as AIDS, tuberculosis and diarrhoea affects the ability of the body to utilise food nutrients.

Diseases such as AIDS affect all aspects of food security (Gillespie, 2006; Chopra *et al*., 2009). HIV and AIDS, and food and nutrition insecurity may become increasingly entwined in a vicious circle, where one causes or perpetuates the other (Loevinsohn and Gillespie, 2003). Food insecurity, for example, heightens susceptibility to HIV exposure and infection while HIV and AIDS in turn heightens vulnerability to food security. In response, improving food and nutrition security has been cited as a key element in the three pillars of response to the disease, namely prevention, care and mitigation (FAO, 2001, 2005; Harvey, 2004; Chopra *et al.,* 2009).

As is shown above in section 2.7.3, the linkages between food security and HIV and AIDS are not fully understood. As is suggested in this thesis, the links between HIV and AIDS and food security are further complicated by the resultant impacts on land use and natural resources by resource poor households particularly those impacted by the epidemic. It is to this key dimension, namely HIV and AIDS, that attention now turns.

3.5.5 HIV and AIDS in South Africa

South Africa has one of the highest burdens of HIV and AIDS infected people in the world with a prevalence rate increase from 1% to 25% within a 10 year period

(Gillespie, 2006; UNAIDS, 2008). The high burden is evidenced by the high mortality and morbidity, resulting in more vulnerable groups of population such as the elderly and children. While the epidemic seems to be stabilising, it is at very high rates with no evidence of changes in HIV related behaviour (UNAIDS, 2008). Prevalence rates vary significantly between provinces, with Western Cape at 15% to 39% in Kwazulu-Natal (Table 3.2). Prevalence rates in Limpopo, where the study area of Agincourt was located, are expected to peak at 65% by 2010, while in 2000, 21.5% of the deaths in the province were attributed to AIDS.

National prevalence is estimated to be 11% with one-in-three women aged between 25-29, and over a quarter of men aged between 30-34, are living with HIV (AVERT, 2009). Despite notable strides in the treatment of the disease, approximately 5.7 m South Africans were living with the HI virus in 2007, with 40% of all deaths in the country attributed to HIV and AIDS, making this the largest epidemic in the world. In 2008, approximately 250 000 South Africans died of AIDS. The birth rate for the country decreased from 1.25% to 0.97% (Statistics South Africa, 2007; UNAIDS, 2008). Household surveys held in 2005 indicated high prevalence rates in the 15–49 age groups (29.5%) as well as in men above 50 years (UNAIDS, 2006). According to Stats SA (2009), there was an estimated 413 000 new HIV infections with nearly 59 000 of these being children. An estimated 15 m of the affected population are 15 years and older and 106 000 children will be in need of anti-retroviral treatment (ART) (UNAIDS, 2008; Stats SA, 2009).

Table 3.2: Estimated HIV prevalence among antenatal clinic attendees, by province (www.avert.org/safricastats.htm)

Province	***2001 prevalence %***	***2002 prevalence %***	***2003 prevalence %***	***2004 prevalence %***	***2005 prevalence %***	***2006 prevalence %***	***2007 prevalence %***
KwaZulu-Natal	33.5	36.5	37.5	40.7	39.1	39.1	37.4
Mpumalanga	29.2	28.6	32.6	30.8	34.8	32.1	32.0
Free State	30.1	28.8	30.1	29.5	30.3	31.1	33.5
Gauteng	29.8	31.6	29.6	33.1	32.4	30.8	30.3
North West	25.2	26.2	29.9	26.7	31.8	29.0	29.0
Eastern Cape	21.7	23.6	27.1	28.0	29.5	28.6	26.0
Limpopo	14.5	15.6	17.5	19.3	21.5	20.6	18.5
Northern Cape	15.9	15.1	16.7	17.6	18.5	15.6	16.1
Western Cape	8.6	12.4	13.1	15.4	15.7	15.1	12.6
National	24.8	26.5	27.9	29.5	30.2	29.1	28.0

The HIV and AIDS epidemic has devastating effects on families and children with an estimated 280,000 children living with HIV in 2007, a figure that almost doubled since 2001 (UNAIDS, 2008). The estimated number of premature deaths due to HIV and AIDS has risen significantly over the last decade from 39% to 75% in 2010 (Harrison, 2009). The loss of one or both parents has devastating effects on families and children, not only emotional but financial as well. One survey on HIV and AIDS impacts on households found that, at least 80% of a study sample would lose more than half their per capita income with the death of the highest income earner, suggesting a lingering and debilitating shock of death (Collins, 2007). There are 1.4 m orphans in South Africa, half of which are attributed the HIV and AIDS epidemic, with 70% having lost a mother to the epidemic (Budlender *et al*., 2008). The huge burden of caring for orphans puts pressure on families and communities impeding their development.

Most of the literature reviewed does not, however, explicitly highlight the magnitude of these issues. Neither are HIV and AIDS mentioned as a serious issue in papers advocating for the eradication of poverty and hunger through agriculture, despite HIV and AIDS's undesirable impacts on agricultural production. Like its neighbours, the impact of the epidemic in South Africa is increasingly felt by the rural poor, exacerbating the prevalence of poverty and food insecurity.

3.6 Mpumalanga Province

The study area for this research, the Agincourt Demographic Surveillance Site, which is currently located in Mpumalanga, was previously located in Limpopo province. Mpumalanga, meaning 'Place of the Rising Sun', is one of the nine provinces of South Africa, situated in the northeast of the country. Mpumalanga occupies about 6.5% (79 490 km^2) of the land surface area of South Africa, and is comprised mainly of parts of a number of former provinces including the 'self-governing territories' and 'homelands'. Mpumalanga covers the area between Witbank in the west and Komatiepoort in the east. KwaZulu-Natal and Free State are found on the southern borders with Limpopo province in the north. Gauteng borders it in the west. The neighbouring countries of Swaziland and Mozambique also share borders with Mpumalanga in the east. Mpumalanga is well known for its scenic beauty, characterized by grasslands and bushvelds in the northwestern region and its richness in cultural diversity with which it is endowed, (SEHD, 2004; Stats SA, 2004). The Lowveld area is rich in the history of pioneers and explorers with gold-rush towns such as Pilgrim's Rest, Graskop, Kaapsche Hoop and Barberton (Figure 3.3) (SEHD, 2004).

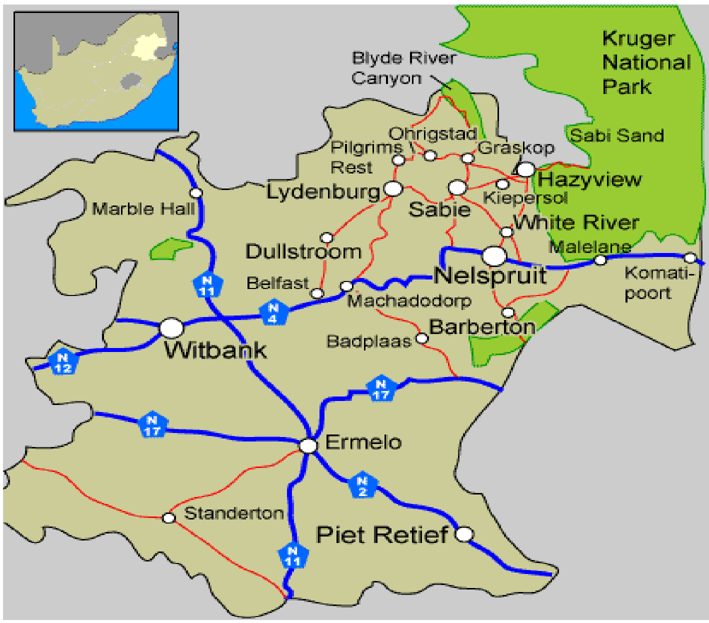

Figure 3.3: Map of the province of Mpumalanga (www.bookaplace.co.za/.../mpumalanga.htm)

An estimated 3 606 800, 7.2 % of South Africa's total population in 2009 resided in this province (Stats SA, 2009). The population density (persons/km^2) increased from an estimated 35 in 1996 to 39 in 2001, with approximately 41% of the total population residing in urban areas in 2001 (Stats SA, 2004; MPG, 2009). The black Africans accounted for approximately 92% of the total population, with higher female to male ratio (92, 1 men per 100 women), and the highest proportion found in the 15–64 year age group in 2001. The language most often spoken in households was siSwati (30.8%), followed by isiZulu (26.4%) and then isiNdebele (12.1%), all of which are national languages (Stats SA, 2004; MPG, 2009). The indigenous cultural groups occupying the province include the Ndebele, the Swazi, the Shangaans and the Pedi (SEHD, 2004). At 29.9%, the unemployment rate of the province is slightly above the national percentage, whereas the households under the poverty line of R800 per month are 25.6%, slightly fewer than the national rate. The Human Development Index (HDI) is 0.66%, worse than the national average (SEHD, 2004).

The province contributed 6.8% to the national GDP making it the fifth highest province, while recording the fifth highest average annual economic growth rate (3%) of all the provinces during 1996–2004. Currently, the province has the fourth largest economy in the country (MPG, 2009). The major industries contributing to the economic growth are mining and quarrying as well as manufacturing industries, which contributed more than 17.8% each over the period 1996-2004. The construction industry had the lowest contribution throughout this period. Predominantly, manufacturing, mining, energy (electricity generation), agriculture and forestry support, in addition to tourism, comprise Mpumalanga's diversified economy. In the future these sectors are anticipated to remain the major generators of economic growth in the province.

3.6.1 Bushbuckridge Municipality

Bushbuckridge municipality is considered to be a "poverty node" under the Integrated Sustainable Rural Development Programme[17] (ISRDP), meaning that it has been classified as one of the most under-developed and impoverished municipalities in the country (Business Trust and DPLG, 2007). It was established in 2000, as a result of the amalgamation of three local councils, north, south and midland. Previously it was made up of two apartheid homelands, Gazankulu which was designated for the Shangaan and Tsonga people and Lebowa which was mainly for the Pedi and northern Sotho people (Business Trust and DPLG, 2007). Until the amalgamation, it was a cross border municipality spreading across Limpopo and Mpumalanga. Bushbuckridge has an estimated population of 499 054 in 2001. The current population density is 235 people/km^2 and the major urban centres are Mkhulu, Thulamahashe, Acornhoek and Bushbuckridge (Business Trust and DPLG, 2007). The municipality borders the Blyde River Canyon in the west and the Kruger National Park / Sabie Sand reserves in the east; Manyeleti and Andover Game Reserves fall into the area along the northern border (Figure 3.4).

[17] ISRDP – Set up by the president in 2002, the aim of the ISRDP is to address the developmental issues in these areas as a matter of priority. The programme is housed under Department of Local Government (DLG)

Figure 3.4: Bushbuckridge Municipality (http://www.routes.co.za/lp/bushbuckridge/index.html0

The Bushbuckridge municipality is extremely poor, with more than 85% of households living below the household subsistence level and only 14% of the adult population being employed. The economy of the municipality is premised upon government and public service, services and retail, agriculture and tourism, with the latter two being recognised as future potential areas of economic growth (Business Trust and DPLG, 2007). Nonetheless, the municipality is facing a series of challenges in terms of economic growth and development. Despite being nested within the Kruger to Canyon Biosphere reserve, which comprises of major tourist attractions including the Kruger National Park, the municipality is battling with stagnant economic growth, out-migration to economic centres, increasing crime and a threat of environmental degradation (Business Trust and DPLG, 2007). According to the municipality report, more or less 70% of economically-active males and 40% of females work outside the area for more than half of the year, while half of the males and 14% of the females between the ages of 25 and 59 are long-term migrant workers (Business Trust and DPLG, 2007).

The stagnant economic growth has also been attributed to the following:

- Historical joint governance of Bushbuckridge by Limpopo and Mpumalanga;
- Lack of adequate skills and capacity in government departments;

- Poor distribution of water to local communities, poor telecommunications infrastructure;
- Limited manufacturing, farming activities, demand for tourism for Bushbuckridge (overshadowed by Kruger);
- Most of the land is currently under land claim and not under formal administration (land claims have hampered investment);
- High levels of unemployment (Business Trust and DPLG, 2007).

The high HIV and AIDS prevalence in the municipality further exacerbate economic growth. Due to the poorly developed health infrastructure, there is poor awareness about the epidemic (Figure 3.5). The prevalence rate which is considerably higher than the national prevalence is still increasing, especially among young adults.

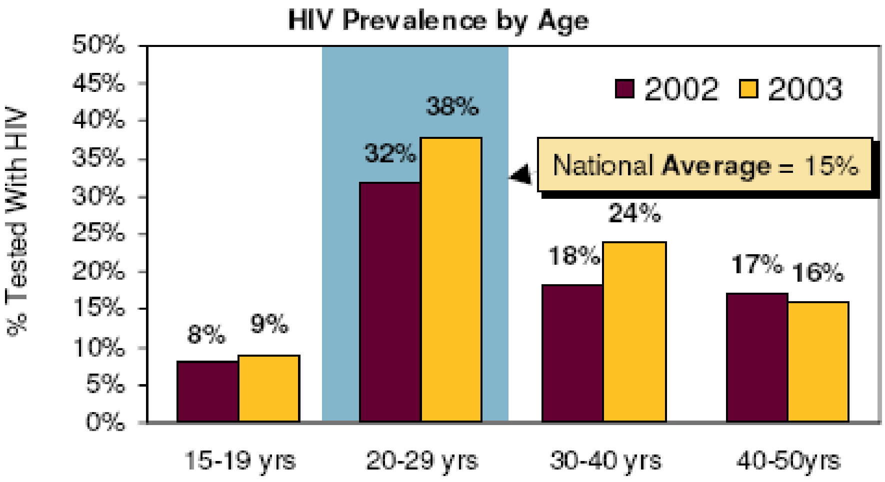

Figure 3.5: HIV prevalence in antenatal women in Bushbuckridge (Business Trust and DPLG, 2007)

The municipality faces further challenges in terms of education delivery. More than 70% of the schools have neither water nor electricity, resulting in overcrowding in the schools and poor attendance. Bushbuckridge is further characterised by high illiteracy levels, with 40% of the adults having no form of schooling. For a comparison of some of the developmental challenges facing the municipality see Table 3.3.

Within the Bushbuckridge municipality is the Agincourt Demographic Surveillance Site. Similarly to the municipality, the study area is also battling with developmental issues and high HIV and AIDS prevalence rates, poverty and unemployment.

Table 3.3: Comparison at national level of the developmental challenges (Business Trust and DPLG, 2007)

Nodal Economic Profiling Project
Business Trust & dplg, 2007
Bushbuckridge

Key data points
Development scorecard

Although electricity and water provisioning compares favourably with other rural nodes, Bushbuckridge continues to lag behind national service levels

Bushbuckridge development scorecard

	Bushbuckridge	Rural node average	All node average	National average	Difference vs national average	Rank within rural nodes (1=Best, 14=Worst)
Poverty incidence (% of households below HSL)[1]	85.6%	84.7%	81.0%	65.3%	20.3%	8
Employment rate	14.0%	15.4%	19.3%	33.7%	19.7%	10
Households without basic access to water[2]	54.6%	64.9%	55.1%	27.9%	26.7%	5
Households without access to electricity[3]	33.0%	56.7%	50.3%	30.3%	2.7%	2
Percentage of adults with low / no education[4]	53.6%	60.3%	54.1%	40.3%	13.3%	3

Better than national avg. Worse than national avg.

Note: [1] HSL = Household Subsistence Level and is equal to R19,200 per annum (R1,600 per month); [2]Defined as not having piped water within a distance of 200m of dwelling (govt. policy on minimum basic human need); [3] Based on households that do not use electricity as a source for lighting; [4]All adults aged 20+ with no schooling at secondary level or above (Stats SA indicator of educational deprivation)
Source: Stats SA Census 2001, Monitor analysis

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3.6.2. Agincourt DSS (Bushbuckridge)

Established in 1992, the objective of the Agincourt Demographic Surveillance Site (Figure 3.6) was to provide accurate information on rural population dynamics, progression of rural health such as burden of diseases and development of a database (Kahn *et al*., 2007). This information would aid the formulation of district level development policies and programmes, including data for advanced community based studies (Collinson *et al*., 2003; Kahn *et al*., 2007). The baseline census was conducted in 1992 and 8896 households were surveyed. The database is updated every year for monitored households. Demographic, health and socio-economic data collected by the unit includes, births, deaths, in- and out-migration, household relationships, resident and refugee status, education, ante-natal and delivery health practices (Collinson *et al.*, 2003; Kahn *et al*., 2007).

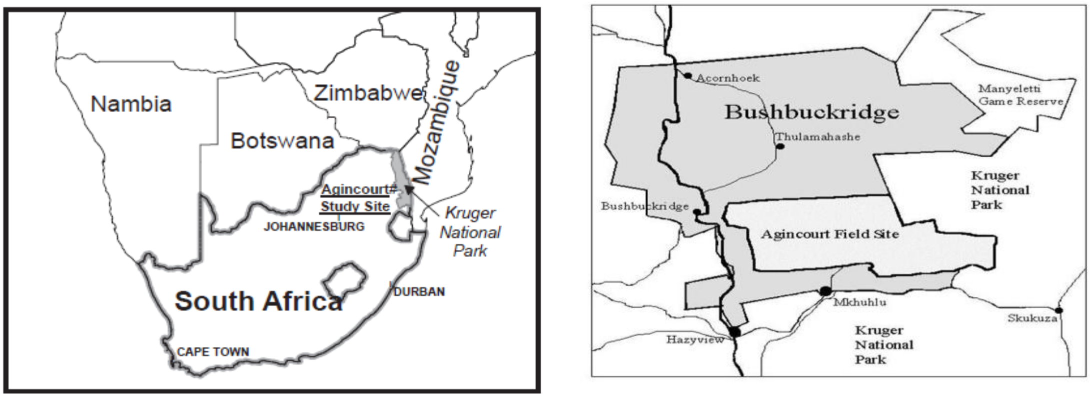

Figure 3.6: South Africa, Bushbuckridge and the Agincourt Demographic Site (Kahn *et al.*, 2007)

A module on chronic cough (for investigating the prevalence of tuberculosis) was introduced in 1999. In 2004, the food security module was added which captured data on general food security, staple foods, protein consumption, including sources of food, either agriculture or utilisation of wild foods (Hunter and Twine, 2005; Kahn *et al*., 2007). In terms of agriculture, the food security module further measures cultivation both on fields around the homestead and fields outside the homestead. A second food security module was conducted concurrently with the 2007 census. Verbal autopsies (VAs) are conducted in conjunction with medical practitioners to ascertain the probable cause of each death in the site. These are conducted concurrently with the census although done by a separate field team (Kahn *et al*., 2007).

Agincourt Demographic Study Site (DSS), situated in the former homelands of Gazankulu and Lebowa had 21 villages, a total population of approximately 66 840 and population density of 172 persons/km^2. Since 2008, the study site consists of 26 villages and the population has risen to 82 000 persons. Located in semi-arid savanna, the area is vulnerable to climatic variability. It has low average rainfall and is prone to droughts on average every 3.5 years, making it unsuitable for agriculture, but suitable for game and cattle farming (Collinson *et al.*, 2006; Kahn *et al*., 2007). Shangaans make up the main population group and Mozambican immigrants, some of whom are former refugees, constitute approximately 29% of the total population (Collinson *et al.*, 2006; Kahn *et al*., 2007). An approximate 60–70 % of potentially economically-active population is not employed. Subsistence farming is the most common livelihood with families cultivating small plots around the homestead. About 60–70 % (2003) of the families cultivate arable fields on the periphery of the village, an increase from the estimated 30–40% in 2000. With 14.7% of the area classified as residential, 7.5% under cultivation and 77.8% under grazing, shortage of land is a livelihood challenge (Shackleton, 2000; Giannecchini, 2001; Giannecchini *et al*., 2007). Given this scenario, reliance on natural resources is imminent with a wide range of products being harvested.

A large migrant population works in mines and manufacturing in the neighbouring urban centres and commercial farms and timber plantations. Thus female-headed households constitute an estimated sizable number (32%) of the total households. While the public sector provides considerable employment, informal-sector activities are widespread, including food and fruit vending (Collinson *et al.*, 2006; Kahn *et al*., 2007). Government grants and pensions play a significant role in the economy of this area as does the natural resource base (Hunter and Twine, 2005). Whilst the area has a health centre and clinics, these are under-utilised despite the services being free, owing to poor drug supply (Collinson *et al.*, 2003; Kahn *et al*., 2007). Among the main health problems recorded for children and the 15–49 age group is AIDS. According to Clark *et al.* (2007), approximately 30% of adult deaths in Agincourt in 2002 were due to AIDS related causes.

Physically, the area is typically savanna woodland characterised by sandy infertile granitic soils, and patches of gabbro[18] intrusions which are characterized by deep clay soils in the east. The study area is enclosed by the Xanthia ridge to the north, the Sabie Sands Game reserve to the east and the Bushbuckridge Nature Reserve to the west (Figure 3.7). The rainfall patterns vary from 800 mm in the west to 500 mm in the east per annum. Most of the rains fall between the months of October and April. The areas

[18] A dark, coarse-grained, intrusive igneous rock rich in minerals. Described as a dyke, the gabbro is characterised by heavy clay soils.

become more arid, eastwards, with a reduction in the mean annual rainfall. As stated earlier, these areas are prone to droughts (Shackleton, 2000). Two main vegetation types are dominant - Lowveld Sour Bushveld located in the west and the Lowveld Bushveld in the east.

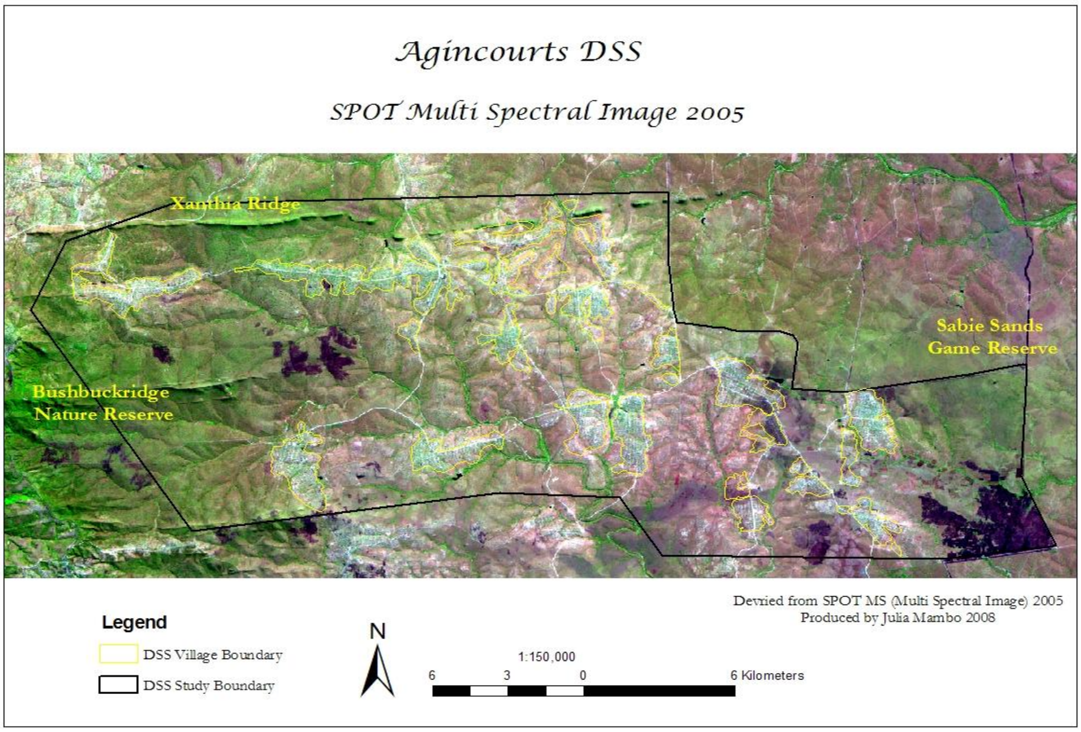

Figure 3.7: Agincourt Study site and surrounds

The settlement pattern within Agincourt is typically rural South African characterised by distinct villages (> 400 households) in a grid formation along transport networks (Hunter *et al.*, 2007). Each village is surrounded by fields used for cultivation and grazing, and woodland areas used for harvesting of natural resources. Homestead yards vary in size and include dwellings, animal pens, and gardens used for small-scale cultivation of maize (the staple crop), vegetables and sometimes fruit (Konz, 2007).

Natural Resource Utilisation in Agincourt

Justification for the selection of Agincourt for this thesis becomes clearer when viewed against the backdrop of natural resource use. An increased trend in the reliance on natural resources has been noted in most of South Africa's rural areas. This has been attributed to the deterioration of the socio-economic environment, high AIDS mortality and the better economic returns gained from natural resource products compared to formal employment (Shackleton *et al.*, 2008). Non-financial benefits derived from natural resources have also been noted in form of improvement of the quality of life for individuals and families, self-esteem and economic independence (Shackleton *et al.*, 2008).

A greater part of households in the study site depends on the natural environment for a variety of purposes such as livestock grazing, fuel wood collection, wild foods, thatching grass, construction timber and other domestic products for both consumption and income generation (Hunter *et al.,* 2007). The natural resources are usually harvested from the village commons that fall under the jurisdiction of the local traditional authority, but in most cases are actually open access to all villagers (Hunter *et al.*, 2007). According to Hansen (in Hunter and Twine, 2005), in 1998, 92% of the rural population in Bushbuckridge consumed wild fruits, insects and bush meat, while 98% depended on subsistence farming, gardens and livestock (Shackleton, 2000; Giannecchini, 2001).

The current and potential magnitude of the HIV and AIDS epidemic in the study area, the levels of food insecurity, unemployment and the limited livelihood options for the rural population, as well as issues of migration and the reliance on the natural resource base make Agincourt a favourable study area to investigate the interactions between the HIV and AIDS epidemic and natural resource utilisation as a livelihood option. Further the availability of longitudinal demographic data enable the monitoring of food insecurity and natural resource utilisation in the study area between the years 2004–2007.

3.7 Summary of Study Area

This chapter has provided a description of the physical, social and economic setting of the area of study. The chapter has further set the scene or the basis for the study, outlining the physical, social and economic challenges faced by the country, the municipality as well as the study site in terms of sustainable development. Issues of interest within the research; food security, HIV and AIDS as well as poverty have been discussed within the context of the study area, as well as the magnitude and the effects of these issues on the local population. With the scene for the research study set, the proceeding chapter will outline the methodologies undertaken to answer the research questions raised in chapter one as well as the justification for some of the methods chosen and the errors associated with them.

CHAPTER FOUR

RESEARCH DESIGN – METHODOLOGY

4.1 Introduction

The previous chapters have discussed in detail the status and the basis of food insecurity, the impacts and possible linkages between food security, natural resource utilisation and HIV and AIDS, including the impacts of the HIV and AIDS epidemic within SSA and the southern Africa region. The discussion has brought to the fore the complexities involved within the food security paradigm, including the linkages between HIV and AIDS, resource use and possible risks to vulnerable and affected communities. The discussion has also delved into the utilisation of natural resources as a rural livelihood strategy, to supplement household food and income and acting as a buffer in times of household or livelihood stress. The utilisation of natural resources as a coping mechanism, when faced with internal or external stresses such as drought, AIDS death, for the mainly rural populations, has also further been explored. The country within which the study area is located, the province, the municipality as well as the study area itself have been described, setting the scene for the study.

This chapter focuses on the research design and methodology employed to answer the research questions outlined in Chapter One based on the hypothesis:

> ***That natural resource utilisation provides a critical 'safety net' particularly for AIDS affected households faced by both chronic and transitory hunger, as a short and long term coping strategy***.

Trying to understand the 'state of the natural resource base' and how humans are interacting with this resource, including what drives such interactions, are all critical aspects requiring investigation. Due to the complexity of such research, two sections of the methodology will be outlined dealing with:

- Demographic data analysis (the social environment);
- Land-use and land-cover change (the physical environment).

The broader research context, data and methodologies as well the ethical considerations for this project are also discussed below.

4.1.1 Ethical Considerations

This research is undertaken using data from the Agincourt HDSS which is covered by a generic clearance certificate described as: The University of the Witwatersrand Committee for the Research on Human Subjects (medical), provided ethical blanket approval for a generic protocol, concerning the study at Agincourt field site entitled "Investigating and responding to changes in the health and population dynamics of rural South Africa" – clearance number M960720. This research falls under this blanket ethics clearance, meant for access to already collected data, with no personal contact between the subjects being studied and the researcher. The nature and sensitivity of the research, pertaining to HIV and AIDS related mortality and the vulnerable populations in the study area necessitated the ethics clearance. The ethics consideration, especially the sensitivity in reporting about HIV and AIDS as well as issues of stigma attached to the epidemic guide the reporting of the results of this research. Thus the investigation pertaining to the epidemic is investigated broadly, based on anonymity of the villages and the households affected.

4.1.2 Broader Research Project Context

This research is being undertaken as part of the Rockefeller Brothers Foundation, of which the broader project entitled *"Investigating and Responding to changes in the health and population dynamics of rural South Africa*" is investigating among other things, the burden of disease on rural livelihoods. The broader project consists of other smaller projects all investigating different aspects of the inter-linkages between food security, HIV/AIDS and dependence on natural resources, including issues of population growth and migration. This research investigates linkages between the HIV/AIDS epidemic and the utilisation of natural resources. The overall aim is to assess the sustainability of resource utilisation and sustainable food security within rural livelihoods. All the other research projects being or that have been conducted are at household level, with not more than 300 households selected from the Agincourt DSS database, while this research uses census data for the whole DSS. The research, for example, by Twine and Hunter (2008) and Hunter, Twine and Johnson (2005) which investigates impacts of the progression of HIV and AIDS mortality on food security and coping strategies for households are closely linked to this research. The overall objectives of the projects as well as the research questions and the methodologies applied differ however. The different projects are guided by investigator interests, with different aims and objectives as well as research questions.

To begin with, this research investigates the broader (village) and not local level (household) impacts of the epidemic, with the aim of assessing sustainability of natural resource utilisation as a coping strategy and the implications on the natural resource based livelihoods. This is over and above identifying the drivers or determinants of food security and the extent to which AIDS mortality is a factor. Twine and Hunter, conversely ascertained the dependence of AIDS affected households on natural resources, investigating the changes in the household dynamics when a death has occurred and other impacts not only those linked to food security. Most of the projects focus mainly on HIV and AIDS and its impacts, while this research investigates other factors that might be driving food security, beyond HIV and AIDS mortality. Secondly, Twine and Hunter, as well as the other projects do conduct extra-specific surveys to supplement the Agincourt data. This research does not collect extra data but is solely dependent on the DSS census and food security data. Thirdly, while some methods are similar, most of the methods are different due to the different objectives, research questions and the nature of the research. For example, Hunter and Twine used NDVI to assess biomass as an indicator for natural resources while this research uses land cover mapping, land cover change and natural resource mapping over and above NDVI. Similarly, the statistical data analysis has overlaps as well as differences in the methods chosen. For example, Twine and Hunter (2008) used the weekly measure of food insecurity, whereas this study uses the monthly variable to measure food insecurity. The calculations for dietary diversity as well as the variables chosen for natural resource gathering also differ between this research and other projects, including Twine and Hunter.

The demographic data choice for this research was guided by the availability of data in the Agincourt DSS database. The variables in the database or the choice of what questions were asked for the food security module was the responsibility of the principal investigators Dr Wayne Twine and Doctor Lori Hunter at the conceptualisation of the Rockefeller project as mentioned above. However, the choice of variables extracted and analysed from the database was the responsibility of the investigator, guided again by the research questions. The choice for the remote sensing data was solely dependent on the investigator of this research as well as the choices of methods and scale of investigation chosen. The village level scale chosen, apart from being guided by the availability of remote sensing data, is also guided by the need to investigate the broader implications on the livelihoods for the whole DSS for policy planning and interventions purposes. Further, in terms of investigating the broader implications on the DSS, the chosen scale was appropriate due to the spatial location of natural resources between and in the village commons. While in terms of teasing out the AIDS mortality impacts, the scale chosen was not appropriate as was expected; the study did reveal some interesting interactions. Matching the scale of this research with the other ongoing projects was not feasible given the different objectives of the research, regardless of the possibility of contradictory results. Thus, the design, the data choices and the methodologies for this research were the responsibility of the investigator.

4.2 Conceptual Model and Data

A conceptual model that depicts the three processes followed in order to answer the research questions has been developed. The model, which outlines a general methodology approach, assists in identifying the causes and manifestations of food insecurity and its related drivers. The model assists in the identification of some indicators of vulnerable households, food insecurity status and utilisation of natural resources based on the demographic data indicated by the dotted pattern (Figure 4.1).

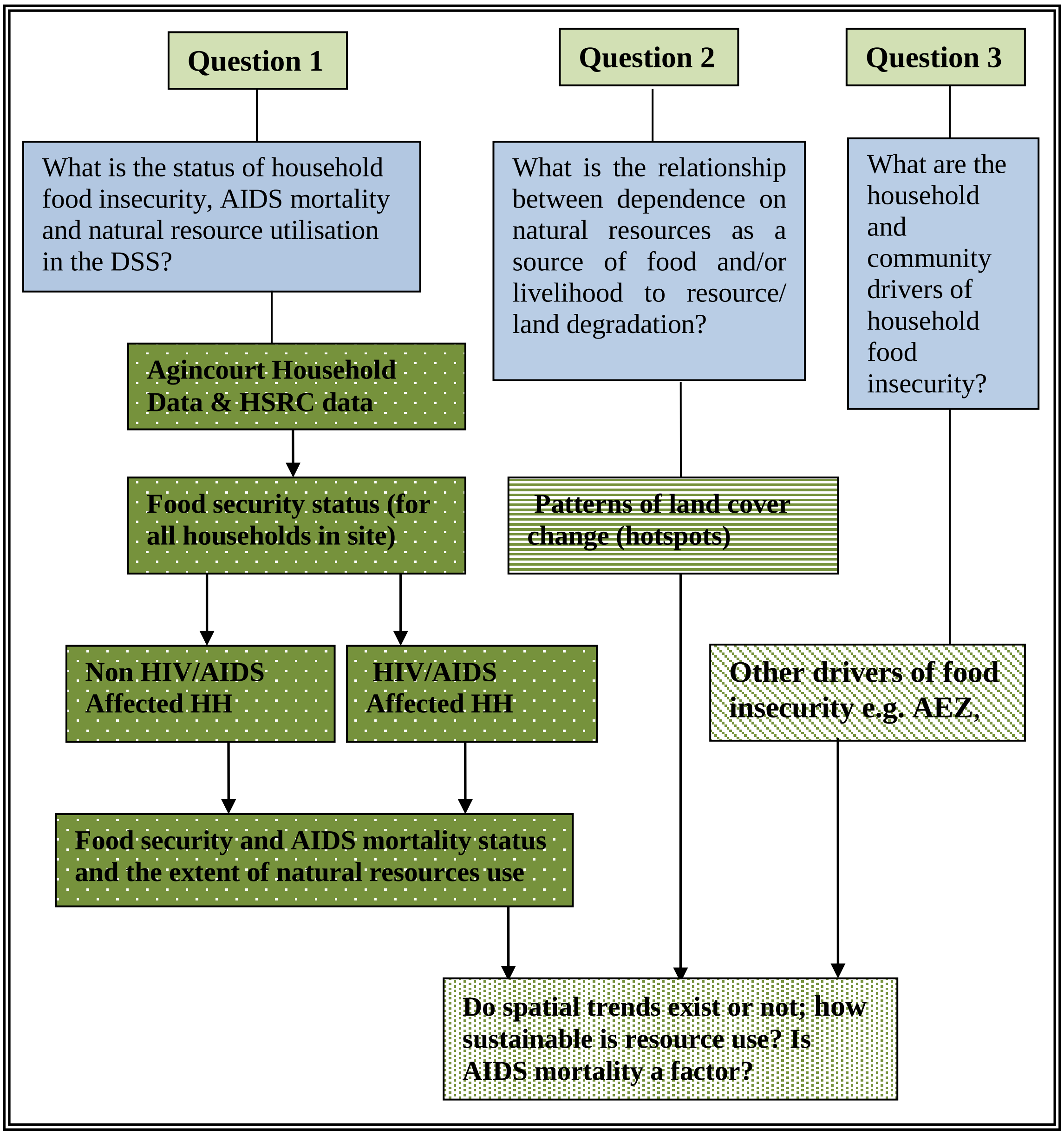

Figure 4.1: Conceptual model of food insecurity, HIV and AIDS and land cover change

To assess the patterns of land cover change at village level, additional satellite remote sensing data is used, indicated by the horizontal striped green pattern on Figure 4.1. Additional possible drivers of food insecurity indicated the by diagonal green stripe are investigated using different data. The model (Figure 4.1) is implemented in a remote sensing and GIS environment, involving image processing for land use and land cover change, and GIS analysis of several data layers according to the conceptual model. Image processing and spatial analysis is carried out using IDRISI™ and ARCGIS™ respectively while the demographic data is analysed in Microsoft Excel, SPSS™ and STATA™.

The model uses a combination of demographic and remote sensing data in a GIS environment as was applied by Twine and Hunter (2008) in their study on resource utilisation mainly by HIV and AIDS affected households in the DSS. This application was successful in terms of estimating or quantifying general resource availability in the DSS using remotely-sensed NDVI images (Normalised Difference Vegetation Index). The overlap between Twine and Hunter's research and this work is the use of NDVI, but in this study, it is used not only to quantify but to assess the health of vegetation as well as identify hotspots of resource degradation. This study applies additional remote sensing techniques to quantify resources availability, such as supervised classification. Twine and Hunter do not assess landcover change or identify areas of possible resource degradation, which this study does using change vector analysis simple differencing techniques.

The demographic data from both studies was derived from the Agincourt DSS database. While Twine and Hunter (2008) mainly focussed on a small sample of households, of which additional specific questions about AIDS mortality and food security as well household dynamics were asked, this thesis focuses on a much larger village scale and does not engage in household level analysis. Rather, this thesis uses data already collected during the DSS census to answer research questions. The village scale chosen would assist in getting a synoptic assessment and view of the interactions beyond the household.

Socio-economic data used to understand some of the human drivers of change in the natural resource base are derived from a variety of sources. Demographic data on AIDS mortality, nutrition and food security status, as well as data on natural resources utilisation for food security are collected from the Agincourt field site database. The data sets representing the variables in the model are presented in Table 4.1. Other socio-economic drivers of food insecurity such as transportation infrastructure and physical data such as agro-ecological zones are utilised as indicated in Table 4.1, to ascertain factors that make some villages more vulnerable or more food insecure than others, when located in the same area. These data sources are identified along with various questions that are framed to answer the key research questions relevant to this thesis (see Table 4.1. below):

Table 4.1 – Data elements used in the study to assess food insecurity drivers and natural resource utilisation

Research Question	Data requirements to answer question
1 – What is the status of household food insecurity, AIDS mortality and natural resource utilisation in the DSS?	Agincourt data on food security and natural resource utilisation to assess the food security status of vulnerable households including those affected by AIDS mortality.
2 – What is the relationship between dependence on natural resources as a source of food and/or livelihood to resource/land degradation?	Landsat ETM imagery to be used to derive NDVI imagery for land use and land cover change analysis. SPOT imagery for the mapping of natural resources – in form of land use and land cover NDVI imagery to be used as additional analysis.
3 – What are the household and community drivers of household food insecurity?	Agro-ecological zones; transport network and distance from urban centres; infrastructure including health centres, schools, shops; current land-use /land-cover.

While a myriad of data was collected from the DSS database, other data that would have enriched the study were not available. This data included data on household income and how much household income, food production and natural resource utilisation contributed to household food and the implications of these dynamics in the DSS. Data on household assets, which would have assisted in answering questions about coping strategies, was also not available for the required years. Other useful data on the migrant populations was difficult to include in the analysis given that both the migrant and the local populations are integrated. If this had been a household study, this data would have been useful but not at village level. This data would have assisted in answering questions about subsistence farming and household income. Further, there was no data on remittances despite these being a big contributor to the economy of the DSS. Market access data which would have assisted in answering questions about food accessibility were also not available, as well data on village differences and resource utilisation, thus these data were not included in the model. Despite these entire missing variables, the data collected from the DSS database was deemed essential to answer the research questions outlined in Chapter 1.

The following section will focus on the methods employed firstly on the demographic data analysis using DSS data and secondly for the land-use and land-cover change as well as resource availability analysis using remotely sensed data.

4.3. Demographic Data Analysis

As previously mentioned, the data choices from the Agincourt DSS, the methods employed and the scale chosen for the research are guided by the aims, objectives and the research questions asked for this thesis. These methods are discussed in detail in the proceeding sections of this chapter.

4.3.1 Demographic Surveillance Site (DSS) Data Analysis

In the context of population and the environment debate, it is essential for this research thesis, as part of the objectives to assess any impacts the growing population of the DSS and their utilisation of the natural resource base might have on the environment. While the remotely sensed data is used to assess and monitor land-use and land-cover change and highlight natural resource availability, demographic data, which includes data on food security and coping strategies is essential for a more comprehensive analysis. This would enable the investigation of any linkages existing between AIDS mortality, population growth, natural resource utilisation and degradation of resources in the DSS, bearing in mind the possible errors in the accuracy of the land-use and land-cover and resource availability data.

The demographic data does not only assist in the identification of natural resource utilisation strategies but also assists in exploring the profiles of the residents of the DSS who would or would not be most dependent on the natural environment. Further, demographic data would reveal other means of supplementing household food by the residents in the DSS. As previously mentioned, the combination of remotely sensed data and demographic data, particularly NDVI imagery has previously been applied in studies to estimate natural resource availability in the DSS by Hunter *et al.* (2007) in the assessment of woody biomass.

The demographic data to be analysed is obtained from the Agincourt Demographic study site database. As mentioned earlier, modules such as food security are conducted concurrently with the annual census albeit not annually. The census is the main method of data collection in the study site, within which all the residents in the 11 000 households in 21 villages are counted and their health, migration, socio-economic and other data collected (Collison *et al.*, 2006). The food security module which was conducted in 2004 and later in 2007, as well as the mortality data collected annually set the basis of analysis in this study. These data are a particularly rich data source for the area.

The food security module captures data on the food security status of households in the DSS. This includes information on how households obtain their food, both through production or purchase, where the food is grown, either home garden or out of village plots. For the households experiencing food insecurity, data to investigate the causes of insecurity is captured. Other options of supplementing household food security such as the utilisation of natural resources are also captured in the module. For details on the food security module see Annex 1.

4.3.2. Data Preparation

While the original dataset was received in STATA format, the data cleaning process was conducted in Microsoft Excel then later imported into SPSS from which the subsequent analysis is carried out. While HIV prevalence is a key factor, food security was used as the main determinant factor for the selection of households. A total of 10 179 households is present in the received database of the food security module. The cleaning process is premised on the food insecurity indicators of hunger recorded for the households. The main indicator for measuring the availability of food in the household on a monthly basis is utilised based on the likelihood of the better accuracy of recall of event of the previous month compared to a recall of event of the previous year (Twine and Hunter, 2008). All households that did not respond with either a yes or a no are removed from the dataset, leaving a total of 9438 households who responded to the key question about hunger in the previous month.

A standard for all the responses implying no problems in acquiring food or producing food is set to 0, while 1 indicate that the household had faced problems in fulfilling its daily dietary requirements or producing its own food. This study sample gives insights into the status of food security in the study site as well as means of obtaining food. The study sample also gives an insight into the reasons of food insecurity or inability to produce enough food at household level. A focus on the prevalence of hunger is measured through various collected indicators for both years 2004 and 2007.

The data preparation for 2007 is based on the 2004 food security module. The sample of households selected in 2004, are selected for the analysis. The 2007 data does not include mortality or gender of the household head as well village data. Therefore, the data clean up and matching is a challenging process and involves several processes in Excel. The identities of all the households from the 2007 data did not match any of the previously selected households in 2004. This is because all households are randomised in the DSS, for ethical consideration, while a permanent numerical identity is kept in the database. In order to select the same sample, the two data sets of household had to be linked resulting in two columns of 2004 households:

- 2004 old which is linked to the villages;
- 2004 which is linked to the 2007 randomised household identities.

Using the VLOOKUP module in excel the two dataset are matched. Some households in the old 2004 are missing, suggesting that these had been dissolved while new households from the new 2004 dataset suggested new households added to the dataset. Migration between villages, into and out of the DSS are some reasons cited for this factor, while, mortally could be a contributing factor towards the dissolution and emergence of new households. A total of 12 000 households is supplied in the 2007 data of which the 9436 households from the 2004 are selected based on the question about hunger in the household in the previous month. The first process results in the removal of 120 households. After the matching process, an additional 600 households are removed as duplicates and the households that are not matched are further removed leaving a total of 8744 households of which the village identities and the 2007 identities had perfectly matched. Villages are essential since the data analysis for the research is premised on a village scale. Figure 4.2 highlights the census data to be analysed for both years 2004 and 2007.

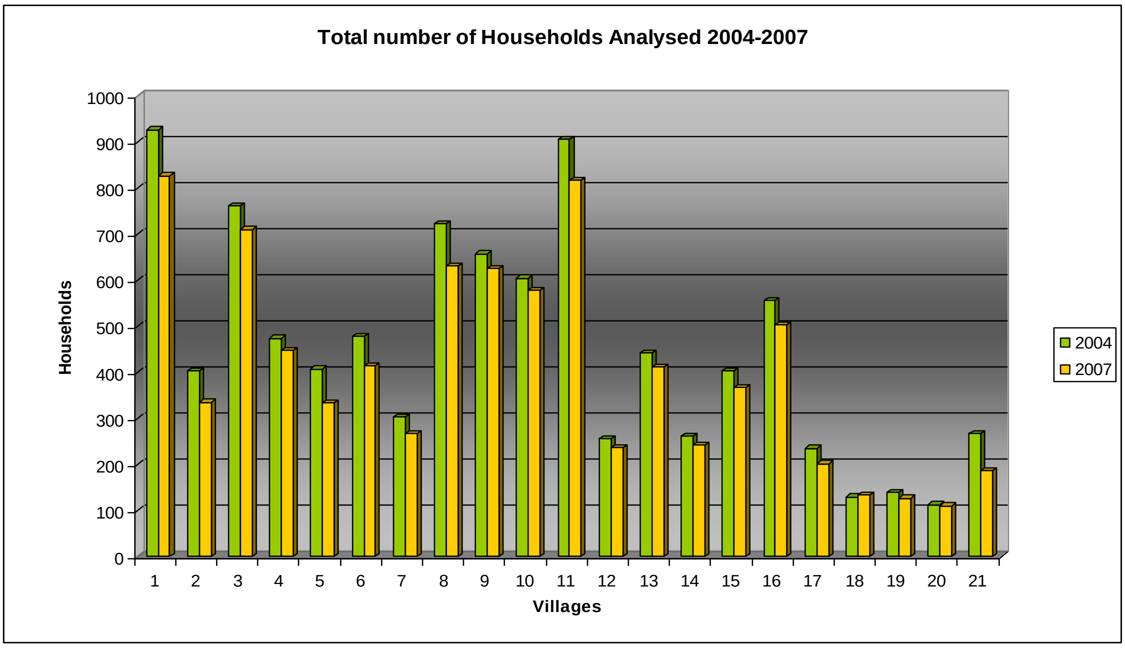

Figure 4.2: Total number of households analysed between 2004 and 2007

4.3.3 Research Sample Synthesis between 2004 and 2007

Given that monitoring food security and natural resource utilisation is one of the objectives of this research, it is important to first highlight the differences in the study sample, which has an impact on the comparison and final analysis of food insecurity and natural resource utilisation in the study area.

There are changes in the research sample between the two years with a little significant reduction in the number of households as discussed below. This reduction could have impacted on the overall analysis of the noted trends especially in the 2007 data set.

The total number of households analysed in 2007 is lower than for 2004, due to the addition and dissolution of households as well the redrawing of village boundaries. For the purpose of monitoring, the same study sample from 2004 is selected for 2007, meaning that non matching households are excluded. The overall reduction is negligible with regards to the whole DSS, but could impact at village level for the three villages which lost substantial number of household, with over 80 households and one village over 100 households, while one village gained households (Figure 4.2). As mentioned above, loss of households is noted for village 1, losing 100 households while villages 8, 11 and 21 lost approximately 80 households each.

4.4 Food Security Indicators Measurements

As previously mentioned several indicators of food security are selected from the DSS database and are used assess the status of food insecurity. These indicators include measurement of hunger prevalence, means of supplementing household food, and coping strategies all of which are captured in the food security module. Coping strategies involve the gathering of natural resource products. While not an indicator of food security, AIDS mortality is included to enable cross sectional analysis of food security among different study sample groups in line with the objectives of the study. The next section gives a detailed analysis and calculations of some of these indicators.

4.4.1 Household Food Security

As mentioned in Chapter 2 part 2 (2.10), household food security is an important measure of well-being, despite not capturing all the aspects of poverty that affect households (Hoddinott and Yohannes, 2002). Measurement of food security commonly refers to the assessment of individual and/or household-level experiences of food insecurity, based on food consumption and diets, using a sequence of resultant indicators in a food security index ((Hoddinott and Yohannes, 2002). Presently, most techniques for developing food security indexes or scores include household vulnerability approaches, experimental tools, coping strategy assessment tools, or combinations of these (Hendricks, 2005). Given the complex and multifaceted nature of food security and the various factors affecting food availability, accessibility and utilisation, the measurement of food insecurity is complicated, extensive and costly (Hendricks, 2005). Further, there has been no agreement in terms of which indicators of food security are more accurate, with new indicators and measurement scales being continually developed and validated (Hendriks, 2005).

According to Maxwell and Frankenberger (1992), numerous indicators may be used to assess household food security. These indictors can be separated into "process indicators", which depict both food supply and food access, and "outcome indicators", which are used as proxies for food consumption. Process indicators include agricultural production, access to natural resources, market infrastructure, and consequences of conflict. These differ between households premised upon season, ethnicity, geographically and socially (Maxwell & Frankenberger, 1992). Outcome indicators can be direct or indirect, with the direct indicators highlighting the actual food consumption and the indirect outcomes depicting nutritional status (Crowther, 2008). While there is no standard measurement tool for food insecurity in South Africa, the recent food and expenditure survey utilised the quantitative indicators such as food poverty and low energy availability for assessing food insecurity (Rose and Charlton, 2002). The developed indicators classified households into four categories ranging from food secure to food insecure (Crowther, 2008).

The indicators used for the assessment of food security are created by the investigator from the variables collected in the 2004 food security module (Appendix A). A total of 19 indicators are created from the food security variables, representing both process and outcome indicators. Indicators of hunger are identified from questions relating to availability and or access to food in the household and the future expectation of the household food security. The number of meals consumed is further used to ascertain the prevalence of hunger in households. The different food groups consumed are used to derive the outcome indicators. Six variables are utilised for the measurement of general food availability and consumption in the household. The high number of unknown responses in the food security module impeded the development of a food insecurity index. The food security index would have categorised households into various food insecurity groups which would then be aggregated to village level.

4.4.2 Dietary Diversity

Among the methods, identified by FANTA, dietary diversity is noted as a good indicator of household access to food. Dietary diversity measures,
"the number of individual foods or food groups consumed over time" (FANTA 2002:2) and is a good indicator due to the following:

- a more varied diet is a valid outcome on its own;
- questions on dietary diversity may be asked on household and individual scale allowing assessment at intra household level;
- the method is relatively simple and straight forward for both the interviewers and the respondents. Further the method is not time consuming, taking approximately 10 minutes per respondent ;
- a more varied diet is associated with numerous positive outcomes such as
  - improved birth weight
  - improved child anthropometric status
  - improved haemoglobin concentrations
  - reduced risk of death from heart and disease and cancer.

In addition dietary diversity is a good proxy for measuring due to the following:

- diversified diet is highly correlated with such factors as caloric and protein adequacy, percentage of protein from animal sources (high quality protein), and household income;
- allows for the assessment of intra household food security;
- increased food expenditure resulting from additional income, even for poor households.

To assess the quality of the diet, the number of consumed food groups is calculated instead of the different foods consumed. An example of the food groups is listed as cereals, roots and tubers, vegetables, fruits, meat-poultry-offal, eggs, fish and seafood, pulses/legumes/nuts, milk and milk products, oils and fats, sugar and honey and finally miscellaneous.

In countries where the technique has been implemented, analysis was conducted to ascertain the relationship between dietary diversity, household per capita consumption and calorific availability. The results gave an indication of a correlation between a change in dietary diversity, per capita consumption and household per capita caloric availability, particularly in staple and non-staple foods. The conclusion was that dietary diversity may be used as a proxy for household per capita consumption and caloric availability, measuring the access component of food security (Hoddinott and Yohannes, 2002). In addition, dietary diversity may be used indicator in diverse situations, from poor to middle income countries and from rural to urban food security (Hoddinott and Yohannes, 2002). Dietary diversity may also be used as proxy for the socio-economic status of households (Maxwell and Frankenberger, 1992). The data collection method for dietary diversity has been referred to as being relatively easy and not time consuming, with respondents being able to respond with ease. However, for dietary diversity to be a useful measure of food security, strong correlation with more established food security measures may be necessary to improve accuracy (Hoddinott and Yohannes, 2002).

In this research, the mainly protein rich food group are considered, such as red meat, chicken and eggs, while in some villages, protein intake is supplemented from bush meat and insects. Whereas the individual dietary diversity score (IDDS) assess the nutritional quality of an individual's diet especially children, the HDDS may be used as a proxy for the socio-economic status of the household (Swindale and Bilinsky, 2005).

Dietary Diversity Score

Within the Agincourt study, the dietary diversity is calculated according the following consumed foods: red meat, chicken, fish, eggs, vegetables and fruits. Further other food groups gathered from the bush are also recorded and these include insects, herbs (consumed as vegetables), fruits and red meat.

The frequency of consumption either in a week, a month or in a year is recorded for each of the food groups highlighted, including for the foods gathered from the bush for supplementation of the household food requirements.

These are aggregated to monthly consumption as follows: weekly consumption = (*4);

- Monthly consumption = 1
- Yearly consumption – (/12 = 0.083)

The score for each food group is added, and the dietary diversity score calculated out of the six food groups gathered. A value of 1 is assigned for the each consumption per week and more than 4 times per week to a score of six with a point assigned for the consumption of any of the food groups in the month.

4.4.3 Household Coping Strategies

During the census, questions were asked about other methods of supplementing household food (see Appendix 1 for the questionnaire of the food security module). For the responses given, it is important to differentiate the coping strategies which are more short-term in nature and adaptive strategies which are long-term and are usually aligned to livelihoods. The livelihood adaptive strategies would include methods of acquisition of food by the households, as well as the means of supplementation in the face of food insecurity. The methods described include food production and food purchase, and for those households who produce their own food, whether they produce enough food to feed all the members in their households. Further, reasons for the insufficient production of food from crop failures due to climatic limitations and water shortage to the lack of labour are recorded.

Coping strategies which are usually short-term would include the harvesting of natural resources for either household food or for supplementing household income by harvesting for resale. For households that supplement their dietary needs from gathering wild foods, the type of food harvested and the frequency are recorded. However, no mention is made if any of the wild foods are stored for future use or for commercial purposes. The importance of social networks is also noted. Some households went hungry because they did not receive remittances or food from neighbours.

Utilisation of the Natural Resource Base

A popular means of supplementing household food and income, whether in times of distress or not is the reliance upon natural resources. The utilisation of natural resources in the DSS is recorded for all the resources that are gathered, including the type of foods and the frequency of harvesting. The utilisation of natural resources may be categorized into direct gathering of natural foods for consumption, or gathering for resale to supplement household income and using natural alternatives such as fire wood to save money even through the utilisation of fuel wood is not captured within the module. However, research conducted by Twine *et al.* (2003) investigated the utilisation of fuel wood in the DSS. Despite access to electricity, households reported using fuel wood as a means to save the much needed household income.

The utilisation of natural resources is analysed to investigate linkages between resource use and food insecurity, which is a key theme for this thesis. However, inconsistencies are noted in the data recorded for the utilisation of natural resources between 2004 and

2007. Some questions previously asked in the 2004 food security module are either changed or removed. These changes were necessitated by the need to simplify the data capture process. Therefore data such as the frequency of collection of resources such as the number of times per week, month or year the resources are collected was not included in the questions asked in 2007. These inconsistencies made data analysis and comparison between the two years difficult. For example, a considerable amount of households indicate gathering insects, bush meat and wild fruit but the frequencies of gathering is not recorded, making it difficult to calculate monthly consumption/gathering, as is preferred. The gathering of wild herbs is the only consistently collected data with the consumption aggregated to a monthly scale. Given the above mentioned data complication, the number of households gathering natural resources are considerably smaller in 2007. The other categories, such as the gathering of insects, fruits and meat consumption are also aggregated to a monthly consumption despite the above noted complications.

4.4.4 HIV and AIDS and Mortality

The prevalence of HIV/AIDS, measured from antenatal surveillance is estimated at 19% in 1998, with AIDS and tuberculosis (TB) recorded as the leading causes of death among the prime aged adults in the DSS (Kahn *et al.*, 1999). HIV/AIDS is also credited with the five times increase in mortality in the region (Kahn *et al.*, 2007a). This study however focuses on mortality and not HIV/AIDS prevalence, with prevalence discussed only to give an indication of the severity of the problem. The mortality data used in this study is from 2004, coinciding with the first food security module. Due to the focus of the research on AIDS mortality, data on the prevalence as well as progression of HIV/AIDS is not included and the impacts of the progression of the disease are not analysed.

4.5 Statistical Data Analysis

As previously mentioned, the data and statistical methods as well as the scale for this research are the sole responsibility of the investigator, guided by the aims, objectives and research questions being answered. More detail on the statistical methods is discussed below.

4.5.1 Descriptive Analysis

Descriptive data analysis is performed on food security data, with frequencies and percentages being calculated for the six food security variables chosen. These are represented graphically. Other measures of frequencies depicting food production and purchase, dietary diversity and supplementation of household food security are performed on the various collected variables in the food security module. This includes the utilisation of natural resources in the meeting daily dietary needs.

A score for the utilisation of natural resources is derived in terms of the herbs, meat, insect and fruit gathered per week, month or year, using the same method as dietary diversity. In addition, the assessment of frequencies based on villages is derived using the crosstab method, which enabled the calculation of frequencies and percentages of all variables at village level. Crosstab provides a summary of bivariate data, to highlight the relationship between two variables (Anderson *et al.*, 1994).

4.5.2. Factor Analysis

It is worth mentioning before describing the statistical methods chosen that these methods were recommended by a bio-statistician and agreed upon by the supervisors, given the limited knowledge of statistics by the investigator of this research.

Factor analysis is used to identify underlying variables, or factors, that could explain the pattern of correlations within a set of observed variables. Factor analysis is used in data reduction to identify a small number of factors that explain most of the variance observed in a much larger number of manifest variables. Factor analysis is also used to generate hypotheses regarding causal mechanisms or to screen variables for subsequent analysis (for example, to identify co-linearity prior to performing a linear regression analysis) (SPSS Manual, 2000).

The factor analysis procedure offers a high degree of flexibility, with seven methods of factor extraction and five methods of rotation available. Three methods of computing factor scores are available, and scores can be saved as variables for further analysis.

A factor analysis is usually conducted in three stages:

1. A matrix of correlation coefficients is generated for all possible pairings of the variables;
2. From the correlation matrix factors are extracted, principal factors is the common method;
3. The factors are rotated to maximize the relationships between variables and some factors and minimize association with others.

Principal component analysis is the most common technique of factor analysis and is the one used in this study. The variables derived from the factor analysis are used in subsequent analysis such as correlation analysis, Spearman's rank and regression analysis including logistic regression. For detailed explanation on these methods see Appendix five.

4.6. Land-use and land-cover change

Monitoring the spatial distribution of land-use and land-cover change is a useful tool in the formulation of policy for the management of natural resources upon which rural populations depend, providing a better understanding of sustainable utilisation of land and natural resources (Lambin *et al*., 2001; Srivastava and Gupta, 2006; De Roeck *et al*., 2008; Wessels *et al*., 2009). However, the causes of land-use and land-cover changes are widely contested, and are importantly associated with anthropogenic influences on the environment such as shifting cultivation and population growth. Other scholars have found a myriad of causes of deforestation, with no distinct patterns identified (Geist and Lambin, 2002). The proximate causes are usually associated with human activities and or immediate local-level actions, for example agricultural expansion directly affects forest cover. Nonetheless, there are underlying causes which impact on land-cover change and these would include demographic dynamics and agricultural policies that underpin the proximate causes. These operate at the local level or may have an indirect impact at national and global level (Geist and Lambin, 2002). According to Geist and Lambin, (2002), economic factors, institutions, national policies and agricultural expansion are among other factors drive environmental change, with less emphasis placed on population growth.

Changes in land-cover; the bio-physical attributes of the earth and land-use, human purpose or intent applied to these resources, are essential and all encompassing, affecting earth system function when aggregated to a global level (Lambin *et al.*, 2001). Some of the detrimental effects include:

- Impact on biodiversity worldwide;
- Contributions to local and regional climate;
- Global climate warming;
- Primary source of soil and land degradation;
- alters ecosystems services that support human life.

The detrimental effects may also lead to vulnerability of places and their inhabitants to climate variability, economic and socio-political conditions.

The changes in land-use and landcover are usually monitored through vegetation and land cover patterns, which require accurate and up-to-date information derived from more than one dataset to determine changes (Lambin *et al*., 2001; Satellite Imaging Corporation, 2008; Wessels *et al*., 2009). Remote sensing techniques (RS) and geographic information systems (GIS) for example, have been employed to obtain data for the monitoring of land-cover changes (Lambin *et al*., 2001; Eastman, 2003; Lillesand *et al*., 2004; Kleynhans *et al*., 2009). Despite improvements in land-cover characterisation attributed to remote sensed data, global and regional land-cover and land-use are poorly measured or quantified. Scientists do however, acknowledge that the magnitude of change is immense (Lambin *et al*., 2001). Nevertheless, the provision of more accurate data through technologies such as remote sensing is not sufficient to measure and project future land-cover change, but enhanced understanding of causes of the change is essential to complement the data.

4.6.1. Remote Sensing Data

Remote sensing technology has become one of the most inexpensive techniques for long-term environmental monitoring (Singh, 1998; Lillesand *et al*., 2004; De Roeck *et al*., 2008). Remotely sensed data is potentially easily integrated into a GIS, which provides a user-friendly platform for storage, retrieval and updating of large datasets for analysis and presentation purposes (Lillesand *et al.*, 2004). Remote sensing provides data for large areas whilst providing essential uniform data with respect to date and detail. The availability of time series data further allows for monitoring of land-cover and land-use change over time (Lillesand *et al.*, 2004; Kleynhans *et al*., 2009). Remote sensing in particular facilitates assessment of the status of vegetation, soil and water, which are three essential natural resources of which rural livelihoods depend (Reynolds *et al.*, 2001; Lillesand *et al.*, 2004; Wessels *et al*., 2009).

Vegetation especially is essential to landcover mapping and monitoring, due to its function in ecosystems and being used as an indicator of prevailing environmental conditions. Various land-use and landcover change classifications always use the presence, absence, condition, type and or use as well as the physiognomic structure of vegetation as a reference (Geist, 2006). Remote sensing and both the data and the image processing, combined with GIS has become a critical tool for the development of land-use cover change models and for analysis. Further, remote sensing provides current and accurate data for land use and landcover change (De Roeck *et al.*, 2008). All these characteristics combined make remote sensing a valuable and popular tool for mapping and monitoring land-cover changes. Through technological advancement in the field of remote sensing, imagery of high spatial, spectral and/or temporal resolution has been produced (Lillesand *et al*., 2004). Remotely sensed data utilisation in land-use and land-cover change has explicitly been for mapping and monitoring, with high resolution imagery used to map and quantify land-cover change at regional scales (Geist, 2006). Moderate resolution imagery is mainly used to classify and characterise land-cover change at a global level (Geist, 2006).

As popular as remote sensing is in environmental sciences, it has not been fully embraced in the social sciences despite the potential applications in this field. ‘Socialising the pixel[19]’ attempts to apply remote sensing and GIS technologies to socio-economic and political and issues that influence land-cover change (Liverman *et al*., 1998; Geist, 2006). This would include analysing beyond the imagery and its natural science application to the social science of which the unit of analysis is the pixel, encompassing the explanatory variables that can be observed through remote sensing and calculated through GIS (Liverman *et al*., 1998; Geist, 2006). For example, satellite imagery observation of land cover may highlight the foot prints of agricultural extension, urbanisation etc, aiding in the measuring of social phenomena and their effects (Liverman *et al*., 1998). However, some of the envisaged challenges of the use of remotely sensed data in the social sciences include finding appropriate scales of analysis for spatial and temporal data (Liverman *et al*., 1998).

A diverse array of satellite imagery has been created including Landsat TM and SPOT imagery. Landsat TM is multi-spectral high resolution imagery with a spatial resolution of 30 by 30 m per pixel[20] while the far infra-red band has a spatial resolution of 120 by 120 m per pixel. The multi-spectral imagery has seven bands recorded concurrently from reflected or emitted radiation from the Earth's surface in the blue-green (band 1), green (band 2), red (band 3), near-infrared (band 4), mid-infrared (bands 5 and 7), and the far-infrared (band 6) (Satellite Imaging Corp, 2008). The characteristics of the bands are described in Table 4.2.

[19] “Socialising the pixel”- means making remote sensing and GIS relevant to social, political and economic issues, with the pixel as the unit of observation.
[20] Each pixel in a TM scene represents a 30 m x 30 m ground area, except in the case of the far-infrared band 7, which uses a larger 120 m x 120 m pixel.

Table 4.2: The characteristics of the Landsat TM band (http://landsat.gsfc.nasa.gov/education/compositor/)

Landsat TM band	Characteristics
Band 1 - Blue	Penetrates water for bathymetric (water depth) mapping along coastal areas, and is useful for soil-vegetation differentiation, as well as distinguishing forest types
Band 2 - Green	Detect green reflectance from healthy vegetation
Band 3 - Red	Designed for detecting chlorophyll absorption in vegetation
Band 4 - Near Infra-red	Ideal for near-infrared reflectance peaks in healthy green vegetation, and for detecting water-land interfaces
Band 5 and 6 – Mid Infra-red	Useful for vegetation and soil moisture studies, and discriminating between rock and mineral types.
Band 7 – Far Infra-red	Designed to assist in thermal mapping, and for soil moisture and vegetation studies

The latest LANDSAT-7 has added Enhanced Thematic Mapper Plus (ETM+). While it has the same seven bands as its predecessor, the ETM+ has an additional panchromatic (black and white) band 8, with a spatial resolution of 15 by 15 m (Satellite Imaging Corp, 2008).

In this research, while Landsat TM is utilised for the assessment of land-use and land-cover change, SPOT multi-spectral (MS) is also used to map natural resources availability at village level. At an even higher spatial resolution of 10 by 10 m, SPOT MS shows more detail than Landsat TM or ETM. SPOT MS is derived from a French satellite and is composed of 4 bands; green, blue, red and near-infrared and a panchromatic band with a resolution of 10 m. SPOT 4, consists of 4 bands including a short wave infrared band, while SPOT 5 has the added advantage of a 2.5 m resolution panchromatic band and 10 m multi-spectral resolution in all three bands; red, green and blue and the near infrared (Adielflitzow, 2008).

Table 4.3: Characteristics and Bands of SPOT Imagery

SPOT 5 Band	Band Resolution
Panchromatic (Black and White)	2.5 m by 2.5 m
Green	10 m by 10 m
Red	10 m by 10 m
Near Infrared	10 m by 10 m.
Short Infrared	20 m by 20 m

Medium-scale mapping is one of the advantages of SPOT 5 imagery, especially at scales between 1: 25 000 and 1: 10 000. Its applications include local urban and rural planning, oil and gas exploration and natural disaster management. In addition, SPOT 5 has a stereo pair imagery which is essential in 3D terrain modelling for flight simulation, pipeline corridors and mobile phone network planning (Adielflitzow, 2008).

4. 6.2 Image Processing

The Agincourt field site is located on one Landsat TM scene, path 168 row 077. Three sets of Landsat TM imagery are utilised; 1990, 2001 and 2005 for the land use and land-cover change study. The 1990 image is chosen as a baseline with the intention to monitor resource utilisation over a 10 year period. However, the unavailability of appropriate anniversary data (for the year 2000) resulted in the utilisation of the next best available image, 2001. The year 2005 is chosen as the year after the first food security module is conducted in the DSS, in an attempt to investigate if any linkages exist between food security, natural resource availability and land-cover change. The 1990 image is downloaded from Global Land Cover Facility[21] which is hosted by the University of Maryland. The 2001 and 2005 images are obtained from The Mareka Institute under the Rockefeller Brothers Project.

Both the 2001 and 2005 images when downloaded are projected into Universal Transverse Mercator Zone 36 N, while the 2001 is projected in Latitude and Longitude, GCS-WGS-1984. Due to the availability of the accompanying vector datasets in the

[21] http://glcf.umiacs.umd.edu

WGS projection, the two UTM georeferenced images are re-projected into latitude and longitude GCS-WGS 1984 using points from the 2001 image. An average of 12 ground control points per image are used for geo-rectification, with a residual error (RMS) of approximately 0.07 m. The georeferencing is conducted in IDRISI KILIMANJARO ™ from tiff images generated from ArcGIS, using the resample module which also extracted the study area. The subsequent processing of the images also carried out in IDRISI Kilimanjaro is described below.

Image Classification

Image classification, a method of developing interpreted maps from remotely sensed imagery, is an important aspect of image processing. Previously conducted through visual interpretation and manual delineation of boundaries of features, advances in digital technology have revolutionised this technique (Eastman, 2003; De Roeck *et al*., 2008). While still relying on the human influence and guidance, digital image classification has become a popular technique (Eastman, 2003) and has gained popularity for its speed and consistency (Eastman and McKendry, 1991; Lillesand *et al.*, 2004; De Roeck *et al*., 2008).

The interaction of different geographic features with the electromagnetic spectrum[22] by either absorbing, transmitting or reflecting electromagnetic energy produces spectral response patterns (SRP) from which classification is based. Digital image classification comprises of two methods, supervised and unsupervised, whose outcome is determined by hard or soft classifiers used within supervised and unsupervised classification (Eastman, 2003; Lillesand *et al.*, 2004). The two methods, unsupervised and supervised, categorise a digital image into land cover classes or themes. The hypothesis for spectral recognition is based on the spatial relationship of a pixel to those surrounding it while the temporal is based on time difference (Eastman, 2003; Lillesand *et al.,* 2004; De Roeck *et al*., 2008). Image classification is carried out to map the land cover in the study area.

[22] Electromagnetic spectrum: Energy rays that are either reflected or emitted as radiation by objects. X-rays, ultraviolet light, visible light, near-infrared light, and heat (thermal) radiation are different wavelengths of electromagnetic energy. http://www.sco.wisc.edu/references/glossary.html

Unsupervised classification methodologies are devised to uncover the major land cover classes present in an image without prior knowledge of what the classes might be (Eastman, 2003; Lillesand *et al*., 2004). This is carried out through the cluster analysis technique, by searching for clusters of pixels with the same reflectance characteristics in a multi-band image to produce broad classes. The *cluster* technique is commonly used for unsupervised classification (Eastman, 2003).

In this study, the classifier Cluster, which utilise formulas to examine and group pixels into different classes according to their natural groupings or clusters, produced an image of spectral response patterns (Eastman, 2003; Lillesand *et al.,* 2004). Cluster is considered a good precursor to training site selection, especially when a new site is being considered for classification (Eastman, 2003). All bands of the Landsat TM images except the panchromatic band are used for the process. The original classification produces over twenty classes resulting in very grainy images which are difficult to interpret. The classification is conducted with an assigned number of eight classes in correspondence to the classes identified in the field. While the images produced are visibly enhanced the noise even after a filter is applied, made the images difficult to utilise but gave an idea of classes in the image.

Unlike unsupervised classification, ***supervised classification*** requires training sites to guide the process. These are produced by on-screen digitizing clusters of cells with similar reflectance. Prior knowledge of the area, together with the quality and size of the training sites developed assists in the accuracy of the resultant image (see section on field work). The training sites are developed into a signature file which is then used to classify the image, based on the selected signatures of the identified land cover classes. For this study, the training sites are developed using GPS[23] points collected during ground truthing conducted in the year 2008 and "trained" on false colour composite image of bands 3, 4 and 5 for all three years. The rest of the supervised classification process is outlined below.

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[23] GPS – Global Positioning System

Signature development, an essential component of supervised classification involves the creation of a signature file, once the training sites are digitised on the image (Eastman, 2003). MAKESIG module is selected and the TRAININGSITES vector file, which defines the training sites, is used. Signature filenames for each feature identifier are then entered. The seven bands are added to the list so that a signature file can be created for each band. MAKESIG essentially creates statistical signature files for each informational training site class (Eastman, 2003).

Signature composition (SIGCOMP) is applied to graphically compare signatures in IDRISI (Figure 4.2). The infrared bands (Band 4) shows the greatest differentiation among vegetation cover types as illustrated by the signature comparison graph showing the mean for the signatures of each of the seven bands. The differentiation for vegetation is a positive indicator that the training sites stage is carried out effectively (Eastman, 2003).

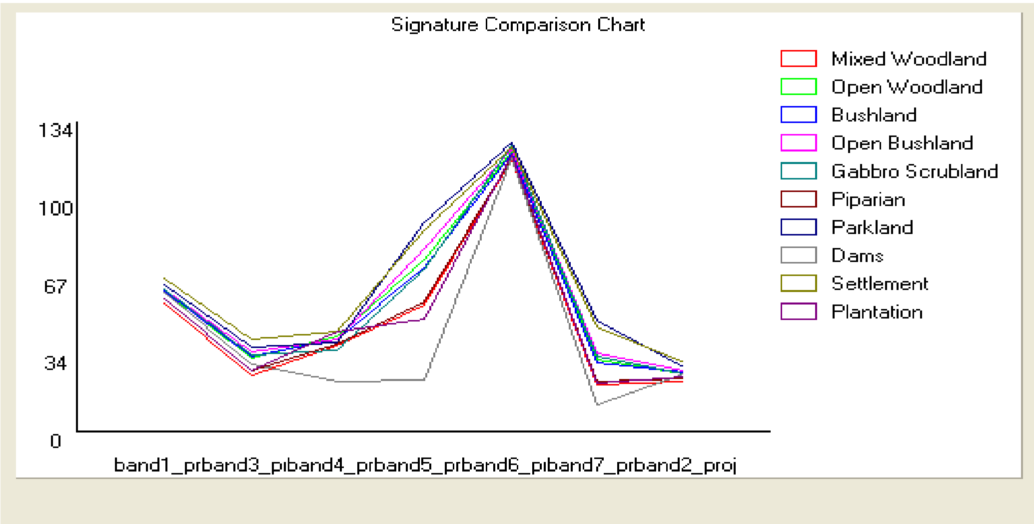

Figure 4.3: Signature comparison graph

To evaluate the accuracy and quality of the developed signatures, the SCATTER technique is applied. This technique produces a scatterplot of the band space between images used in the creation of signatures (Eastman, 2003). The smaller the overlap of the signature boundaries on the lower left corner of the scatterplot, the better defined the signatures (Figure: 4.3). The classification process commences once the signatures are satisfactory.

Once the signature development is satisfactory, classifiers are selected. Three supervised hard classifiers are applied for the image classification, the MINDIST (minimum distance), the MAXLIKE (maximum likelihood) and the Fisher classifier. For detailed explanation on the classifiers used see Appendix 3.

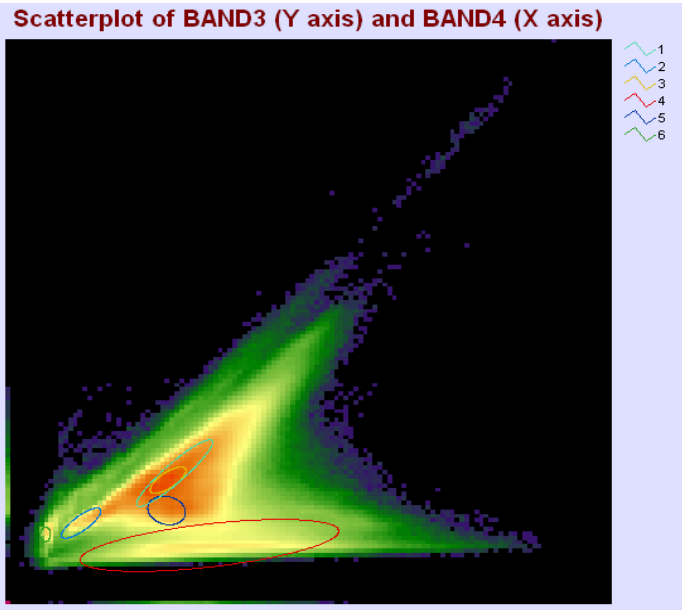

Figure 4.4: Scatter plot of bands 3 and 4 showing the areas where the bands overlap.

In this study, the MAXLIKE classifier produced the best results when applied to Landsat TM data and is thus used for further analysis. Unlike with Landsat, the FISHER classifier produced better results with the SPOT MS data which is used to map natural resource availability. This may be attributed to the different pixel size and the fewer bands used 4 bands compared to the 7 bands of the Landsat.

Post classification, there are many isolated pixels belonging to classes that differ from the majority of classes that surrounded them. This could have been an accurate description of reality, but for mapping purposes, a common post-processing operation is to ***generalise*** the image and remove these isolated pixels (Eastman, 2003). This is done by passing a mode filter over the result, which replaces each pixel with the most frequently occurring class within a 3 x 3 window around each pixel. This effectively removes class patches of one or a few pixels and replaces them with the most common neighboring class (Eastman, 2003). In addition abnormally high pixel values or low values, relative to surrounding pixel values are often produced by random noise. With the assumption that noisy reflectance values show abrupt changes in reflectance from pixel to pixel, filtering operations are further applied to replace these values with another value generated from the interpretation of surrounding pixels. The FILTER module in IDRISI provides several options for this purpose, with several filters available such as 3 x 3 or 5 x 5 median filter (Eastman, 2003). The noisy pixels are replaced by the median value selected from the neighbours of the specified window and all pixels are processed by median filtering. However, some detail and edges could have been lost in the process (Eastman, 2003).

In this study, a 3 by 3 adaptive box filter is utilised to enhance the quality of the classified images. The adaptive box filter corrects the 'salt-and-pepper' noise data where pixel brightness is related to the image (Eastman, 2003). The enhancement makes it easier to interpret the image, resulting in better quality and visual presentation of the classified images.

4. 6.3 Monitoring Vegetation Changes

Vegetation analysis and detection of changes in vegetation patterns are essential tools for natural resource assessment and monitoring. Consequently, the detection and quantitative assessment of green vegetation is one of the important applications of remote sensing for environmental resource management and decision making (Eastman, 2003, Kuzera *et al.*, 2005; Wessels *et al.*, 2009). Healthy canopies of green vegetation have a distinct interaction with energy in the visible and near-infrared regions of the electromagnetic spectrum. Plant pigments especially chlorophyll, cause strong absorption of energy, peaking in the red and blue areas of the visible spectrum, leading to the characteristic green appearance of most leaves (Kuzera *et al.*, 2005; Lu *et al.*, 2008; Wessels *et al.*, 2009). In the near-infrared, energy is strongly scattered by the internal structure of most leaves, leading to a very high apparent reflectance, highlighting the contrast between the amount of reflected energy in the red and near-infrared regions of the electromagnetic spectrum. This has been utilised in the development of quantitative indices of vegetation condition (Eastman, 2003; Wessels *et al*., 2009).

A wide range of vegetation indices have been developed for the quantitative assessment of green biomass. These are applicable to low and high spatial resolution satellite images, such as NOAA AVHRR, Landsat TM and MSS, SPOT HRV/XS, and any others that sense in the red and near-infrared regions. Vegetation indices are applied as a proxy study of overall environmental change, especially in the context of drought and land degradation risk assessment (Eastman, 2003; Wessels *et al*., 2009). Soil status, particularly soil colour, moisture, texture or presence of organic matter influence the spectral reflectance of vegetation thus influencing calculated vegetation indices (Lyon *et al.*, 1998; Eastman, 2003, Huete *et al.*, 2006; Wessels *et al*., 2009).

Spectral Vegetation Indices further constitute an important indicator in monitoring vegetation, soil and moisture. Vegetation indices, which monitor vegetation, are premised on vegetation reflectance in the electromagnetic spectrum in the red and infra-red wave lengths (Eastman, 2003; Huete *et al.*, 2006). Different types of vegetation indices have been produced:

- Slope Based VIs indicates both the status and abundance of green vegetation cover and biomass. And to separate green vegetation from its background soil brightness, e.g. Normalised Differentiated Vegetation Index (NDVI) is the most commonly used;
- Distance based VIs - designed to cancel the effect of soil brightness in cases where vegetation is sparse and pixels contain a mixture of green vegetation and soil background. This is particularly important in arid and semi-arid environments e.g. The Perpendicular Vegetation Index (PVI);
- TASSCAP VIs express green vegetation through the development of their second component using principal component analysis (PCA) the Green Vegetation Index (GVI).

Normalised Differentiated Vegetation Index (NDVI)

Because of its capabilities to measure soil and vegetation moisture, taking into consideration topographic and other extraneous factors (Lyon *et al.*, 1998; Singh, 1998), NDVI has evolved over time as a primary tool for monitoring vegetation change and the impact of climactic/weather events on the biosphere (Young, 1998, Eastman, 2003; Lillesand *et al.*, 2004). Introduced by Rouse in 1974 and derived from satellite remotely sensed data, NDVI are developed from brightness values of different absorption, transmission and reflectance of energy by vegetation in the red and infrared bands (Lyon *et al.*, 1998, p143). It separates green vegetation from its background soil brightness and is expressed as the difference in reflectance values between the near infrared and red band normalised by the sum reflectance of the two bands (Eastman, 2003, p235; Huete *et al*., 2006).

NDVI is expressed as a ratio between measured reflexivity in the red and the infra red bands. It is calculated as:

NDVI = (NIR – R) / (NIR + R), where NIR is near infrared band 4 and R is red band 3.

NDVI can be used to identify areas showing distressed or degraded vegetation, leading to identification of possible degraded areas (Barrow, 1991; Booth *et al.*, 1994), and has been shown to correlate well with ground measurement of biomass (Huete *et al.*, 2006). Vegetation indices assist in assessing if the vegetation canopy has been altered and image differencing of NDVI has been hailed as the most accurate among other vegetation change detection techniques (Lyon *et al.*, 1998; Singh, 1998; Sohl, 1999; Huete *et al.*, 2006).

4. 6.4 Change Detection

Various methods of detecting change have been devised including the most commonly used simple image differencing which entails the subtraction of the later from the earlier image. Various change detection methods have been proposed and basically two approaches were identified, namely:

- Comparative analysis of independently produced classifications; and
- Simultaneous analysis of multi-temporal data (Lambin and Strahler, 1994; Huete *et al.*, 2006).

The classification process produced four images of land use/land cover, three Landsat images and one Spot MS image and three NDVI images for the three years 1990, 2001 and 2005.

Simple Image Differencing

Simple image differencing, which require a pair wise comparison of spectral reflectance values, is a technique used for change detection in geographical environments (Singh, 1998). By subtracting the reflectance value of each pixel from corresponding dates, the resulting image will represent areas of change. Two important properties of this procedure are:

1) Strong differences in the spectral reflectance of different features may be emphasised; and
2) Topographic effects and normalised differences in irradiance of multi date imagery will be suppressed (Singh, 1998).

Although considered too simplistic, simple differencing has produced reasonably good results when compared with the other more complex methodologies (Singh, 1998).

Thresholding

The limitations associated with this method are traceable to thresholding, which is applied to determine the areas of positive, negative and no change as well as distinguish true change from natural variability (Eastman and Mckendry, 1991; Eastman, 2003). Thresholding ascertains the upper and lower limits of normal variation, aiding in identification of significant change, based on the standard deviation obtained from the histograms of the concerned image. The natural breaks in the histogram of the simple differencing image forms the basis for choosing thresholds (De Roeck *et al.*, 2008). Thresholding is subjective given its dependence upon the discretion of the user and sensitivity of the procedure to geo-registration (Eastman and McKendry, 1991; Lambin *et al.*, 1996; Singh, 1998). Ordinarily the most applicable standard deviation out of a possible three is chosen based on the results of the produced images. There are no firm guidelines for this operation.

Sohl (1999) observes that even though thresholding identifies areas of change, the method has been criticised for failing to provide adequate qualitative data in terms of the nature of change or a distinction of the type of vegetation. He further cautions that differencing should not be solely relied upon to for change analysis. Other commonly used methods for change analysis include image rationing, image regression, simple differencing, change vector analysis and cross-tabulation (Sohl, 1999; Chen *et al.*, 2003).

In this study, simple image differencing is done on the supervised and unsupervised images for the different dates, with the objective of identifying spatial areas of change, while image differencing of the NDVI images identifies areas of biomass loss. To highlight only the spatial and biomass patterns of change, thresholding is performed using the RECLASS command in IDRISI. Threshold values, based on the standard deviation and the mean are derived from the histogram of each image. Through interactive processes, a standard deviation of 2 is used since a standard deviation of 1 seemed too generalised and a standard deviation of 3 is too restricted. The reclassified images depicted areas in three categories:

- 2- positive change which means more vegetation cover or increase in biomass over time;
- 1- negative change which means a less vegetation or reduction in biomass over time; and
- 0- the no-change areas.

Change Vector Analysis

Another method applied for change analysis is CVA (change vector analysis). CVA is used to identify differences in the state of objects or phenomenon over time (Eastman

1991; Singh, 1998 and Lambin *et al.,* 1998). This technique has been widely used for monitoring land cover change, shifting cultivation, deforestation and land degradation among other applications. Considered an extension of simple differencing (Eastman and McKendry, 1991), CVA analyses each pixel value in multi band data from different years (Figure 4.5).

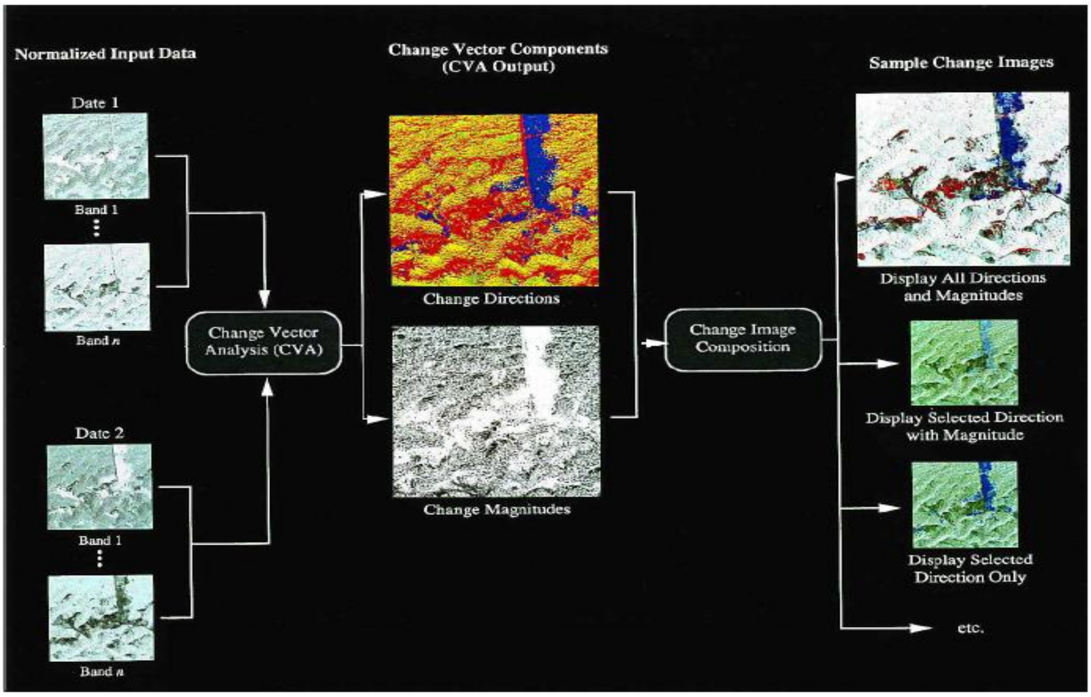

Figure 4.5: Flow diagram of CVA based change detection (Johnson and Kaschicke1998)

Change Vector Analysis (CVA), a radiometric technique is used to detect all changes using multi-spectral data and it is capable of using diverse types of sensors (Johnson and Kasischke, 1998). CVA is especially recognised for its ability to capture and differentiate between all changes, particularly as a prerequisite for further analysis areas of interest. Additional advantages of CVA include:

- Ability to concomitantly process and analyse change in multispectral input data layers instead of selected bands;
- Avoidance of compounding of spatial-spectral errors inherent in multi-date classifications;
- Capability of detecting change in both land cover and condition;

computation of separation of multidimensional change vector components and composition of change images that retain this information and facilitate change interpretation and labeling (Johnson and Kasischke, 1998).

Applied in monitoring forest and vegetation change CVA produces two images, one high lighting the direction of change, (expressed as an angle) and the other showing the magnitude of change (Singh, 1998). For details on how the direction and magnitude images are derived see Appendix four.

While one of its advantages is providing qualitative data, the main **limitation** of CVA is the complex steps involved which makes interpretation of the results difficult (Sohl, 1999). The accuracy of results is also highly dependent on availability of anniversary dates data and the correct geo-registration of all the images to be compared. While the differences over time are readily assessed, identifying and isolating true change from the normal environment has proven to be a challenge (Eastman and McKendry, 1991; Chen *et al.*, 2003).

According to Chen *et al.* (2003) other limitations associated with employing the CVA technique include:

- Stringent requirements for reliable image radiometry. CVA is based on pixel wise comparison, thus it is essential to alleviate the effects atmospheric disturbances such as solar angle, soil moisture, vegetation phenology. While no other change method can remedy these effects, with CVA the utilisation of the same date images in different year reduces the errors;
- The unavailability of automated or semi-automated techniques to effectively determine the threshold of change magnitude between the change and no change pixels. While the determination of the optimal threshold between change and non-change pixels, is regarded as the most important as well as the most challenging, the (Johnson and Kasischke, 1998), the threshold in a specific CVA is determined by manual trial and error methods, thus requires experienced image analyst (Chen *et al.*, 2003);

- The discrimination of different phenomenological types of changes is problematic when a large number of bands are used. (Chen *et al.*, 2003).

Below (Figure 4.6) is the methodology flow diagram for the land cover change.

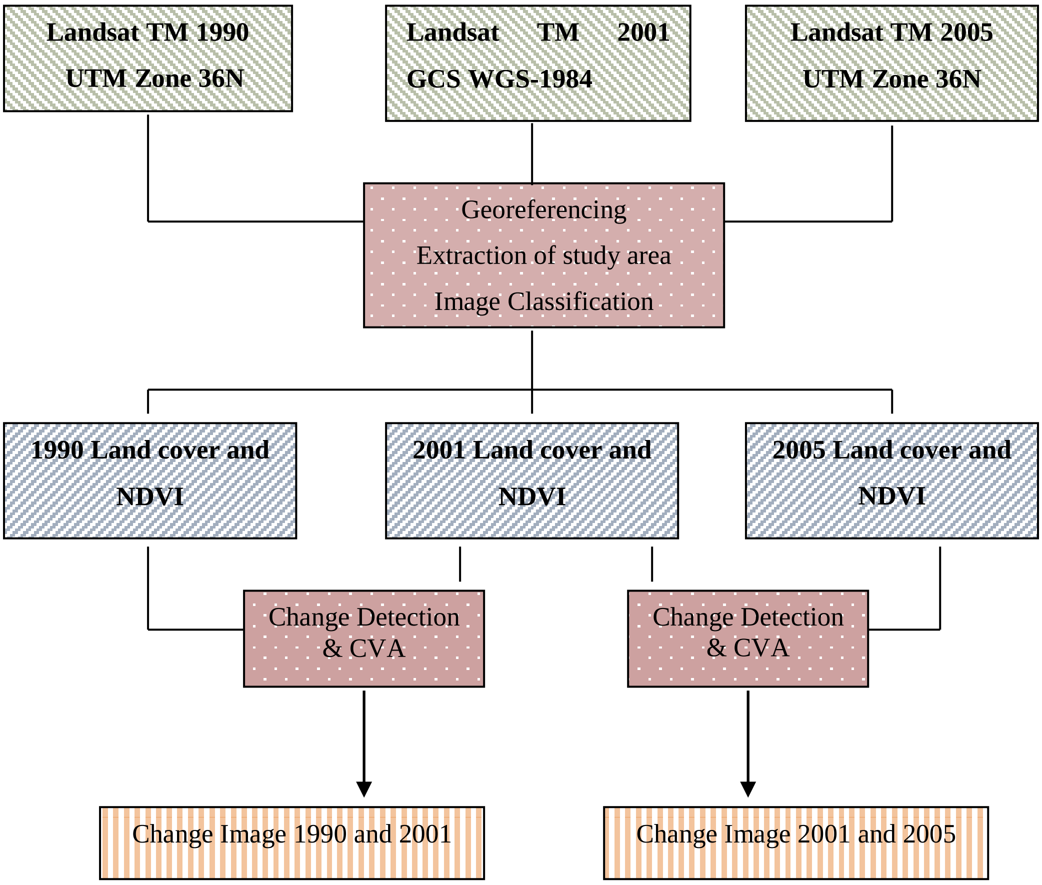

Figure 4.6: Methodology Flow summary of the land cover and land cover change mapping

4. 7. Descriptions of Vegetation Types

The previous section has described the importance of remote sensed data in mapping and monitoring of vegetation change. The advantages of using remotely sensed data for long-term environmental monitoring and highlighting degradation hotspots has also been explored. The discussion included some of the methods for image processing and image interpretation of which classification forms a part of. With image classification as the most important method of image interpretation into land cover classes, the identification of existing land cover classes in the study area is an essential step for mapping. The next section will highlight the land cover classification process and the various land cover classes indentified in the study area, based on the knowledge gathered during fieldwork.

4. 7.1. Introduction

The savanna biome, where the study area is located, takes up one third of South Africa and is characterised by vegetation comprised of distinct upper layers of woody vegetation, with a lower layer comprised of grassland (DEAT, 1996). The savanna would be classified as shrubveld if the upper layer vegetation is short and closer to the ground in a dense wooded canopy cover of 1 to 20 m in tree height, with the rest of the savanna being classified as bushveld with tree heights ranging from 3 to 7 m (DEAT, 1996). A variety of environmental factors determines the separation between classes such as altitude, soils, rainfall, fire and frost; which in turn determine utilisation of the biome, with most species found being adaptive to these elements, especially fire (DEAT, 1996). It is important to mention that land cover pertains to the woody of non woody vegetation that covers the area while land use refers to the types of activities that land or area is used for.

The land use for the savanna biome is mainly grazing, with cattle, goats and game being found in the different types of savanna biomes found such as Sweet Lowveld Bushveld. Most of the savanna is characterised by national parks making tourism and big game hunting an important activity (DEAT, 1996).

4. 7.2. The Description of Land-cover classes in Agincourt

Vegetation types are based on communities sharing the same species, with similar vegetation structure and the same ecological processes (DEAT, 1996)[24]. Within Agincourt, the description of the land cover classes is adapted from the classes used by

[24] http://www.ngo.grida.no/soesa/nsoer/Data/vegrsa/vegstart.htm

Giannecchini *et al.*, (2007)[25]. These are based on the classification by Thompson in 1996 and later modified in 1999 by White (Giannecchini *et al.*, 2007). The description is based on the physiognomic structure of the vegetation, family tree height and canopy cover. While the presence of human disturbance or a lack of it is noted for some of the classes, species types are considered to differentiate between two classes in some cases. Additional classes are added which are not necessarily woody cover classes but exist in the study area. All the above mentioned classes are agreed upon after a reconnaissance survey is conducted to ascertain the layout of the landscape with the assistance of the resident ecologist[26] based at WRF. Most of these vegetation classes are multiple land use classes, with grazing, cultivation, fire wood and other natural resources collection being carried out.

Woodland

Mixed woodland (Figure 4.7) is found on and along the Xanthia ridge and in areas within and bordering Bushbuckridge Nature Reserve and the Sabie Sands Game reserve. These woodlands are relatively intact, with minimal human disturbance, limited mainly to grazing. The average tree height is approximately above 4 m and the canopy cover dense. A wide range of species are found including *Terminalia*[27] which is found mainly in the seep line and as indication of wet areas.

Figure 4.7: Mixed Woodland

Figure 4.8: Open Mixed Woodland

[25] Giannecchini *et al.* (2007) studied land cover change and human-environment interactions in a rural cultural landscape in South Africa. Their study site was in Mpumalanga, the same environment as the Agincourt DSS.

[26] Dr Wayne Twine

[27] Botanical name - *Terminalia sericea*, common name - Silver Cluster-leaf

Open Mixed Woodland (Figure 4.8) has the same characteristics as the mixed woodland but displays a difference in the canopy cover. This woodland is more open, with grassy patches in places. The disturbance is relatively similar and limited to grazing.

Bushland

Bushland areas (Figure 4.9) are located closer to the villages and show more evidence of human disturbance. While grazing is still evident in the areas, the other uses of these multiple zone land uses could not be ascertained. The tree height in these areas is below 4 m, while the canopy cover is dense. Most coppicing bushland is classified in this group due to their density. The most common species in the dense bushland are *Acacia* and some *Terminalia*.

Figure 4.9: Bushland

Figure 4.10: Open Bushland

The open bushland (Figure 4.10), has the same characteristics as bushland, but is distinguished by the canopy cover. Open bushland is less dense and is characterised by large open grassy patches. *Terminalia* is again a common species along with *Dichrostachys cinerea*[28]*, and Combretum collinum*[29] in this class. This is the most disturbed woody cover class and is located closer to the villages. Human activities include firewood collection and grazing and harvesting of other natural resource products.

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[28] Botanical Name - *Dichrostachys cinerea* – common name - Chinese lantern: *Dichrostachys cinerea* is a thorny, fast-growing woody bush or treelet which invades fields, wasteland, road sides and other disturbed areas *D. cinerea* causes losses in agricultural production and its management involves frequent, heavy and expensive work. *(http://www.issg.org/database/species/ecology.asp?si=161&fr=1&sts)*
[29] Botanical Name - *Combretum collinum* common name - bush-willow

Gabbro Bush/Shrub Land

These areas are located on the Gabbro dyke intrusion which is characterised by deep dark clay soils. These areas could be classified as grasslands (Figure 4.11). The presence of shrubs and bushland like vegetation influenced the classification, however. While Giannecchini *et al.* (2007) separated the classes to open and closed based on disturbance, in this study both are considered as one class.

Figure 4.11: Gabbro Bush/Scrubland

Figure 4.12: Parkland

Riparian/Closed Woodland

Originally classified as riverine, the riparian woodland occurs mainly along the rivers, composed of reed beds and trees above 4 m in a dense canopy. Closed woodlands are also located along the north face of the Xanthia ridge, extending to areas where aloes are the main vegetation type.

Parkland

Parkland areas (Figure 4.12) are located around villages and are composed of active, fallow and abandoned fields. Most of the abandoned fields are located between villages and in and around abandoned homesteads. Most parkland is characterised by large indigenous fruit trees, mainly marula[30] (*Sclerocarya birrea*) and jackal berry[31] (*Diospyros mespiliformis*) which are left standing. While Giannecchini *et al.* (2007) classified parkland and cropland as separate, in this study they are considered as one,

[30] Botanical name *Sclerocarya birrea*, common name – Marula
[31] Botanical Name *Diospyros mespiliformis* common name – jackal berry

due to the resolution of imagery used SPOT data versus aerial photography which shows much more detail and enables the distinguishing of the two classes.

Figure 4.13: Settlement

Figure 4.14: Dam

Other Classes

Settlement are villages (Figure 4.13) which are comprised of homesteads, animal pens and small gardens. Another class is sisal **plantations** which are found on the 1990 images as well as **fire scars**. These are present on all the images processed, especially on the 1990 image. It is, however, assumed that these areas are currently under woodland. A few **dams and water bodies** are identified, on the original images and during the field work (Figure 4.14). Dams are, however, difficult to classify due to the small size of the signatures and the scale used for the output images. Thus while they exist, as indicated in the areas statistics graph, dams as a class are not represented on the final classified maps. For a summary of the vegetation classification see table 4.4.

Table 4.4: Vegetation Classification

Woodland Type	Characteristics	Species	Comments
Mixed Woodland	Tree < 4 m, dense canopy cover	*Terminalia sericea* (Silver Cluster Leaf)	Found along Xanthia ridge, areas bordering and within the Bushbuckridge and Sabie Sands Game reserve, disturbance limited to grazing
Open Woodland	Tree height < 4 m, open canopy with grassy patches	*Terminalia sericea*	Disturbance limited to grazing
Bushland	Tree height > 4 m, dense canopy	*T. sericea*, and *Acacia*	More disturbed
Open Bushland	Tree height > 4 m, open canopy with large grassy patches	*T. sericea*, Acacias *Dichrostachys cinerea*, and *Combretum collinum*.	Closer to villages, most disturbed class
Gabbro Bush/Shrub Land	Deep clay soils, grasslands with shrubs & bushland vegetation		
Riparian/Closed Woodland	Reed beds and trees above 4 m in a dense canopy.		Riparian occurs along rivers and closed woodlands located along the north face of the Xanthia ridge.
Parkland	Active, fallow and abandoned fields with indigenous fruit trees	Marula (*Sclerocarya birrea*), *Diospyros mespiliformis*	Located around and between villages, abandoned fields located between villages & around abandoned homesteads.
Settlement	Villages comprised of homesteads, animal pens & small gardens		
Plantation	Sisal plantations		
Dams and Water Bodies.	Small water bodies.	Reeds beds	Difficult to classify due to the small size of the signatures, but stats were generated.

4. 8. Field Work

A SPOT Multi-spectral (MS) image from 2005 was used as the basis for the field work. A band combination of 432 was utilised to maximise the visual difference between the non-vegetation and vegetation classes. As previously mentioned, a reconnaissance survey to ascertain the various land cover classes was undertaken before the actual field work began.

A minimum of 4 field points were collected for each class, except for dams, plantations and riparian/closed woodland. A total of 57 points was collected over a period of four days, with the assistance of a local assistant who was familiar with the study area and the changes that have occurred over the years. These changes include the removal of the sisal plantations that were present during apartheid times. For each point collected, the latitude, longitude, elevation and a description of the land class were recorded, including a reference photograph.

The recorded points were used as training sites to undertake a supervised classification of the images in IDRISI Kilimanjaro software. The same points were adjusted for use on the classification of the additional Landsat TM images from 1990, 2001 and 2005. Additional image processing involved:

- Unsupervised classification of all images (Landsat TM);
- Extraction of study area;
- Image differencing of the subsequent years (subtracting the later year from the earlier year);
- Image reclassification/thresholding to ascertain the areas of negative, positive and no change, between the subsequent years;
- Production of NDVI images from the Landsat images and image reclassification to ascertain areas reduction and/or gain in the greenness of vegetation;
- Filtering of the processed images to remove noise and enhance visibility;
- Calculating of area in km^2 for each land cover class.

The datasets used were as follows: Landsat TM, taken on the following dates 25 May 1990, 28 April 2001 and 20 July 2005, SPOT PAN, SPOT PMS and SPOT MS.

4. 8.1. Limitations of the Methodology and Data Used

Most remote sensing based methods have limitations associated with the different environments, the analytical methods and the scales of application (Reynolds *et al.*, 2001). The most notable limitation is access to appropriate anniversary imagery. The SPOT MS (Multispectral) image is used for the ground truthing. The resolution of the SPOT PAN and the SPOT PMS is too grainy, making it difficult to decipher between vegetation classes. The resolution for the Landsat TM images is too high at 30 m to be used in the field.

On all the available images there is a presence of fire scars, which makes it difficult to classify these areas. This is most notable on the 1990 image, which is classified firstly with the fire scars and secondly without the fire scars. The major land cover classes affected by the fire scars in all images are settlement, dams, mixed woodland and the Gabbro scrubland, as will be further highlighted by the produced statistics.

The ground truthing itself is limited by difficulty in accessing some of the areas of interest. While the road network in the area is quite extensive, some areas are not reachable by vehicle. On the importation of the collected points, some of the points are slightly off the intended mark. This may be due to problems in GPS accuracy, and this could have influenced the classification of the images. These points are adjusted using the local knowledge gathered during the field work. Further, the collected points which are based on SPOT MS are adjusted for use on all the Landsat images. This may have affected the accuracy of the resultant images. It is worth noting that any automated process has some margins of error, thus the resultant images from the supervised and unsupervised classification do have some probability of error.

4.9 Summary of Methodologies

Physical Natural Resource Data - Two different types of data sets discussed in the methodology are employed for this study. The data relates to land-cover data as well as the land-cover change data derived from remotely sensed Landsat TM and SPOT data. These data allow for the identification of hotspots of landcover change and possible natural resource degradation in the study area from 1990 to 2005. The data also assists in the identification of areas of high natural resource utilisation. Further, the availability of natural resources at village level, accessed through land cover mapping using satellite imagery, underlines the importance of the availability of natural resources for rural livelihoods and in turn for food security.

Social Science Data - In an attempt to understand or identify the drivers of the above identified change, a second set of data relating to socio-economic and demographic data derived from the DSS database are analysed. As previously mentioned, the application of remote sensing data and GIS in social studies has been limited. While this research is not a social sciences study, it aims to apply social data to investigate or explore the possible social drivers of environmental change. Using GIS and remote sensing, the physical and social data are combined to explore trends in population, food security, natural resource utilisation and natural resource availability.

This research aims to use these techniques to investigate the bio-physical and socio-economic linkages driving land-cover change and how these two entities are linked or not linked to natural resource utilisation. The identification of drivers of change will be useful in designing area specific interventions for the sustainable utilisation and management of natural resources.

This chapter has given an outline of the methodologies and the data used in this study as well some of the problems or errors associated with these methods. It is important to note that only the methods actually applied in the research are discussed. These are by no means exhaustive as there are many more methods that are available for the land-use and land-cover change and the demographic data analysis. Further, these methodologies were chosen on the basis of familiarity by the analyst. The subsequent chapters deal with the results derived from the data analysis using the above mentioned methodologies. Chapter 5 will analyse the demographic data exploring the trends in food security, AIDS mortality and natural resource utilisation, while Chapter 6 will explore land use and land cover change, resource availability and degradation hotspots.

PART TWO

LINKAGES BETWEEN FOOD SECURITY, HIV AND AIDS AND NATURAL RESOURCES UTILISATION

Part Two of this dissertation presents results from the data analysis of remotely sensed and demographic data answering the three research questions outlined in the beginning of the research thesis: What is the status of food insecurity, AIDS mortality and natural resource utilisation in the DSS? What is the relationship between dependence on natural resources as a source of food or livelihood to resource/land degradation? and What are the household and community drivers of household food insecurity? These will be presented in chapters 5, 6 and 7 respectively. With reference to the conceptual model, various sectors are pattern coded for ease of reference; the dots for (Chapter 5), the horizontal stripe (Chapter 6) and the diagonal stripe (Chapter 7) are covered in this part of the thesis as indicated in Figure 5.

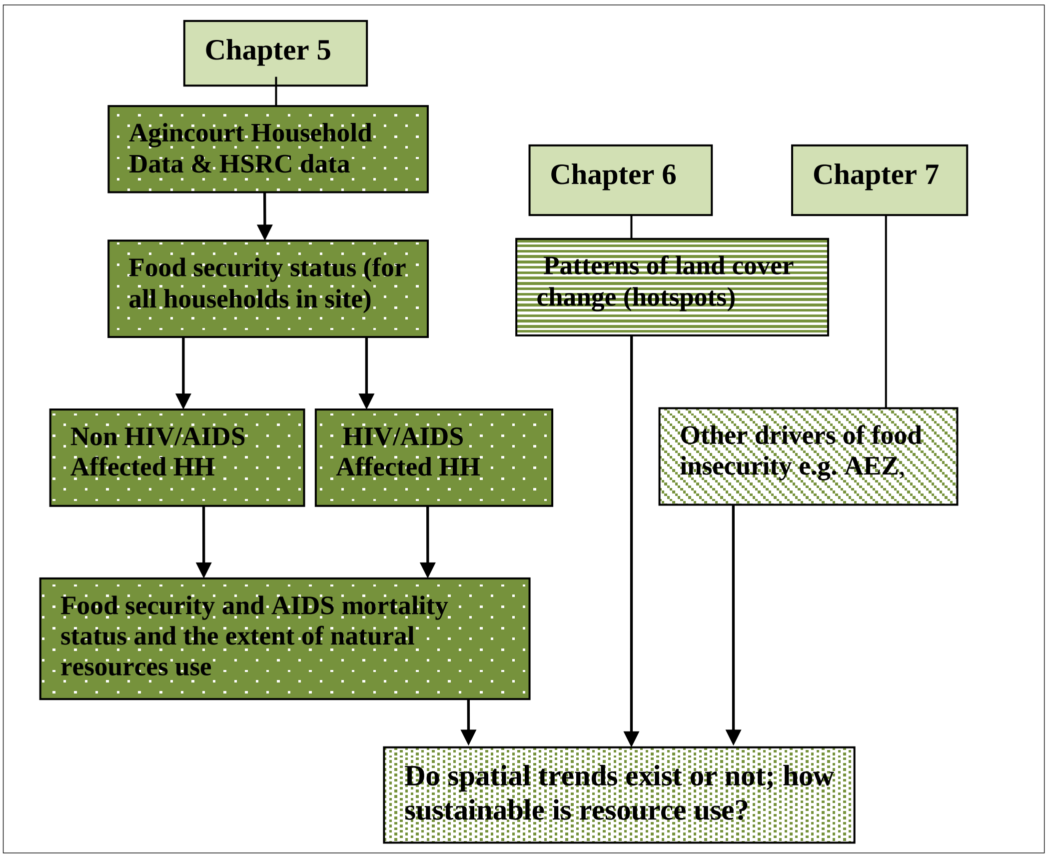

Figure 5: Conceptual Diagram of research design and chapter layout

CHAPTER FIVE

PREVALENCE OF HUNGER, HIV AND AIDS AND NATURAL RESOURCE UTILISATION

5.1 Introduction

This chapter presents results for research question one: ***"What is the status of food insecurity, AIDS mortality and natural resource utilisation in the DSS?"*** This question analyses various variables collected from the DSS database. The question investigates the prevalence of food insecurity in the DSS; to what extent AIDS mortality is a factor driving food insecurity and to what extent coping strategies such as utilisation of natural resources contribute to food security for the residents of the DSS. All these are analysed at village level. Natural resource utilisation, pertaining to the type of resources collected and the frequency of gathering are analysed. While additional data such as assessing the methods of natural resource collection, amount of natural resources gathered per household per month, household income, poverty and assets data would have enriched the research; this data was not collected during the census or was not available for the dates required.

Some of the findings for this research question are listed below:

- The population in the DSS is not as food insecure as anticipated with 56% of households food secure in 2004 and 80.2% of households food secure in 2007;
- Big villages, in both population and spatially, have more food insecure households while villages with higher migrant populations are more food secure;
- There is an immense improvement in food security and a slight improvement on food production but there is a reduction of dependence on natural resources over the three years;
- Availability of income or money is the key driver of food security with 91.6% of households buying staple foods such as maize, potatoes and rice;

- Natural resource utilisation is an underlying driver of food security while food production or subsistence farming is not a key factor in obtaining food and is also hindered by lack of rainfall and inaccessibility of land;
- More than half of the households (56.9%) both food secure and insecure utilise natural resources for consumption and as a means to save household income and there is no evidence that AIDS mortality affected households heavily dependent on natural resources;
- Mortality, AIDS or non AIDS, has no impact on food security and resource utilisation at village level, with 61% of households affected by AIDS mortality being food secure despite 72% not producing enough food;
- Gender dimension: 62% of female headed households utilise natural resources implying more vulnerable for female headed households.

The section of the conceptual framework being covered in this section is highlighted in the Figure 5.1 below.

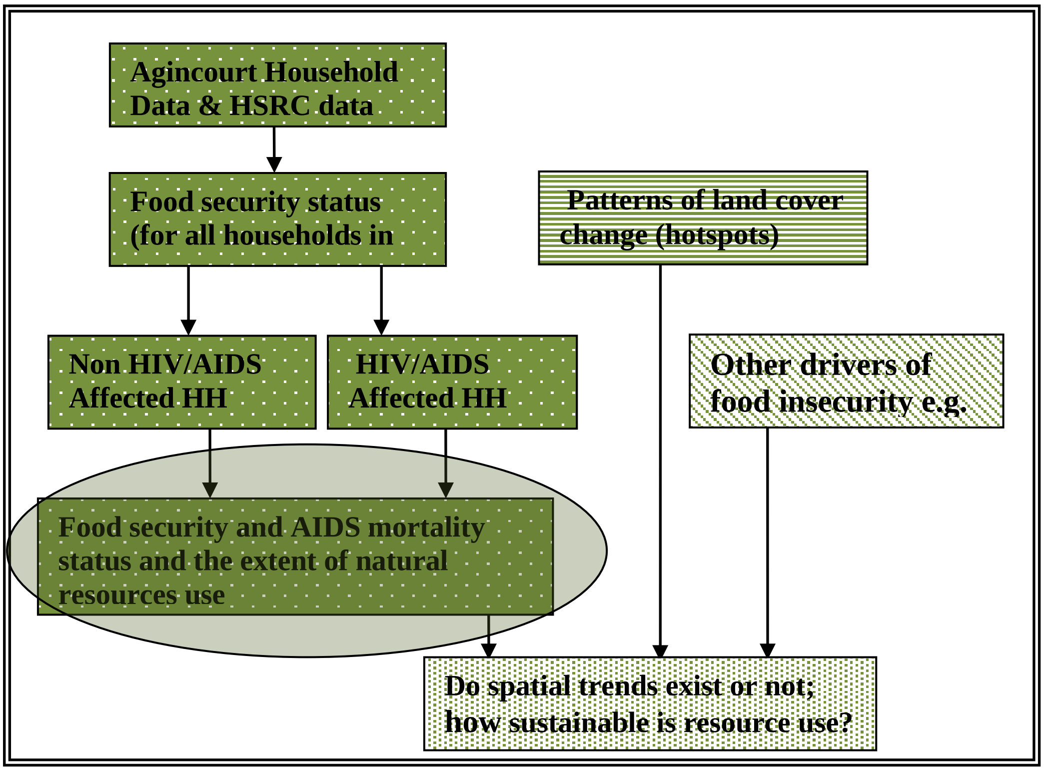

Figure 5.1: Conceptual diagram highlight section covered in chapter 5

The **first and second section** of this chapter will present the results of the statistical data analysis, including the descriptive statistics derived from variables in the 2004 and 2007 food security module such as:

- hunger in the household in the previous month and year;
- number of meals consumed in the household on a normal day;
- food production;
- other means of supplementing household food;
- Gathering of natural resources;
- AIDS Mortality in 2004.

These variables represent factors driving food availability and access, as well as frequency and collection of natural resources, including the types of resources collected by households. These variables are analysed to describe the state of food insecurity, the extent of the utilisation of natural resources and the extent of AIDS mortality in villages across the DSS. While the number of AIDS deaths is included in the 2004 analysis, which is set as a baseline year, mortality is not included in the 2007 analysis which is set as the monitoring year, to allow the monitoring of food security and the extent of natural resource utilisation for mortality affected households. Factor analysis, conducted to assess the significance of various variables on food security, including principal component analysis, correlation and logistic regression analysis are reported in the last section of this chapter.

It is important to note that the food security survey was conducted between August and November of 2004 and 2007, just after the winter season and the interviews were conducted with the most adult person in the households most of whom were women. The green harvest (green maize cobs) usually occurs between mid February and April, with the main harvesting season taking place between April and July. Therefore the food security survey was conducted just after the main harvesting season, meaning that most households should have had food stocks available from the just ended harvest. For most southern African countries including South Africa, October to February is considered the hunger season, when the food stocks will have dwindled and most rural populations will be awaiting the next season harvest (FewsNet, 2009). Further, the lack of rainfall mentioned during the census would refer to the 2003-4 summer season of which the rainfall received was the normal average of between, 450–750 mm (AGIS, 2004).

5.2 Prevalence of Food Insecurity in the DSS – 2004

As previously stated, the prevalence of food insecurity is based on a few variables chosen from the food security module of the DSS database. Frequencies and percentages of hunger prevalence or food insecurity are produced from process indicators such as availability of food in the household during the previous month, year and, the expected food availability in the coming year are analysed. Variables such as prevalence of household hunger in the previous month are also used by Hunter and Twine (2005) in their study of the linkages between household food security and natural resource utilisation in the same area (Hunter and Twine, 2005). Food production and the number of meals consumed by males, females and children on a daily basis in the household are further processed to ascertain food availability in the households. The results are presented below.

5.2.1 Hunger Experience - 2004

The hunger experience, which is based on the availability of food during the previous month as a key proxy, measures the extent or the status of food insecurity in the household, in particular if the household had no food or was hungry in the previous month. The hunger experience is divided into three categories, depending on the number of hungry households in each village, with high hunger prevalence characterising villages with more than 200 hungry households, medium hunger prevalence with between 101 to 199 hungry households and low hunger prevalence with less than 100 hungry households recorded per village. The three categories indicate the progression of hunger in household per village from high to low.

In the DSS in 2004, 3420 (36.2%) of households out of the 9438 households in 21 villages, experienced hunger or did not have enough food to eat, while 6012 (63.7%) are food secure, as indicated in Figure 5.2. In terms of high hunger prevalence, the villages highlighted in reddish brown (Figure 5.2) villages 01, 03, 04, 09, 10, 11 and village 16 have more than 200 hungry households each. Of these villages, village 01 has the largest population, 14% of which is comprised of refugees, followed by village 11 as the second largest, with a 34% refugee population. The rest of the villages in this category have considerably large populations (between 7411 and 3657), although the percentage of refugee population vary, with village 10 having the highest refugee population of 57%. Spatially these villages have the largest land areas as well. These same villages further have the highest percentages of food secure households as highlighted in Figure 5.2., which shows food secure and insecure households in each village. This may be attributed to the large populations found in these villages resulting in competition for resources.

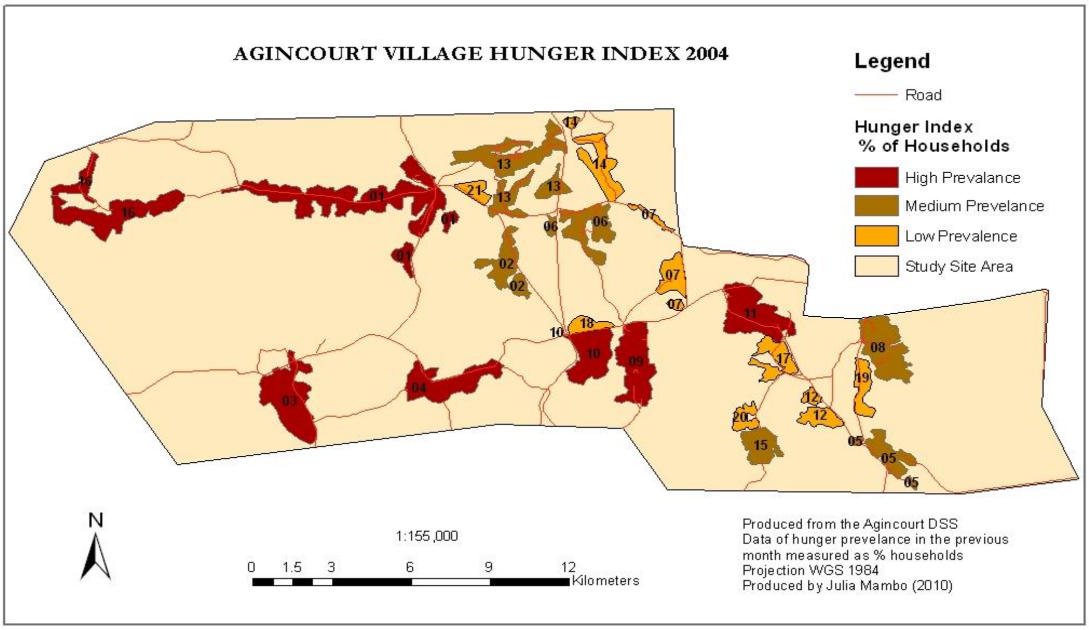

Figure 5.2: Hunger Prevalence mapped per village

Other highlighted villages include those in the medium hunger prevalence[32] with between 101 to 199 hungry households (Figure 5.3). These are villages 02, 05, 06, 08, 13 and 15 indicated on the map (Figure 5.2) in colour brown. These villages vary in population size from big to medium (5317–3983) and most of the villages in this strata

[32] Medium Hunger Prevalence means village have between 101 and 199 hunger households

have more the 20% refugee population except for village 13, the smallest in this category, with 10% refugee population.

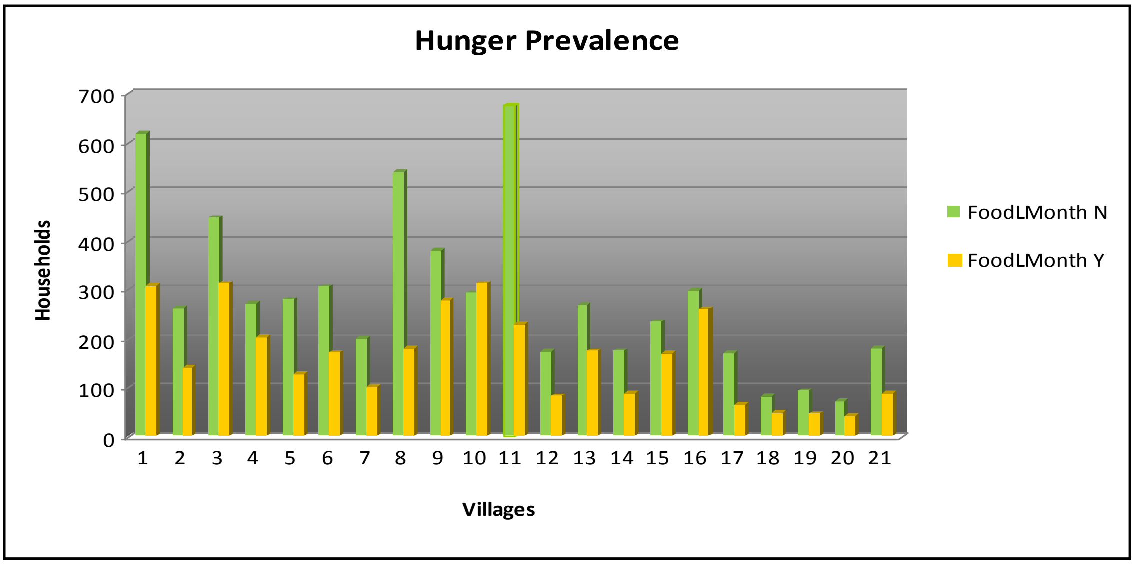

Figure 5.3: 2004 -Prevalence of hunger by village; N = not hungry; Y = Hunger experienced

There are eight villages in the low hunger prevalence[33] with less than 100 hungry households per village recorded (Figure 5.3). These are indicated by the orange colour on the map (Figure 5.2). Five of these villages, 12, 17, 18, 19 and 20 are smaller in population size, but have the highest proportion of refugee populations ranging from 75% to 97%. The trend of food insecurity seems to indicate that the higher the refugee population in a village the more food secure it is.

The presence of hunger in the household is further described according to frequency of hunger, in terms of how many times during the month a household experiences hunger, never, often, sometime or rarely (see Table 5.1). This gives an indication on the level of food insecurity in the households.

[33] Low Hunger prevalence means villages have less than 100 hunger households

Table 5.1 Food unavailability - 2004

Hunger Frequency	Households	Percentage	Description/month
N	3	0.0	Never
R	149	1.6	Rarely 1 day
O	744	7.9	Often 8 - 14 days
S	2075	22.0	Very Often 15 - 30 days

Of the food insecure households, 4.7% very often experienced hunger, 7.9% often experienced hunger and 22.0% sometimes experienced food insecurity in the previous month. The number of days in a month when a household did not have food was recorded (Table 5.1). Furthermore, 1.6% rarely experienced hunger, with 3 households not experiencing any hunger despite having indicated not having enough food in the previous month. Despite the overall household food security in the DSS, the number of households experiencing hunger very often (15–30 days) indicates the severity and vulnerability to food insecurity for some of the household in the study area.

Most of the analysis depended on hunger in the household during the previous month, which captured mainly short term or transitory hunger in the study area. In order to assess long term vulnerability to food insecurity, implying households that had failed to meet their food requirements in the past year in the DSS, the experience of hunger during the previous year was analysed. At least 38% of the households are food insecure during the previous year compared to the 36.6% food insecure households in the previous month**,** indicating possible long term vulnerability to food insecurity for the affected households, attributed to either poor harvests or change in household dynamics. These two variables are closely linked, with the likelihood of the same households experiencing food insecurity during both the month and the year. In terms of the future expected food shortage, only 7.7% expect to have less food in the coming year, with 30.9% not expecting any change in their food security status and 8.3% expecting to have more food. Again the number of "do not know" responses comprised half of the study sample, 52% with no responses from further 1.1% households. Worrying about food is regarded as a proxy of food insecurity and thus an import measure and the 7.7% in this study is not a substantial population, implying a generally food secure population.

5.2.2 Hunger Experience - 2007

Of the total 8743 households, 80.2% are food secure, while 14.3% are food insecure, this based on the availability of food in the previous month.

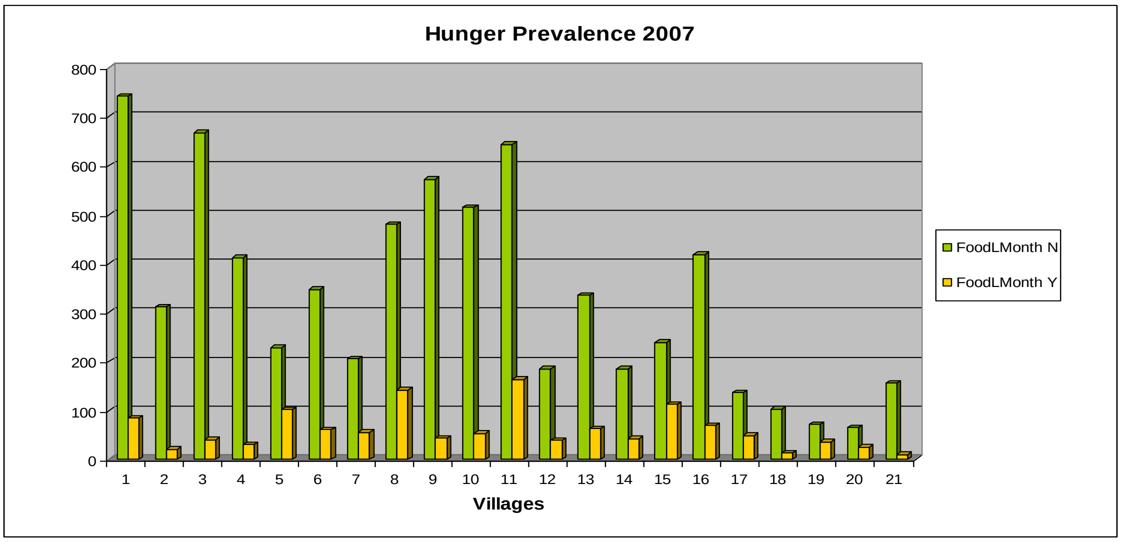

Figure 5.4: Prevalence of hunger mapped per village - N = no hunger, Y = hunger

Some of the previously highly food insecure villages (2004 data) such as villages 1, 3, 9, 10 and 11, have the highest number of food secure households with over 500 households each, followed by villages 4, 8 and 16 with over 400 food secure households each as indicated by Figure 5.4. This implies an immense improvement in the food security in these villages.

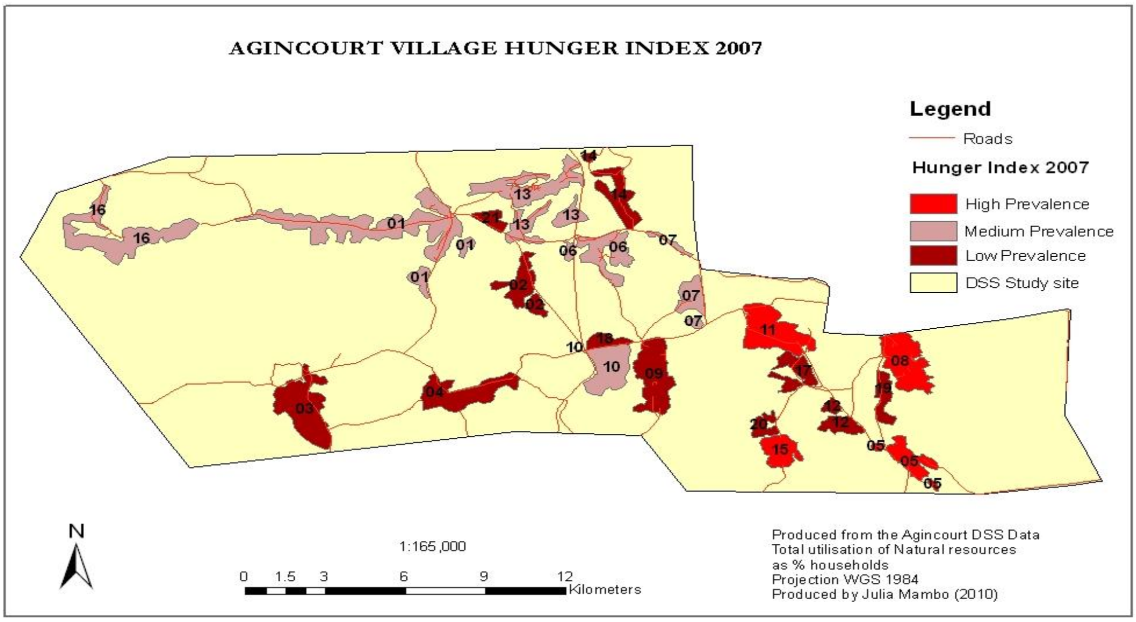

Figure 5.5: Hunger prevalence in the DSS in 2007

In Figure 5.5, villages highlighted in red indicate high food insecurity and these include villages 05, 08, 11 and 15. Villages such as 3, 4 and 9 which in 2004 are highly food insecure are now in the low strata of food insecurity, while the other previously highly food insecure villages such as 1, 10 and 16 are in the medium category of hunger in 2007. Village 11 is the only village that stands out as being highly food insecure in both years, whilst also having high numbers of food secure households in both years. Village 11 has a total population of 7182, which is the second highest population in the DSS, of which 34% are refugees. Further, village 11 has the second highest number of temporary migrants, 16% with 803 male and 397 female migrants. Thus remittances should be playing a key role in the economy of the village although this does not seem likely given the high hunger prevalence. Three villages 5, 8, and 15 that have medium hunger prevalence in 2004 are categorised as having high hunger prevalence in 2007, implying an increase in the number of hungry households over the four years. The frequency of hunger for the food insecure households in a month is further analysed, indicating the depth of food insecurity in the households. These results are presented in Table 5.2 below.

Table 5.2: Food Unavailability 2007

Hunger Frequency	Households	Percentage	Description/month
N	5	0.1	Never
R	75	0.9	Rarely - 1 day
S	734	8.4	Sometimes 2 - 7 days
O	260	3.0	Often - 8 - 14 days
V	160	1.8	Very Often 15 - 30 days

Of the food insecure households in 2007, 8.4% sometimes experienced hunger, 1.8% very often experienced hunger while 3% often experienced hunger. These percentages are lower compared to 2004 as supported by the improvement in food security status.

In terms of food insecurity in the previous year, approximately 13.3% of the households experienced hunger, 6.8% experienced hunger during the summer months and 8.8% households experienced hunger during the winter months. In 2007, when asked about the possible changes in the food security status for the coming year, 65.1% households did not expect any change in their food security status, 9% expected to have more food while 7% expected to have less food.

Various reasons are given for the lack of food experienced in food insecure households, and these are similar in both years (Figure 5.6 and 5.7) and are described below. While various reasons are given, households were required to give only one reason for their food insecurity.

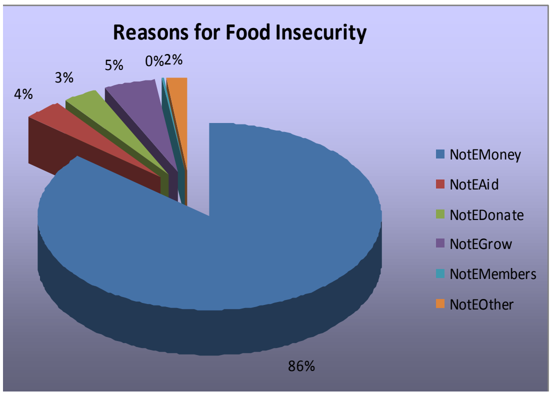

Figure 5.6: Reasons for food insecurity 2004

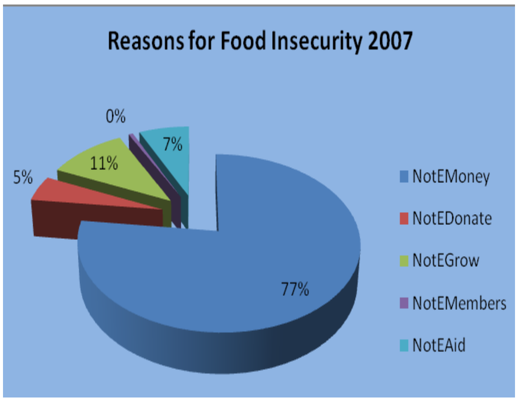

Figure 5.7: Reasons for Food Insecurity 2007

- NotEMoney – 86% in 2004 and 77% in 2007: money from the bread winner, family member or government grant is not received in time or not all and sometimes the money received is not enough to buy food to feed all the members;
- NotEAid and NotEDonate - donations from family members, NGOs or church organizations are not received;
- NotEGrow – 5% in 2004 and 11% in 2007: the household is not able to produce enough food. Lack of rain/drought is cited as a hindrance;
- NotEMembers – new members or visitors put pressure on food availability

Other specific reasons for the unavailability of money recorded include:

- Illness of the bread winner or other family member. This implies that there is no income from the bread winner and household income is spent on medical bills;
- The government grant is not enough to support the household;
- Retrenchment of the household head;
- Death of the bread winner and or death of the grant receiver;
- Money spent on building a house and not food;
- Money spent on paying fees for tertiary education.

There is a reduction in the number of households citing lack of money as a main driver of food insecurity from 86% in 2004 to 77% in 2007. This could be attributed to the increase in temporary migration resulting in increased remittances and more cash flow in the economy of the DSS. Despite an increase in the number of households producing their own food in 2007, there is also an increase in the number of households citing failure to produce own food from 5% in 2004 to 11% in 2007 and there is an increase in the number of households citing lack of aid/donations from 4% in 2004 to 7% in 2007.

5.2.3 Food Production

Subsistence farming is an essential contributor to household food security. Households that produce their own food are asked if they produced enough food to feed all the members in the household. The factors contributing to the failure to produce enough food are investigated.

Food Production – 2004

A total of 76% of households out of the 9437 did not produce enough food to feed the household, with only 23.1% producing enough food (Figure 5.8). Assessment of food production included both on the household gardens and fields plots usually located outside the villages.

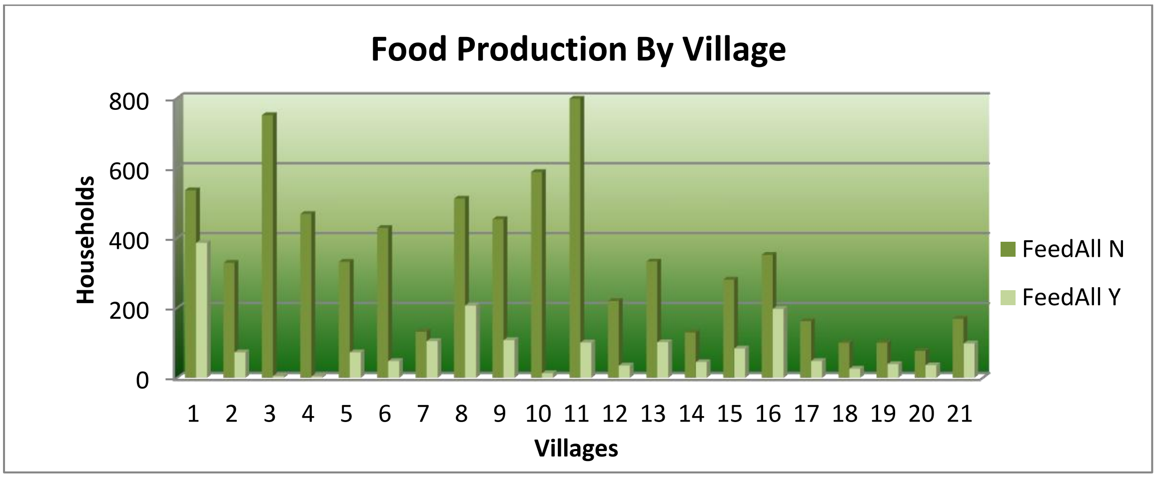

Figure 5.8: Food production by village - 2004 (Feed All=N – household did not produce enough food; Feed All=Y – household produced enough food to feed themselves)

According to Figure 5.7, none of the villages produced enough food. Villages 3 and 11 stand out as the worst affected, with more than 700 households not producing enough food. These are followed by villages 10, 9, 8, 6, 4 and 1, with more than 400 households affected. Villages 1, 8 and 16 had the highest number of households producing enough food. The two factors hindering food production are lack of rain or drought cited by 83% of the households, followed by the lack of labour cited by only 17% of households (Figure 5.9).

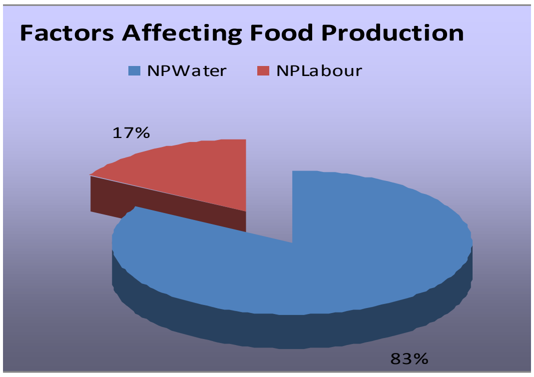

Figure 5.9: Factors affecting food production in 2004

Food Production - 2007

Regarding food production in 2007, 71.5% did not produce enough while 25.3% did produce enough food (Figure 5.10). This figure is lower compared to the 76% from 2004, implying a slight improvement in food production across the DSS.

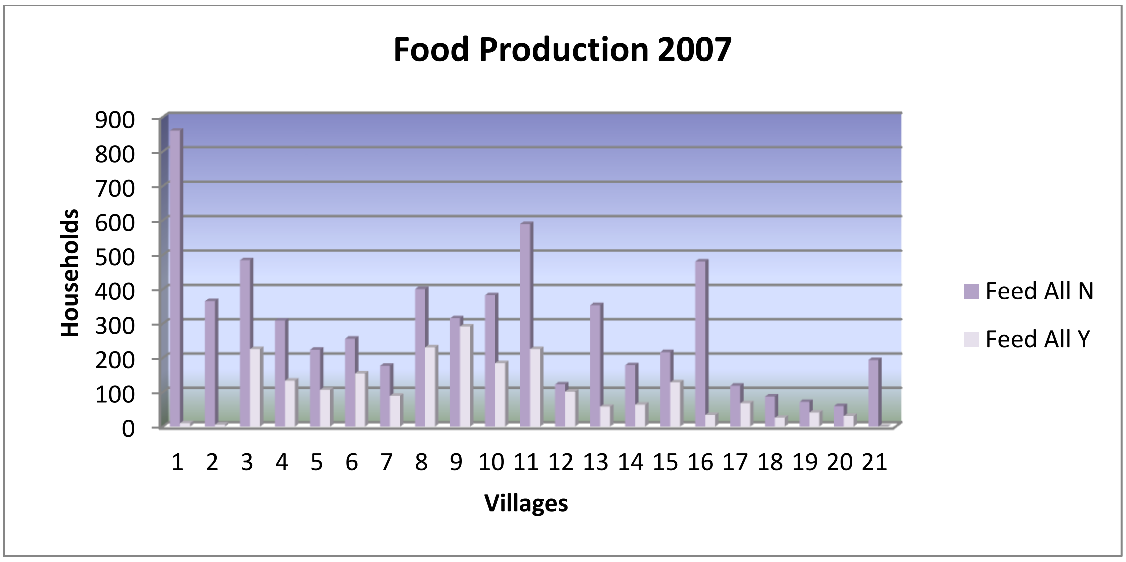

Figure 5.10: Feed All N = did not produce enough food Y = enough food was produced

Four villages stand out as not being able to produce their own food, 1, 3, 11, 16 and 21, with households in villages 1, 2 and 21 not producing any food. Unlike in the 2004 census, more information was collected in 2007 on the reasons for poor food production. A myriad of factors attributed to this failure are listed as follows (Figure 5.11):

- the size of the fields;
- availability of fertiliser;
- availability of water;
- lack of labour to till the land.

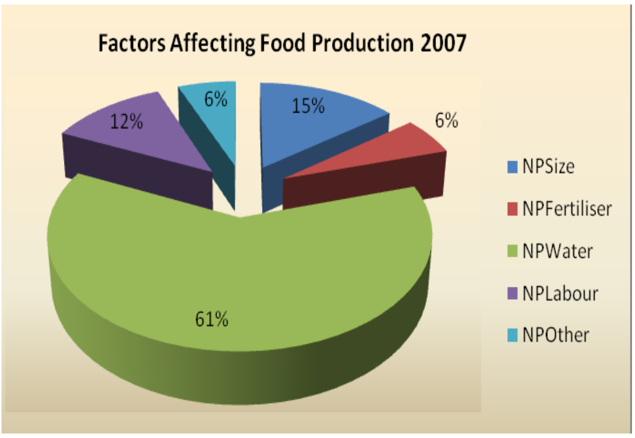

Figure 5.11: Factors affecting food production

Other reasons cited for the inability to produce enough food varying from crops being eaten by livestock to destruction of crops by birds, chickens and rats are noted in some cases. Further, a substantial number of households do have access to gardens, fields or plots where they could plant crops. The lack of land or the small size of plots is more prevalent within the Mozambiquan settled villages, where in general most households cultivated two fields, around their homesteads and outside the village. This was necessitated by the need to meet their food requirements, this prompted by the poor yields received previously (Giannecchini *et al*., 2007). For the households that do have access to land reasons given for not producing enough food include:

- fields located in the wetlands thus the crops drowned;
- did not plant any crops and no specific reason is given for this;
- a death occurring during the ploughing season affecting planting;
- lack of labour to weed resulted in poor harvest;
- late planting due to delayed rainy season;
- laziness to work in the field.

Maize is the commonly grown staple with 52.5 % and 11.4 % households growing food in their plots and fields respectively. Other crops grown include fruits and vegetables such as ground and bamboo nuts, beans, cassava, bananas, sugar cane, pumpkins, water melons and sweet potatoes and staples such as potatoes. An estimated 73.9% of households grow more than just maize, with 64% growing fruit, 44.5% growing vegetable and 7.4% growing other crops in their plots. Regarding growing of other crops in the fields, the percentages are much lower, with only 19.9% households utilising fields to grow other crops and lower percentages in terms of fruits, vegetables and other crops. Access to fields and the proximities of these fields to the households could be contributing factors to the low utilisation rates. Further, as previously mentioned, climate variability is common in this area, with droughts occurring every three to four years making the availability of water an essential factor in food production for the residence of the DSS. Nonetheless, given the high number of households in all villages not producing enough food, subsistence farming does not seem to be the main livelihood and thus may not be the solution to food insecurity in the study area.

A number of coping strategies are employed by households to supplement food, the most common being purchasing and then gathering food from the bush. Of all the households in the DSS in 2004, more than half of the DSS residents, 56.9% supplement household food by **gathering natural resources** or food from the bush and these resources vary from herbs, bush meat to traditional medicinal plants. The fact that more than half the population utilised natural resources to supplement household food is an essential indicator of the importance of natural resources in rural livelihoods and is pertinent for this research thesis. In addition, most of the households supplemented food through purchase, with at least 96.1% of households buying food staple foods such as maize, potatoes, bread and rice. Whilst the number of households depending on donations, aid or borrowing, particularly from friends, relatives and neighbors are minuscule, they do show, to some extent the importance of social networks in attaining food security, as a safety net especially in rural livelihoods.

5.2.4 Meals Consumed in households 2004 - 2007

The number of meals[34] consumed in a household on a normal day and the previous day are further analysed to measure food availability for males, females and children. In **2004**, meals consumed ranged from 1 to 8 meals a day with **adult males**, in 46.5% households consuming at least 3 meals, followed by 21.2% of households having at least 2 meals. There are two extremes of 1 meal a day for 78 households and 7 meals a day for 1 house hold. In **2007**, 42.4% households have 3 meals in a normal day, followed by 23.1% consuming at least 2 meals a day. 2.2% households had only 1 meal a day with an extreme 33 meals and 47 meals consumed in 1 and 2 households respectively. A few other households consume between 4 and 5 meals a day.

In terms of **adult females**, in **2004**, 65.1% households consume three meals, preceded by 24.5% which consume two meals a day, with the extremes of one meal a day by 78 households and five meals a day by 4 households. In 2007, a**dult females**, consume an average of 2 and 3 meals a day, with 54.2% households consuming 3 meals and 27.6% eating 2 meals a day. 2.5% households consume 1 meal a day with a few households consuming between 4 and 5 meal. Two extremes of 22 and 47 meals a day are recorded for 2 households. The widest range of meals consumed is observed for the **children**. At least 59.2% households consume three meals a day, preceded by 9.7% household consuming two meals a day. Children in 0.1% households consume only one meal a day, with an extreme of 8 meals per day in 2 households. Further, 9.3% households feed their children 4 times a day. In 2007, meals consumed by **children** followed the same trends as for the males and females, with the highest consumption recorded for 3 meals by 49.8% households, 2 meals by 17.3% and 5.7 % households having 4 meals. The extremes are noted in 1.3% households at 1 meal a day and 2 households at 22 and 54 meals a day.

The extremes of 33 meals eaten in 1 household by an adult male, adult female and children in a normal month are noted, raising questions as to the definition of a normal meal. The fact that this extreme frequency of food consumption is noted for only one

[34] A meal is considered to have some kind of staple and meat

household makes this an uncommon occurrence within the DSS, or any other rural areas in South Africa, of which three basic meals a day is the norm. Thus, food consumption does not indicate any food insecurity.

5.2.4 Dietary Diversity

The average number of meals per day indicates reasonable availability of food. According to the 2007 data, maize as the main staple food is the most consumed, with most of it grown on the fields and plots; some is purchased, borrowed and or given by friends, relatives and neighbours. Other staples include rice (75%), bread (79.9%) and potatoes (31.5%) as the most notable ones. Other staples such as cassava, mealie rice, samp and pasta are also consumed. This data was not collected for 2004. While the 2004 food security data included consumption of fruit, the 2007 module did not, resulting in fruit consumption being dropped from the 2007 analysis. However, the quality of food is necessary to assess the nutritional value or dietary diversity of the food consumed.

High protein foods such as chicken, fish, red meat, eggs and vegetables are considered, with the data being obtained from the DSS database. Households needed to have consumed each food group at least once a week to get a score of 1, which is then summed up to produce a dietary sufficiency score. The dietary sufficiency is then added up to produce a dietary diversity score, measured as a scale from 0 – least diversified to 5 most diversified. The dietary sufficiency, which implies that the food consumed from the above mentioned foods is adequate, is also analysed, giving an indication that vegetables and chicken are the most consumed with red meat being the least. For ease of analysis the six scores are divided into 3 quintiles, scores from 0–1 are classified as low, 2–3 as medium and 4–5 classified as high.

In **2004**, out of the total 9437 households, 10.3% households had a low diversity score. The majority of the households, 55.3% are classified as medium diversity score. The households with a high score are recorded as 34.3%, thus the distribution of dietary diversity is well balanced within the DSS (Figure 5.12). Only 2 villages, 1 and 11, had a low diversified diet, with more than 100 households each. The majority of the villages

(14 villages) has more than 100 households in the medium dietary divesity category, followed by villages 1, 4, 9, 10, 11 and 16. Villages 1, 8 and 11 also featured prominently in the medium dietary diversity group. While a low number of households have low dietary diversity, villages 1 and 11 had the highest number of households in this category followed by village 7. It is interesting to note that villages such as 1, 11 and 16 had high number of households in all the three categories of diversity. Villages of concern are identified as those that had a low number of high diversity and comparably high number of low diversity, such as village 17.

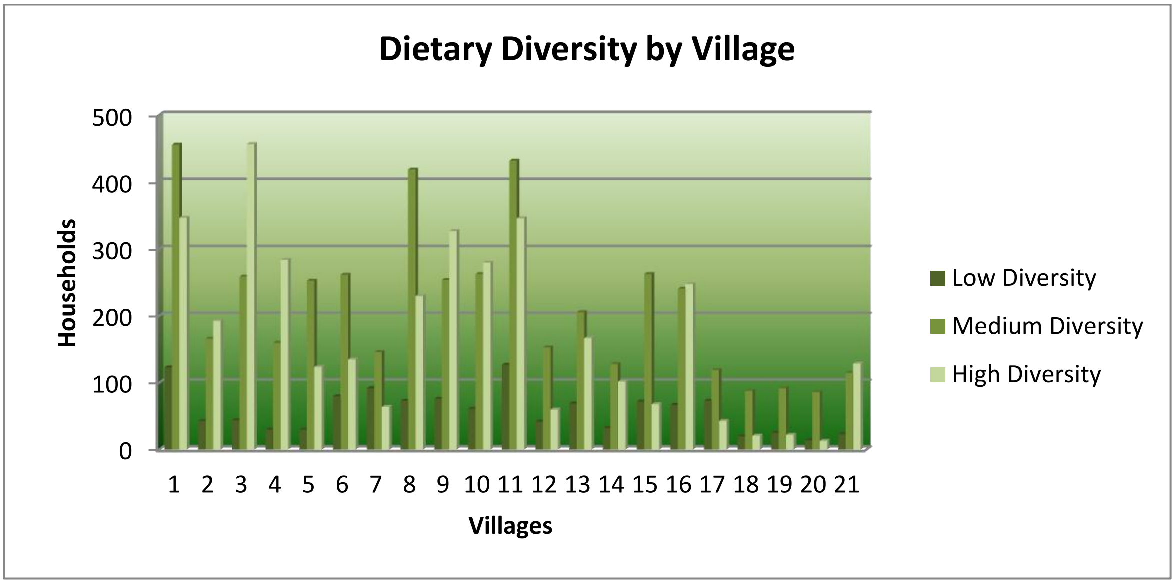

Figure 5.12: Dietary Diversity in Agincourt by Village in 2004

In terms of dietary diversity in **2007**, 33.4% households in the study sample have a high dietary diversity score of 5, followed by 26.9% households with a score of 4. At least 9.3% households had a score of 1, an indication that their diets are not diversified at all and only 3.2% households have a score of 2, 16.2% have the highest score of 6. The dietary diversity analysed at village is presented in Figure 5.13.

Only a few of the villages had low diversity, while the villages with the highest diversity are 1, 3, 8, 9 and 11. Villages 1, 8, and 11 also had the highest number of households in the low diversity quintile.

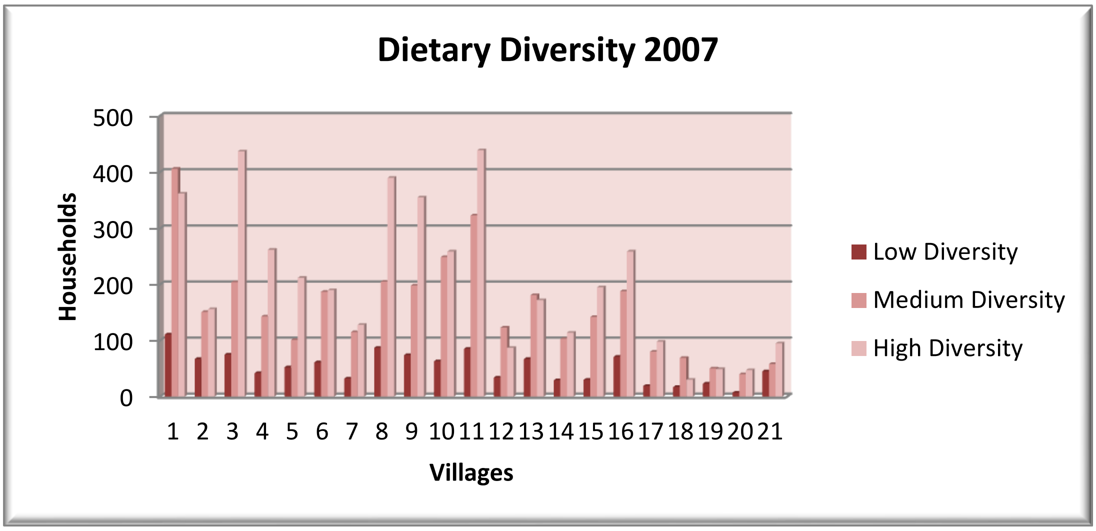

Figure 5.13: Dietary Diversity per village

The dietary diversity score for the DSS in both years indicates reasonable food security, with the DSS population able to consume other nutrient rich foods. As previously mentioned dietary diversity maybe used as a proxy for availability of household income and this is supported by the general good food security status in both years.

5.3 Utilisation of Natural Resources

There are inconsistencies noted in the data recorded for the utilisation of natural resources between 2004 and 2007. Some of the questions previously asked during the 2004 food security module are either changed or modified. These changes are necessitated by the need to simplify the data capture process. Therefore data such as the frequency of collection of natural resources in terms of the number of times per week, month or year these resources are collected is no longer included in the questions asked to the residents of the DSS. These inconsistencies made data analysis and comparison between the two years difficult. For example, a considerable amount of households indicate gathering insects, bush meat and wild fruit but the frequencies of gathering is not recorded, making it difficult to calculate monthly consumption/gathering, as is preferred. The gathering of wild herbs is the only consistently collected data with the consumption aggregated to a monthly scale. Given the above mentioned data complication, the number of households gathering natural resources are considerably smaller in 2007. The other categories, such as the gathering of insects, fruits and meat consumption are also aggregated to a monthly consumption despite the above noted complications.

As noted above, at least 56.9% of the households in 2004 supplemented food by gathering from the surrounding natural resources. Supplementing household food and income through gathering natural resources is cited as one of the coping strategies used by households facing different stressors (Dovie *et al.*, 2007; Shackelton *et al.*, 2007; Twine and Hunter, 2008). Wild foods gathered include herbs used as vegetables and medicinal herbs, locusts and frogs as well as wild fruits for consumption and trade. In Agincourt, products collected/gathered as well as the frequency of collection are recorded and these are aggregated to a monthly rate, to correlate with the monthly food insecurity.

A substantial number of households both food secure and insecure, including households that did not answer the question about hunger in the household during the previous month, did gather natural resources to supplement household food. This implies that natural resources are not only utilised by food insecure households but are also used by other households as a means of saving household income. By using natural resources which are considered "free", households get to save money on energy by using firewood and wild or survival foods (Hunter and Twine, 2005; Dovie *et al*., 2007; Shackleton *et al*., 2007). According to Hunter *et al.* (2005), in the DSS, more than half the households have access to electricity but still use firewood for big energy consumers such as cooking, heating bath water and keeping warm, with electricity restricted mainly to lighting. Hunter and Twine (2005) also noted that the utilisation of natural resources in the DSS is regardless of mortality of the bread winner in the household. According to research conducted by Hunter *et al*. (2005), the use of firewood is central to household economies, with various acquisition strategies employed (Appendix 6, from Hunter *et al.,* 2005).

5.3.1 Natural resource Use in 2004

The broad utilisation of the natural resource base is calculated based on the number of households that utilise natural resources that is herbs, insects and fruits. The gathering of the three resources is aggregated to a monthly consumption which is then summed up to derive a total consumption from here on referred to as the NRU (Natural Resource Utilisation)[35]. The maximum NRU within the DSS is recorded at 124 and the minimum at 1. The range is stratified into three categories which are aggregated to:

- 1–40 (low utilisation);
- 41–79 (medium utilisation);
- 80–124 (high utilisation).

Out of a total of 9437, at least 43.6% households did not gather any resources while 56% of households collect herbs. 16.4 % and 11.3 % households collect resources 10 and 12 times a month respectively. In terms of wild fruits, 20% of households collect fruits. Only 0.6% (54) of households consumes bush meat and frogs. Within the low NRU (Figure 5.14), the majority of households gather wild resources at least eight times a month, followed by four times and twelve times a month. Within the high natural resources utilisation category, two villages 03 and 11 show up significantly, highlighted by the blue colour on map (Figure 5.14).

[35] The NRU is based on consumption of any natural resource not necessarily all three.

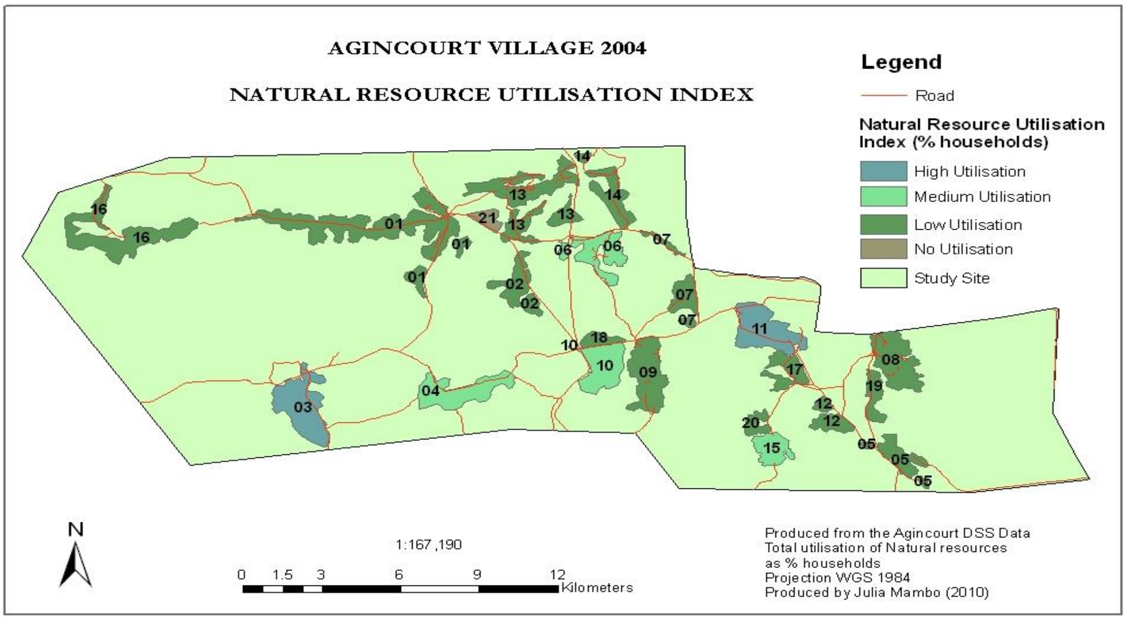

Figure 5.14: Natural Resource Utilisation in 2004

Only four villages have medium utilisation, indicated by the light green colour on the map (Figure 5.13) and the rest of the villages had low utilisation of natural resources. Only village 21 had no households using natural resources.

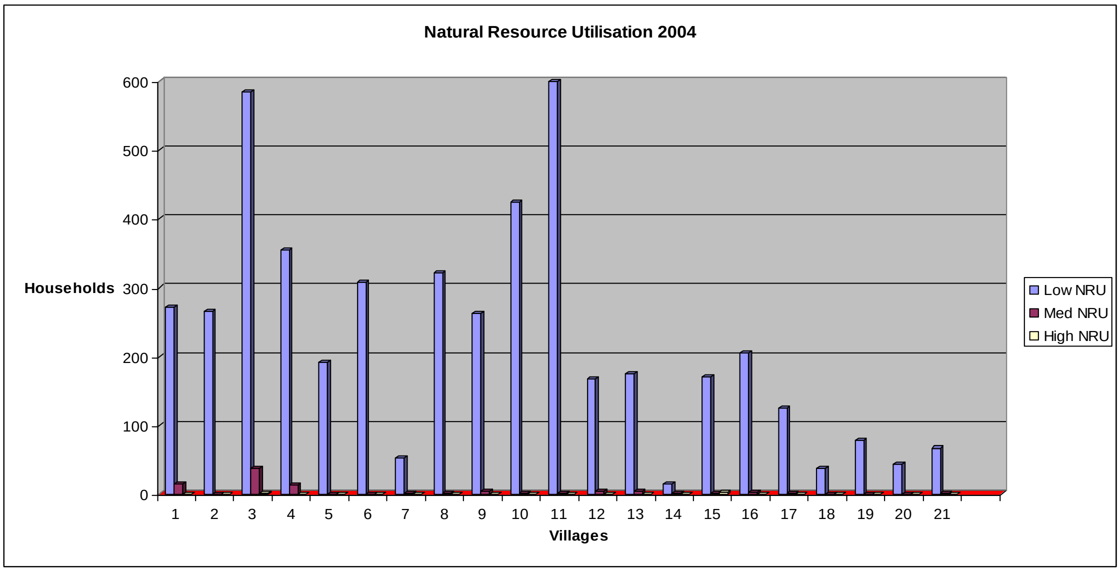

Figure 5.15: Natural Resource Utilisation by Village in 2004 –Low NRU = Low Natural Resource Utilisation; Medium NRU = Medium Natural Resource Utilisation; High NRU = High Natural resource Utilisation

The number of households in the low utilisation quintile is 55.7%, while the medium quintile has 0.9% households. The high utilisation has only 4 households described in Figure 5.13. Two villages 3 and 11 have high NRU. The frequency for high utilisation is negligible, with minimum chances to cause any long-term environmental impacts.

The gathering of bush meat is minimal, with one out of the 13 households gathering bush meat as many as 12 times in a month. An additional 14 households whose monthly aggregated bush meat gathering is below 0 are not included since this range and is considered negligible and not enough to cause any substantial environmental impact. Again the quantities or the species of wild animals hunted specifically is not collected. The gathering of frogs (rain frog), which is included in the category for bush meat is also minimal with only 3 households collecting these on an average frequency of once a month. The quantities collected for all these resources are not recorded. Bush meat gathering is of great concern, especially since an increase in consumption by current and new households could lead to possible extinction or unsustainable utilisation of the wild life. The gathering of insects is low with the highest recorded being 16 times by 1028 households. Four villages stand out as having high gathering of insects, villages 3 with more than 200 households, village 6 and 10 with more than 100 households and village 11 with almost 200 households (Figure 5.14). Again villages 3 and 11 which are high hunger prevalence villages feature in this analysis.

The collection of herbs is more balanced across the DSS. Some villages are visible in terms of little utilisation of all three resources such as villages 7, 14, 18, 19, 20 and 21. These are medium to low hunger prevalence villages, bringing about the question about the linkage between natural resources use for food security and to what extent natural resources are key for food security. Herbs are collected by a substantial number of households, varying from 1 to 120 times a month, with 16.4% of households gathering herbs 8 times, 11.3% gathering 12 times, 4.7% gathering 16 times a month. Further, during the data collection, no distinction is made between gatherings for consumption, medicinal purposes and or commercial purposes, all of which would impact differently on the sustainable utilisation of these herbs.

The other commonly gathered resource is wild fruit, collected by as many as 19.6% households and collected as much as 60 times in a month by one household. While the collection of fruit is expected to be higher, given the importance of marula fruit in the informal trade (marula beer and marula jam), only village 3 again has approximately 400 households gathering the wild fruits (Figure 5.15) with the other villages, 1, 4, 6, 19 and 11 having more than 100 households. This high number of households collecting fruit in one village has an impact on the contribution of the informal trade given the market limitations, as noted by Shackleton *et al*. (2004). The utilisation, which is measured on monthly utilisation, is again divided into quintiles ranging from 1–20 (1060 households) as the lowest; 21–40 (104 households) as the medium utilisation, and 41–60 (1 household) as the highest utilisation range. The NRU by resource type is analysed at village level and the results are presented in Figure 5.16.

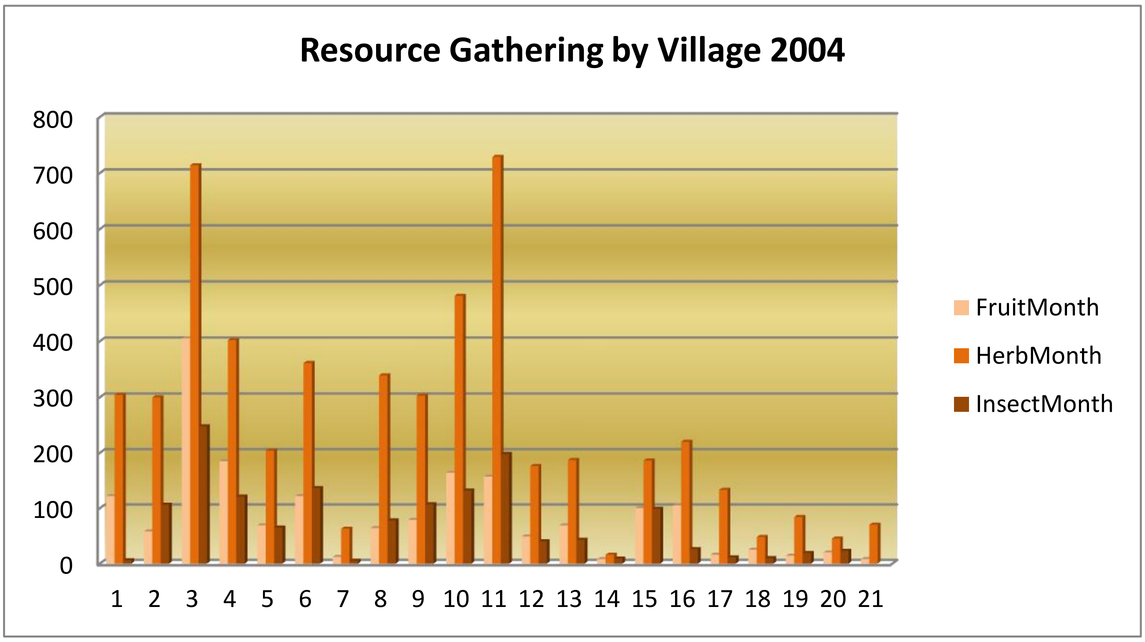

Figure 5.16: Resource gathering classified by village

Only 2 households indicate to have gathered resources 120 and 124 times in a month, which is very high utilisation. For ease of analysis these households are included under the high utilisation quintile. While the number of households is minuscule, the high frequency of gathering could indicate vulnerability to food insecurity for a very small number of households in the DSS as well as bringing attention to the importance of natural resources in meeting dietary needs. However, in a study sample of over 12000 households, to have only 2 households using resources at that high a rate implies that the DSS residents are not as vulnerable to or as food insecure and as poor as anticipated, especially since this area is located in a municipality designated as an poverty[36] node, noted for extreme poverty and food insecurity according to the President's office.

For the 4076 households that did not gather any resources from the bush, 34.8% households are male headed, 64.6% under female headship. Out of the 5265 households that gathered resources, those that had low NRU, 37% are **male headed** and 62% **female headed.** The same trend is noted for medium and high NRU categories, with more female than male headed households gathering resources. This could imply that female headed households are more susceptible to food insecurity or use more natural resources than male headed households. The susceptibility of female headed households to higher levels of poverty and to higher food prices, both causing food insecurity is noted in rural areas (Chopra *et al*., 2009; Le Roux and van Huyssteen, 2010).

Two possible explanations may assist in explaining this trend, firstly being the absence of male breadwinners who may be migrant workers; or the lack of formal employment for the female household's heads meaning the unavailability of cash for the purchase of food, as well poor access to social security grants. According to a study conducted by Reddy and Moletsane (2009), women and girls are considered to be most-at-risk-populations and are therefore vulnerable to food insecurity due to the limited access and control of resources such as land, water and other support systems. Further, it is noted that women are playing a key role in households in terms of food security (Reddy and Moletsane, 2009).

5.3.2 Natural Resources Use in 2007

Utilisation of natural resources in 2007 is limited, with at least 83% of the households not using any natural resources. At least 2.55% of households gathered resources at least

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[36] Presidential Poverty Nodes are characterised by underdevelopment, contribute little to the GDP, and incorporate the poorest of our urban and rural poor

once a month, 8.8% gathered resources at least 16 times a month. The range of utilisation varies from 0.5 to 48 times by one household, with a monthly average of 16 times for the majority of the households. The frequency of data collection is available for only 364 households for wild fruit and 253 households for the bush meat.

The gathering of natural resources is tabulated by the type of resource collected and by village. Herbs are the most collected resource, especially in villages 1, 2, 8, 9 and 16 which had more than 100 households, followed by villages 3, 5, 11, 13, 15, 17 and 21 with at least 50 households collecting herbs the rest of the villages have below 50 households. Regarding wild fruit gathering, no villages recorded households more than 50, with village 9 recording the highest number by 50 households. Villages 8 and 1 had 24 and 21 households respectively and the rest of the villages had households below 20.

Regarding the gathering of insects, similar to the gathering of wild fruit, no villages have households above 100, with village 9 having more than 50 households, and villages 8 and 15 with 22 and 20 households respectively (see figure 5.17). The rest of the villages have less than 20 households gathering insects which are too small to make a substantial impact.

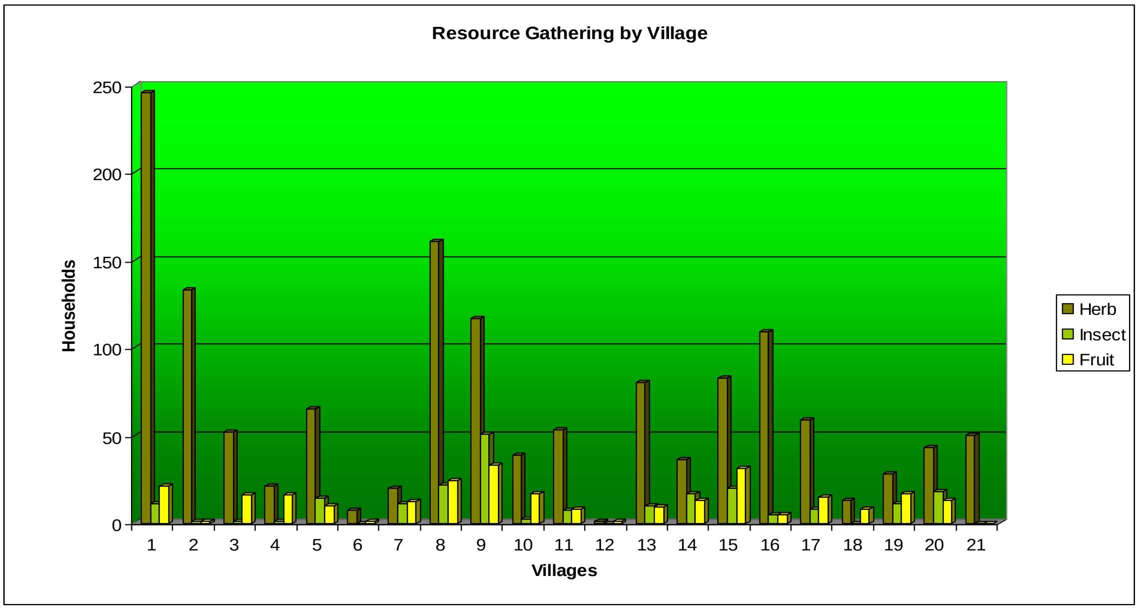

Figure 5.17: Resource gathering by village in 2007

The gathering of bush meat is analysed separately since this resource will most likely face serious threat from over utilisation while the other resources such as fruits and insects are seasonal and herbs are collected from the fields and pastures. The highest number of households gathering bush meat is recorded in village 1, followed by villages 8, 11 and 5 with households between 38 and 41. The rest of the villages have below 15 households and below, which does not seem significant.

In terms of the NRU, the high category has the least households, with villages 3, 8, 14, 15 and 20 having one household each. Villages 8 and 9 have the highest number of households in the medium category (22 each), villages 5 and 20 with 16 households each and villages 1, 7, 14, 15 and 19 having between 10-13 households each. In terms of low utilisation, village 1 has the highest number of households 236, followed by village 8 with 146 households, village 2 with 134, village 16 with 125 and village 9 with 109 households. The remaining villages have less than 100 households. It is important to note that the bigger the villages the higher the number of households recorded in each category (Figure 5.18).

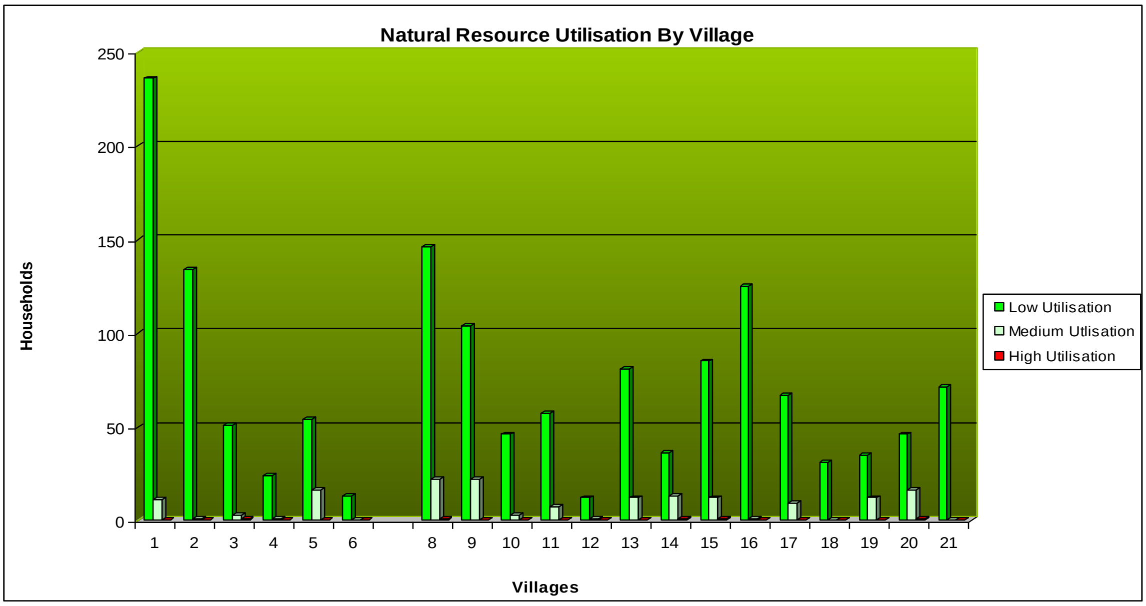

Figure 5.18: Natural Resource Utilisation by village in 2007

Despite the noted discrepancies in the natural resources data between the two years 2004 and 2007, influencing the natural resources utilisation categories, this analysis is important to highlight the general use of natural resources across the DSS and in households. Over 50% of households utilise natural resources, this based on the direct question asked about supplementing household food. While poverty or household income data would have assisted to quantify the monetary contribution of natural resources to household food or for saving household income, this data was not available.

5.3.3 Natural Resource Utilisation and Dietary Diversity

A previously mentioned, dietary diversity may be used as a food security indicator in diverse situations, from rural to urban food security as well as a proxy for the socio-economic status of households, indicating increased food expenditure resulting from additional income, even for poor households (Maxwell and Frankenberger, 1992; Hoddinott and Yohannes, 2002). The comparison between dietary diversity and natural resource utilisation was conducted to ascertain to what extent natural resources contributed to a diverse diet.

For the villages with low NRU (used the least natural resources) more than 500 households have a high dietary diversity. Over 500 households again are in the medium category of dietary diversity, with less than 100 households in the low dietary diversity strata. The low diversity households do not seem to be adequately using their natural resources for nutrition security, implying that natural resources are not playing an important part in the nutrition of these households.

The number of households is significantly reduced between the low and medium NRU categories, with less than 100 households in the high dietary diversity and less than 100 households in the medium and low dietary diversity. In this analysis, dietary diversity does not seem linked to natural resource utilisation. In the high natural resource utilisation category, only 5 households are recorded for all the categories of dietary diversity. The above mentioned results are contradictory to studies that have indicated supplementing protein foods from natural resources or even the use of natural resources to save household income for other purchases such as protein rich foods (Shackleton *et* *al*., 2008). Further, the dietary diversity in the DSS (high to medium) to does not imply a highly impoverished and food insecure population as is expected.

In the category of households that have low utilisation of natural resources, 609 households have a highly diversified diet, 559 households have a medium dietary diversity while only 87 households have the lowest diversity. If using dietary diversity as a proxy for household's income and natural resources as a coping strategy, more households have more income to spend on dietary/healthy foods without relying on the natural resources to provide the income. On the other end the of the spectrum the small numbers of the high natural resource users may imply that even the utilisation of these resources is not making much of an impact on the household's diet or income, possibly highlighting these households as extremely vulnerable to food insecurity. In general the large number of households in the low natural resource use category implies that the residents of the DSS are not poor as anticipated.

5.3.4 Natural Resource Utilisation and Food Security

To investigate the relationship between NRU and food security/hunger in the DSS a cross tabulation was conducted in SPSS (Figure 5.19 below).

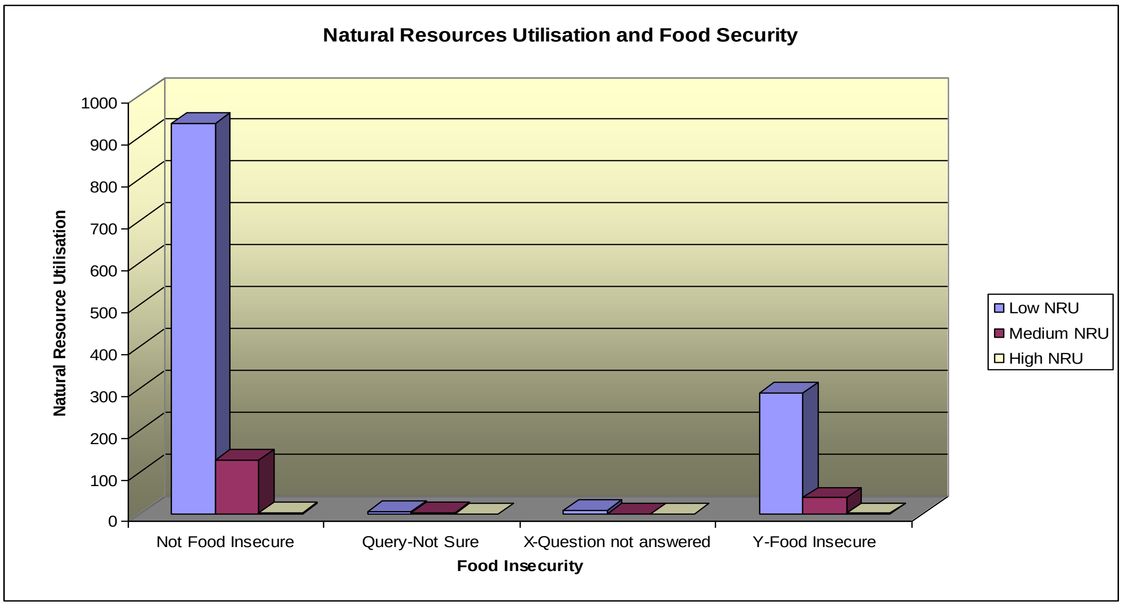

Figure 5.19: Relationship between household hunger and utilisation of natural resources

Of the households that are food insecure, 290 are classified as having a low NRU, 39 in the medium NRU and only 2 households have a high NRU. Within the food secure households, 933 are in the low NRU, 130 in the medium NRU and only 3 in the high NRU. The analysis indicates that the food secure households are the most users of natural resources, with at least 900 food secure households in the low utilisation category. In the medium utilisation category, over 100 food secure households gather natural resources. While the number of food insecure households utilising natural resources is expected to be higher, the comparison of the 2 variables indicate that the food insecure households do not rely on natural resources as much as expected, despite natural resources being recognised as a coping strategy for food insecurity.

5.4 Mortality

The utilisation of natural resources in the DSS has been investigated in the above section, highlighting the importance of these precious resources in rural livelihoods for household income and consumption. According to the hypothesis, natural resources have further been cited as one of the coping strategies engaged in by households affected by the HIV and AIDS epidemic as well as AIDS mortality, especially in the absence of social security safety nets (Twine and Hunter, 2008). The next section investigates what impacts adult AIDS mortality has on food security and consequently on natural resource utilisation at village level, as part of the objectives of the study. Due to the sensitivity and stigma associated with the HIV and AIDS epidemic and the ethical issues considerations within this study, the epidemic‘s impacts on food security are investigated broadly, with association to natural resources explored at village level, despite the data being collected at household level.

It is also important to note the distinction between HIV/AIDS affected households and AIDS mortality households, especially for this study. HIV/AIDS affected are households bearing the burden of an infected and ill member while AIDS mortality affected households are affected by the death of an adult in due to AIDS or AIDS related illness. This study focuses mainly on AIDS mortality, thus endogeneity issues, gender sensitivity, timing of death and misdiagnosis of cause of death, while important are not covered in this study.

In this study, the analysis of the impacts of AIDS mortality is conducted at village level, while the data is collected at a household scale. In addition, the investigation of the impacts of adult AIDS mortality on household food security and consequently utilisation of natural resources has already been conducted as part of the overall study for the RBF project (Hunter and Twine, 2005, 2008; Hunter *et al.*, 2006) which this research thesis builds upon. These studies are conducted at household level with a much smaller study sample in comparison to this study which used village level as the scale of analysis.

Table 5.3: HIV/AIDS mortality and Food Security

		FoodLMthNew		Total
		0	1	
HIVDeath_Cnt	1	109	69	178
	2	3	6	9
Total		112	75	187

The table above (5.3) is a comparison of HIV death count and household hunger in 2004 where: - HIVDeath Cnt measures AIDS mortality,

- 1 = a single death
- 2 = double mortality in one household.
- The column FoodLMtnNew highlights the availability of food in the household during the previous month,
- 0 = food security
- 1 = indicating food insecurity.

The first analysis investigated the village level food insecurity and to what extent households affected by adult AIDS mortality are food insecure. Firstly, only 187 households in the DSS are affected by AIDS mortality in 2004, which is only 2% of the study population. Of these households, only 9 are affected by multiple AIDS deaths, of which 6 experienced hunger during the previous month. Of the 178 households that had at least one HIV death, 69 (39%) experienced food insecurity and the other 109 (61%) are food secure. This highlights the high level of food insecurity in AIDS affected households is not highly prevalent, and is in contrast to the findings by Twine and Hunter (2008) of which the households affected by adult AIDS mortality are more food insecure than non-affected households. According to Hunter and Twine (2005), households affected by quick non AIDS death are the most food insecure of the three strata studied, AIDS mortality, quick non AIDS death and no mortality. In addition, households affected by AIDS mortality are found to have a lower dietary diversity (Twine and Hunter, 2008), with only 28.8% of the households in the highly diversified diet category.

Out of the total of 187 households affected by mortality, 134 (72%) did not produce enough food, although only 9.1% of these households indicate a lack of labour as a problem. The unavailability of enough money is a major driver of food insecurity as noted by 40.1% households, implying food purchase (accessibility) and not food production (availability) is the main driver of food insecurity. However lack of money may also influence purchasing of resources such as fertilisers for farming as noted in 2007, adversely impacting on food production. These results correlate to the findings by Twine and Hunter (2008) as well as Giannechinni *et al*. (2007), especially the reliance on income for food purchase instead of producing own food.

In terms of utilisation of natural resources by the AIDS mortality affected study sample, the numbers are small, with only 97 households gathering herbs on a monthly basis for those households affected by one death and only six households for those affected by 2 deaths. Even fewer numbers of households are recorded for the utilisation of wild fruit, with 37 households affected by one death and two households affected by multiple deaths recorded. The same trends are observed for the utilisation of insects with 26 households and 2 households affected by multiple deaths recorded. These figures imply that the utilisation of natural resources as a buffer against internal or external stressors, either as a food source or for supplementing household income does contribute to household food and income for a small affected population but is not popular among the bigger population of households affected by one or multiple AIDS mortality.

Throughout this mortality analysis it is important to note the rather small sample that is being analysed in relation the whole DSS. While all the villages in the DSS are affected by adult AIDS mortality, the total number of deaths, at 187 is not very significant in a sample of over 8000 households and a population of over 12000. In terms of the village analysis, only three villages had mortality above 18, which is again not big enough to have serious impacts at village level on food security. The identity of these villages cannot however be disclosed due to ethical considerations.

Given the results of the small sample of households affected by mortality at this point in time, this analysis does not in any way discount the impacts of AIDS mortality at household level as noted in studies by; Hunter *et al.* (2005, 2007) and Twine and Hunter (2008). This instead highlights the importance of the scale of analysis, with the village scale applied for this research not appropriate to tease out the interactions between mortality and natural resource utilisation at household level.

The descriptive statistics above have been premised on the analysis of six variables extracted from the food security module of the 2004 and 2007 census, assessing availability, accessibility and utilisation of food as well as coping strategies for food insecurity in the study area. The variable used as proxies were, hunger in the household in the previous month, number of meals consumed in the household on a normal day, food production, other means of supplementing household food, gathering of natural resources and AIDS Mortality in 2004. In terms of dietary diversity, variables on the consumption of key food groups such as protein and vegetables were calculated to supplement data on food security and household income. As previously stated, food security improved from 2004 to 2007, together with food production. Natural resource utilisation however, decreased from2004 to 2007. The reasons given to for poor food production are consistent between the two years, lack of household income and lack of rain, with other reasons given for 2007 such size of land. Dietary diversity was however, consistent between the two years. Similarly, the number of meal consumed by adult male, adult female and children followed the same trend, indicating a food secure population.

5.5 Factor Analysis

The previous section has discussed the status of food insecurity in the DSS for 2004 and 2007, using various indicators selected from the database. The indicators chosen ranged from highlighting food availability, accessibility and utilisation as well the coping strategies for coping with food insecurity and household income. Given the many indicators used, there is a need to assess which of the selected variables is the most significant as a driver of food insecurity in the DSS in 2004 which is the baseline year. This is done using factor analysis of which the results are covered in the next section. The results of the factor analysis will be used for the logistic regression later in the chapter.

As previously mentioned, factor analysis is applied to reduce and classify the number of variables by detecting structure in the relationships between the variables, using principal component analysis (PCA). The consecutive variables that account for less variability are reduced until little variability remains and this is guided by methods such as eigenvalues. Eigenvalues and Eigenvectors represent the relative contribution of each component to the total variation in the data and are for each variable and the bigger the eigenvalue the direct indication of the importance of that variable in explaining the total variation within the data set.

5.5.1 Principal Component Analysis

A principal component analysis on the variables representing food security indicators which are derived from the DSS database is conducted, in an attempt to identify and thus extract or eliminate variables of less significance to food security (Figure 5.23). The variables considered are:

- *Crop failure* – poor or no harvest of food in the case where food is grown resulting on food insecurity, for example destruction of crops by animals and poor rainfall;
- *Lack of money* – whether the household received any money either from the government grant, remittances or from employment;

- *No food aid* – whether the household received any food aid from government, neighbours, family and or friends;
- *Resource Utilisation* – how much resources did households collect from the natural resources and how did these influence their monthly food security;
- *AIDS mortality* (including diseases such as Tuberculosis);
- The *gender of the household head* - how the gender influence the food security status of the household;
- The *number of people* in the household.

It is important to remember that correlation does not imply causation but tests the significance of the different independent variables on the dependent variable which in this case is availability of food in the last month. The results of the PCA analysis are presented below.

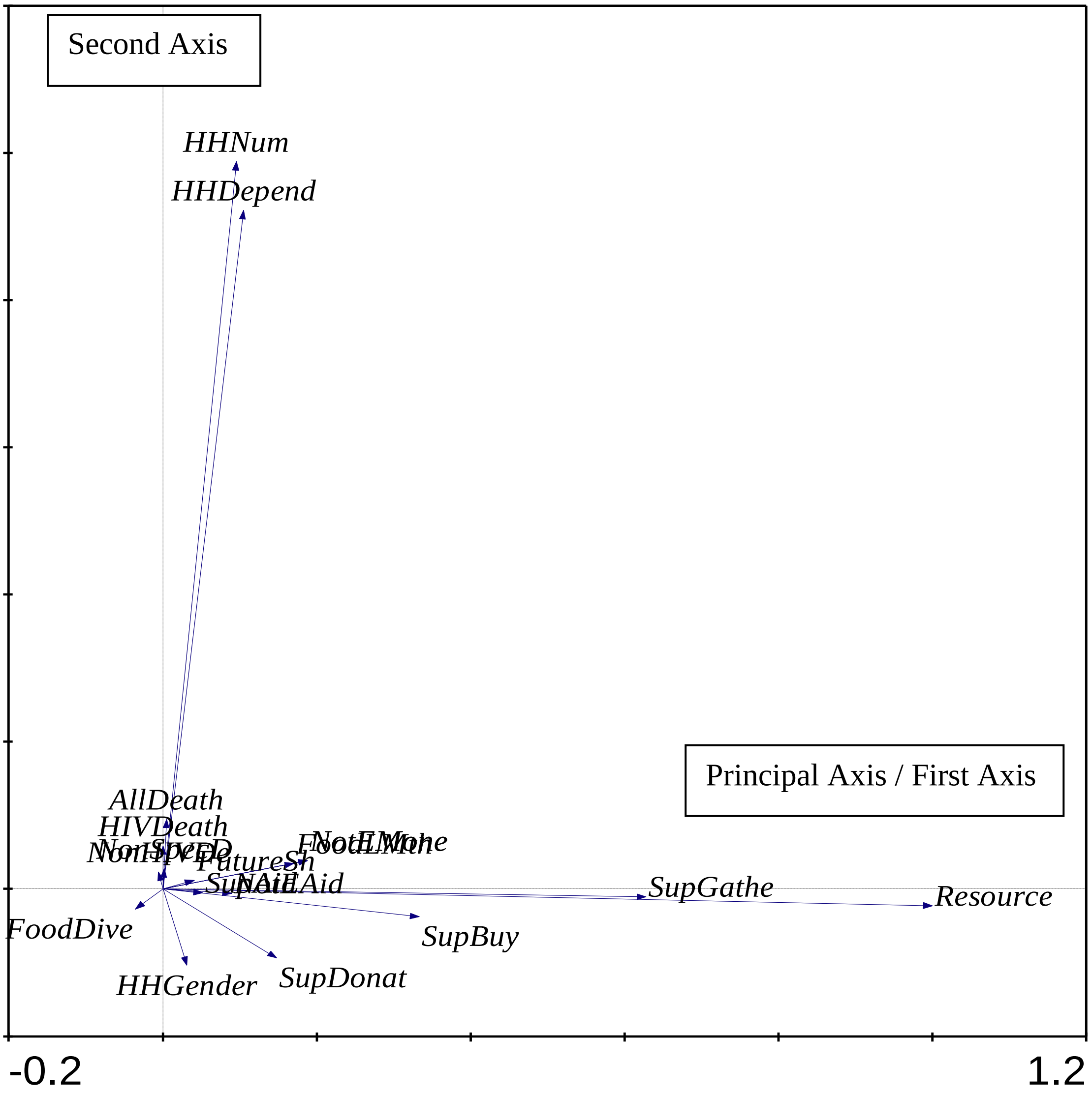

Figure 5.19: The PCA analysis

Variables in the **first axis (the horizontal line/principal axis)** of the PCA (Figure 5.19) describe the largest percentage of the data at 77.4% cumulative variance (Table 5.4). As previously mentioned, a small angle and long vector indicate high significance of the variable in explaining the total variation of the data set. In this instance, resource utilisation has the highest significance, implying that resource utilisation plays a key role in the food security of the residents in the DSS in 2004. Natural resources utilisation is the calculated total use of the different natural resources; herbs, fruits and insects tallied for the villages in the DSS. Thus the number would be higher due the different resources used by both food secure and insecure households.

Table 5.4: PCA analysis

Axes	1	2	3	4	Total Variance
Eigenvalues	0.774	0.173	0.017	0.013	1.000
Cumulative % variance of data	77.4	94.7	96.5	97.7	
Sum of all Eigenvalues					1.000

The second most significant variable is supplementing food through the gathering of natural resource products (SupGathe). This could be attributed to the more that 50% of the residents in the DSS, both food secure and insecure, using natural resources and gathering resources to supplement household food and income. Even though some of the households did not indicate using natural resources to supplement food, by not answering the question, these households are counted in the first variable measuring the usage of the individual resources. Along the same axis SupBuy (supplementing through purchase of food), SupDonate (supplementing food through donation) and HHGender (the gender of the head of household) all seemed to be significant, implying that whether the head of the household is male or female made a difference to the food insecurity of a household. In this case as previously highlighted, male headed households are more food secure compared to the female headed households.

The cumulative variance for the second axis is also significant to the total variability in the data at 17.4% (Table 5.6). Other variables, such as the total number of residents in a household (HHNum) and the number of dependents in the household (HHdepend) show some significance. The dependency is gathered from the number of children under the age of 14 and the number of elderly over the age of 50 who reside in the household, with the assumption that these groups are not economically active. Therefore, the number of people in the households both children and adult is significant, the more the people in the household and the more dependents, the less food secure the household is. This is despite the fact that these dependents could be social grant holders and may contribute to the household economy. While further investigation on this trend would shed some light on household dynamics and household income, it is however beyond the scope of this study. Not having enough money is also significant, but is not as significant as expected from previous analysis, given that over 70% of the households in the DSS supplemented food through purchase.

Axis three and four have a cumulative variance of 1.8% and 1.2% respectively, both of which are not significant. The variables clustered at the intersection of the axis one and two, mainly All death, AIDS death, as well as not enough aid or supplementing through aid and future shortage are not significant indicators. The clustering of the households indicates that the identified highly significant variables are strongly driving food insecurity for these households with approximately 75% of the data in this quadrant. As expected, a sizeable number of households are outliers, being found further from the intersection of axis one and two.

The PCA analysis indicate that the most significant variables influencing the dependent variable, not enough food in the previous month, are the utilisation and gathering of natural resources, supplementing through purchase and the number of people and dependent people in a household.

5.5.2 Regression Analysis

The factor analysis or the reduction method allowed for the discrimination of the less significant variables, leaving the significant ones for the logistic regression analysis. The variables considered for the logistic regression are:

- Number of people in the household, number of dependent people in the household, Resource Utilisation, Supplementing household food through gathering, Supplementing household food through purchase, Supplementing household food through donations and gender of the head of the household.

A binary logistic regression analysis, using the forward step-wise technique is conducted for the above variables. The omnibus tests which measure how well the model performes contain a chi-square static and a significance level for the variables analysed. If the step is to remove a variable, the exclusion is based on the significance of the change if large (i.e., greater than 0.10). If the step is to add a variable, the inclusion made sense if the significance of the change was small (i.e., less than 0.05). Five of the variables added in the model are indicated to be highly significant at a measure of 0.00 except for the sixth variable (on step 6) which is not highly significant, measured at 0.44, see model summary (Table 5.5)

Table 5.5: Logistic Regression Model Summary - FoodLMonth

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	7523.645(a)	.401	.549
2	7464.616(a)	.405	.555
3	7435.267(a)	.407	.557
4	7411.024(a)	.408	.559
5	7404.410(a)	.409	.560
6	7400.363(a)	.409	.560

A: Estimation terminated at iteration number 5 because parameter estimates changed by less than .001.

a. Variable(s) entered on step 1: NotEMoney.

b. Variable(s) entered on step 2: SupDonate.

c. Variable(s) entered on step 3: SupBuy.

d. Variable(s) entered on step 4: HHGender#.

e. Variable(s) entered on step 5: Hhdependent.

f. Variable(s) entered on step 6: Resource.

The dependent variable for this model is the availability of food in the household during the previous month (FoodLMonth). The availability of money in the household to buy food is the most significant variable, explaining more than half the data at 54.9% (Table 5.6), indicating the importance of economic factors for food accessibility. The next variable (SupDonate) shows little significance at 6% compared. All the subsequent variables SupBuy, HHGender and HHdependent with 2% and 1% of variability in the model are the last to be included in the model. The variation explained by Resource utilisation is measured below 0.001 (from the last variable), HHdependent, thus is not included in the model.

A measure below 0.001 implies that the variable being analysed does not add any variation nor has any impact to the overall model. Other variables not included in the model are: Feed All, SupGather, and HHTotal. While SupBuy, SupDonate and HHGender are included in the model, the percentage variability is rather neglible with a maximum of 0.006 between step1 (NotEMoney) and step 2 SupDonate and rest being 0.002. The Hosmer and Lemeshow Test, another chi-square test showing goodness-of-fit of the model gives similar results. Goodness-of-fit statistics assist in determining whether the model adequately describes the data (Kinnear and Gray, 2000). This may imply that natural resources, despite being widely used are used as a last resort, when all the other options have been exhausted.

Table 5.6: Variables in the Equation - FoodLMonth

		B	S.E.	Wald	Df	Sig.	Exp(B)
Step 1(a)	Resource	-.006	.004	2.142	1	.143	.994
	FeedAll#	-.120	.141	.721	1	.396	.887
	SupBuy	-.232	.109	4.478	1	.034	.793
	SupDonate	-.885	.126	49.565	1	.000	.413
	SupGather	-.012	.093	.015	1	.901	.989
	NotEMoney	-3.506	.062	3235.793	1	.000	.030
	Hhdependent	-.018	.029	.378	1	.539	.982
	Hhtotal	-.011	.017	.395	1	.530	.989
	HHGender#	-.314	.062	25.329	1	.000	.730
	Constant	2.957	.129	524.131	1	.000	19.242

A Variable(s) entered on step 1: Resource, FeedAll#, SupBuy, SupDonate, SupGather, NotEMoney, Hhdependent, Hhtotal, HHGender#.

The Logistic regression model using the Enter method of analysis presents results similar to the Forward step wise. Not Enough money is again highly significant, followed by SupDonate, HHGender and lastly SupBuy. Only the Sig (significance) value below 0.05 is considered significant in the model, as a driver of the dependent variable. Given the high variance explained by NotEMoney in the first logistic regression about food in the previous month, another logistic regression is conducted controlling for this variable to ascertain what variables are driving NotEMoney (not having enough money), which is the most significant variable driving food insecurity in the previous month.

Table 5.7: Logistic Regression Model Summary – NotEMoney

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	11859.204(a)	.043	.059
2	11814.863(a)	.047	.065
3	11799.588(a)	.049	.067
4	11781.128(a)	.051	.070
5	11770.843(a)	.052	.071

A: Estimation terminated at iteration number 4 because parameter estimates changed by less than .001.

a. Variable(s) entered on step 1: SupGather.

b. Variable(s) entered on step 2: Resource.

c. Variable(s) entered on step 3: Hhdependent.

d. Variable(s) entered on step 4: HHGender#.

e. Variable(s) entered on step 5: FeedAll#.

In this case SupGather explained 59% of the variance in the model (Table5.7), followed by Resource at 0.006%. In this instance, the utilisation of natural resources may determine the availability or lack thereof for money to buy food. The use of natural resources to save household income, especially the use of fire wood is also noted by Twine and Hunter (2008). Household dynamics in terms of the number of dependents and the gender of the household head are also significant, driving the availability of money (Table 5.10). As previously mentioned, these dependents might have access to social security grants which would impact on the availability of money in the household. FeedAll, based on the ability to produce enough food, is the last variable considered significant in the availability of income in the household, with the significant variable at 0.025. Variables such as HHTotal, SupDonate, and SupBuy including all the categories of mortality are not significant drivers of food insecurity or household income (Table 5.8), meaning that any form of mortality is not a driver of food insecurity in the DSS at this time.

Table 5.8: Variables in the Equation - NotEMoney

		B	S.E.	Wald	Df	Sig.	Exp(B)
Step 1(a)	Resource	.019	.003	35.234	1	.000	1.019
	FeedAll#	.233	.104	4.992	1	.025	1.263
	SupBuy	-.004	.079	.002	1	.963	.996
	SupDonate	.089	.096	.860	1	.354	1.093
	SupGather	.563	.069	66.249	1	.000	1.757
	Hhdependent	.026	.021	1.589	1	.207	1.027
	Hhtotal	.014	.012	1.274	1	.259	1.014
	HHGender#	.196	.046	18.277	1	.000	1.217
	Constant	-1.697	.094	327.806	1	.000	.183

A: Variable(s) entered on step 1: Resource, FeedAll#, SupBuy, SupDonate, SupGather, Hhdependent, Hhtotal, HHGender#.

5.6 Discussion Food Security, HIV and AIDS; and Natural Resource Utilisation

A few food security indicators are selected from the Agincourt DSS database based on the Food security module of 2004 and 2007, with the availability of food in the household during the previous month, being used as the main indicator of household hunger or the dependent variable. The other variables chosen include the production of enough food to feed all the members of the household, the number of daily meals consumed by men, women and children in the household as well as dietary diversity. This allowed for the assessment of the general food security/insecurity status in the DSS between 2004 and 2007.

The prevalence of hunger in the DSS varies between the villages in the duration of the study, with food insecurity increasing in some villages and decreasing in others over the 3 year period. For example the prevalence of hunger measured at village level in 2004, 36.2% of the households in the DSS are hungry while in 2007 only 14.3% households are hungry. It is important to bear in mind that the 2007 study sample is smaller than the 2004 sample. The other indicators of hunger measured such as food production highlight that most residents in the DSS acquire food through purchase instead of growing their own food. This is supported by the results of the logistic regression which indicate not having enough money as a significant variable in determining household food security. The money could be in form of remittances, wages, grants or donation from relatives and or neighbours. This is in addition echoed by Giannecchini *et al*. (2007) who notes an increase in South African households engaging in the cash based informal economic sector, including the trade in natural resource products in the same area. Further, there is an increase in the dependence on social welfare grants making grants an essential aspect in the household economy. Nonetheless, a few of the Mozambiquan households do not have access to these grants due to lack of identification documents (Giannechinni *et al*., 2007). While none of the villages had households producing enough food to feed all the members of their households, villages with higher percentages of former Mozambican refugees are more food secure and produced more food that their South African counterparts. This is despite the spatial location of these villages in the Gabbro which has limited woody natural resources and thus one would assume less livelihood options.

The analysis of dietary diversity indicates that most households have diversified diets, an indication of availability of household income, despite unavailability of money being the most significant driver of food insecurity. This could imply that the more than 56% of food secure households do have enough income to spend on a diversified diet, while the food insecure households are more concerned about the availability of any food. There is little variation in terms of dietary diversity with highly diversified diets for both years; 34.3% for 2004 and 33.4% for 2007. One of the villages has more than 500 households in the medium diversity group. There is also an increase in more villages with more than 100 households in the high diversity range in 2004 compared to less than 450 households as the highest in any village in 2007. While the hypothesis focuses on HIV and AIDS as contributors to food insecurity at village level, all types or mortality including from HIV and AIDS did not have much of an impact on food security. This does not however discount the impact of the epidemic at household level and the potential future impacts, given the anticipated increase on adult mortality and consequently the increase in vulnerable households. Neither is there evidence of the heavy dependence on natural resources by HIV and AIDS impacted households in the DSS, this measured again at village level.

Regarding the general food production, the lack of water or climate variability (rains coming late) is cited as a major contributor to the poor harvest for both 2004 and 2007, followed by a lack of labour as the second most important factor attributed to failure to produce enough food in 2004. The lack of labour might be attributed to AIDS mortality, illness and migration in and out of the DSS. Further the size of the fields and plots contributed to poor yields in 2007, with many households cultivating two fields to increase crop yields as noted in other part of the region (Giannechinni *et al*., 2007).

As mentioned earlier, the likely drivers/causes of food insecurity based on the indicators are further explored and these vary from physical, social and economic. The availability of money and the gathering of natural resources were the most significant drivers of food insecurity in the DSS in both years. Despite not being a pertinent driver of food insecurity, according to the regression analysis, the lack of labour is cited by 17% of households in 2004 and 12% in 2007 as the second and third causes of inability to produce enough food, contributing to food insecurity. This could have resulted in the considerable areas of abandoned and fallow fields noted during field work, especially between villages. Field work was conducted in the summer, during peak cultivation time for staples such as maize. It was easy, therefore, to differentiate between the active, fallow and abandoned fields. Some of the abandoned fields are located close to abandoned homesteads. Various hypotheses may be advanced to explain this trend.

Firstly, there might be a lack of labour to till the land as a result of:

- Aids deaths, which are robbing the area of prime aged adults and killing more women than men. Traditionally it is the duty of women to till and cultivate the land;

- Unemployment and a lack of livelihood options in the area may have led to out-migration by the younger population, including women to search for jobs in the nearby towns and farms, leaving limited household members to till the land;

- A general trend across Africa to abandon agriculture for livelihood options associated with more urban, cash-based lifestyles, even in rural areas (Bryceson, 1999).

The phenomenon of migration, both permanent and temporary has been noted by Collinson *et al,* (2007)[37] on studies on migration in the surveillance site, during two study periods, from 1994–1998 and 1998–2003. It has been noted that permanent migration for younger women (ages 15–34) and children has increased compared to their male counterparts over the same periods. Similarly, in terms of temporary migration, more males aged from 25–54 are migrating compared to their female counterparts and this involves more than half the male population. While the rates of temporary migration for the females is lower than for the males, it is still higher than for the permanent migration, involving women aged 25–49. Temporary migration is undertaken mainly for seeking employment while permanent migration is undertaken more for personal reasons such as marriage or divorce (Collinson *et al.*, 2007). In 2009, five villages in the DSS, villages 1, 3, 9, 11 and 16, have more than one thousand temporary male and female migrants. Village 1 has the highest number of temporary migrants, with 1168 male and 747 female migrants, followed by village 11 with 803 male and 397 female migrants, while village 3 has 702 male and 365 female migrants. These villages are also the more food insecure. The more food secure villages, 18 and 19 have the less than two hundred male and female migrants, while village 20 has 203 migrants. In light of these findings, it would be interesting to investigate the influence of migration on household food security through remittances. Another possible explanation for some of the abandoned fields is the relocation of some families from isolated settlements to more formalised ones, as noted again during the field work.

Regarding supplementing of household food, in 2004, 43% of households gathered natural resources, as the second highest means, with the first being buying of food. The utilisation of natural resources as a buffer against internal and external stressors as well as a means of saving households income cuts across all the different strata, the food secure, food insecure, HIV and non-HIV impacted households. As highlighted by the

[37] Collinson *et al* studied migration settlement change and health in post apartheid South Africa

second logistic regression, the utilisation of natural resources is a significant variable in the availability of household income. The second logistic regression to ascertain the drivers of not enough money is conducted given the high variance explained by this variable on the dependent variable, food in the previous month. Natural resource utilisation is based on the total utilisation of all natural resource products. Other significant indicators are, the total number of dependents in the household, the gender of the household head and if the households produced enough food to feed themselves. While it is important to remember that correlation or significance does not mean causation, the importance of money and the natural resource base as drivers of food security in the DSS are significantly noted, supporting previous studies by Hunter *et al*. (2007) and Twine and Hunter (2008). The broader implication of these findings and the discussion above serve to highlight the complex nature of food security and the myriad of adaptation and coping strategies as well as the social and economic dynamics in rural households, rural economies and livelihoods. The findings have further highlighted the vulnerability of female headed households to food insecurity. These complexities have adverse implications in the designing of policies and or interventions intended to address food security, health and environment issues in an effort to make rural livelihoods and food security sustainable.

In terms of answering the first question, investigating the prevalence of hunger, the impact of AIDS mortality on food security and the utilisation of natural resources, the analysis has indicated that there are some correlations between mortality, both AIDS and non AIDS related and food security at household level. These correlations are not so clear at village level, a scale undertaken in this study. Further, the utilisation of natural resources is prevalent for all households in the rural areas, which is important for the management of these important resources and for the livelihood of people in the DSS.

CHAPTER SIX

LAND-USE LAND-COVER CHANGE AND NATURAL RESOURCE DEPENDENCE

6.1 Introduction

The previous chapter has presented the results of the demographic data analysis, giving insight into the status of food security and utilisation of natural resources in the DSS based on various indicators, including food production. The utilisation of natural resources to supplement household food and income, in particular the types of natural products gathered and the frequency of gathering were examined. More than half the population in the DSS relied on natural resources especially wild herbs and wild fruit, as well as insect and bush meat to supplement food and household income.

As highlighted in Chapter 5, while availability of household income is the main driver of food insecurity, the utilisation of, or the gathering of natural resources is the main underlying driver of food insecurity in the DSS. The collection or gathering of these natural resources, mainly done in areas between the villages and in the village commons is a coping strategy for most households, be they food secure or insecure and whether they are affected by AIDS mortality or not. Thus chapter 5 has highlighted the importance of natural resources to all households in the study area, raising questions of proximity and availability of these resources to the villagers. While quantifying natural resources is essential, the optimum utilisation of the resources is also dependent on the state of the available resources, with issues of resource degradation being of grave concern. Quantifying of natural resources, in this case is conducted through the assessment of woody vegetation, premised on the classes defined in Chapter 4, with the assumption that woody vegetation resources offer more choices for supplementing dietary diversity, such as the gathering of bush meat and rain frogs and for supplementing household income such as collection of wild fruit and fuel wood. The assessment of woody vegetation resources in this research is conducted using remote sensing tools for vegetation mapping and landcover change analysis to allow the monitoring of natural resources. The vegetation indices, mainly NDVI allows for the monitoring of the state of vegetation.

In this chapter, the availability and state of natural resources will be analysed with the aim to quantity resource availability and status, to identify possible hotspots of degradation. As previously mentioned, the location of the natural resources influenced the choice of scale for this study, with the areas of focus including the village commons or areas between villages where most of the natural resources are located.

This chapter presents results for research question two, *"What is the relationship between the dependence on natural resources as a source of food and/or livelihood to resource or land degradation?"* relating to land-use and landcover change and the identification of possible hotspots of resource degradation in relation to resource availability and dependence. Different data sources are used and these include Landsat TM and NDVI (Normalised Difference Vegetation Index) for land cover change analysis and SPOT imagery for the mapping of natural resource availability.

Some of the findings for research question two are:

- There is a general decline in some forms of natural resources, especially woody vegetation resources, with spatial (in terms of area) and biomass losses in most woody vegetation classes;
- Reduction in other vegetation classes although these losses are small and these resources are more or less renewable;
- Hotspots of possible resource degradation are identified where there is a correlation between household hunger and resource utilisation;
- Hotspots of degradation implying possible over exploitation as a cause and effect of food insecurity.

The **first section** of this chapter discusses land cover change from 1990, 2001, 2005 and natural resource mapping. The reclassification of the land cover maps, highlighting areas of change and hotspots of possible degradation are presented including the two methods for this process, NDVI simple differencing and CVA (Change vector analysis). The section of the conceptual framework being covered is highlighted in Figure 6.1.

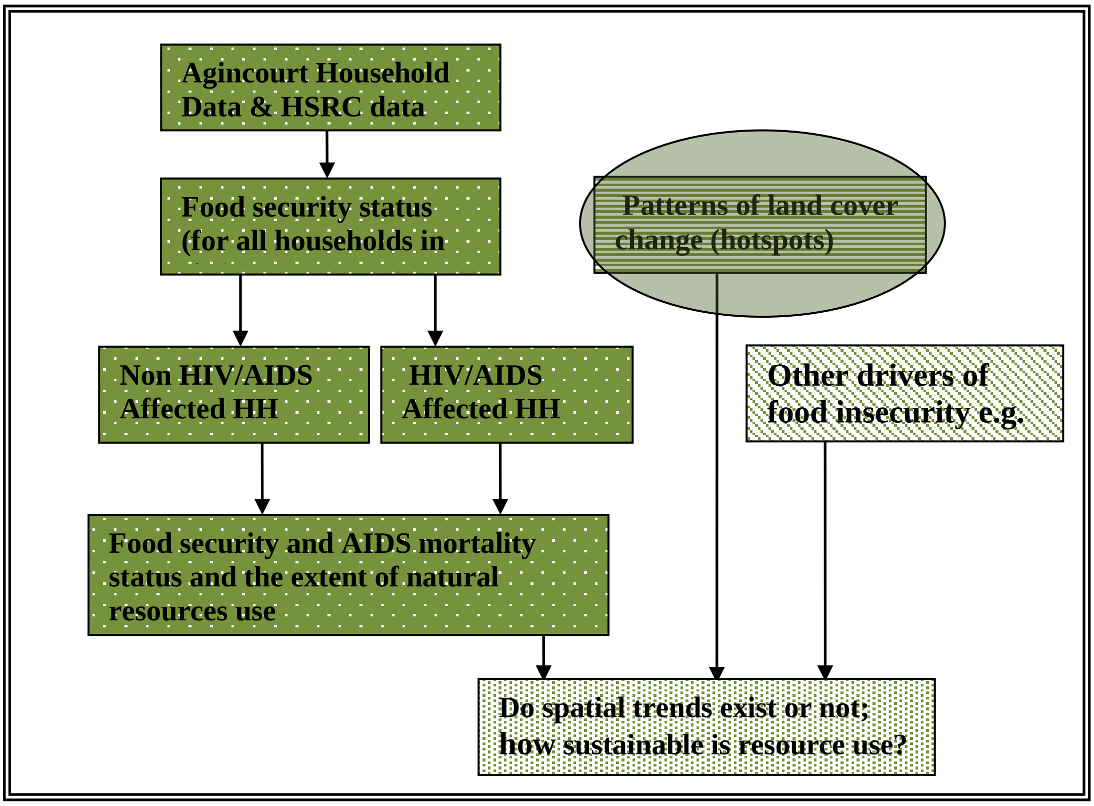

Figure 6.1: Conceptual diagram highlighting section covered in chapter 6

The analysis of natural resources utilisation produced a map of village natural resource utilisation (Figure 6.2) which is further utilised in the analysis of land use and land cover data derived in this chapter. The natural resource utilisation data is analysed in an attempt to investigate existing linkages between natural resource utilisation and areas of land cover change as well as resource availability in the DSS.

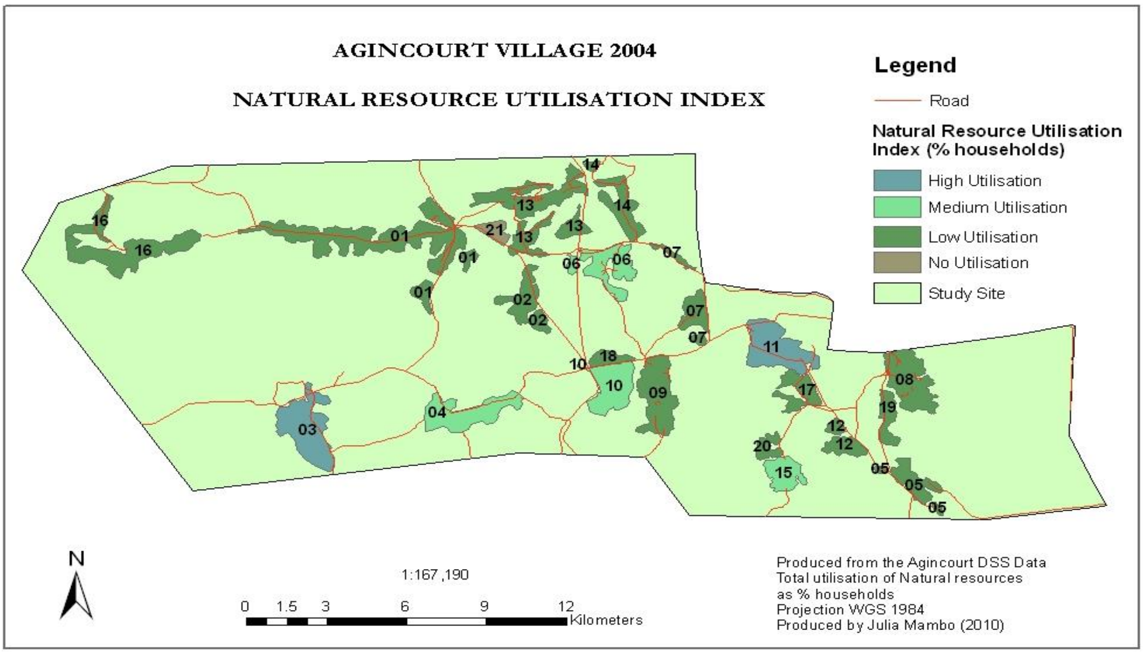

Figure 6.2: Natural Resource Utilisation by Village in 2004

6.2 Vegetation/Land cover Mapping

Vegetation mapping or landcover mapping as well as the landcover change is conducted using satellite remotely sensed (RS) data, Landsat TM in a Geographic Information systems (GIS) and remote sensing (RS) environment. While the vegetation mapping will highlight or map the landcover based on the vegetation classification in Chapter 4, the intention of the landcover change will investigate areas of possible degradation and or over utilisation of forest resources. As mentioned in the methodology, three different types of image classification are conducted and the best results chosen for further analysis. The results of the different methods are presented below.

6.2.1 Land Cover Classes 1990

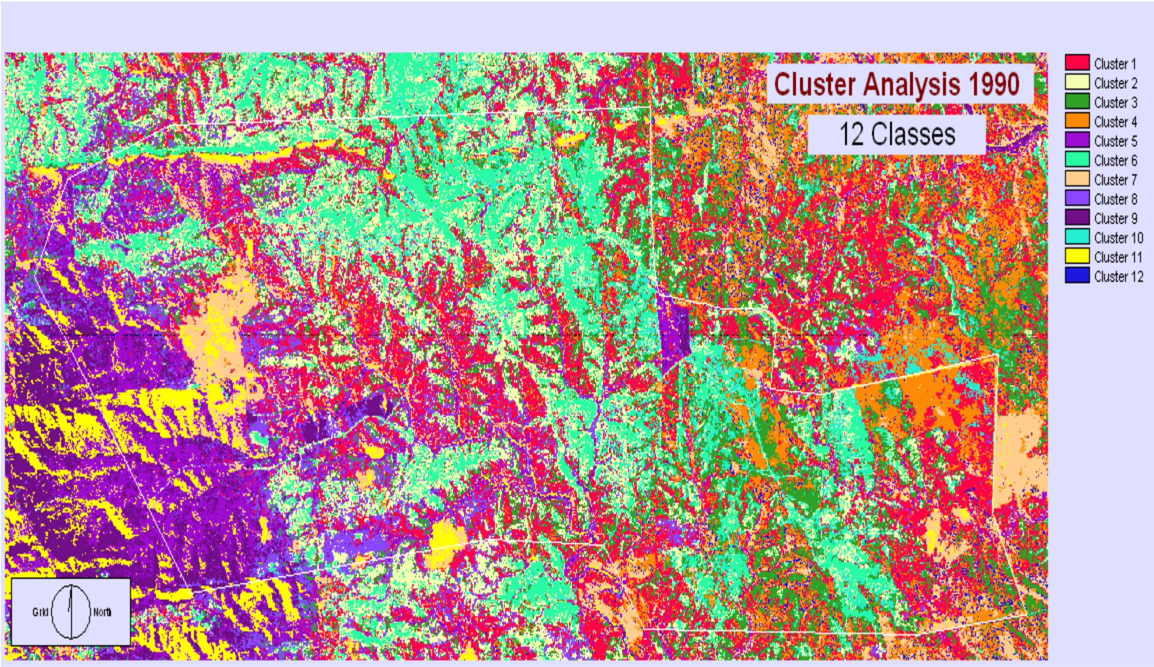

Figure 6.3 Unsupervised classification of Landsat TM 1990

The unsupervised classification provided an idea of the possible landcover classes in the study area (Figure 6.3), with 12 classes identified, which are highly fragmented and the images are too grainy but some distinct classes are noted. These classes, in conjunction with the field points collected are used as a basis for training site development.

The image chosen for further analysis is derived from the MAXLIKE (maximum likelihood) classification (Figure 6.4), which presents the best results for the classification and is presented below.

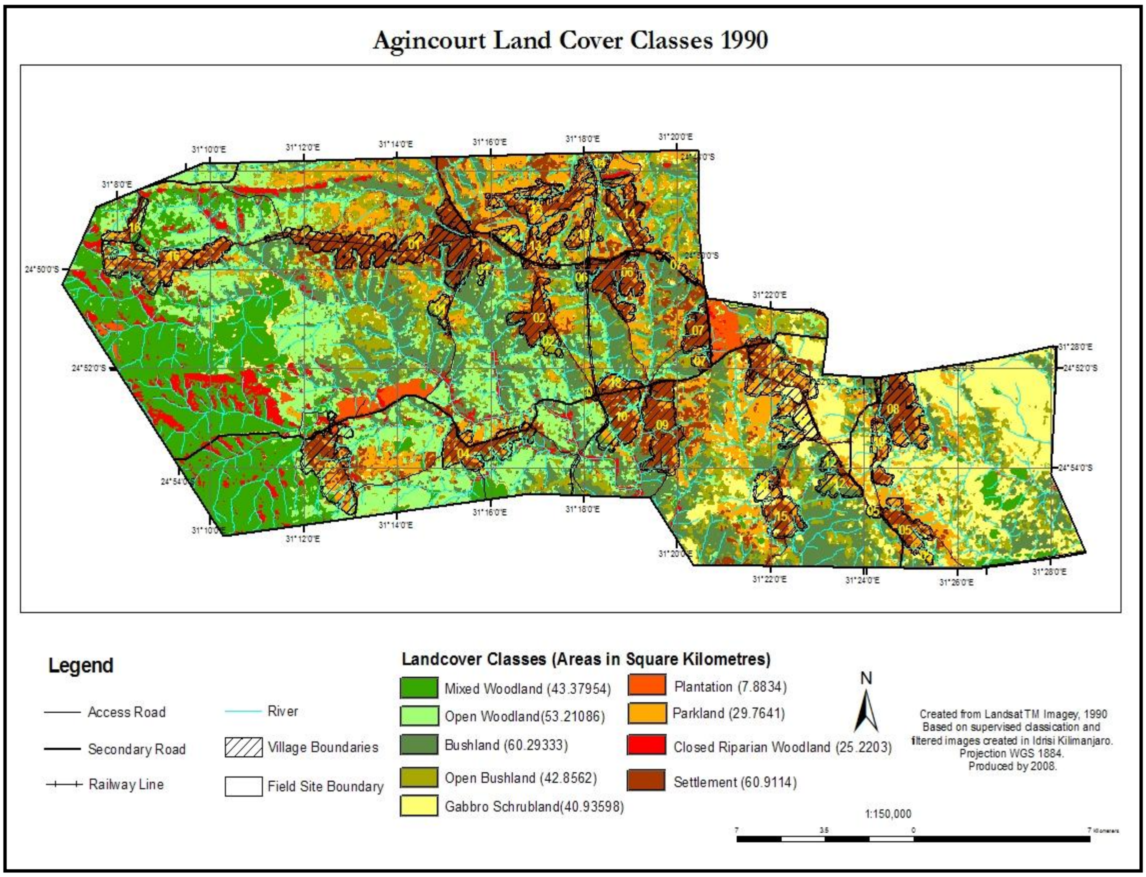

Figure 6.4: Land Cover classes based on Landsat TM 1990

The area extent for settlements or the villages and parkland, which are areas of cultivation, are notably smaller in 1990 compared to 2001 and 2005. The settlements are overlaid with the 2006 village boundaries, highlighting the difference in the actual extent of the settlements on the image. This is especially noted around village 16, where the hatched area is the current extent of the village and the dark brown areas the estimated area of the village in 1990 (see Figures 6.9 a, b and c). However the statistics generated for settlement highlight a size of 60.9114 km^2, making settlement in 1990 larger than the other two years. There are fragmented settlement areas that are not in designated villages such as near villages 07 and 09, between villages 03 and 04, and in the areas above village 13. These areas could have augmented the total area of settlement in 1990. The area for parkland (which is mainly cultivated fields), on the other hand, is smallest in 1990 and increases with the progression of the years. This corresponds with the growth of population from 1992 when the DSS is established and consequently the increase in parkland as the population continues to grow, requiring more land for subsistence farming. Similarly, the statistics for the mixed woodland follow the same trend with mixed woodland in 1990 at 43.37954 km^2, being smaller than in the years 2001 and 2005. The size of the Gabbro scrubland, as one of the classes affected by fires fluctuates between 1990 and 2001. The classification of dams is problematic due the similarities in reflectance of water and fire scars. Further the size of the dams on the original images is too small to collect reasonable test signatures for classification.

In this image, additional classes such as sisal plantations, which existed during apartheid, are mapped. These were abandoned after apartheid and it is clearly visible that as the years progress, the plantations become fragmented into bushland. The Gabbro intrusions seem much larger on this image compared to the other two years. This could be attributed to, amongst other factors, the classification based on adjusted field points which, as mentioned previously, are based on SPOT imagery, but are adjusted for use on Landsat imagery.

6.2.2 Land Cover Classes 2001

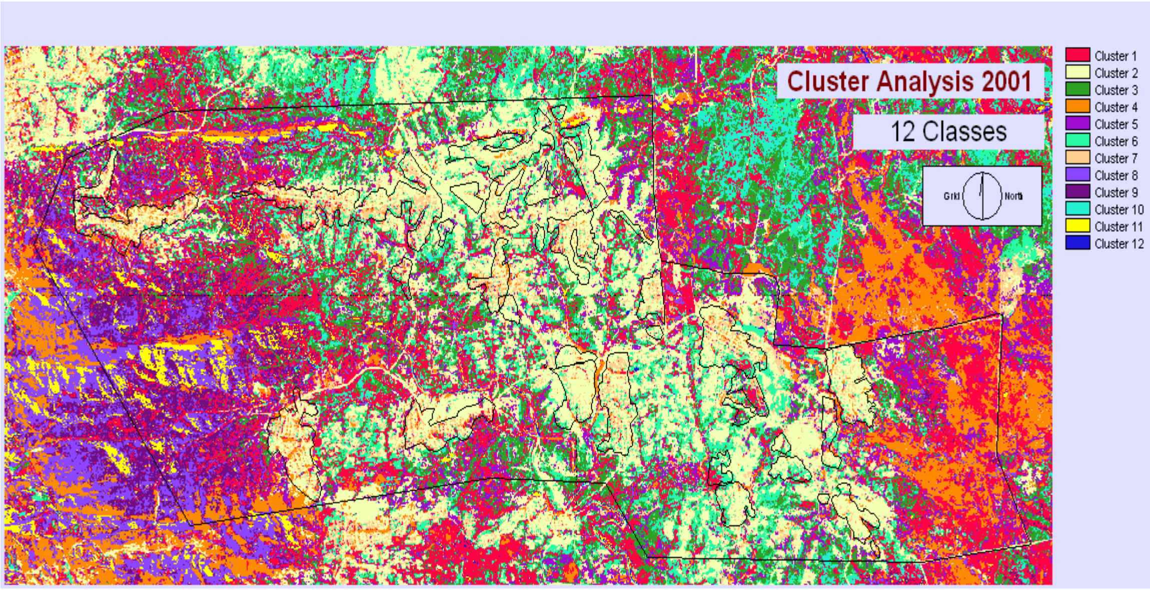

Figure 6.5: Unsupervised Classification 2001

The unsupervised classification image (Figure 6.5) is based on the twelve classes similar to the 1990. The settlement areas are well highlighted in this classification as well as parts of the Gabbro dyke. However, the rest of the classes are fragmented and the polygons too small. Unlike the 1990 unsupervised classification, the riverine in 2001 is not well defined; neither is the burnt or forest area highlighted. This image provides a good indication of the growth in settlement in the area.

The 2001 MAXLIKE image (Figure 6.6) shows an increase in the extent of parkland from 29.7641 km^2 to 61.5462 km^2 in 2001, particularly observed between the villages. The substantial increase may be attributed to the growth in population, while settlement is considerably reduced to 44.7211 km^2 over the eleven year period. Whilst the statistical areas seem reduced, there is still evidence of growth within the formalised villages. In addition, there are still fragmented areas of settlement outside the village boundaries. Migration from isolated dwellings to more formalised villages might be a likely explanation for this trend. This was observed in some areas during the field work and was mentioned by the field guide.

The large area extents of fire scars noted in the 1990 image have now been replaced by woodland. Fires are a regular occurrence in this area happening annually. Fires are a necessary ecosystem tool for savanna woodlands, assisting in the regeneration of new vegetation (Twine, pers. comm. 2007), thus the combination of fires and good rains would result in vegetation growth in previously burnt areas. The extent of the mixed woodland in 2001 is considerably larger than in the previous year, 1990, possibly due to areas previously mapped as fires scars in 1990 being classified as mixed or open woodland, especially toward the Bushbuckridge Nature reserve. Possibly the recovery of the vegetation after the fires contributes to this increase in area. Consequently, fire scars towards Sabie Sands are classified as riparian/closed woodland and Gabbro bushland/scrub land. These results correspond to the change image (Figure 6.13), which shows positive change in the same area between 1990 and 2001. While open woodland and bushland are located near the villages, open bushland seems to be the most dominant class in this image. It is yet again problematic to map dams in this image.

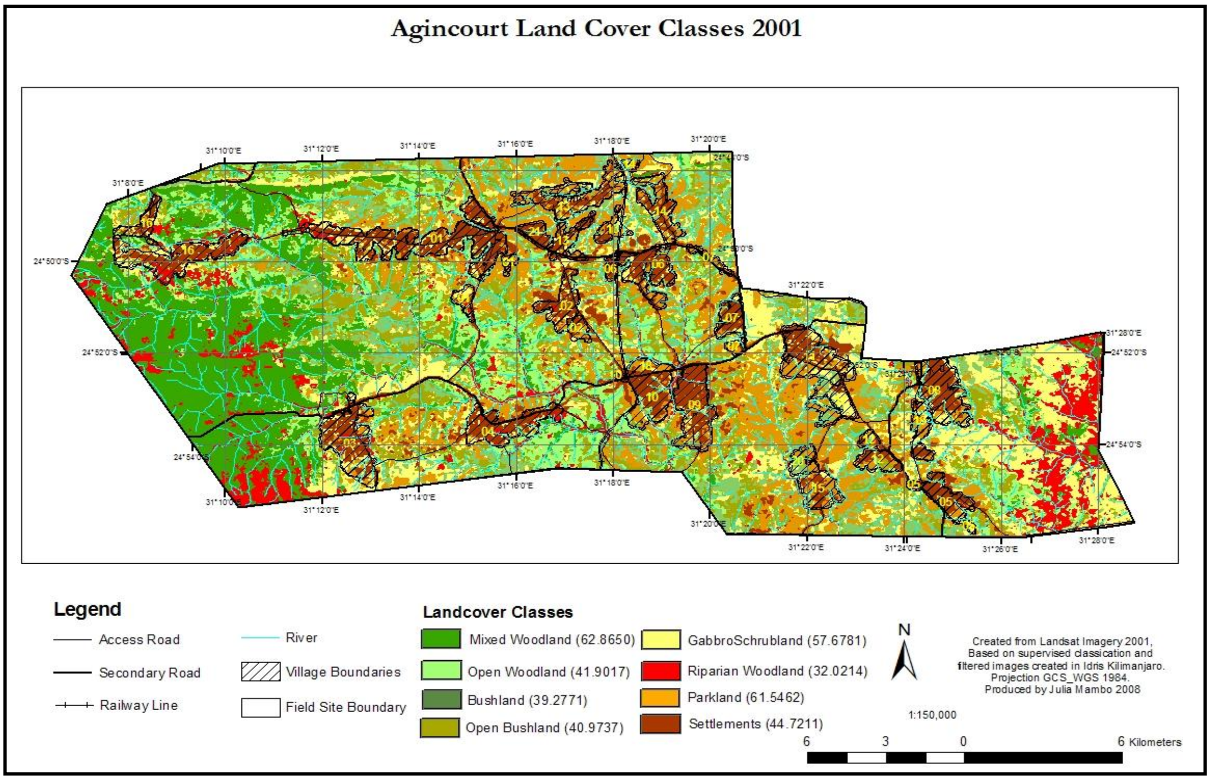

Figure 6.6: Land Cover classes based on Landsat TM 2001

6.2.3 Land Cover Classes 2005

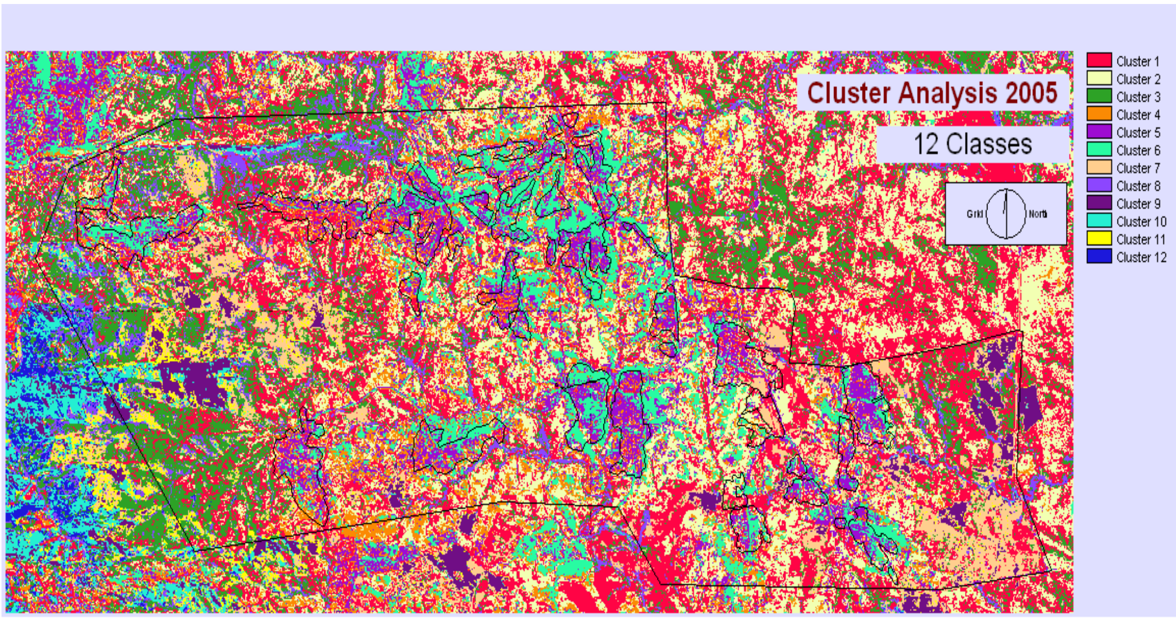

Figure 6.7: Unsupervised classification 2005

Unlike the 2001 unsupervised classification in which the settlement class is well defined, no distinct classes are identified in 2005 (Figure 6.7). Similarly as in the previous MINDIST methods 1990 and 2001, the results for 2005 are not any different and are thus not included in any subsequent analysis or discussion.

In contrast to the previous two years, the analysis for 2005 landcover is based on the FISHER classification (Figure 6.8) which produced better results than the MAXLIKE. This could be attributed to the pre-processing of the 2005 image which is resampled and re-georeferenced from a different geographic projection to match the 1990 and 2001 images. The extent of settlements, at 53.5584 km^2 particularly in and around villages 01, 04, 09 and 16, has increased in comparison to year 2001. Although there is still evidence of settlements outside the formal village boundaries, the area extent is still smaller than in 1990. There is an overall increase in other village extents in the study area. In addition there is a consolidation in the area under parkland, especially between villages 04 and 05, where as in 2001 it is fragmented, with settlements. Parkland is the biggest landcover class in this image, with a size of 78.2228 km^2.

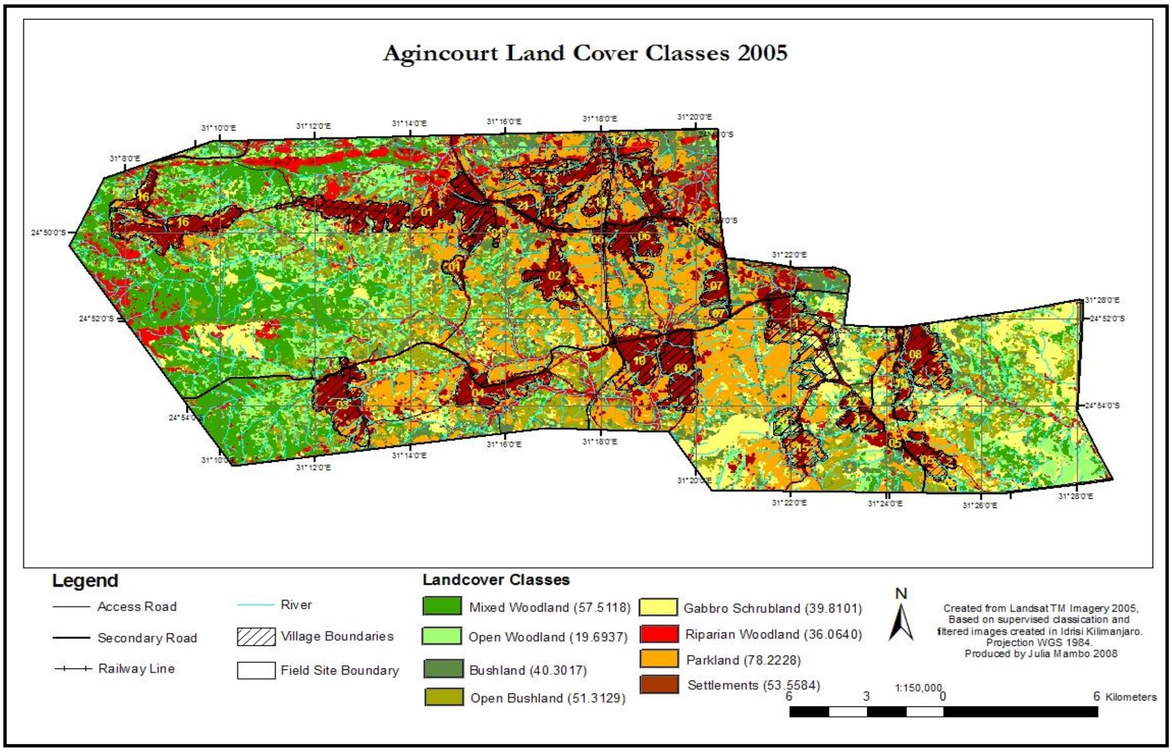

Figure 6.8: Land cover classes in 2005

6.2.4 Land-cover classes 1990 – 2005

There is a steady increase in the riparian/closed woodland from 25.2203 km^2 in 1990 to 36.0640 km^2 in 2005. In 1990, it is mainly the vegetation along the rivers and within the nature reserve that is classified as riparian/closed woodland. In 2005, the increase in the same class is mostly visible around and along the Xanthia ridge and along riverine areas. This landcover class as well as the species located in these wet areas influence the change in area. Further, the increase in area could be attributed to the field points collected and possibly the time of year the images are taken and the time of the ground truthing. The ground truthing is conducted after good rains in the area.

The extent of the Gabbro area increases considerably due to the classification of areas that are previously fire scars being added to this class. As evidenced in the landcover maps, the Gabbro areas which are mainly grasslands are prone to fires. However, some areas of the Gabbro are characterised by bushland type vegetation while other have fire scars, both of which are bound to influence the areas of this class. It is also important to remember that errors do occur during any automated process which can also impact on the area and outcome.

The extent of the woodland and bushland areas seem greatly reduced, giving way to open bushland, parkland and riparian/closed woodland. Parkland areas as described in chapter 4 are located around villages and are composed of active, fallow and abandoned fields located between villages and in and around abandoned homesteads. The increase in parkland is maybe attributed to the increase in population in the study site, increasing the demand for cultivation land and fields. As highlighted in Chapter 5, there is a shortage of land for subsistence farming in this area, forcing households to cultivate more than two fields to increase yield in order to feed themselves. Further, as more households move into the formalised villages, areas especially those around the villages get converted from either mixed woodland or bushland to parkland, resulting in a change in land use. Mixed and open woodlands as well mixed and open bushland are woody vegetation classes with different tree species as described in Chapter 4. Another change in land use is noted in the plantation class which is not open bushland, giving access to grazing for the villagers.

Mixed woodland and open bushland are the larger classes, despite the reduction of woodland from 2001, especially around the Bushbuckridge Nature Reserve. Despite this reduction, mixed woodland remains the largest woody cover class on this image, with an area of 57.5118 $km^{2.}$ It is important to note that before the formalisation of the villages and the formation of the DSS, this area was largely comprised of mixed woodland, with households and small villages sporadically located. Thus, while the growth of population, including the influx of immigrants from Mozambique as well as the demand for woody resources increased, the area of mixed woodland and open bushland remains big. Mixed woodlands are relatively intact, with tree heights approximately above four metres and the canopy cover dense as well as minimal human disturbance, limited mainly to grazing. The mixed woodland is replaced mainly by bushland and open bushland classes, particularly towards the villages. Open bushland with an area of 51.3129 km^2 is the second largest, despite the aforementioned reduction. Open bushland is located closer to and surrounding some of the villages. The reduction in these two classes may be attributed to an increase in harvesting of resources by the surrounding villages, due to the growth in population driving this demand, given that bushland and mixed woodland are utilised for grazing and collection of natural resources. The reduction in these two classes is an indication of the pressure on natural resources in the study area, with important implications for over exploitation and possible degradation of natural resources.

Plantations are replaced by a fragmentation of bushland and open bushland, changing the land use for these classes from mainly plantation to bushland, used for grazing and collection of natural resources. Further, other tree species have been introduced into these plantations giving them the bushland characteristic. For a comparison of the statistics for land cover classes from 1990, 2001 and 2005 refer to Figure 6.8 below.

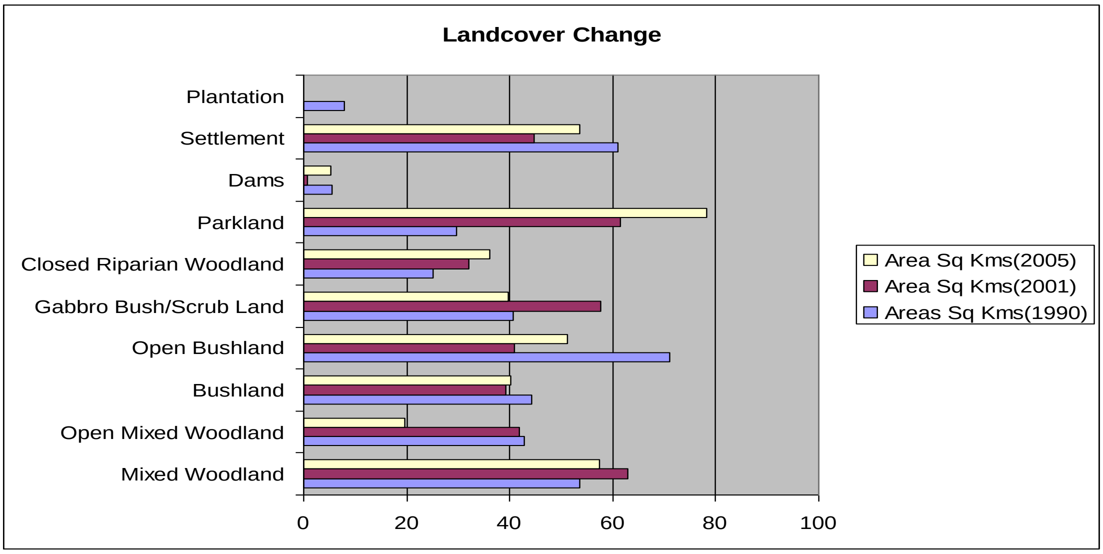

Figure 6.8: A comparison of the land cover classes for 1990, 2001 and 2005.

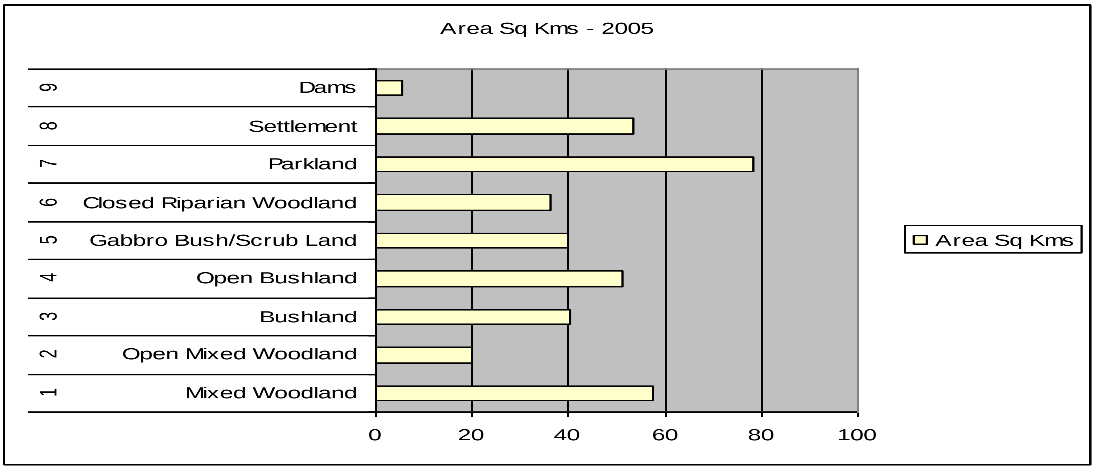

Figure 6.8 a: Land cover statistics – 2005

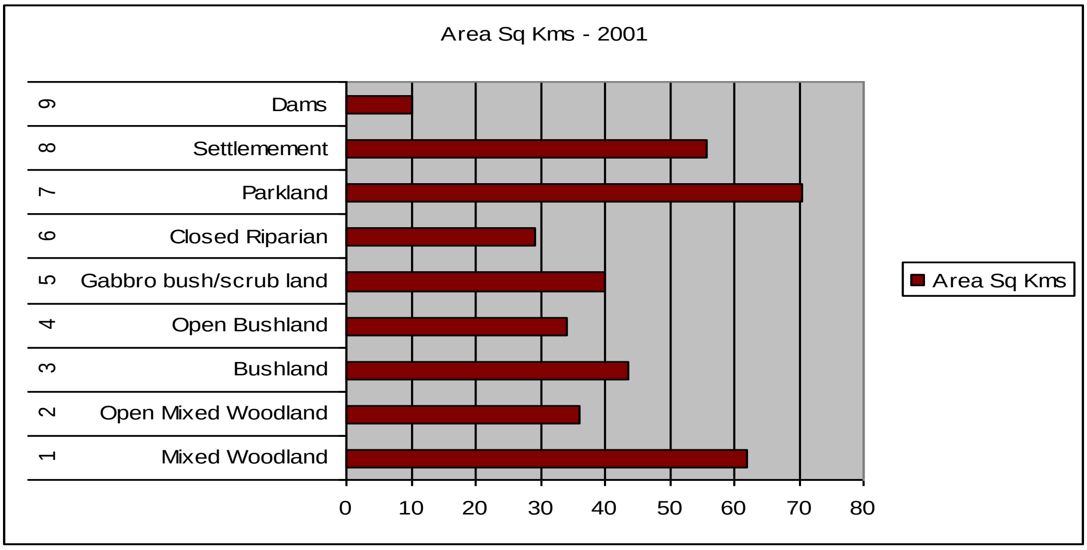

Figure 6.8 b: Landcover area statistics – 2001

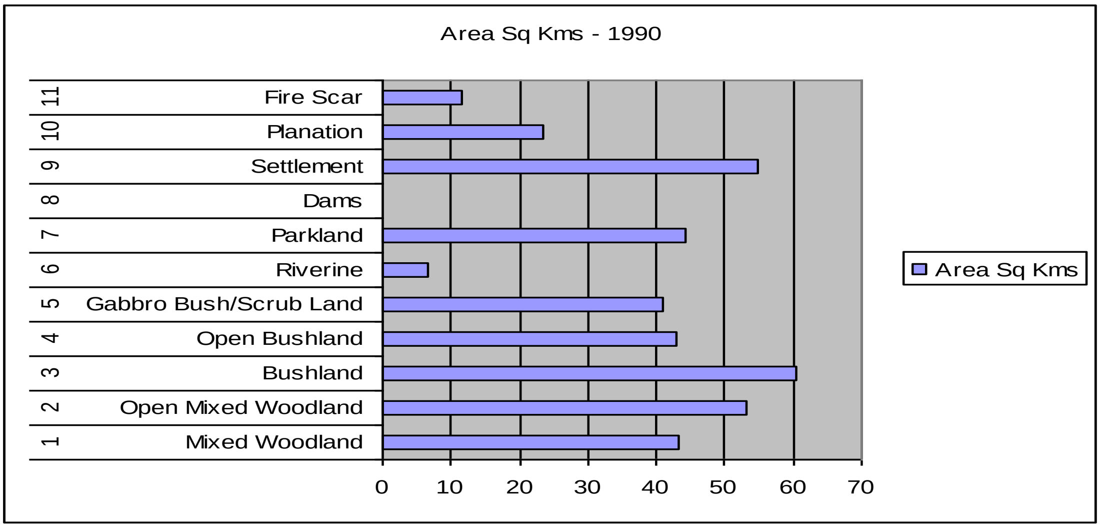

Figure 6.8 c: Land cover area statistics – 1990

6.2.5 Comparison of growth of settlement over the years 1990, 2001 and 2005

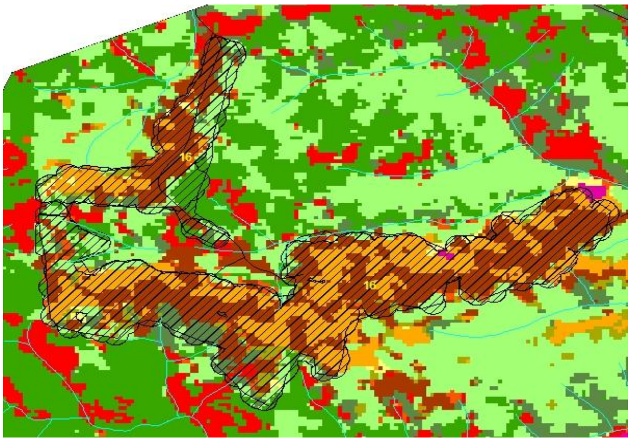

Figure 6.9a: Village 16 in 1990

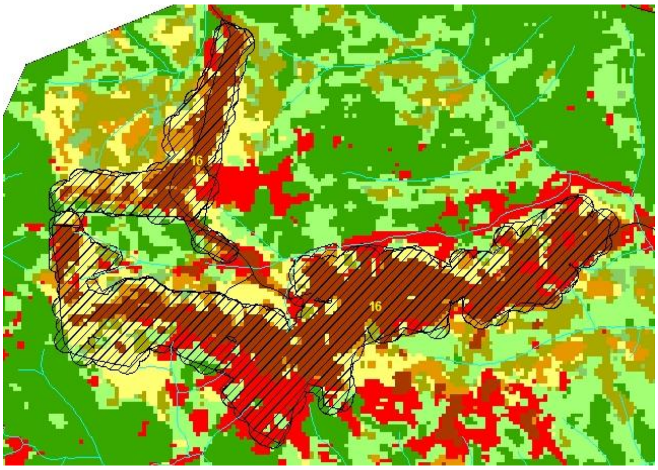

Figure 6.9b: Village 16 in 2001

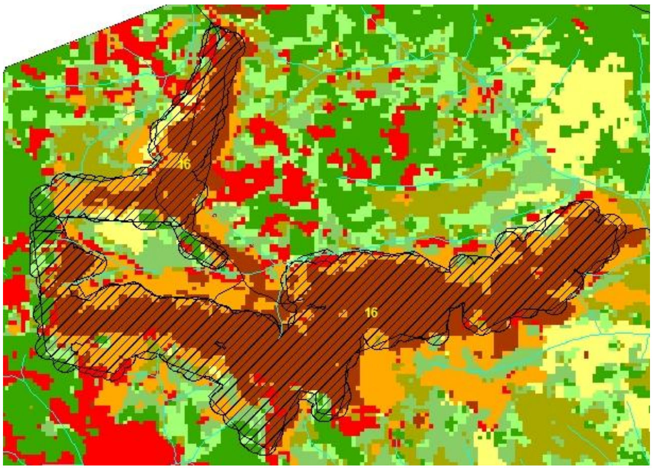

Figure 6.9c: Village 16 in 2005

The changes in the settlement of village 16 are mapped from 1990 to 2005 (Figure 6.9a-c). Village 16 is chosen because of its medium size in terms of spatial area and location (isolated from other villages) and population size. Additionally, the changes in settlement patterns in this village are clearly illustrated, as noted in the images. In 1990, the settlement is fragmented with parkland. In 2002, the parkland has been replaced by settlement and there is limited parkland. In 2005, the parkland is now located on the outskirts of the settlements. Consequently there is an increase in parkland in and around the villages, with additional increase in settlement areas. As mentioned earlier, approximately, 60–70% of the families cultivated arable fields on the periphery of the village in 2003, an increase from the estimated 30–40% in 2000 (Shackleton, 2000). This is noted through the increase in parkland area in the DSS as illustrated in the previous chapter, coinciding with the increase in population in the DSS, from 8896 households in 1992 to over 12000 households in 26 villages in 2008.

The generated land cover images are subtracted from each other to determine areas of change between 1990 and 2001 as well as 2001 and 2005. The subsequent image processing is conducted on the resultant images and the results are discussed in the next section.

6.3 Landcover Change Analysis

As previously mentioned, the reclassification of change images is a technique for highlighting areas of negative (loss in vegetation), positive (gain in vegetation) and no change, with areas of negative change possibly linked to hotspots of degradation.

6.3.1 1990–2001 (Figure 6.10)

The change images are derived from the **image differencing** of all images with the first one from 1990 to 2001 and the second from 2001 to 2005 and these are further reclassified to show areas of positive change in white, negative change in red and no change in black. The change results are consistent for all images derived from the unsupervised and supervised classification (Figure 6.10).

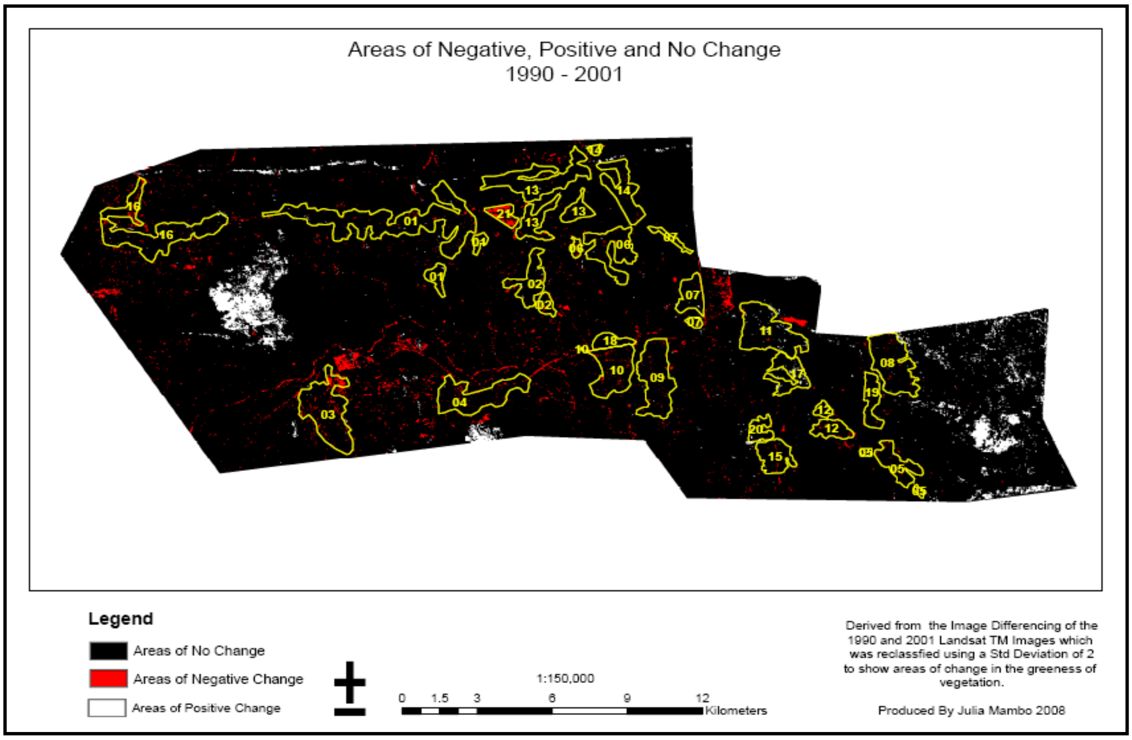

Figure 6.10: Land cover change in the Agincourt DSS between 1990 and 2001

The area of most vegetation loss is around village 21, where vegetation is cleared to make way for an RDP village. More negative change is observed between villages 03 and 04 and in areas located close to village 16. The area that is previously plantation, located near village 3 also indicates negative change, an indication of vegetation loss. More negative change is noted between villages 7 and 11 and the area next to village 11 which shows high negative change currently comprises of a dam, suggesting that vegetation was cleared for dam construction. Vegetation around the villages 05, 13 and 15, which experienced spatial and population growth, also indicate negative change during this period. Negative change is also observed where the roads have been constructed, especially around villages 3, 4 and 10.

There is however some positive change in the areas around the Xanthia ridge and areas where the fire scars are located, mainly in the Bushbuckridge Nature Reserve and the

Sabie Sands Nature Reserve. The positive change may be attributed to the year 2000 being a very wet year, characterised by high rainfall and floods. This may have promoted more tree growth on ridges, which are usually well drained therefore often quite dry due to runoff. Fire stimulates new growth, removes much of the dead, moribund material, and results in coppicing. This combined with the good rains received may account for the increase in vegetation cover in the fire scar areas. Further investigations in the areas of positive change may be needed but is that is beyond the scope of this study.

6.3.2 2001–2005 (Figure 6.11)

The most notable change between 2001 and 2005 is shown within the boundary of village 08 of which the food security status changed from medium prevalence in 2004 to high in 2007, but has low natural resource utilisation status (see Figure 6.11). It is also important to remember that village 08 is located in the Gabbro of which woody vegetation resources are limited. Other negative changes are noted around village 21 where vegetation continued to be cleared for the new RDP village. More areas showing negative change are located on the Xanthia ridge, around villages 13, 14 whose food security status is consistent in both years, medium and low respectively, while village 1‘s food security status changes from high hunger prevalence in 2004 to medium prevalence on 2007. It is interesting to note that despite being surrounded by woody vegetation classes, all these villages have low utilisation of natural resources.

Generally, the areas showing negative change are consistent, with the negative change considerably less compared to the earlier period, attributed to the different length of observation four years compared to the previous eleven years.

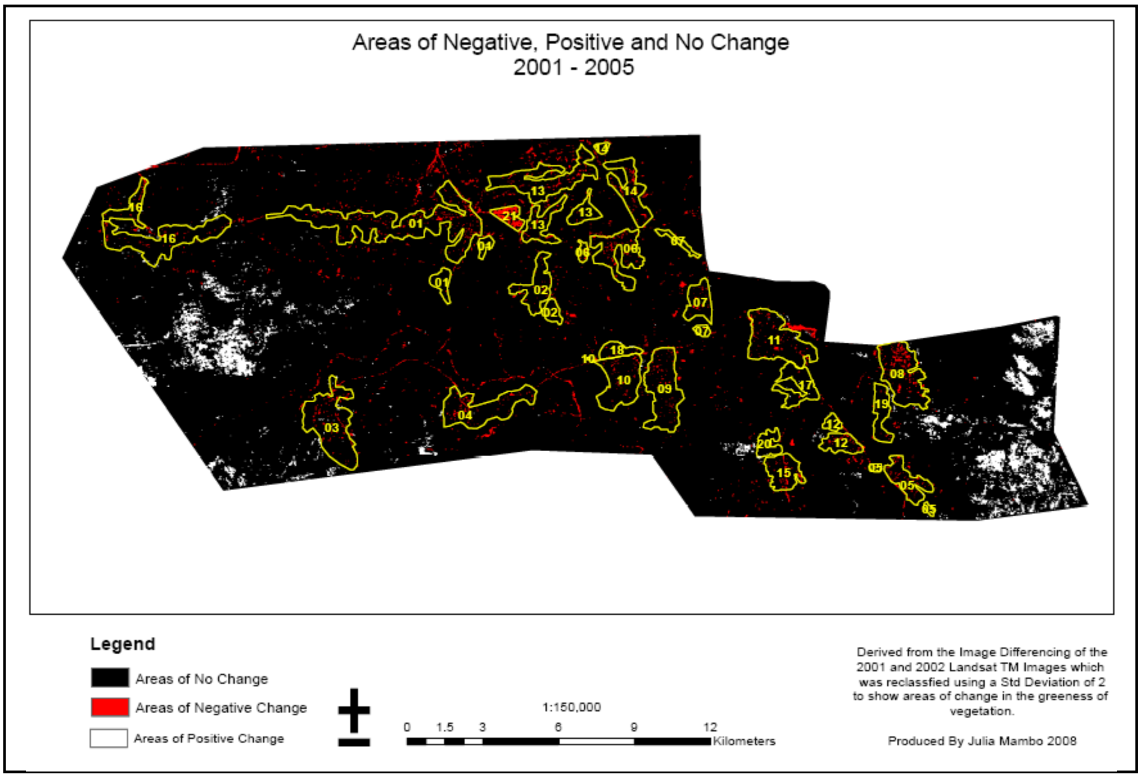

Figure 6.11: Land Cover Change in the Agincourt DSS between 2001 and 2005

The magnitude of positive change is much higher in the later period, 2001 to 2005; especially for the open bushland and the Gabbro bush and or scrub land. These areas are previously burnt as indicated in the 1990 image.

6.4 Monitoring Vegetation Change using NDVI (Normalised Difference Vegetation Index)

While three different dates of imagery are used in this study, the monitoring of vegetation change is conducted for only two dates, the commencement and the end date - 1990 and 2005 to highlight any broad changes in the biomass as well as indicate vegetation/resource condition.

Both NDVI images are derived from the Landsat imagery using two bands – band 3 the red band and band 4 the near infrared band. NDVI images indicate the greenness of vegetation in the two dates, with vegetation greenness being used to measure the health of vegetation, to highlight vegetation in distress and or vegetation degradation and hotspots.

6.4.1 NDVI 1990

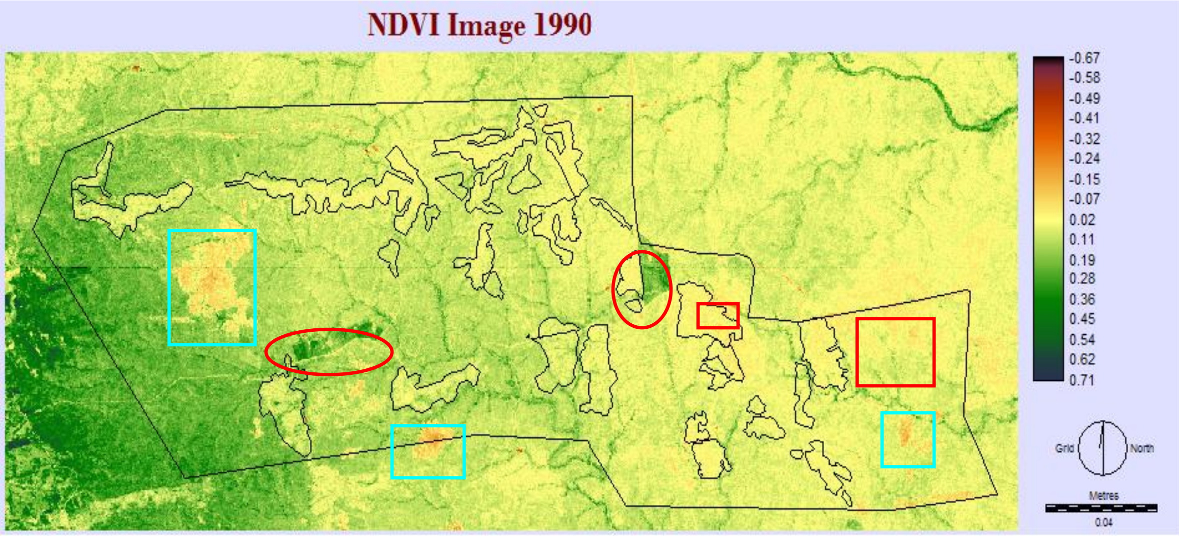

Figure 6.12: NDVI image 1990

The vegetation greenness in 1990, with higher values of up to 0.71, indicates healthier vegetation. The areas in the west side (near the Bushbuckridge Nature Reserve) and the central areas indicate healthier vegetation (Figure 6.12). This includes areas where the sisal plantations are located in the north east of the image, highlighted by the red circles on the image and the riverine vegetation (along rivers). The orange areas on the image with greenness values ranging from the negative 0.07 indicate areas with fire scars (burnt areas) with no vegetation highlighted by the blue squares. These areas are confirmed with the tones on the original image. The other orange tones indicated areas where roads had been constructed as well the presence of moisture and water, highlighted by the red square areas on the image, with the smallest red square indicating a dam. Other areas of moisture are located in the eastern area of the image where the Gabbro dyke is located. The greenness of vegetation is also higher in this image, especially for villages located in the eastern part of the DSS. This was a normal year in terms of rainfall received in the area.

6.4.2 NDVI 2005

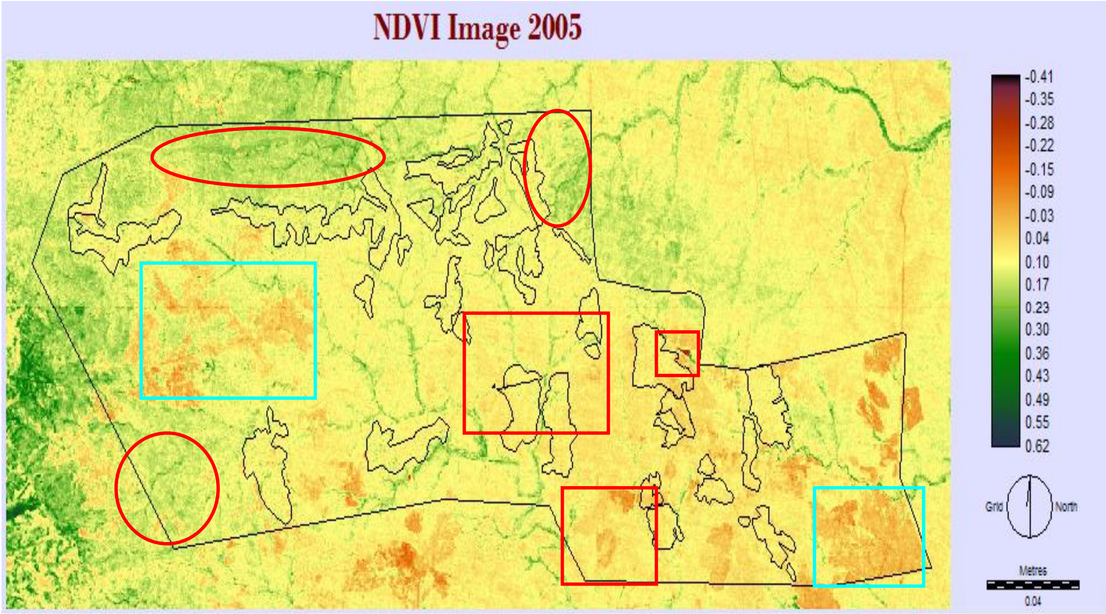

Figure 6.13: NDVI Image for 2005

The greenness values on this image are lower than on the previous image reaching only a maximum of 0.062 compared to the 0.071 on the 1990 image (Figure 6.13). The general greenness on the image is greatly reduced in the eastern and central parts leaving the only greenness restricted to the Xanthia ridge highlighted by the red oval shape on the image, and along the rivers. The other areas with some amount of greenness are indicated by the red circles on the image. The greenness within the village boundaries is immensely reduced as well. There are more moisture areas on the image as highlighted by the orange tones. The small red square, with a deep orange tone indicate a dam while the bigger red squares indicate areas of moisture which are again located in the Gabbro. Areas highlighted by the blue squares are previously burnt areas. The increase in the orange tones on the image could indicate that 2005 is a wetter year compared to 1990.

The general reduction of healthy green vegetation from 1990 to 2005 confirms the trends identified in the change images of a general decline in the woody vegetation classes. The reduction is highly noticeable in the east both within and outside the village boundaries. This trend is of concern in terms of the status of woody vegetation and resources and the implications for the livelihoods for the local population. Despite the indication that 2005 was a wetter year, provided by the amount of moisture on the image, the greenness of vegetation on this image is still greatly reduced indicating possible vegetation degradation across the whole image.

6.4.3 NDVI Change Image 1990–2001

The change image derived from the image differencing of the NDVI images further confirms the trends of change identified in the supervised classification image. The red areas show negative change, the white areas show positive change and the black areas have no change (Figure 6.14). Similar areas of change are noted for the same period despite one image being based on vegetation classification and the other on image transformation (NDVI). Vegetation reduction in Village 21 does not seem as concentrated as in the later NDVI change image, suggesting a spurt of growth from 2001. There is increased vegetation reduction or negative change in the 1990-2001 images as well, especially in the plantation areas and between villages in the south of the study area. The areas of positive change are almost identical to the classification change detection image over the same period, represented by the white areas.

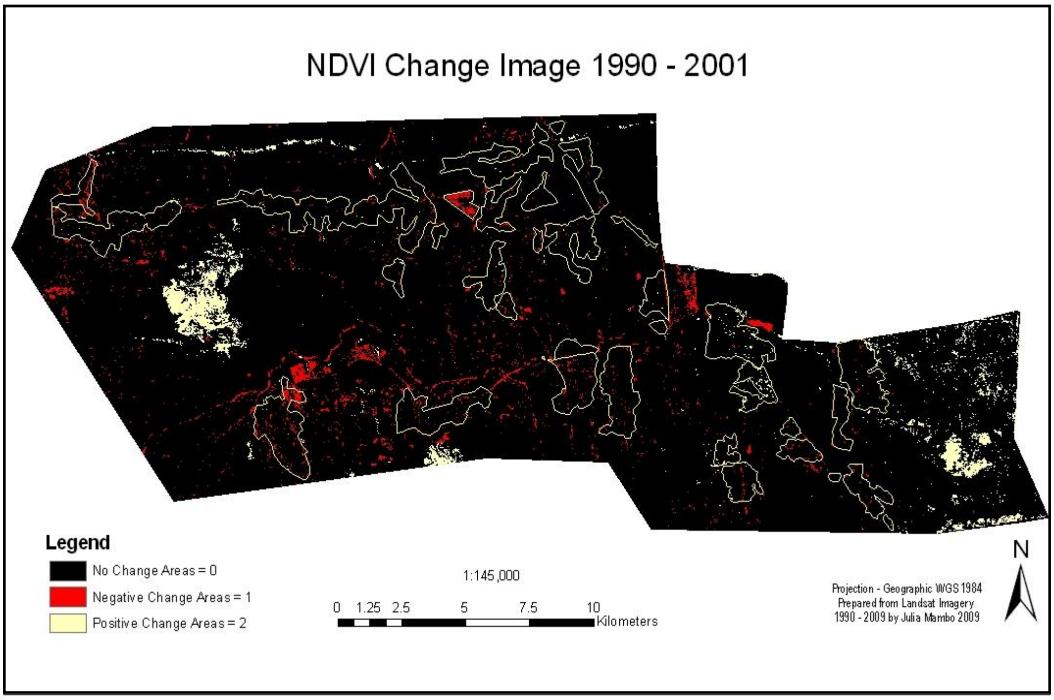

Figure 6.14: Change image derived from NDVI 1990 – 2005

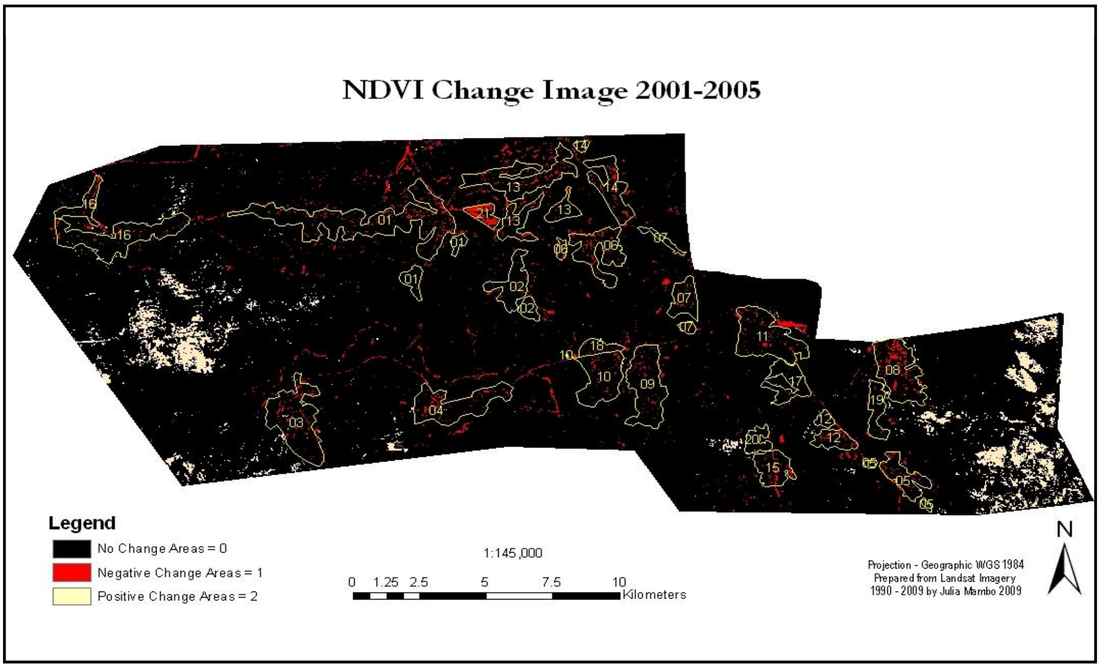

Figure 6.15: NDVI Change image 2001-2005

The changes in the NDVI change image for the later period are again almost similar to the classified change image of the same period (Figure 6.15); with the road construction particularly highlighted and increased vegetation reduction in Village 21. The plantation around village 3 has completely disappeared. The areas of positive vegetation gain are however identical on the two change images of the same period.

The general trend of vegetation change for the study period 1990–2005 (Figure 6.16), indicate that most of the vegetation reduction or negative change occurred in the west, around village 3 and 4, village 16 and the lower section of village 1, which are bordering the Bushbuckridge Nature Reserve. This suggests encroachment onto the forest reserve to access the woody and other resources. In addition, the plantations areas are indicated as negative vegetation zones, with small areas shown in the south east. Most of the negative change that occurs including the areas around Village 21 is not highlighted. Neither are roads constructed in the study area nor the dam areas indicated over this eleven year gap. The possible explanation for the observation could be the study period being investigated, with the first change detection between 1990 and 2001 and then 2001 to 2005, which are much shorter periods of change, while this change detection is conducted over the 11 year period, from 1990 to 2005. Further, the first and second change detection is conducted on land-cover images, which have been classified and thus would have shown reduction in vegetation spatially. The classification of NDVI images (Figure 6.15) is based on the change detection based on the health of vegetation (based on the chlorophyll reflectance) and would have shown areas of poor vegetation health or potential degraded woodlands.

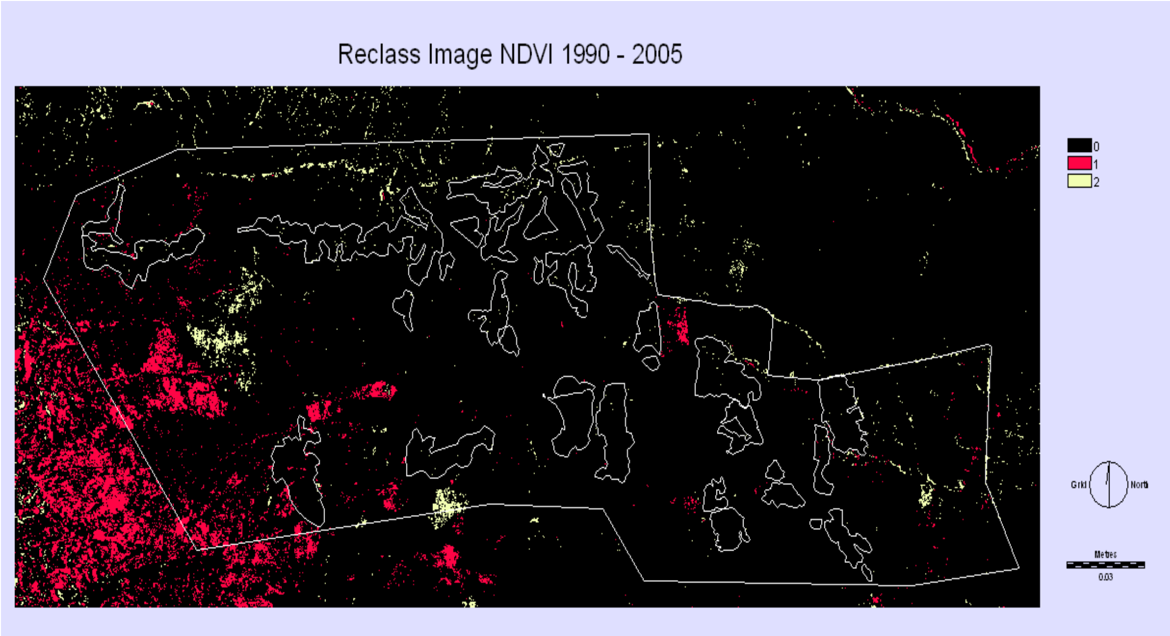

Figure 6.16: NDVI Change image 1990 - 2005

6.5 Change Vector Analysis (CVA)

The CVA process produces two images, one indicating the magnitude of change and the other indicating the direction of change, both measured as an azimuth.

The image showing **direction** of change (Figure 6.17) confirms the changes noted in the above process. The main areas of negative change are highlighted as reddish, with the higher values of direction of change from 268.62 to 358.49. The higher the direction of change on the image, the higher the negative vegetation change there is. These areas are highlighted by the yellow circles on the image. Areas with the smallest to minimum direction of change (-1.00 to 21.00) indicate vegetation growth (purple squares). These areas are previously burnt in the classification images and show positive growth in the change process conducted above.

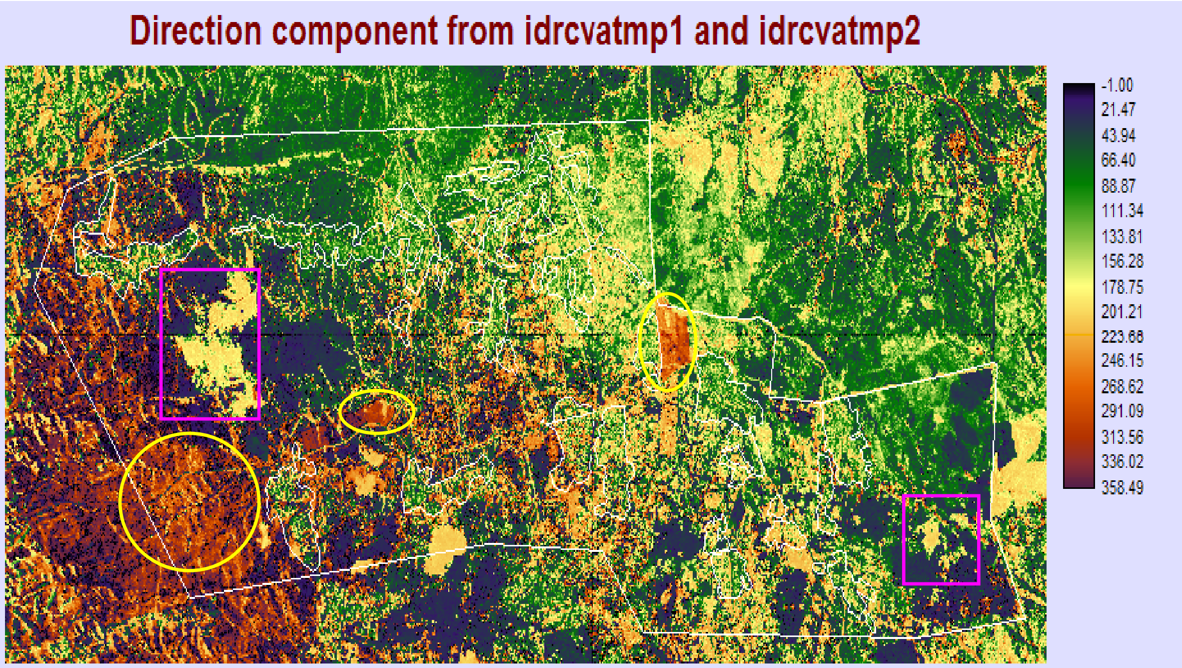

Figure 6.17: Direction of change 1990 – 2005

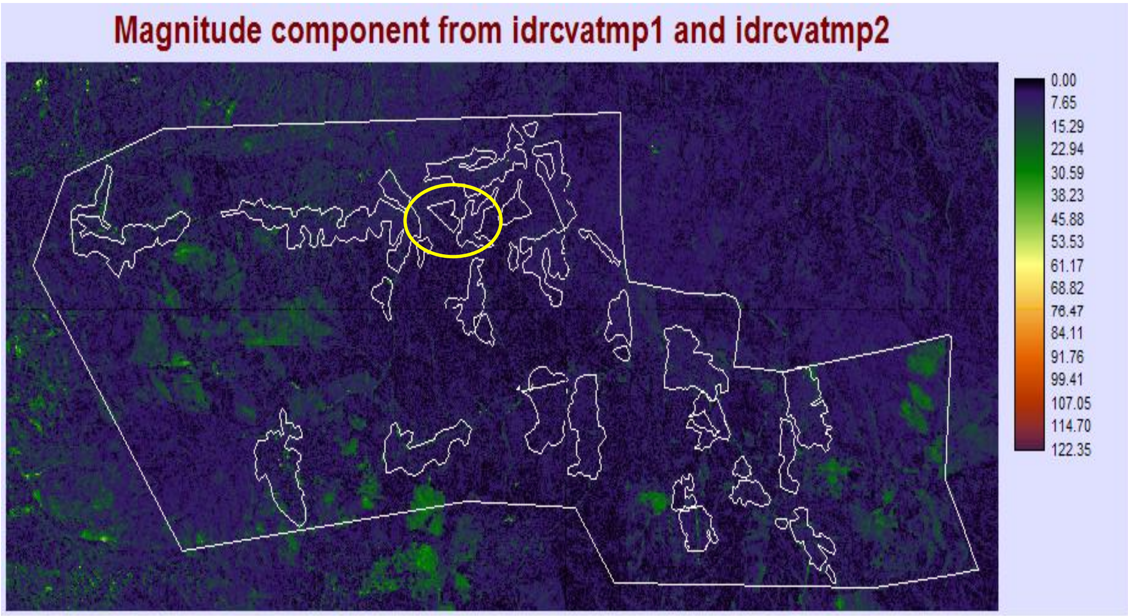

Figure 6.18: Magnitude of change between 1990 and 2005

The image showing **magnitude** of change is not as striking as the direction image (Figure 6.18). However the high magnitude areas correspond to the high direction of change, indicted by the green areas on the image, showing an estimated 45% change in are areas of vegetation gain. Most of the change is estimated at 7.5% in areas of negative change and 0% in areas of no change.

It is important to note however that the area around village 21 (yellow circle) which is picked up in the previous change detection procedures is not highlighted in the CVA method as having high direction and /or magnitude of change. Again the length of the study period is a factor in the results as well as the different method of change detection used, including the change in land use, from woody vegetation to settlement.

6.6 Mapping of Resources

The land cover map derived from SPOT MS is used to map resource availability in and around the settlements. SPOT MS with a resolution of 5 m shows more detail than Landsat imagery at 30 m resolution. A one kilometre buffer is imposed around the villages' boundaries. It is assumed that the residents would go for an average of one kilometre to look for water, firewood or other natural resource products.

6.6.1 Results of resource mapping

The most common landcover classes surrounding the villages and in the areas of buffer overlap are parkland, open bushland, riparian/closed woodland and, to a limited extent, mixed woodland. While some of the villages have exclusivity for their surrounding resources, most of the inner villages share resources. This is indicated by the buffer areas imposed extending as far as the buffer zone for the adjoining village. In some instances, the buffer zones extend as far as the adjoining villages' boundaries (Figure 6.12). Villages whose buffer zones are either completely within the buffer zone of the adjoining village or whose buffer zones intersect with those of the nearby villages may have limited access to natural resources. This would be compounded by undue pressure on these resources and issues of conflict on accessibility within and between the villages (Konz, 2006). The growth of all the villages in population size could have possibly increased the demand for resources for these villages, in addition to these areas being common property resources.

Villages not surrounded by any woody cover such as woodland or bushland whether open or closed may further be restricted in the resources they can access. While there is not much documentation on the utilisation of the Gabbro dyke in the study area, the characteristics of it, as mentioned earlier, are not favourable for agricultural production. These areas are also prone to fire as evidenced by the presence of fire scars in all the images. This could make villages around this area vulnerable, both in terms of cultivation of food and the availability of resources to utilise as a diversification of livelihood strategies. The immigration status of some of these villages may further exacerbate their attainment of food security, due to restricted access to government services and grants (Hunter *et al*, 2007).

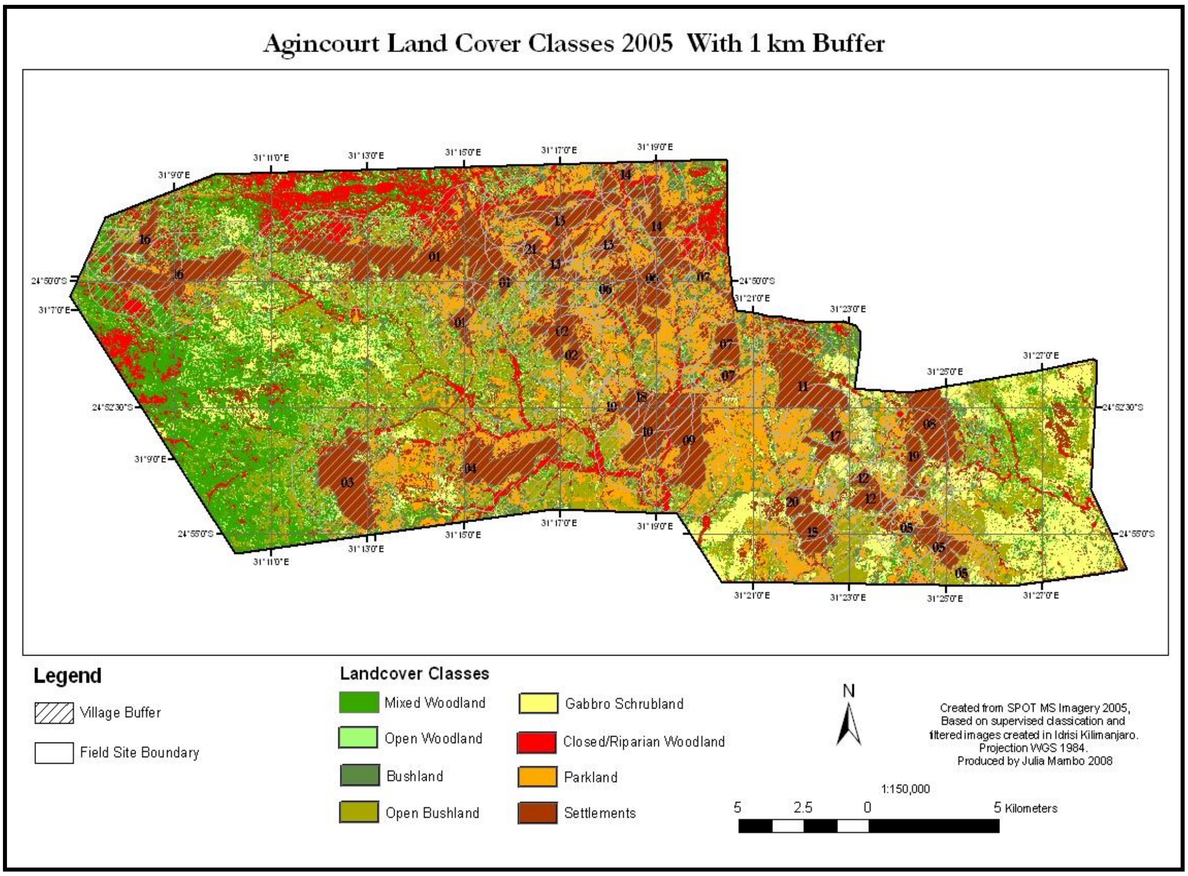

Figure 6.18: Village Resource availability based on 1 kilometre buffer

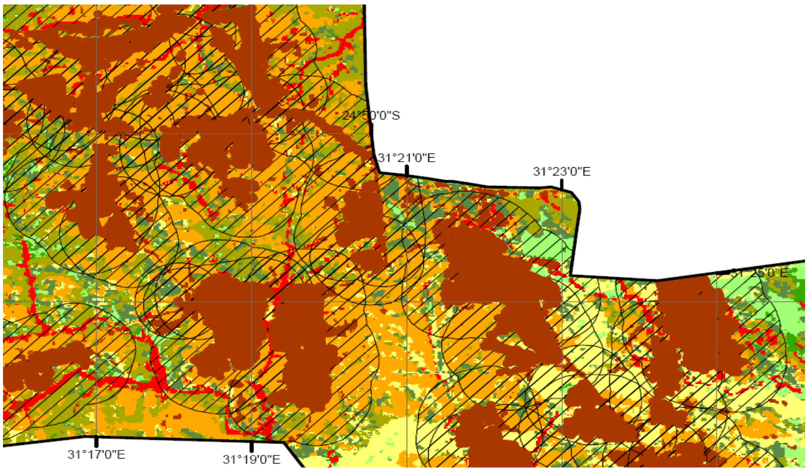

Figure 6.19a: The hatches indicate the buffer zones around the villages. The brown areas are the village extent

A comparison of the natural resource utilisation and the available natural resources highlights that one of the villages with the **highest natural resource** utilisation, village 03 is surrounded by open bushland, open woodland, Gabbro as well parkland. Village 11, also with **high natural resource utilisation** is surrounded by open woodland, Gabbro and parkland. However, unlike village 3, village 11 does not have exclusivity to its surrounding natural resources due to its close proximity to village 17, which falls under the medium utilisation category and is a smaller village. It is important to remember that these two villages are also categorised by high hunger prevalence in the DSS. Four villages; 4, 6, 10 and 15, which are stratified in the medium category of natural utilisation are mainly surrounded by parkland, with fragmented open bushland and Gabbro. The rest of the villages are categorised as low natural resource utilisation. These are mostly located in the south east of the DSS and are mainly characterised by the Gabbro such as villages 5, 8, 12 and 17. This implies a limitation in the natural resources to be harvested in this area due to the nature of the Gabbro, little woody cover and mainly grassland with clay soil belts. The villages in the north west of the DSS, with low utilisation such as 1, 13, 14 and 16, are surrounded by mainly woodland, open woodland and open bushland with fragments of parkland. Only one village, 21, did not utilise any natural resources. This is an RDP village, with a much smaller population.

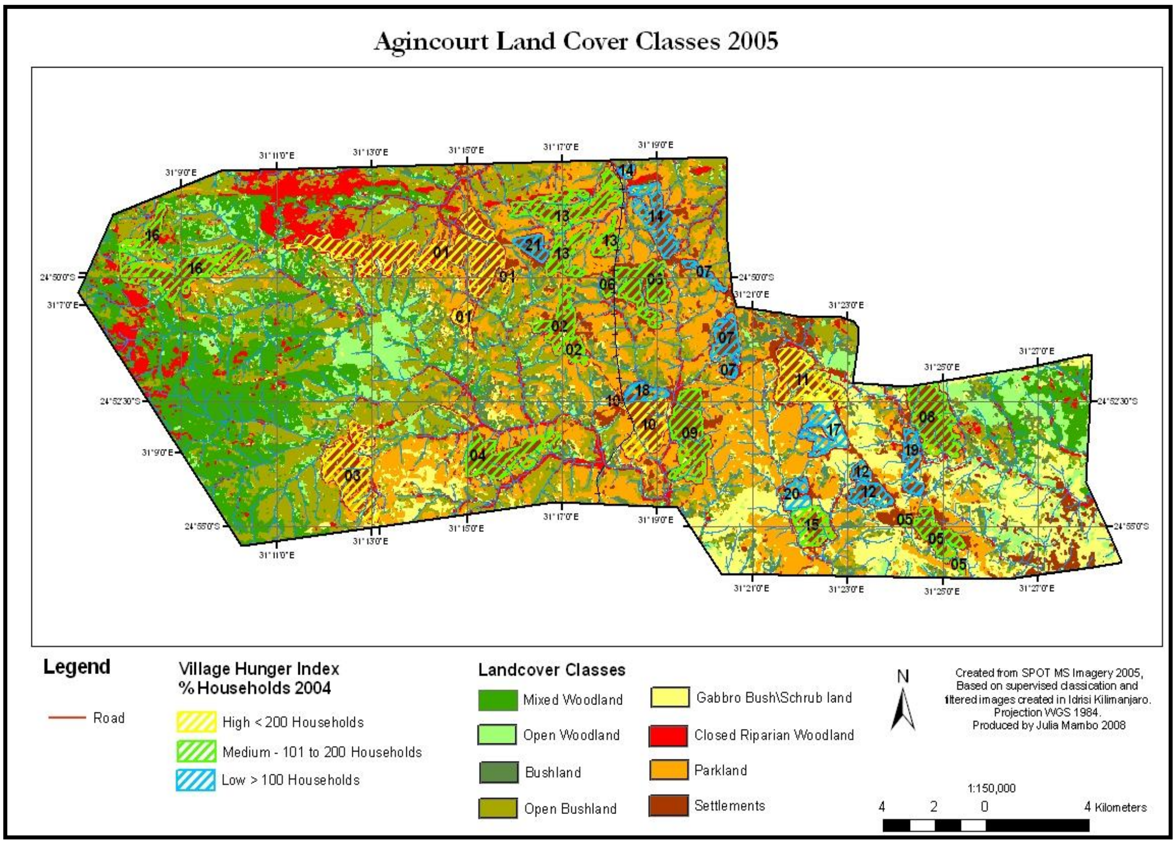

Figure 6.20: Natural Resource availability and food security

In terms of natural resource availability and food security (Figure 6.20), there are no clear trends identified on whether resource availability has a direct influence on the food security status of the village. For example and as mentioned in Chapter 5, villages which are more food secure such as villages 12 and 17, are located in the Gabbro dyke and are surrounded mainly by parkland, with little or no woody or forest resources. While villages 1, 3 and 11, which are surrounded by mixed and open woodland as well as bushland are food insecure. Further, most of the villages with medium hunger have villages located in both non forested and forested areas in the DSS. The assumption would have been that the less woody or forest resources available the more food insecure or vulnerability to food insecurity the village would be. As Figure 6.20 highlights, the availability of woodlands does not seem to contribute to the food security status of a village, rather food production and as has been previously mentioned household income.

6.7 Discussion - Land-use, Landcover Change and Natural Resource Availability

The general decline in mixed woodland, open woodland and bushland, and the increase in open bushland, settlement and parkland is observed for both study periods. The greatest change is noted in the first period of study, between 1990 and 2001, which is over 11 years.

The most observed land cover changes in this area occurred during the 1980s, influenced by the arrival of Mozambiquan refugees, who were allocated land which was subsequently cleared for settlement and the surrounding natural resources utilised for house construction (Giannecchini *et al*., 2007). Further, during this time there were no restrictions on the use of natural resources; for example fuel wood and it was not considered an issue due to the small population at that time. However the formation of villages brought with it control over the natural resources, enforced by the local authorities (Giannecchini *et al*., 2007). While there are trends of continued decline in the woody vegetation, which in itself is an indication of degradation, most of the resources gathered (as recorded in the DSS database) such as herbs, insects and wild fruit do not actually impact negatively on the existing resources as they are seasonal and would thus not be over utilised.

Activities of concern would be harvesting of fuel wood for consumption and for resale and harvesting of resources such as reeds for crafts. As noted by Giannecchini *et al*. (2007) and Baiphethi and Jacobs (2009), there is a significant increase in the number of South African households engaged in the informal economic sectors including selling clothes, garden produce and natural resource production in the area. Of interest is the trade in firewood by most South African households which doubled during this time with most of the firewood harvested from the village commons, which are located between the villages and in the buffer areas (Figure 6.19a). This could have led to a substantial decline in the woody resources located in woodland, bushland and open bushland, which show evidence of being disturbed. Further, the progressive change in vegetation status, from mixed woodland and bushland to open woodland and open bushland could indicate is of concern. This could be an indication of over utilisation, especially the progressive decline from woodland to bushland and further to open bushland and parkland over the years.

The growth of the settlement areas corresponds to the growth in population and villages in the DSS. The original population monitored in 1992 is 57 509 individuals in 8896 households which increases to 66 840 individuals in 10 500 households by 1999 to a population of 86 000 by 2007. There is evidence of continued population growth in the later period of observation, which is 2001 to 2005. While the debate on the contribution of population growth on natural resource utilisation is contentious, as mentioned in Chapter 2, there is possible evidence that the increase in population in the DSS and the formalisation of villages might have had an impact on natural resources. The formalisation of villages resulted in the scattered population being concentrated in smaller formalised areas, putting pressure on the surrounding natural resources as well as resulting in the increase in parkland due to demand for land for subsistence farming.

There was an increase in crop land during the 1990s, particularly in the Mozambiquan settled areas, with most of the fields being small in area and with households cultivating more than one small field in order to increase crop yield (Giannecchini *et al*., 2007). This is supported by Kepe (2009) who notes in his studies the small size of agricultural plots and lack of access to grazing and arable land for people without rights to land. This could be describing the refugees in the DSS. Kepe (2009) also notes that new settlers in former homeland areas had to complete with existing residents for resources putting undue pressure on the natural resources. Further, agricultural expansion is one of the leading proximate causes of land-cover change noted by Geist and Lambin (2002), with the underlying causes noted as population growth, both of which are noted in the study area.

In terms of answering the research question 2, *"What is the relationship between dependence on natural resources as a source of food and/or livelihood to resource/land degradation?"* the chapter has highlighted resource availability based on proximity of villages to woody vegetation resources and plantations. The assumption is that availability and/or access to woody vegetation resources is a livelihood option for the affected villages. Food security would thus not be severely affected due to presumed availability of direct and indirect income as well as food from these resources. Most of the villages, including those with high hunger prevalence are surrounded by fragments of open bushland and woodlands as well as bushland, suggesting availability of resources at the disposal of all the villages. The exceptions are villages located in the south east because they are surrounded mainly by the Gabbro which is characterised by grasslands and little woody land-cover.

In terms of resource degradation and the assumption of over utilisation, the presence of negative change (possible degradation) in the high hunger prevalence and high natural resource utilisation areas could be an indication of the high dependence on natural resources. This is mainly for the villages such as village 11 which has high hunger prevalence in both 2004 and 2007. In terms of village 3, which has medium hunger prevalence in 2004 and has high hunger prevalence in 2007, there is evidence of high negative change, especially in the previous plantations surrounding the village between 1990 and 2001, indicating change in land use as well, from plantation to grazing. Further, the high negative change on the NDVI image (Figure 6.18) suggests encroachment on to the Bushbuckridge nature reserve which is on the boundary with village 3.

The results further highlight areas of possible resource degradation and/or areas where resources are likely to be under severe utilisation pressure (hotspots), affecting sustainability of use in terms of the period of regeneration and recovery of the exploited resources. This is highly noticeable in the village commons between 1990 and 2001 (Figure 6.16), especially between village 3 and 4; and villages 7 and 11. Other negative change is noted within the village boundaries, suggesting clearing of vegetation for settlement purposes. This may coincide with the formation of the DSS in 1992 and the formalisation of villages with defined boundaries as mentioned previously. For the question of resource dependence to be adequately answered results from this chapter will be cross analysed with results from Chapter 5 which among other variables measures natural resource utilisation and or dependence in Agincourt. These will be discussed in Chapter 8.

CHAPTER 7

OTHER FACTORS DRIVING FOOD INSECURITY

7.1 Introduction

The possible contribution of the HIV and AIDS epidemic, AIDS mortality in particular, to food insecurity in the DSS has been investigated and discussed in Chapter 5. The discussion includes the possible influence of a growing DSS population and the need for agricultural expansion on land-use and landcover changes experienced in the area. While it has been acknowledged that HIV and AIDS and population growth have impacts on household food security and income, and consequently on the natural environment, often minor or not immediately apparent drivers may be important to food insecurity and natural resource utilisation.

According to Lambin *et al*. (2001), population and poverty are not the only drivers of land-cover change globally but rather peoples' responses to economic opportunities, as noted by the doubling of trade in firewood in the DSS during the 1990s and the utilisation of natural resources. The not so apparent drivers would include the geographical or physical attributes that affect food production; with the unavailability of rainfall hindering agricultural production in the study area as a case in point. Other physical attributes noted in Chapter 5 would include poor quality as well as shortage of land for farming. Another not so apparent driver would be distance to urban centres which would affect not only access to food but access to markets for livelihood strategies. This is especially important given that the majority of the population in the DSS buys its staples such as maize meal, rice and potatoes as noted in the previous chapter. This chapter will thus investigate some of these not so apparent drivers of food insecurity in an attempt to investigate factors that make other villages more vulnerable to food insecurity as well as other factors driving landcover change.

This chapter presents results from research question three, ***"What are the other drivers of food insecurity in the DSS?"*** Findings include:

- There are clear linkages between bio-physical factors and food security, e.g. areas of high hunger prevalence are not restricted to any particular land capability zone;
- There is a correlation between the geographic size of the village and hunger prevalence, suggesting a relationship between food insecurity and increasing pressure on natural resources;
- There are other drivers of food insecurity since no correlation has been established between food insecurity and bio-physical factors in turn influence food production.

The conceptual framework below (Figure 7.1) has assisted in tracking the progress of the research results from the first question, for this section, the part of the conceptual framework for question three is highlighted below.

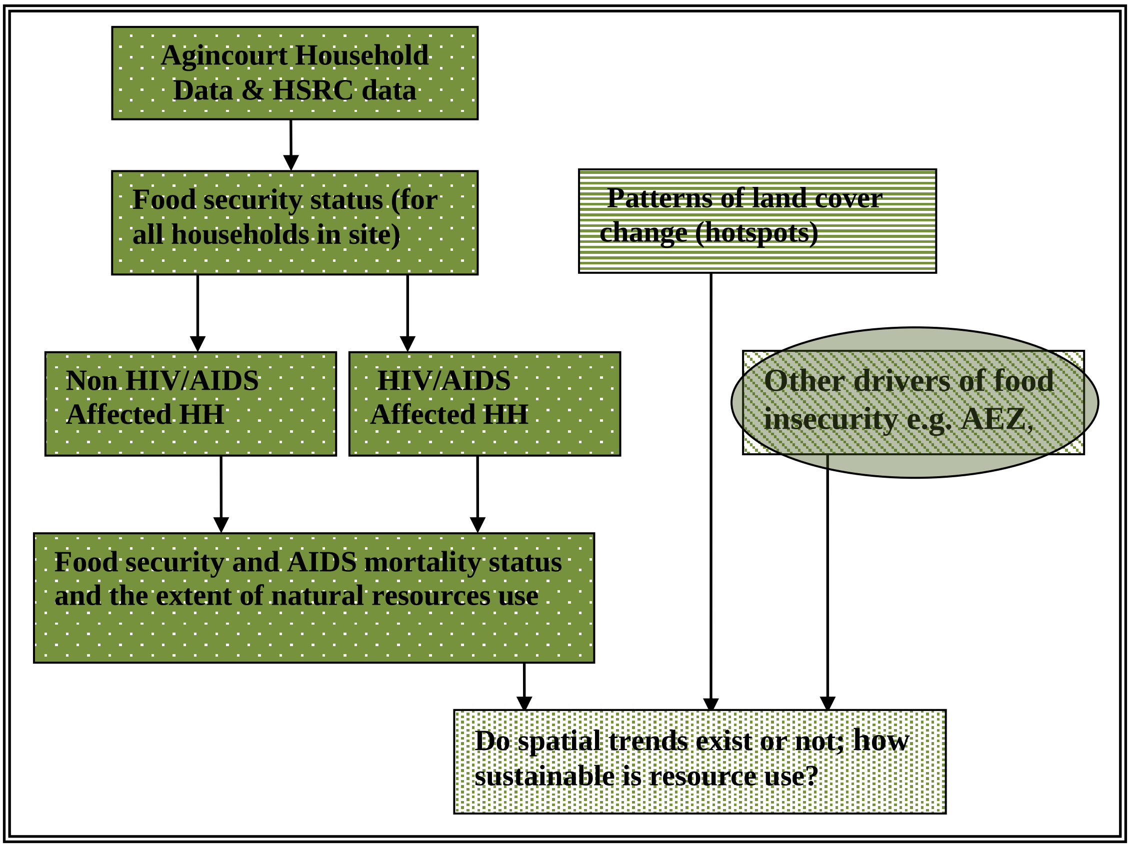

Figure 7.1: Conceptual diagram highlighting section covered in chapter

Physical factors affecting food production and food accessibility are analysed through Agro-ecological or land capability and National Land Cover (NLC) data. These two datasets will highlight food production capabilities in the DSS. The **road network** for access to markets and other infrastructure such as clinics will also be analysed given the importance of infrastructure to access food and markets. While the data on clinics or health centres in the DSS was mapped, the spatial data on the schools infrastructure was not obtained.

7.2 Agro-Ecological Zones/Land capability

Physical factors affecting food production are investigated to assess whether the spatial location of the villages impact positively or negatively on food availability through production. Unlike the vegetation classes analysed in the previous Chapter 6, which are based on the physiognomic classification of tree species, including tree height and canopy cover and other natural vegetation, land capability is based on the potential of land for agricultural production. Physical factors have long since been attributed to the success and or failure of crop harvest, especially for subsistence agriculture which is rain fed. As noted in the previous chapter, physical attributes such as lack of rain and poor land resulted in poor agricultural yields impacting on food security. Organisations such as Food and Agricultural Organisation (FAO), created agro-ecological zones to map agricultural capability of different regions based on bio-physical features such as:

- Rainfall;
- Temperature;
- Soils types;
- Slope (including aspect and altitude).

Agro-ecological zones are based on crop modelling and other methodologies that identify crop specific limitations as listed above. These estimates together with the geographical location assist in various applications including:

- Quantification of land productivity potential;
- Areas of land with rain fed or irrigation potential;
- Estimation of population to be supported; and

- Optimisation of land resources (http://www.iiasa.ac.at).

Agro-ecological zones are designed to match crop production and suitability, especially for the production of staple crops such as maize, which is sensitive to the above physical factors. As a staple crop for the majority of developing countries a maize crop failure has the potential to cause mass hunger and starvation. Factors such as agro-ecological zones, referred to in South Africa as Land Capability, premised on the physical attributes for both subsistence and commercial food production, will provide more details on the physical vulnerability of villages in the DSS. It is important to note that land capability highlights land use while the land cover classes in the previous Chapter 5 are based on the physiognomic characteristics of land cover, mainly woody vegetation.

7.2.1 Land Capability

Land Capability is determined by the combined effects of soil, terrain and climatic factors, to highlight the potential of land for rain fed agriculture while at the same time indicating limitations associated with the different land use classes (AGIS, 2008; Wessels *et al.,* 2008). Eight land use classes are derived for the land capability and classified into two distinct classes, grazing and forestry; and crop production. These classes are further differentiated by their arable or non-arable status (AGIS, 2008; Wessels *et al*., 2008). The broad and specific land use classes are outlined in Table 7.1 with the factors used to determine the classes:

- **Terrain**: Flood hazard, erosion hazard;
- **Soils**: Depth, texture, erodibility, internal drainage, mechanical limitations, acidity;
- **Climate**: Moisture availability, length of moisture season, length of temperature season, frost hazard, wind hazard**,** hail (NDA, 2002).

Table 7.1: Land Capability Class Descriptions (www.agis.gov.za)

Land Capability			Intensity of use for rain-fed agriculture								
Orders		Classes	Wildlife	Grazing & Forestry				Crop Production			
				Forestry	Veld	Veld reinforcement	Pastures	Limited	Moderate	Intensive	Very Intensive
Arable	A	I									
		II									
	B	III									
		IV									
Non arable	C	V									
		VI									
		VII									
	D	VIII									

The following classes are identified;

Class A - Arable land - high potential land with few limitations (Classes I and II);

Class B - Arable land - moderate to severe limitations (Classes III and IV);

Class C - Grazing and forestry land (Classes V, VI and VII);

Class D - Land not suitable for agriculture (Class VIII).

7.2.2 Land Capability Classes in Agincourt

Land Capability Class III

Land capability class III has severe limitations that reduce the choice of crops or need special conservation practises, in other cases both (Figure 7.2). Limitations may act in unison or as a combination, impacting on the time of planting, tillage, harvesting and choice of crops to be planted (AGIS, 2008). While it may be used for crop production, the conservation measures are usually more difficult to apply and maintain. Some of the factors resulting in the associated challenges/limitations in this class include moderately steep slopes, susceptibility to wind and water erosion; and soil limitations such as low fertility, water logging, salinity or sodicity and very slow permeability of the sub soil;

and moderate climatic limitations among other factors (AGIS, 2008). In the DSS this is the smallest class with 14.487 km$^{2.}$ The biggest area of this class is located in the east of the DSS with two other minute areas in the south and the west.

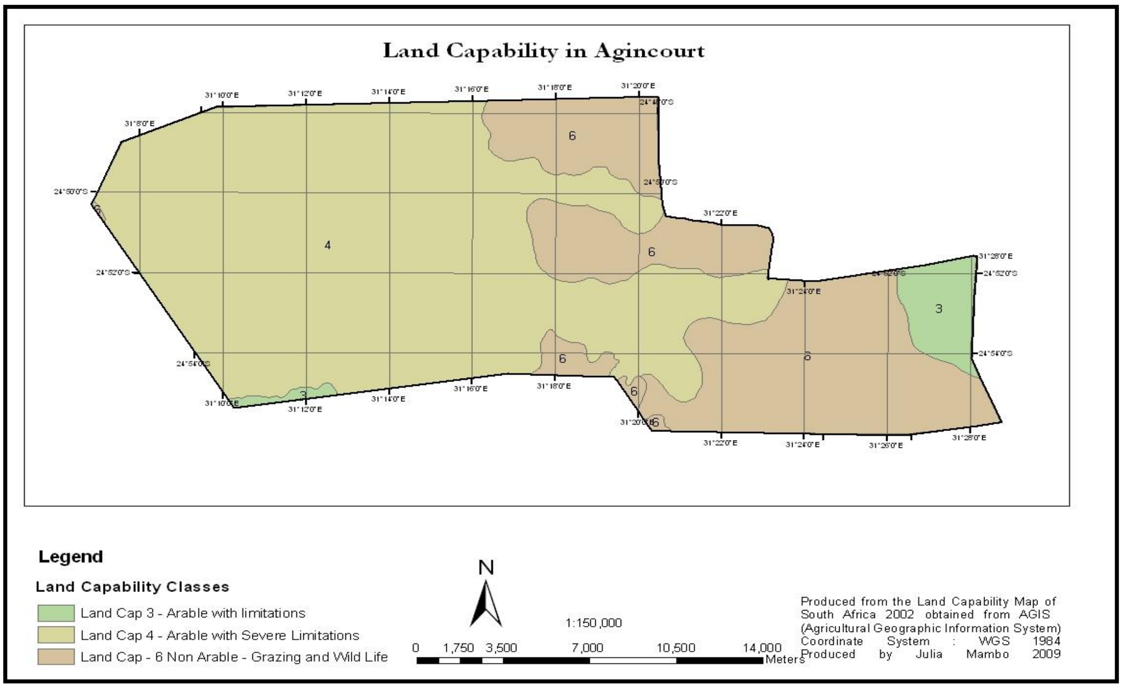

Figure 7.2: Land Capability Classes in Agincourt

Land Capability Class IV

While this class has more or less the same characteristics as the Class III, in sub humid and semi arid areas Class IV may produce good crop yields for the better adapted crops especially during years of above average rainfall and crop failures in the years of poor rainfall (AGIS, 2008). Some of the characteristics of this class that result in limitations include steep slopes, severe susceptibility to erosion both wind and water, shallow soils, flooding, excessive wetness and water logging; severe salinity or sodicity as well as moderately adverse climate (AGIS, 2008). This is the biggest land capability class in the DSS with 243 km^2 and it is centrally located. It is ironic however, to note that with the exception of village 8, all the villages that had more than 400 households not producing enough food in 2004 (Figure 5.7) are found in this land capability class with 83% of the households citing land of rain as an issue. In 2007, conversely, all the villages that had more than 400 households not producing enough food (Figure 5.7) are all located in this land capability class with lack of rain cited by 67% and size of land cited by 15%.

Land Capability Class VI

This land capability class is classified as non arable, compared to the above two classes that are arable but with limitations. It is unsuitable for agriculture and is more suited for pasture and range, woodland and as a wildlife habitat. Most of the limitations in this class cannot be corrected such as steep slopes, severe erosion hazard, effects of past erosion (degradation), stoniness, shallow rooting zone, excessive wetness or flooding, low water holding capacity, salinity or sodicity and severe climate (AGIS, 2008). Further, the physical characteristics may need improvement for specially adapted crops. Also, depending on soil and climate, this land class may accommodate poor suited woodlands (AGIS, 2008). In Agincourt, land capability class IV, is the most dominant covering the west including the natural forest reserves and at approximately 123.41 km^2, it is the second largest land capability class. Apart from village 8 which had more that 400 households not producing enough food, the rest of the villages in the study areas fall under this land capability class, including those villages that did produce enough food in both 2004 and 2007 (Figures 5.7, 5.9). Again this is ironic given that this class is not suitable for farming.

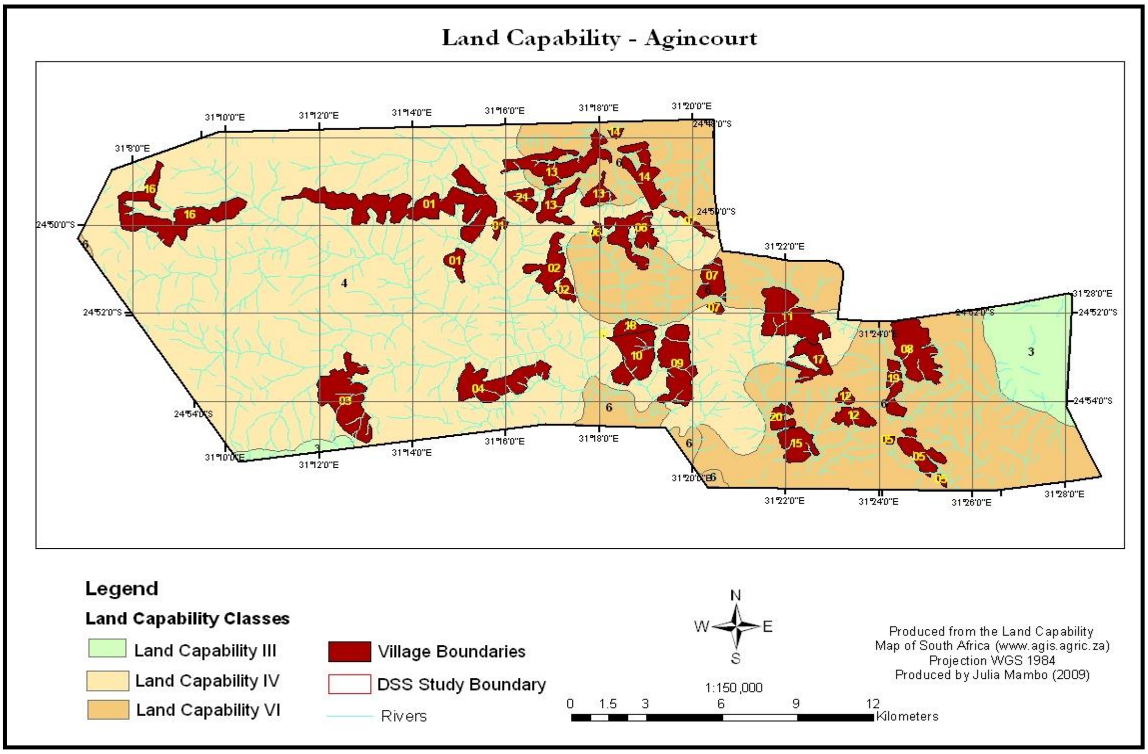

Figure 7.3: Land Capability Classes and Villages

The spatial distribution of the villages in relation to the land capability classes (Figure 7.3) shows that there are no villages located in the most agricultural productive land capability class III, with the bulk of the villages located in land capability class IV, which although is listed as arable has severe limitations, requiring financial resources to make agriculture viable. Fewer villages are located in the non arable land capability class VI which is more suited for livestock due to the grazing capabilities as well as being suitable for wildlife, but not agricultural production.

According to the above land capability descriptions we know that land capability class 4 has severe agricultural limitations, requiring some investment to make farming viable while land capability class 6 is mainly restricted to animal grazing and wild life. Whatever farming activities are conducted in these LC zones may result in the area being susceptible to land and resource degradation unless costly conservation practises are established.

7.3 Land Capability and Food Security in the DSS

The comparison between food production and the land capability classes is additionally conducted, given the fact that the bio-physical factors mapped by land capability affect food production. The village hunger map is overlaid with the land capability classes to ascertain what if any linkages exist between the spatial location of the villages and food production, and the results are presented in Figure 7.4 below. It is important to note that Agincourt is largely on unsuitable farming land, impacting negatively on food production, as noted in Chapter 3.

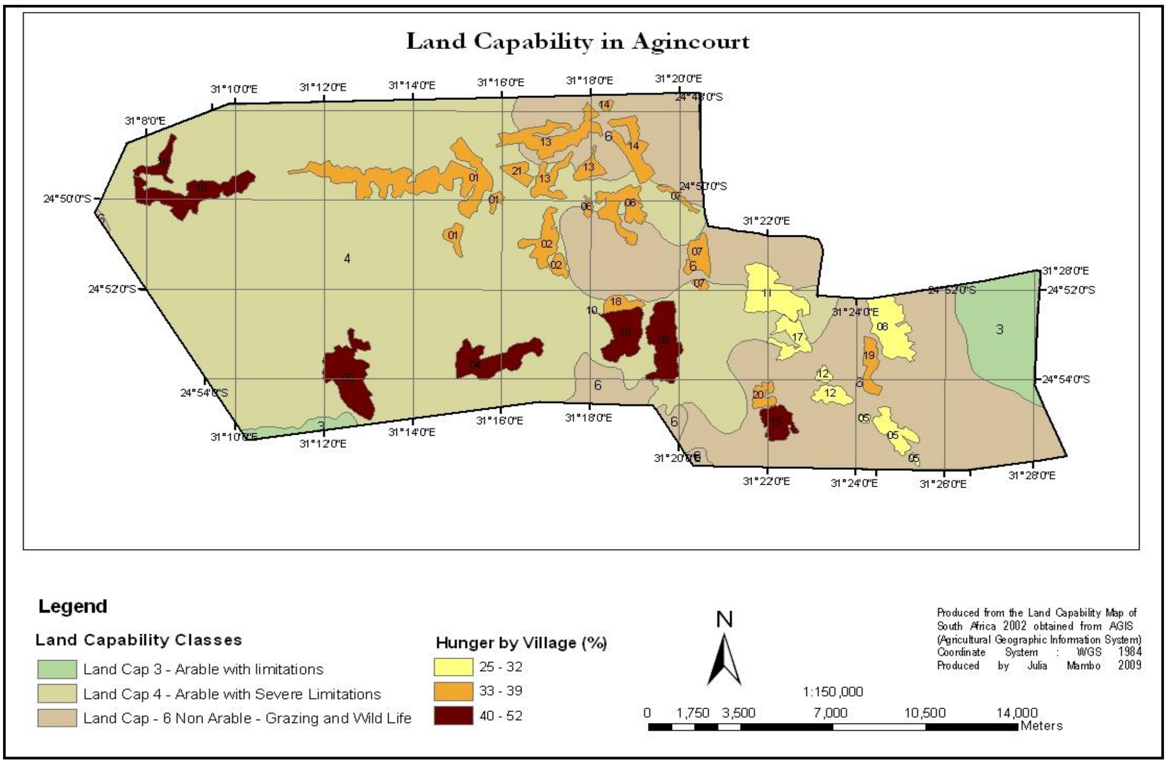

Figure 7.4: Land Capability overlaid with Hunger prevalence

In this analysis, as mentioned above, most villages that did not produce enough food are located in land capability class 4, which although is classified as non-arable, is the better of the two main classes found in the DSS. The four villages with the highest proportion of high hunger prevalence, villages 3, 4, 16 are located in this land capability class. Even more interesting is that village 11, with the highest percentage of households that are unable to produce enough food, and falling under the high category of food insecurity, straddles land capability class 4 and 6. Given that land capability class 4 is the second most arable class in the DSS, one would expect these village to be more food secure compared to the rest of the villages due to their geographic/spatial location.

Most villages located in land capability class 6, which is non-arable and not suitable for any kind of agriculture, while expected to be food insecure, are not, falling under the medium and low hunger prevalence. Despite not having produced enough food to feed all household members, it has been noted that the refugees/migrants do produce more food than their South African counterparts in the DSS (Twine, pers. comm. 2008). This could be attributed possibly to the different cultures and historic backgrounds of the two population groups. As mentioned earlier in Chapter 2, in South Africa, the apartheid era destroyed African agriculture, with the majority of Africans being used as industrial labour, in industry, farms and mines (DOA, 2002; Kepe, 2009). Further, most of the Mozambican migrants cultivated more than one field to supplement low crop yields (Giannechinni *et al*., 2007). The same Mozambican villages, particularly those located in the east of the DSS, such as villages 5, 8 12 and 19, are also located in the Gabbro dyke, which is characterised by clay soils, albeit with limited capacity due to the rainfall dependency. Most villages with more than 50% of Mozambican residents, such as villages 8, 12, 20 and 17 are located in land capability class 6, except for villages 10 and 18 which are located in land capability class 4.

Other studies have shown that agriculture plays a key role in households that do not have access to wages and pensions and acts as a safety net in times of need (Baiphethi and Jacobs, 2009; Jacobs, 2009; Kepe, 2009). As previous stated, most of the refugees do not have access to social grants due to a lack of South African identity documents. However, it would be interesting to investigate what if any role the clay soils play in the food security of these villages; this is, however, beyond the scope of this research.

In terms of adequate food production, none of the villages fared well in both years, regardless of which land capability class they are located. However some contrasts are noted, such as villages 1, 16 and 21 had a significant number of households producing food in 2004 but showed drastic reduction in the number of households producing food in

2007. For example in 2007 in village 1, out of a total of 879 households, only 10 produced enough food, while in village 21, no household produced enough food. The opposite is realised for other villages such villages 3 and 9, which had more households producing their own food in 2007 compared to 2004. This affects only a few villages, however with a general trend in the DSS towards not producing food. The reasons given for the inability to produce enough food include the unavailability of rain, size of land and a lack of labour to till the land in 2007, while in 2004 only lack of water and lack of labour are cited as the contributing factors. Further, as noted by Bryceson (1999), there is a general trend towards cash based livelihoods with fewer and fewer people turning to subsistence farming as a livelihood option. This is further supported by Giannecchini *et al*. (2007) who noted an increase in the cash based strategies with land based activities, such as farming being used as a means to supplement household income. Further, most of the village commons are characterised by abandoned fields as noted during the field trip. This is supported by Backeberg (2009) who noted that despite the high levels of poverty and under nourishment in rural areas, land resources are hugely under utilised.

The river network in the DSS is quite extensive, although most of the streams are seasonal. The northern parts of the DSS receive good rains on average and this should enhance food production thus unavailability of rain should not be an issue. However, two of the hungriest villages are located in areas of higher elevation with good rains, raising question about other drivers influencing the inability to produce enough food despite the favourable location.

7.4 National Landcover Data (NLC)

The National land cover data (NLC)[38] is used to evaluate the landcover classes, especially considering the NLC includes degraded classes. This augments the land cover data produced in Chapter 6, especially the identification of degraded land. Further, it is hoped that the NLC data will assist in highlighting other factors that might influence food security, especially food production. In addition the data includes settlements, labelled as either formal or informal villages.

[38] National Land Cover data was produced by the Agricultural Research Council in 2000.

The two biggest classes in the NLC are woodland and thicket bushland clumps (Figure 7.5). These classes are fragmented except for the eastern part of the DSS in areas bordering the Bushbuckridge Nature Reserve. These areas are classified as settlements but do not fall inside the boundaries of the formalised villages from chapter six, especially in areas in the south west of the DSS. While it is understood that there are no informal villages in this area, one of them are classified as informal. A few water bodies are noted in this landcover that are difficult to highlight in the classification process in Chapter 6. The area classified as grassland in the previous analysis is stratified as a fragmentation of the woodland and bushland thickets.

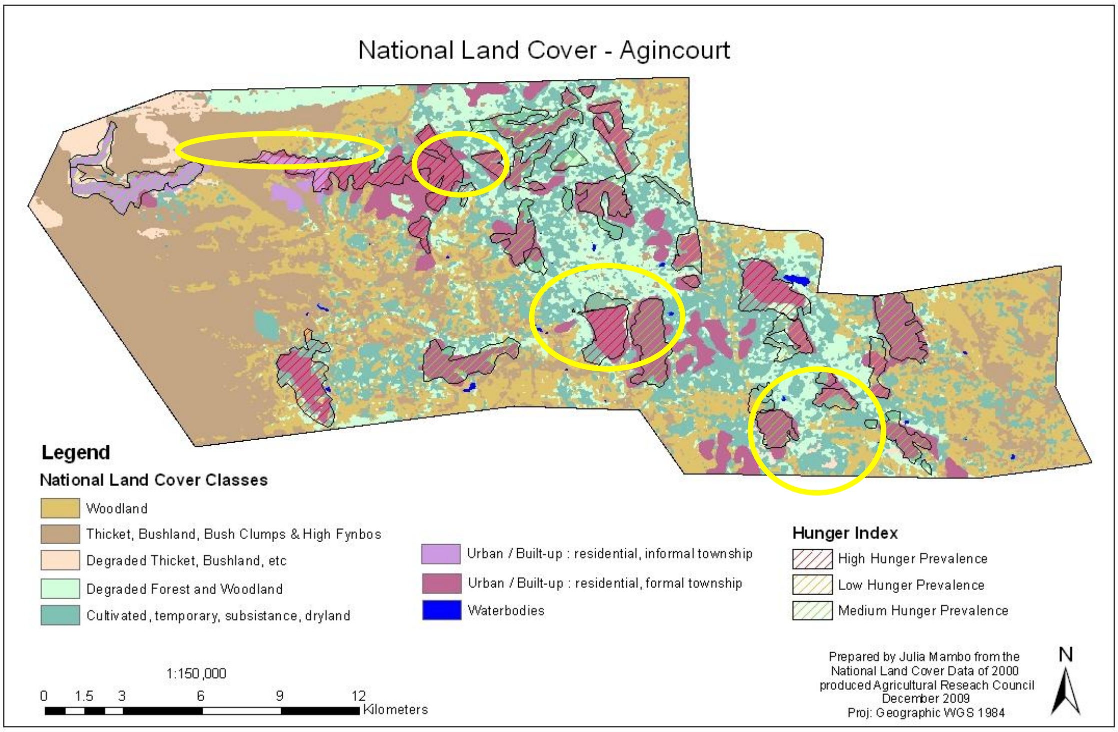

Figure 7.5: National Land cover Data and hunger prevalence

The cultivated temporary subsistence dryland and the degraded forest and woodland are located mainly between villages and in the centre of the DSS. Most of the villages are surrounded by cultivated, temporary subsistence dryland, which in the previous land cover classification is stratified as parkland, which is the area designated for subsistence farming. The fact that this cultivation area is classified as dryland implies possible rainfall restrictions, a factor noted as the biggest contributor by most households that did not produce enough food to feed themselves.

7.4.1 Degraded Land

When compared to the maps showing areas of change, the degraded area on the NLC coincide with the area of negative change, albeit the negative change is noted inside the village boundaries and to some extent in the village commons. The possible explanation could be the difference in the scale used between the NLC which was at a 250 000 and secondly the different classification used for degraded land. In this study no specific characteristics were defined for degraded land except the spatial identification.

The degraded land in the NLC is located centrally, between villages and along the Xanthia ridge and in the areas of overlap between the villages, (highlighted by the yellow rings in Figure 7.5) which are also common property areas. Villages located in the centre of the DSS, with high and medium hunger prevalence are located in areas with degraded forest and woodlands. Of concern is the close proximity of the villages to each other, as indicated by the buffer map in Figure 6.21 in Chapter 6. The degraded woodland and bushland have already been identified as areas of concern in the previous chapter, but the added degradation status based on NLC makes them highly vulnerable to increased degradation. Given that sustainable utilisation of the natural resources is one of the objectives of this research, these areas become hotspots in terms of sustainable food production especially the areas that are designated for the subsistence farming as highlighted in Figure 7.5.

The degradation in this area implies over utilisation, leading to limited availability of resources thus affecting food security. Ironically, the villages with the high hunger prevalence are surrounded by cultivation subsistence land, with the degraded forest and bushland surrounding areas of medium to low hunger. This could imply that there is limited access to natural resources for these villages. Further two of the high hunger prevalence villages are isolated compared to other villages which are clumped in the middle. These isolated villages would have more resources at their disposal, increasing their food security. However, this is not the case as these villages are characterised by high and medium hunger prevalence. Unfortunately, there is no data on the quantities or monthly food consumption from natural resources or from agriculture that would assist in quantifying the contribution of natural resources and subsistence agriculture to household food. Given, as noted in the above section that food production is supplementary and food purchase the primary source of food security, the focus now shifts to accessibility to markets and urban centres for food security by analysing the transport network.

7.5 Distances to Urban Centres

Distance to the nearest urban centres has been cited as a deterrent of accessibility to food based on proximity to markets for purchase of food as well market to sell goods to supplement or earn household income. As previously mentioned, more than half the population in the study areas purchases staple foods, making access to urban centres and markets detrimental for food security. In this part of the study the distance to the nearest urban centres is analysed to ascertain if any correlation exists between distance from urban areas and food insecurity.

The Agincourt DSS is not located anywhere near the major urban centres such as Phalaborwa which is approximately 121 km and Nelspruit. Acornhoek is the nearest urban centre to Agincourt at 35 km (Figure 7.6). There are however smaller settlements such as Thulamahashe, Mkhulu and Bushbuckridge, which although they are not within the boundary of the DSS are much closer than the major urban centres.

The transportation costs to these smaller urban centres are reasonably high, restricting travel to these centres unless they have other business to attend to. Thus the local population hardly frequents these small urban centres for the sole purpose of buying food (personal communication – field guide Sinah).

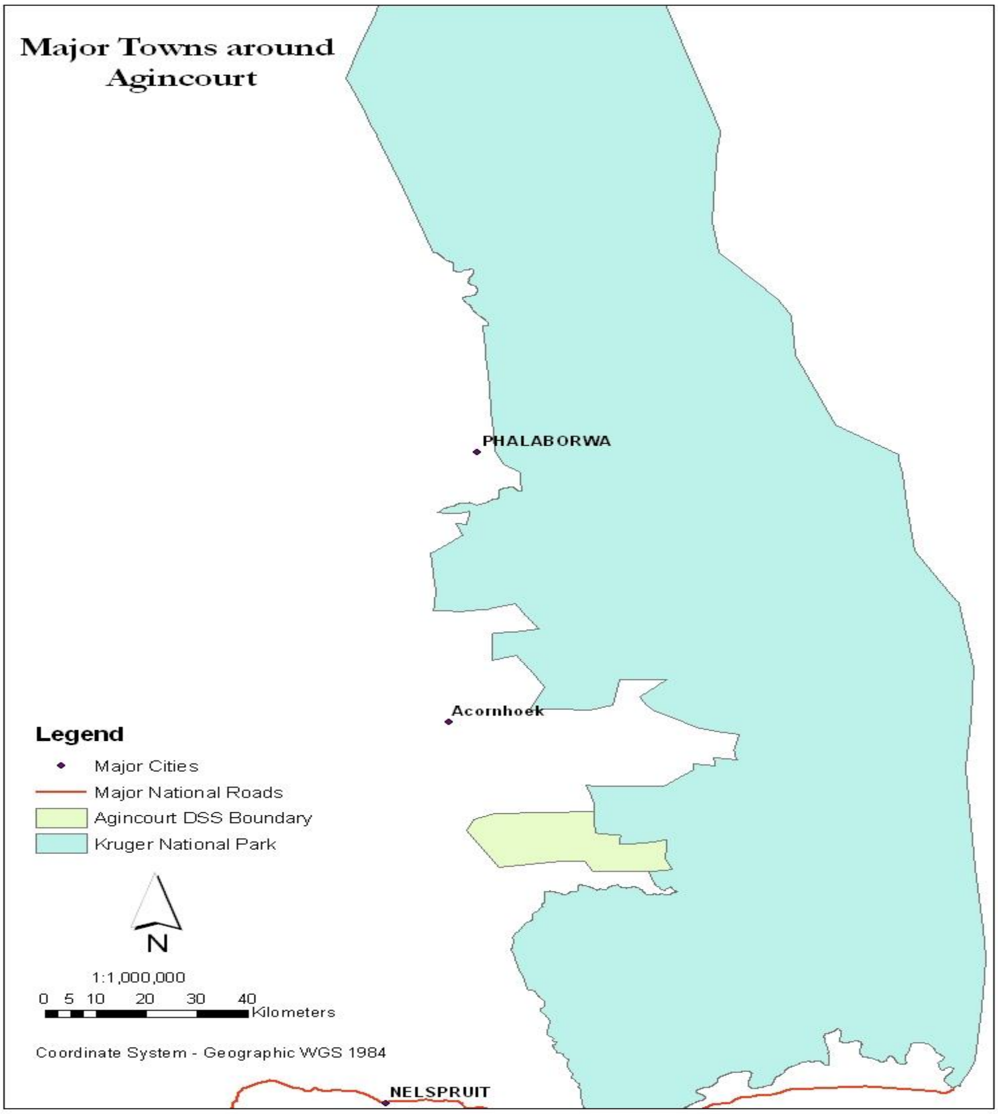

Figure 7.6: Location of Study Area to Nearest Urban Centre

The transport network represented by the roads is quite extensive within the DSS (see Figure 7.7) to and from the smaller urban centres around the DSS such as Mkhulu, Bushbuckridge, Thulamashe as well as Acornhoek. The main road although in a good condition is dirt, with no tarred roads observed in the study area. The road network reaches all the villages, giving the impression that access due to transport availability should not be problematic.

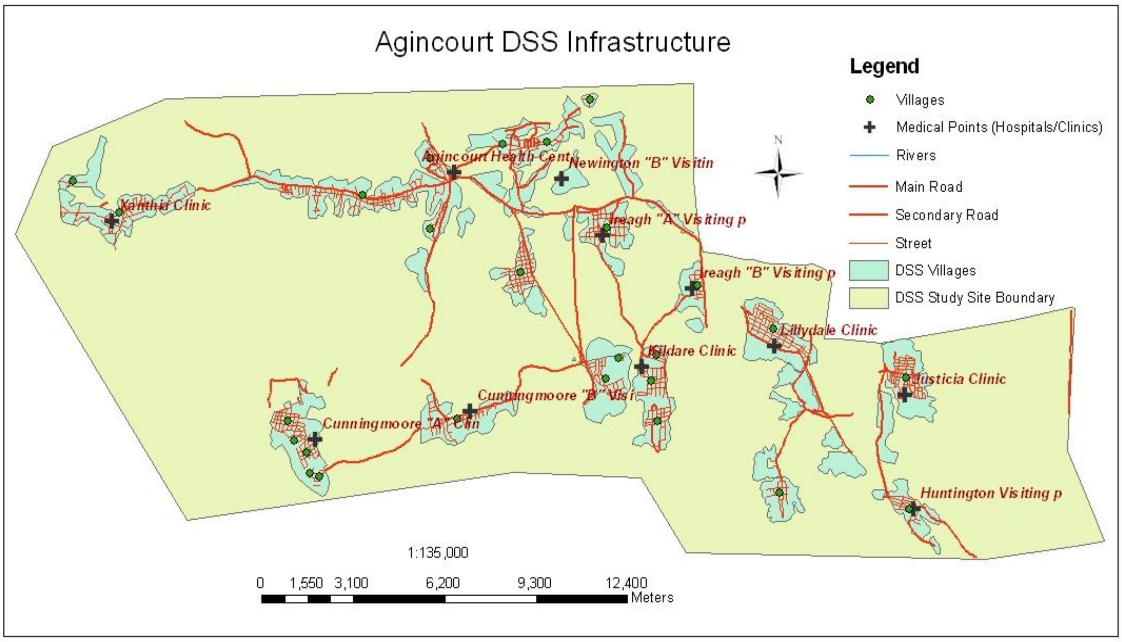

Figure 7.7: Infrastructure in the DSS

A few methods of transportation were observed during the field work, mainly taxis and buses which mainly transport workers who commute from the villages to the nearby urban centres. A few private vehicles are also observed transporting school children. Thus there is a choice for the mode of transportation to be used although these differ on cost with buses being the cheapest. Buses are however available only in the mornings and evenings, with limited service during the day. The volume of traffic noted during the field work indicated that there was a lot of movement between the villages and these centres, where not only a wide variety of stores and supermarkets are found but health facilities such as hospital, as well as police stations and other local government offices.

Albeit most villages have their own health facilities or clinics, the location of these centres is mostly not central, making them inaccessible to residents located furthest away. A few villages do not have health facilities within their boundaries, making these villages vulnerable to food insecurity since food utilisation is affected by health and access to health facilities. While clinics or health facilities are located within some of the villages, (Figure 7.7), the major referral hospitals are found in the urban centres such as Tinswalo hospital in Acornhoek.

Regarding access to food, small shops are noted especially along the major roads within the villages visited during the fieldwork. The concentration of the small shops decreased as one travelled further inland and away from the major roads and as one travelled from the west towards the eastern areas of the study site. Further, mostly dried goods and pre-packed food are found in these shops, with limited or no fresh food such as meat, vegetables and fruits found. While a few stalls located in these semi business centres sell vegetables, the quantity was too little and the quality of the merchandise did not appear to be of a high standard. With the assumption that some residents grow some of their vegetables, the question then is on the access to healthy food to determine a healthy diet and not just access to food in general. The question would include not only the time travelled but also the cost of transportation and cost of food in the far off small shops.

7.5.1. Government Grants/Market Days

As noted during the field work, fresh fruit and vegetables, including meat such as chicken and eggs can be purchased during the market days which coincide with the payout of the government grants in the area. These markets are held once a month and are a common occurrence in most of rural South Africa, including in the DSS. While fresh food and meat (live chickens) are available during these grant market days the prices are highly inflated and are sometimes sold on credit, an issue which was highlighted in the food security module by some residents as a coping strategy. Then the observation is that fresh fruit, vegetables and meat are mainly consumed in the first few days after the grants payouts after which these supplies are exhausted (personal communication – field guide). Buying food on credit, while a coping strategy, seems to perpetuate the cycle of poverty within the residents of the DSS, not only reducing the opportunities for the residents to save or invest any of the money received in income generation schemes but forcing them to buy food at inflated prices.

Other services such as money saving clubs (stokvels) and funeral insurance companies are also present during the grants payment days as well other merchandise such as clothes, cooking and cleaning utensils. All these serve the reduce the income the patrons take home after the grants have been paid and in some cases reducing the money for buying food during the month if the food runs out, forcing some of the residents to get food on credit (see Appendix 2).

The grant day markets seem to be an essential player in the nutrition and food security of members in the DSS, but they also seem to perpetuate poverty due to the reduction in the spending power of the money received by the grant recipients through purchase of costly food. While no documentation and or research on the role of grants market days in the rural economy are found, these markets are an essential contributor to food security in rural areas.

7.6 Bio-physical factors and Food Security

While the creation of a cost surface raster, indicating the cost of travel from the villages to the nearest urban centre would have been ideal, the lack of knowledge on the cost of transport, be it bus, taxi or private vehicles was not obtained, making this task intractable. Only one type of major road is identified which links most of the villages, with smaller roads indicated as streets within the villages. However the creation of a digital elevation model gave some indication of the physical attributes of the study site.

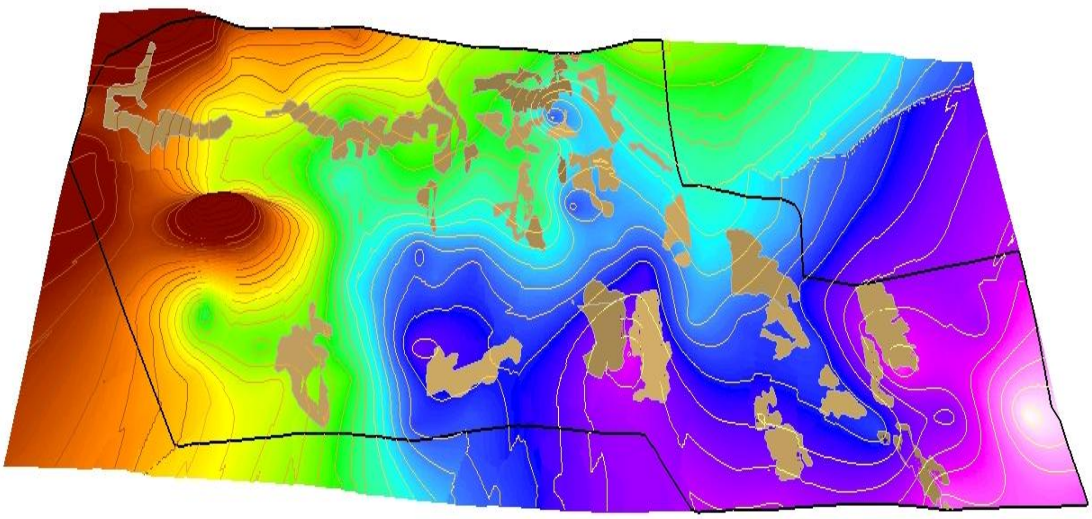

Figure 7.8: Digital Elevation Model – Agincourt DSS

This is essential given the fact that two of villages most affected by hunger are located along the Xanthia ridge, in the green areas of high elevation (between 718–658 m) (Figure 7.6) where rainfall should be abundant. Further these two villages are isolated from the rest of the villages which are clustered in the middle of the study area, raising question about whether the location of these villages influences their food security status.

While only one village which is characterised by medium hunger is located in the area with the highest altitude, the area has abundant rainfall. Most of the villages with low or medium hunger are located in the lower altitude and fairly flat areas of the DSS, mainly in the west. The noted trend in this analysis is that the more food secure villages are located in low altitude flat areas, despite the high rainfall availability in the high altitude areas.

7.7 Discussion - Other Factors Affecting Food Security

The importance of physical characteristics for food production and consequently food security has been highlighted in this chapter, using the land capability, national landcover and elevation datasets. Further, food accessibility through transportation and distance to urban centres as well as food utilisation through proximity to health centres has been explored and discussed.

No clear patterns or linkages between the physical attributes presented by the land capability data and sustainable food security are noted, given that villages with high hunger prevalence are not restricted to a particular land capability zone. Further, it would be expected that villages in land capability class 4 would be more food secure due to a better chance to produce own food compared to villages in land capability class 6. This would have been attributed to the availability of better soils and temperature conditions as well as availability of water all which are essential for farming. Further, neither are these high hunger prevalence villages located in any particular range of elevation, with one village located in the high, the other two villages in the higher range and the other two in the medium to low range. In addition, the hungry villages are geographically big, implying bigger population levels, which may increase pressure on resources availability and access to food.

The villages of medium and low hunger prevalence are also located across the DSS, in both land capability class 4 and 6. As mentioned previously, only one village (1) of high hunger prevalence stands out as having a very high proportion of hungry households, comparing the proportion of hungry against not hungry households within the villages. This village is located in an area of high elevation and is isolated from the rest of the villages in the DSS, implying that maybe its geographic location might be influencing the villages' food insecurity. Due to its isolation, the distance of other villages markets and shopping centres possibly increase the vulnerability of this village, in terms of higher food prices and higher transport costs.

In terms of the other villages, no significant findings are evident barring the fact that most of them are surrounded by degraded forest and bushland, as well as subsistence dryland cultivation. This might decrease the livelihood options for the villages in terms of natural resource utilisation and consequently food security. It is around these villages however that some concerning trends are noted in terms of the degraded resources. Other areas of concern are highlighted especially in villages were food production is an issue despite the favourable geographic location, such as areas in higher elevation where rain should not be an issue for subsistence cultivation. These villages are characterised by higher numbers of hungry households that are unable to produce their own food.

In terms of food accessibility, premised on the availability of transportation and distance to the nearest urban centres, most villages in the eastern and northern part of the DSS should not be vulnerable to food insecurity given the extensive structured transportation network, reaching every village in the DSS. Internally many streets are also found resulting in wider transport network. The ample road network and the presence in the choice of mode of transportation, from buses, taxis and private vehicles would make the urban centres easily accessible. However the cost of transportation would be a prohibiting factor for many of the poor households.

In terms of access to food within the DSS, enough small shops and businesses (trade centres) were noted during the field work, where food maybe be purchased, even though intake of protein rich foods such as meat may be limited. The presence of these grant market days does make up for this imbalance, providing fresh food and meat, albeit at exorbitant prices. This leads to the issue of accessibility to safe and nutritious food based on availability of income or money and from the characteristics of the study area discussed in the Chapter Four it is already clear that the Agincourt DSS has high poverty and unemployment figures.

Another area of concern are the villages located in the eastern drier part of the DSS, where fewer small shops and trading centres were noted during the fieldwork, implying limited availability and access to food by nature of inaccessible location. It is in this area that most of the villages with higher percentage of Mozambiquans are located and despite the above factors, these villages have low hunger prevalence, a fact that may be attributed to the Gabbro and its fertile clay soils. As previously mentioned, it has been noted that the refugees/migrants did produce more food than their counterparts in the DSS (Twine, pers. comm. 2008). The transport network is also limited in the villages in the south eastern of the DSS with most roads located in the central part these villages, while some village have very little road structure. This impacts not only on access to food but access to the health facilities as well, in an area with already exorbitant transport costs.

While areas of concern have been noted, and their vulnerability in terms of surrounding land cover and land capability discussed, additional research would be required to ascertain the contrasts indentified in the analysis regarding geographic location and food security, given that the physical attributes play an important role in the production of food, which goes a long way to improve food security. In this part of the research the physical attributes or geographic location does not seem to have much influence in the food security status of the villages no matter where they are located or in which land capability class they belong to, suggesting that there are other factors at play.

PART THREE

SYNTHESIS AND CONCLUSIONS

FOOD SECURITY, HIV AND AIDS AND NATURAL RESOURCES UTILISATION

Part Three of this research report synthesises the important findings from the research results as outlined in Part Two. The synthesis draws on the results from chapters Five: on the prevalence of hunger and HIV and AIDS, as well the utilisation of natural resources, Chapter Six; land-use and land-cover change and resource availability, and Chapter Seven, other factors driving food insecurity to address the objectives of the research on sustainable food security and natural resource management (Figure 8).

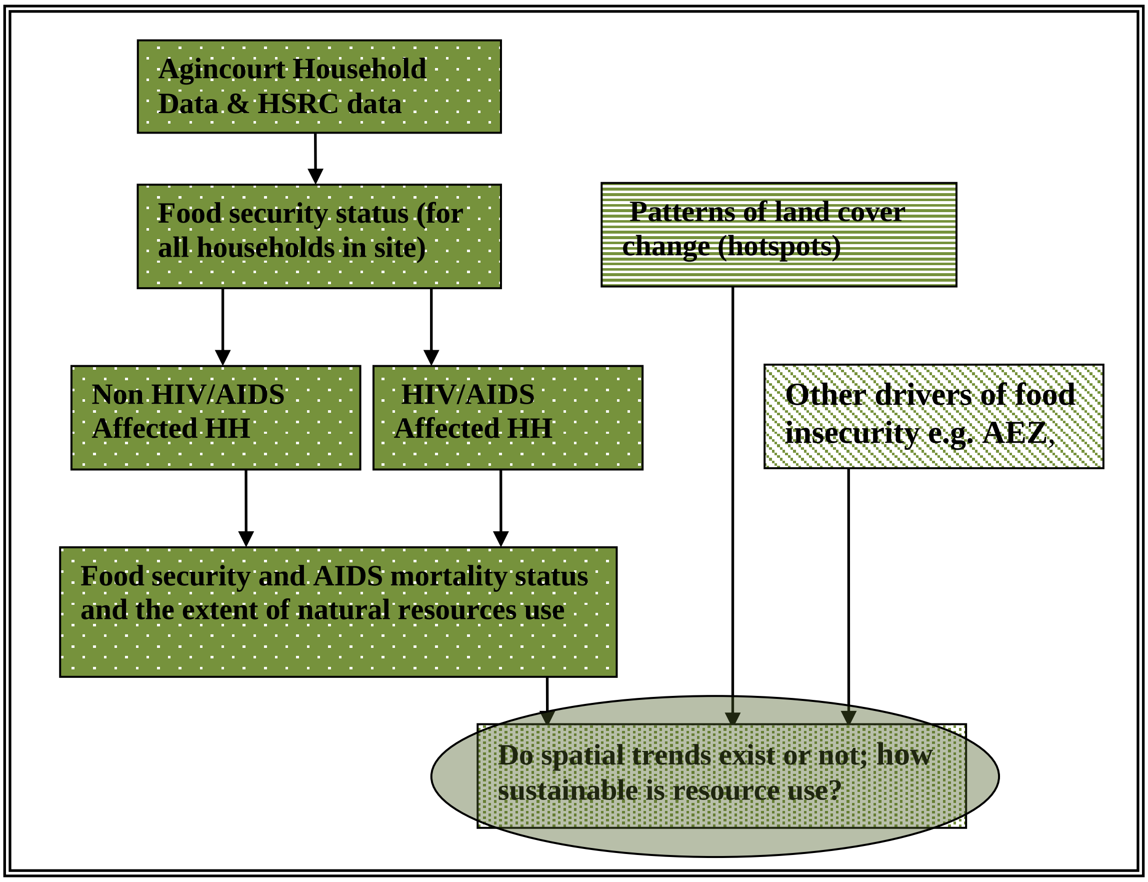

Figure 8: Conceptual diagram highlighting section covered in section of thesis

CHAPTER 8

SYNTHESIS: FOOD SECURITY, HIV AND AIDS AND NATURAL RESOURCE UTILISATION

8.1 Introduction

The preceding chapters have analysed the possible relationships and linkages between the HIV and AIDS epidemic, food security and utilisation of natural resources, as well as the diverse food and household income acquisition and coping strategies employed by rural households. This study endeavours to increase understanding of the dynamics between HIV and AIDS, food security and natural resource utilisation. An understanding of these dynamics, especially in South Africa, could hardly be more relevant, given the high HIV prevalence, high AIDS mortality and high food insecurity among the country's poor (de Klerk *et al.*, 2004; Chopra *et al*., 2008; UNAIDS, 2007, 2008) described earlier in this dissertation, and elsewhere. While there has been high awareness and investment in prevention and treatment of AIDS as well high awareness on food insecurity, with initiatives such as FIVIMS-ZA established to identify populations that are food insecure and those that are vulnerable to hunger, the role of natural resources in this nexus has lagged far behind. Given the role of natural resources in rural livelihoods, especially in the face of food insecurity, changing climate and natural resource availability, attention now needs to focus on natural resources in terms of investment, research and sustainable management.

In this synthesis chapter, six key findings on food security, the HIV and AIDS epidemic and sustainable natural resources utilisation are synthesised based on the three research questions and reviewed in distilling the key trends that have emerged. These trends help to address the final research objective – *to determine the impacts of food security and the HIV and AIDS epidemic on natural resources*. Key emergent trends are explored to highlight the value of a holistic framework for redefining interventions to address food security and the management of the natural resource base for rural livelihoods. The six key findings are listed below and discussed in this chapter:

- The Agincourt population is not as food insecure as anticipated, with significant improvement in food security observed over the study period;
- The former Mozambican refugees are not as vulnerable to food insecurity and as anticipated;
- Household income is the main determinant of food security, followed by gathering of natural resources as the second most influential factor for food security;
- AIDS mortality is not a significant driver of food insecurity in the DSS in the baseline year 2004;
- Gathering of natural resources is an important coping strategy for all households in the DSS and is not limited to AIDS afflicted or food insecure households;
- The natural environment is not a key factor for the attainment of food security with under utilisation of natural resources noted;
- There are strong linkages between resource degradation and high hunger prevalence villages.

8.2 Food Security

- ***The Agincourt population is not as food insecure as anticipated, with significant improvement in food security observed over the study period***

The population of the DSS is not as food insecure as anticipated, given its state as an ISRD node. While the hunger prevalence is higher in 2004 with 36.3% of households compared to 14.3% of households in 2007 (Figure 8.2), approximately 63.7% in 2004 and 85.7% households in 2007 are food secure. This is observed despite the poor food production performance across all villages, especially in 2004, reinforcing that fact hat food production is not the main source of food. In addition food production may be hindered by the unavailability of farming land and rainfall as noted earlier. However, an improvement in food production is noted, which may have resulted in the improvement in food security. While eight villages had more than 400 households not producing enough food in 2004, this number is reduced to four villages, showing a significant improvement.

While the prevalence of hunger varies between villages, there is a significant improvement in food security across the study area in 2007 compared to 2004 (see Figure 8.1), with food insecurity increasing in very few villages but decreasing in most villages, over the 3 year period. It is important to note that the total number of households analysed in 2007 is much smaller than the total number in 2004 thus the results may appear contradictory. Villages that indicated improvement in food security also indicated improvement in food production, with the improvement noted in both demographically and spatially big and small villages. For example, food security in villages 3, 9 and 10 improved from high hunger prevalence in 2004 (Figure 5.1) to medium hunger for village 10 and low hunger prevalence for villages 3 and 10 in 2007 (Figure 5.4). In 2004, village 3 and 10 had almost no households producing food while village 9 had less than 100 households producing food (Figure 5.7). In 2007 however, food production in villages 3 and 9 had more than 200 households with village 10 just fewer than 200 households producing enough food (Figure 5.9). However, some villages of concern are noted which still have more than 50 hungry households per village with the worst being village 11, indicating persistent hunger in both years, with more than 150 food insecure households in 2007. Coincidentally, village 11 has the highest number of households not producing enough food in 2004 and is the second highest in 2007. Given the high food insecurity and the poor food production status of village 11, subsistence farming, despite not being the most important source of food, might have a role to play towards securing food in the DSS and in this village.

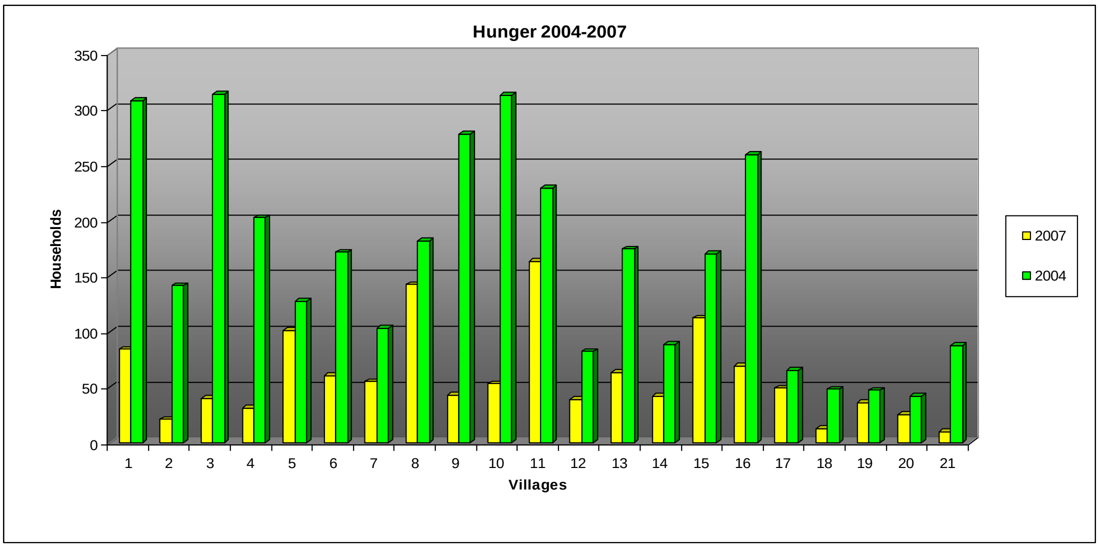

Figure 8.1: Comparison of hunger in DSS from 2004 – 2007

- ***The former Mozambiquan refugees are not as vulnerable to food insecurity and as anticipated***

The villages with higher migrant populations are located in the eastern drier parts of the DSS and within the Gabbro dyke. The spatial location and migrant status of these villages, together with the small size of plots in these villages would seem to combine to enhance vulnerability to food insecurity. The food security situation would be exacerbated by the economic status of the migrants, especially poor or lack of access to government grants and other government services (Schatz, 2009). However, despite these unfavourable attributes, the migrant villages had the least number of hungry of households in both years. Further, the migrant villages showed significant improvement in food production, particularly in 2007. According to Twine (pers. comm. 2007) migrants are known to be more active subsistence farmers compared to their local counterparts.

One of the possible explanations as to why migrants are more active farmers or harvest more food than their local counterparts is that most Mozambiquan households cultivate more than one field as well as around their homesteads as noted by Giannechinni *et al.* (2007). Another possible explanation might be traced back to apartheid. As previously mentioned in Chapter 3, the various policies under apartheid resulted in the estrangement of the local people from their land and farming practises, to become labour in the mines and industry. This estrangement could have result in the loss of knowledge and skills on subsistence farming for the generations that followed (Kepe, 2009).

While many migrants practise subsistence agriculture, household income does play an essential role, with longer term livelihoods strategies employed. These strategies include seasonal or permanent employment in the neighbouring commercial farms, mining and in the tourism industry. Other strategies are based on informal trading business, especially in natural resource products such as crafts, liquor and selling of firewood, making contributions to the much needed household income. According to Golooba-Mutendi and Tollman (2001) remittances, while not always regular or even sufficient, provide an adequate basis for survival in this migrant community as a paramount livelihood. Thus, whilst household income is still the most important for food security, one cannot discount the imperative role of subsistence agriculture for the migrants in attaining food security.

The importance of subsistence agriculture to household food security and income in South Africa rural livelihoods is acknowledged, with an estimated contribution of between 6–12% of livelihoods income and especially in the absence of social grants and other income (Backeberg, 2009; Chopra *et al.*, 2009; Jacobs, 2009; Kepe, 2009). Different forms of subsistence agriculture are said to further contribute considerably to household nutrition and without which the food security of rural households would be greatly reduced (Kaschula, 2008). Further, organisations such as the World Bank support subsistence agriculture and land reform as a fundamental tool out of poverty and inequality.

The importance of subsistence agriculture in overall rural livelihoods has, however, been debatable, given the lack of access to arable land faced by many rural households (Francis, 2006). In addition, the lack of adequately sized land for the harvest of good yields as noted by Giannechinni *et al.* (2007), and the small size of plots noted by Francis (2006), exacerbates the problem of food production. The slow and poor delivery of the land reform programme has only served to impede subsistence agriculture, particularly in former homeland areas (Francis, 2006; Kepe, 2009). Further, the under utilisation of land resources has been noted in rural areas (Backeberg, 2009), including in the study area, especially the vast tracts of abandoned or fallow parkland identified in the village commons.

While agriculture is advanced by government and international organisations such as the World Bank, as the solution to poverty and inequality, access to land in rural and former homelands remains a challenge. This is exacerbated by the AIDS epidemic given the epidemic's adverse effects on agriculture at household level, in particular the lack of labour and the diversion of household income to care for the sick and funeral expenses (Hunter and Twine, 2005; Backeberg, 2009; Kepe, 2009). The importance of agriculture does not discount the importance of cash based income livelihoods and household income and expenditure which play an essential part in the economy of the DSS and in food security.

8.3 Factors Influencing Food Security

- ***Household income is the main determinant of food security, followed by gathering of natural resources as the second most influential factor for food security***

While diverse household food acquisition strategies are employed by the rural population in many African countries, rural livelihoods in South Africa are less reliant on subsistence farming, being attributed to government grants and remittances which are paramount to rural economies. Thus household income and expenditure, particularly supplementing household food by purchasing food becomes the main determinant of food security. As evidenced in this research, in 2004 at least 96% of the households were buying staples such as maize, potatoes, bread and rice and 51% of households in 2004 supplementing non-staple foods through purchase. Further, according to the DSS database, not having enough money was cited by 77% of the residents as the main contributor to household food insecurity in 2007.

The importance of remittances in the DSS economy is noted by the increase in temporary migration for both males and females. According to Collinson *et al*. (2003), in the Agincourt DSS temporary migration for work is a common coping strategy implying an increase in remittances. While government grants and remittances are pertinent in this rural economy other sources of household income exists and these include wages from formal and informal employment and donations from relatives or church organisations. Therefore the delay or non-receipt of money from these diverse sources culminates in food insecurity. However, village 11, despite having a higher number of temporary migrants in 2007 still has high hunger prevalence, raising questions about the contribution of remittances to food security in this particular village.

The importance and role of household income is also echoed by Giannechinni *et al.* (2007) especially the increase in informal employment, for example the increase in trade of firewood and other natural resource products such as reed mats and brooms, in other villages in the same study area where this research is conducted. This trend termed *de-agrarianisation* by Bryceson (2000) reiterates the gradual transition from agricultural-based livelihoods towards "*income earning orientation*" livelihood such as informal trade in clothes, firewood and other natural resource products as noted in rural areas in sub-Saharan Africa including in South Africa.

Bearing in mind the high illiteracy and high unemployment rates in the DSS and the importance of household income and expenditure in food security, the main contributing factor to food insecurity in the study area in both 2004 and 2007 appears to be strongly economic, with 80% in 2004 and 76% in 2007 citing unavailability of household income as the determinant factor.

Regarding how the relationship has changed between food security, household income and natural resources, explained within the context of the proposed hypothesis, rural livelihoods and the rural economy are driven by household income. Despite natural resource utilisation being considered a main underlying driver of rural livelihoods and consequently food security, in rural South Africa unlike the rest of southern Africa money has a key role to play in the sustainability of livelihoods. Nonetheless, with natural resource utilisation as the proximate driver for availability of household income, natural resources are still pertinent in rural livelihoods, as indicated in Figure 8.2.

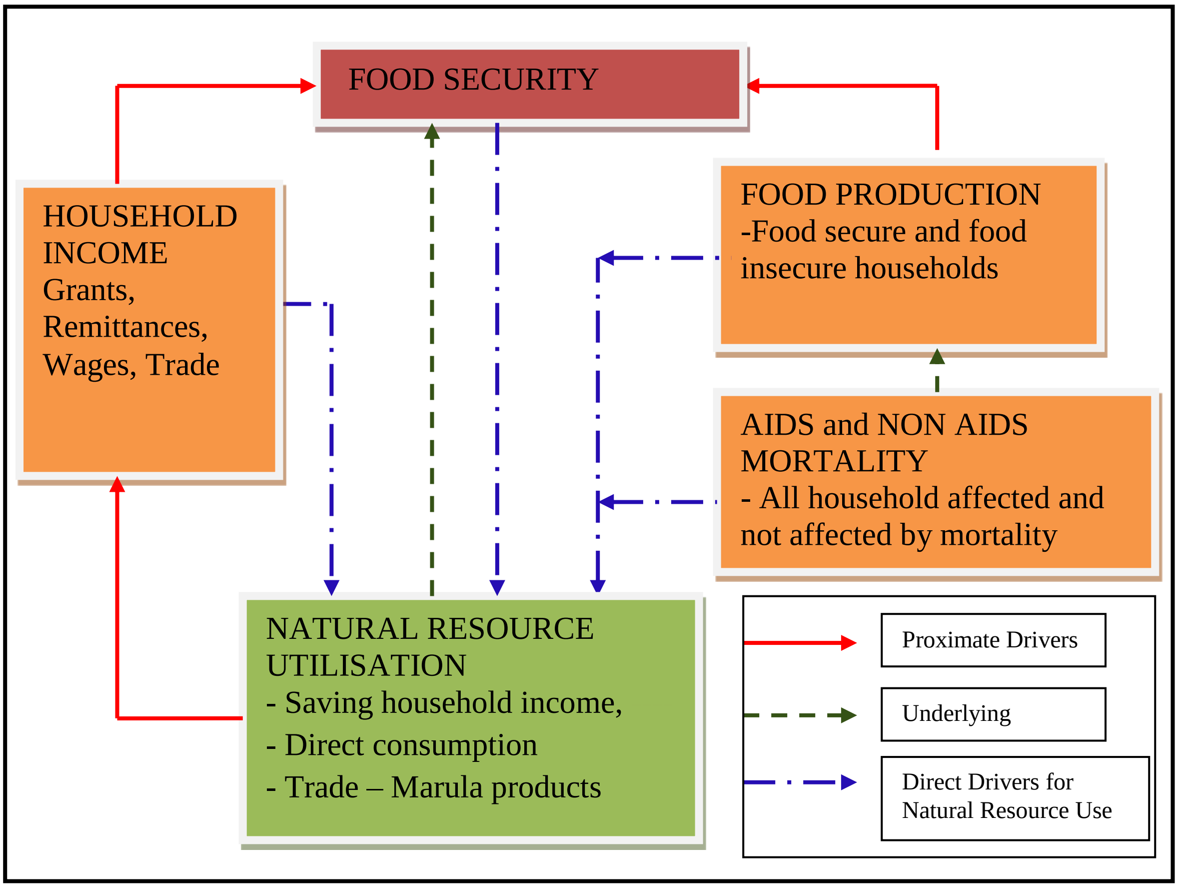

Figure 8.2: The relationship between Food Security, Household income and Natural Resources

Of particular interest is the utilisation of natural resources by all households in the study area, food secure and insecure, and AIDS affected or not AIDS affected, placing natural resources under immense pressure. The growth in population in the study areas further exacerbates conservation of these precious resources, resulting in over exploitation and ultimately resource degradation. This is despite the reduction of resource use in the DSS, which could be attributed to a stabilizing population, among other factors.

8.4 Mortality and Food Security

- ***AIDS mortality is not a significant driver of food insecurity in the DSS in the baseline year 2004***

The influence of AIDS mortality on household food security and utilisation of natural resources is a key question in this thesis as well as other studies conducted in the study area, albeit at different scales of study, e.g. household *versus* village level. The high HIV prevalence in the DSS, culminating in high adult AIDS mortality increased in the 1990s, with the mortality of women exceeding that of men (Clark *et al.*, 2007). It is assumed that HIV/AIDS, through the mortality of especially women, undermines food security by specifically eroding food security resilience in varying degrees, e.g. within households and at multiple levels for example households, villages and communities. HIV/AIDS also affects the diverse food acquisition strategies employed in the rural areas especially if the breadwinner, household head or the resources gatherer becomes sick or dies (Kaschula, 2008). In addition, the focus on the interaction between HIV and AIDS and household food security in South Africa has primarily focused on household income and expenditure given the key role played by household income in rural economies.

AIDS related mortality is low, in the DSS in 2004 which is selected as the baseline year, with mortality from TB and pneumonia being listed as unrelated despite the strong association between them and HIV infection. A total of 187 households (2%) from the selected study sample of 9143 households in the DSS are affected by single or multiple AIDS mortality. With only 40% of the households affected by AIDS mortality experiencing food insecurity (Figure 8.3), there does not seem to be a clear linkage between AIDS mortality and the worsening or improvement of food security for the highly affected villages.

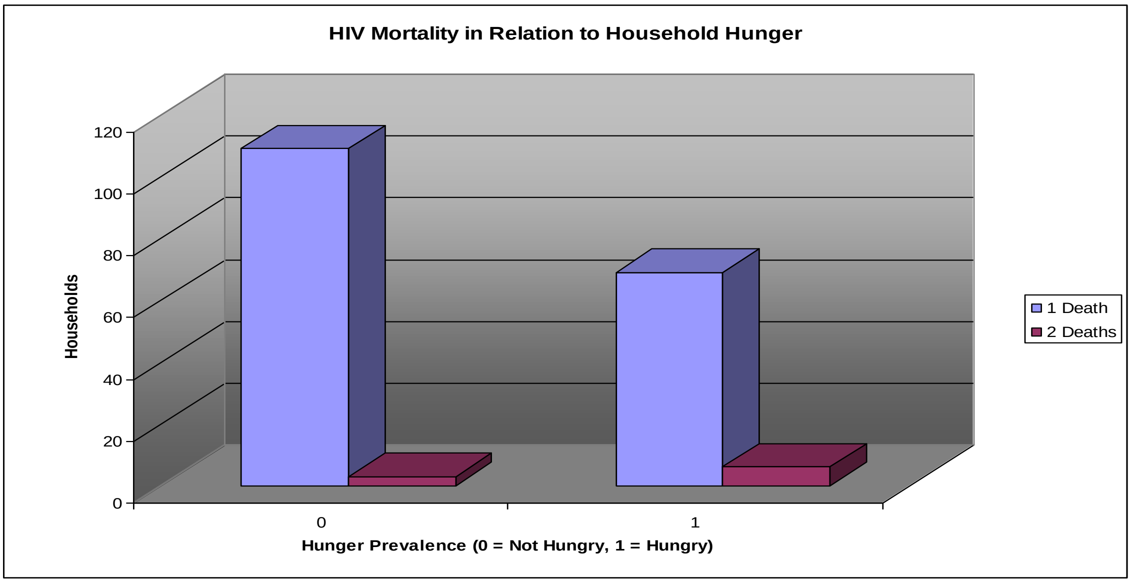

Figure 8.3: HIV Mortality and Household hunger

Logistic regression analysis, both forward stepwise and enter method[39] revealed that AIDS mortality and mortality in general are not direct drivers of food insecurity. Rather, the significant or indirect drivers identified are lack of household income, influenced in turn by mortality of the bread winner. Depending on the function of the bread winner in the household, whether it was full time or part time employment, gathering of resources or subsistence farming, the lack of that contribution will have detrimental impacts to the household's food and income. The surviving member of the household would have to take over the duties of the deceased breadwinner. The second significant driver is identified as the gathering of natural resources. As already discussed in Chapter 5, the gathering of natural resources plays an important role in supplementing household food and income for all households and not only those affected by mortality. The last significant driver is the gender of the household head, with female headed households being more food insecure than male headed households as noted in Chapter 5.

The second logistic regression on factors influencing availability of household income, highlighted natural resource utilisation as an important factor for household income and consequently food security in the DSS. Approximately the more than 900 households

[39] SPSS software was used for this analysis

that did utilise natural resources are not food insecure (Figures 5.22, 6.19). As already indicated food security is influenced by household income which in turn is influenced by natural resource use.

Possible explanations could explain this trend and these are firstly, the size of the two study samples that could not be compared given the significant difference in numbers. **Secondly**, the scale for this study was too large to highlight any meaningful linkages at village level between household food security and AIDS mortality, given that other studies conducted on mortality and food security, in the DSS are conducted at household level. For example, Twine and Hunter (2008) in their study asked a small sample of household's specific questions about the impacts of adult AIDS mortality on household income and food. At the household scale, linkages between AIDS mortality are identified but not at village level. **Thirdly,** according to studies by Hunter *et al.* (2007), Kaschula (2008) and Twine and Hunter (2008), AIDS mortality does affect household income and consequently food security especially if the bread winner or the migrant child or spouse dies with detrimental effects, which is then mitigated through the gathering of natural resources. These studies also indicate that these impacts are not peculiar to AIDS mortality alone.

In this research, the comparison of non-AIDS mortality and food security yielded some interesting insights, highlighting high hunger prevalence for the two villages which had higher non-AIDS mortality than AIDS mortality. Non-AIDS mortality would include sudden deaths from stroke, heart attack, traffic accidents or crime related. Some likely explanation for this trend would be that, with a sudden death, the family members are totally unprepared and thus would struggle emotionally and economically to come to terms with the sudden loss of income or labour (depending on the role or duties of the member in the household) (Twine, pers. comm. 2007). On the other hand, for families faced with AIDS mortality, the length of illness would have prepared the members of the households for the inevitable death and thus by time the infected member passes on, coping strategies would have been put in place for the sustenance of the family.

The linkage between non-AIDS mortality and high food security are also noted by Twine and Hunter (2008) despite a small number of non-AIDS mortality affected households sampled in their study. An increase in non-AIDS mortality, from life style diseases such as stroke and heart attacks is noted by Kahn and Tollman (1999) in the same study. Households that experienced non-AIDS death are more likely to experience hunger and engage in coping strategies including gathering natural resources, than AIDS affected households. These two factors are further linked to poverty, given that in non-AIDS mortality households, the deceased member would have contributed either income or was involved in gardening or farming, while in AIDS impacted households the deceased would have been involved in natural resource gathering (Twine and Hunter, 2008). Given that non-AIDS impacted households are generally wealthier than AIDs impacted households, the capacity of non-AIDS affected households to recover from the death is higher making the adverse effects of mortality short term in nature (Twine and Hunter, 2008). On the other hand the AIDS affected households are generally poorer, possibly due to the use household assets to care of the sick and funeral expenses making the adverse effects of mortality long term.

8.5 Utilisation of Natural Resources

- ***Gathering of natural resources is an important coping strategy for all households in the DSS and is not limited to AIDS afflicted or food insecure households***

Natural resources utilisation is widespread and not only restricted to food insecure and AIDS affected households but all categories of households (Figure 8.2). The utilisation of natural resources is cited by DSS residents as a supplementing strategy for food insecurity and household income, with approximately 56% households in the study sample in 2004, both food secure and insecure gathering natural resource products. These statistics are for only those households that answered the question about hunger in the previous month. There are indications from the data for this research that even households that are excluded from the study sample (those that did not answer the hunger question) gathered natural resources, implying possibly a higher percentage than the 56% stated above. There is, however, a significant drop in the number of households using natural resources to only 17% in 2007. It is interesting to note that this significant reduction in natural resource utilisation correlates with the improvement in food security in the DSS in 2007, implying less reliance in the natural resource products.

Possible explanations for the drop in the number of households using natural resources could be an increase in migration as noted by Collinson *et al*. (2006) which may have resulted in increases in remittances, relieving some pressure on natural resources. Secondly, the data compatibility issues and the inconsistencies in the food security data collection between 2004 and 2007 mentioned in Chapter 5 resulted in a significant reduction in the 2007 study sample, impacting on the natural resource utilisation data sample. The reduction in natural resources use and the improvement in food security in the DSS in 2007 would warrant further investigation at a household level but is beyond the scope of this research.

While all categories of households gather natural resources products, this was more pronounced in households affected by all mortality as noted by Twine and Hunter (2008). In particular, the gathering of natural resource products for resale was more common among non-AIDS mortality impacted households, and these products include reed mats, marula beer and fire wood (Hunter and Twine, 2005). Further, some rural households in South Africa derive nutritional benefit from edible gathered resources, while non-edible resources may be sold for cash income or used to save the much needed household income (Shackleton and Shackleton, 2004; Kaschula, 2008), through the replacement of previously purchased goods with non-edible natural resources (Hunter *et al.*, 2007; Twine and Hunter 2008). In addition, the gathering of natural resources has been more recently associated with and considered to ameliorate food and nutritional security for HIV and AIDS afflicted households (Kaschula, 2008). As evidenced in both the study conducted by Twine and Hunter (2008) and in this research, wild leafy vegetables or herbs and fuel wood are the most commonly utilised natural resources, in mortality affected households.

In contrast to the proposed hypothesis associating natural resource utilisation with adult AIDS-mortality affected households, this research reveals that natural resource gathering is a common coping strategy for all households including those that are neither affected by mortality nor food insecurity. While these linkages are not explicit at village level in the later year (2007), these are clearly identified in the baseline year, 2004, and is supported by Hunter *et al.* (2007) and Twine and Hunter (2008). Whilst an essential coping strategy at the household level as evidenced by Twine and Hunter (2008), natural resource utilisation does not seem key at village level scale analysis. The same trends are noted for the non-HIV and AIDS mortality affected households, with both villages stratified in the medium utilisation category of natural resource utilisation (Figure 6.1). However, given the potential increase in mortality due to the high HIV prevalence and anticipated increased AIDS mortality in the study area, it is important not to disregard the possible future impacts of the epidemic on the natural resource base and sustainable food security.

The importance of natural resources in supplementing household food has nevertheless been highlighted both in terms of the descriptive frequencies of the variables and the logistic regression analysis. This is echoed by the research by Twine and Hunter (2008) and Hunter *et al.* (2007) and Shackleton *et al.* (2007). The utilisation of natural resources highlights the use of wild foods as having a positive impact on the household's dietary diversity, especially the consumption of insects and wild vegetables. With dietary diversity as an indicator of availability or status of household income, the use natural resources in saving household income becomes a key aspect of these inter-linkages. Further, as noted by Hunter *et al.* (2005), most of the households are most likely to use natural resources as a means to save household income, for example the use of firewood instead of electricity. These would be the villages located close to woodland or bushland cover classes including within the buffer areas (Figure 6.21). The availability and state of these resources becomes irrefutably essential for the sustainability of livelihoods and as indicated by change analysis (Figures 6.12, 6.13) these resources are already facing some measure of degradation.

8.6 The Natural Environment

- ***The natural environment is not a key factor for the attainment of food security with under-utilisation of natural resources noted***

The natural environment, in terms of access to and proximity to woody resources and land resources for subsistence farming are not a vital factor to food security in the study area. The natural environment, assessed through land capability, the digital elevation and the resource mapping indicates that most of the villages are situated in land capability zones four with severe limitations for agriculture and zone six which is not suitable for agricultural production.

Premised on the land capability map, villages located in the Gabbro, in land capability class six which is non-arable (Figure 7.3), instead of being food insecure as expected had the least number of hungry households per village. Further, the villages in this area are surrounded by limited woody cover classes, mainly bush, scrubland and parkland which according to the National landcover data (NLC) are also degraded. This is aggravated by the lack of exclusivity of access to these degraded resources (Figure 6.21). Therefore the reasonably good state of food security in these villages could imply efficient utilisation of the Gabbro for subsistence farming, attributed to better climatic conditions. By contrast, villages in land capability zone four (the more arable class), surrounded by woodland classes and while having exclusivity of use to natural resources have high numbers of food insecure households. These villages due to the nature of their location, in the more arable agricultural zone and surrounded by abundant woodland resources for gathering of a myriad on natural resources, should have been more food secure. Arable land and woodland resources are essential for viable rural livelihoods and consequently food security. Thus, there are no clear spatial trends noted in terms of food security and physical attributes for food production as well as with the availability of woody resources and the utilisation of these resources in the DSS or in the livelihood strategies for the resident of the DSS.

8.7 Resource Availability and Degradation

- ***There are strong linkages between resource degradation and high hunger prevalence villages***

The general trend in reduction of woody cover classes and increase in parkland and settlement areas is common over both study periods, especially for resources located next to villages. According to Giannechinni *et al.* (2007), significant socio-economic changes occurred, including the arrival of the Mozambiquan refugees in the 1980s and weak institutional control of natural resources. This could have substantially impacted the population growth, including settlement and parkland class increases from the 1990s onwards. Some of the cash based livelihoods, such as the harvesting of fuel wood for sale, had a huge impact on natural resources (Giannechinni *et al.*, 2007), leading to deforestation and resource degradation. According to Twine (pers. comm. 2007, Hunter and Twine, 2005), despite the majority of households being electrified, dependency on firewood is still high. Given the continued growth of the villages, the demand for firewood will increase, with consequences on sufficiency and sustainability of supply for these already degraded resources.

As illustrated in Figure 6.18, from 1990 to 2005, the high negative change (red colour) indicate degradation and possible deforestation within the village boundaries and village commons towards and within the boundaries of the Bushbuckridge nature reserve, which coincidentally are areas of overlap (buffer areas) between villages (Figure 6.21a). High levels of human disturbance were observed during the field work especially in the woody cover classes which show high degradation, with animal grazing, fuel wood collection and resource collection taking place. Open bushland, which is the most common land class surrounding the villages, is highly disturbed. As previously mentioned, most of the natural resources (including herbs) are gathered from the village commons which according to Figure 6.12 are showing high degradation between 1990 and 2001 (red colour). These areas are considered to be hotspots. This evidence is supported by the NLC (national landcover data (Figure 7.5) showing degraded areas, drawing attention to the management and sustainable utilisation of these mainly common property resources. It is intriguing to note that most of the degraded forest and woodland common property resources are located between villages that are food secure. This could mean that natural resources are playing a key part in the food security and income availability of these villages.

In light of this, policy makers should address issues of local governance, regarding access and utilisation of these key resources to mitigate against further degradation. Better management policies for the identified hotspots are essential. Further the identification of hotspots, as set out in the objectives of the study, allows for continual monitoring of the natural resources for current and future use.

8.8 Future Directions of Potential Research

As mentioned above, the results of this thesis will form the basis for further research, being used as a baseline for monitoring HIV and AIDS impacts on, food security and sustainable natural resource utilisation in the Agincourt Demographic Surveillance Site. Further, the findings of this research may also be used to better understand food security and natural resource utilisation in rural livelihoods in other rural areas of South Africa, especially in this era of HIV and AIDS.

Potential opportunities for future research which have been raised in this research are outlined below.

First: is to investigate the importance of remittances in the economy of the DSS given the importance of availability of income for food security and given the increase in both male and female migration and therefore increase in remittances. There is also a need to investigate the relationship between household income, household assets and natural resource use and the contribution of each to household food security.

Second: given the poor level of food production in the DSS despite food insecurity, the role of subsistence agriculture is questioned, as a means to achieve food security and for poverty alleviation as well as addressing the past inequalities in rural livelihoods.

Further, the role of subsistence farming is questioned given the shift from farming to cash based livelihoods (Bryceson, 1999; Giannecchini *et al*., 2007). As noted in this study and supported by Backeberg (2009), the land resources in the rural areas were hugely under utilised, raising question about the key strategies to underpin rural development. Is the lack of credit finance, agricultural inputs and extension as well access to arable land critical to boost local food production?

Third: to decipher the actual contribution of the HIV and AIDS epidemic impact on natural resources given the multiple stressors happening concurrently especially poverty and climate variability, this done at individual village level scale and not just at household level.

Fourth: Given the prevalence of food insecurity in non-AIDS affected households and the increase in non-AIDS related mortality in the DSS, it would be important to investigate the significance and vulnerability of non-AIDS mortality affected households.

Fifth: With Village 11 in mind, the question arises as to what kind of village level vulnerabilities exist and how or what type of village level inventions may be put in place to raise awareness, to protect and encourage sustainable utilisation of natural resources especially in the village commons?

Sixth: What policies are currently in place for the management and governance of common property resources in the DSS and in rural South Africa in general, either at village, district or provincial level and how these policies can be augmented by studies such as this one to ensure sustainable management and utilisation of these precious resources?

CHAPTER 9

CONCLUSION

9 Conclusion

The importance of natural resources in rural livelihoods in the DSS is well documented. Hunter *et al.* (2007), Twine and Hunter (2008) and Shackleton *et al.* (2008) investigated not only the utilisation of the natural resources harvested, but the dietary and financial importance of these resources. The escalation of deaths from AIDS and increased HIV infection as well as population growth means natural resources will continue to play a pertinent role in the lives of villagers in the DSS. While the role of natural resources in livelihoods and in poverty alleviation has been contested (Neumann and Hirsch, 2000, in Shackleton *et al.*, 2008), various studies have illustrated the importance of natural resources to the rural poor in relation to food security and household income. Further, this study has highlighted how natural resources play an important role in the availability of household income as well as dietary diversity and that the utilisation of natural resources is cross cutting for all the residents in the DSS. In addition, vulnerability to food insecurity does not imply prevalence of food insecurity as noted in the DSS.

Of note is the key role played by poverty and climate variability as major drivers of food insecurity in the DSS indicating the importance of addressing these two phenomena when addressing improvements of food security and concerns of sustainable food security, keeping in mind the huge migrant population in the DSS. While HIV and AIDS do not seem to be an issue in terms of food security and natural resource utilisation at village level, its detrimental impacts at household levels are already being felt. To comprehend such impacts and consequences, more detailed social probing using for example participatory research techniques is required to investigate and tease out the social dynamics driving food insecurity and natural resources utilisation within the HIV and AIDS context. Given the predicted escalation in AIDS mortality, and the current economic climate, the effects at village and community level will soon become visible, despite not being visible in this study.

A possible explanation for this invisibility could be attributed to the methodology and the scale chosen for this study, given that the methods are experimental, bringing together bio-physical and socio-economic as well as demographic data. While most of the studies on the interactions of HIV and AIDS, food security and natural resource utilisations are conducted at household level, this research needed to investigate the broader implications of these interactions on communities and villages, given that the natural resources accessed by households are located between and in the village commons. Further, the availability of physical data, particularly satellite remote sensing data, for the assessment of natural resource availability and landcover change is appropriate at village level scale.

Conversely, the statistical methods for the analysis of the DSS data investigated more of the determinants of food security, thus did not reveal the actual impacts as expected. The determinants investigated are however believed to influence the impacts on food security and natural resource utilisation. The choices for these methods are influenced by the available data, given the inconsistencies in the collected data itself as highlighted in Chapter 4. Further, the small number of AIDS mortality in the study area influenced the unexpected outcomes and this would have been regardless of what methodologies are applied. However, given the expected increase in AIDS mortality in the DSS, the current economic crisis which has resulted in retrenchments, impacting on remittances and availability of income, a follow up study will possibly yield very different outcomes even with the same methodologies.

Another contributing factor to the unexpected results could be the hypothesis itself. While the hypothesis is very applicable to most rural communities in southern Africa, this is not so in South Africa, due to the social protection and grants systems. Rural household affected by the HIV/AIDS epidemic, are cushioned from bearing the full brunt of the epidemic‘s adverse impacts, financially and medically, as indicated by the importance of money in the attainment of food security and to a certain extent agricultural production. The findings of this research, while not as expected according to the hypothesis, have highlighted some interesting facts, forming the basis for further village investigations for HIV/AIDS interactions, food security and natural resource utilisation, including the role of social protection in rural South Africa as a new dimension.

Another key finding of this research is that the attainment of food security is not a clear cut and simple process, with different drivers acting individually and concurrently to exacerbate food insecurity, leading to over exploitation of natural resources, land cover change and consequently natural resource degradation. The myriad of factors influencing food security and availability of household income to purchase food indicate dynamic rural economies with various coping strategies including migration and natural resource utilisation. According to Hawkes and Ruel (2006), the natural environment is but one of the ways agriculture and health interact through people. Interactions between agricultural systems, especially subsistence, climate variability and the natural environment may affect human health, in terms of food production of fibres and plants with medicinal properties essential for human health (Nugent and Drescher, 2006; Wheeler *et al.*, 2010). The effects can also be negative, especially some of the agricultural practices that impact on the environment and consequently on human health (Nugent and Drescher, 2006). These interactions on the other hand present crucial opportunities for improved synergies in this nexus, especially for policy and planning (Hawkes and Ruel, 2006).

This research has served to highlight again the multifaceted nature of food insecurity and the various coping strategies rural communities engaged in to attain food and sustain rural livelihoods. This is exacerbated by the prevalence of multiple stressors such as HIV/AIDS, poverty and the current economic climate driving migration. In addition, climate change and climate variability present increased challenges especially the response of staples or cereals to climate variability, which is anticipated have detrimental impacts on food availability (Wheeler *et al.*, 2010). This is amid concerns of the ability to feed a growing population and balancing between under and over nutrition, and the proposal that health should be the key driver of future agricultural production (Hawkesworth *et al.*, 2010). Of concern however is the decline or unpopularity of subsistence agricultural productivity, as a means to achieve food security. This has been noted not only in the study area but in other developing countries as well, especially in Africa. According to the new emerging research agendas focussing on agriculture and health, food production has and will continue to play an essential part not only in the availability of food but in quality and nutritional importance impacting on human health and livelihoods (IFPRI, 2010). Given the adverse impacts of malnutrition especially on HIV/AIDS affected communities, nutrition becomes a critical interface between agriculture and health. Agriculture contributes to good health through the production of healthy staple foods making it a useful tool for nutritional security (Ruel, 2010). In addition, agriculture increases the access to micronutrient rich foods, raising income and employment (von Braun, 2010) as well as affecting the income earned and labour for people working in the industry, presenting both opportunities and risks (IFPRI, 2010). While the contribution of agriculture in the form of improved food production resulted in an increase in food security in particular villages in this study, in general, there are no clear indications whether changes in agriculture improve or worsen health and nutrition, (Hoddinott, 2011), given the food safety issues arising (Lang, 2006).

Food safety, as a result of modern intensive agriculture has become problematic, resulting in a nutritional transition, from the consumption of healthy fibre and whole grains to the increased consumption of sugar and processed foods (Lang, 2006; Hawkesworth *et al.*, 2010; Waage *et al.*, 2010). This transition seems consistent with the urbanisation of poor societies such as the population in the Agincourt DSS, with increased trends in chronic conditions such as cardiovascular disease, certain types of cancer and diabetes as well as increases in obesity (Lang, 2006; Hawkesworth *et al.*, 2010). This new trend has also been noted in the Agincourt DSS, raising question about the quality of food access with improved household income (Hoddinott, 2011). In the study area, between 1992 and 2000, there was a marked increase in female mortality of all ages from non communicable diseases such as stroke, hypertension and diabetes, with a sharp increase in hypertension from 1996 (Kahn *et al.*, 2006).

The concerns about access, availability and the nutritional status of food globally and in rural areas, given the importance of agriculture and health in this debate, has raised calls for the identification and improvement of synergies between agriculture and health (Bos, 2006; Hawkesworth *et al.,* 2010). According to Bos (2006), agricultural policies such as the conservation of the natural resources base, the protection of livelihoods and food security and safety for the poor; are determining factors for the health of these communities (Bos, 2006; Hoddinot, 2011). While the previous focus on the relationship between agriculture and health was considered one directional, the HIV/AIDS epidemic has highlighted the bidirectional interlinkages between the two, particularly the effects of nutrition on health, encouraging synergies between the two (Bos, 2006; Hoddinot *et al.,* 2011). Opportunities for synergies between agriculture and health have further been identified through the implementation of MDGs (Hoddinot *et al.,* 2011)

In terms of the policy implications of this research, to begin with, there is a need to rethink the contribution and importance of subsistence agriculture as a poverty alleviation tool in rural livelihoods, especially in South Africa. As noted in this study, poverty, resulting in unavailability of household income has adverse impacts on food security and consequently on natural resources. This is important in a country with one of highest rates of inequality and a high population living in poverty. Subsistence agriculture is further exacerbated by climate variability as well as a shortage of suitable land for farming. The issue of land is a contentious one in South Africa, plagued by the slow delivery, land claims and politics, meaning the redistribution of land is not an immediate solution to the subsistence farming decline. As noted in this study, subsistence farming is not the most important contributor to household food security.

The second policy consideration is the management and conservation of natural resources, given their importance in rural livelihoods, going beyond the South African context. The management of natural resources would include putting measures in place to govern access and methods, as well as quantities of resources gathered. Further, the monitoring of utilisation will assist in guarding against further degradation as well assisting with the designing of methods and policies for conservation of both woody and non woody natural resources. This needs to be done at a local level, with priorities set and implementation undertaken here.

The last policy implication would be based on the health factors, especially HIV/AIDS, given the impacts of the epidemic on both food security and natural resource utilisation, especially in rural livelihoods. There is also need to include non-AIDS mortality, given the increase and the impacts of this type of mortality on households as indicated in Chapter 5. Thus, policies or interventions for poverty alleviation, improvement of food security, livelihoods and health needs to consider these interactions. The above identified need for synergies between food security, health and natural resource utilisation are supported, given the complex interaction among these three factors.

It is hoped and believed that the work from this thesis has increased the understanding of the dynamics between mortality, food security and natural resource utilisation, with villages specific interventions advocated for, given that most of the dynamic factors are village specific. The specific intervention as well as policy formulation for natural resource management should be all encompassing including management of village commons, sustainable food security and the potential impacts of all types of mortality on natural resources. Unless immediate measures are taken to address the concerns of sustainable food security and sustainable natural resources management, the long term impacts will prove extremely challenging for residents of rural Africa and the Agincourt DSS.

APPENDICES

APPENDIX ONE

Appendix A: AHPU CENSUS 2004, V2.0 – HOUSEHOLD FOOD SECURITY QUESTIONNAIRE

Village	Dwelling	Household ID	Fieldworker	Date of Visit

1) How has your household obtained maize (mealies/mealie meal) over the last year? (You may select more than one option, write all numbers in the box.)		1 – Grown in own garden or homestead plot 2 – Grown by household members outside of own garden or homestead plot	3 – Purchased 4 – Borrowed 5 – Get it free (food aid/food parcel) 6 – Other
If other, specify:			
2) What staple foods other than maize (mealies/mealie meal) does your household often consume?		1 – Rice 2 – Bread	3 – Potatoes 4 – Other
If other, specify:			
3) Has your household grown food crops other than mealies in a garden on your homestead plot over the last year?		Y – Yes N – No	X – Don't know Q – Query
4) If (3) = Yes, which crops? (You may select more than one option)		1 – Fruit 2 – Vegetables	3 – Other
If other, specify:			
5) Has your household grown food crops other than mealies in a field outside of your homestead plot over the last year?		Y – Yes N – No	X – Don't know Q – Query
6) If (5) = Yes, which crops? (You may select more than one option)		1 – Fruit 2 – Vegetables	3 – Other
If other, specify:			
7) Have your fields/gardens produced enough crops to feed all the members of your household over the whole of the last year?		Y – Yes N – No	X – Don't know Q – Query
If other, specify:			
8) If (7) = No, why do your fields/gardens not produce enough crops to feed all the members of your household?		1 – Our fields/gardens are not large enough to produce enough food 2 – We do not have enough fertilizer 3 – We do not have enough water 4 – No-one available to work on the field/garden 5 – Other	
If other, specify:			
9) If (7) = No, how do you supplement your food requirements? (You may select more than one option. Write all numbers in the box)		1 – Buy food from the market 2 – Relatives, friends or neighbours bring food 3 – Food aid from the government 4 – Gather food from the bush 5 – We manage with the food we have	6 – We sell household goods, eg. furniture to buy food 7 – We sell livestock to but food 8 – Borrow money to buy food 9 – Other
If other, specify:			
		Number of times (1,2,3 etc)	Per week (W) Per month (M) Per year (Y)
10) If (9) = 4 'Gather food from the bush', what	1 – Wild herbs (eg. Guxe)		

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do you gather and how regularly?	2 – Wild fruit (eg. Marula) 3 – Wild insects (eg. locust, flying ant, mopani worm)		
	4 – Bush meat (eg. small mammals, birds, etc)		
	5 – Other		
If other, specify:			

11) Has your household not had enough food to eat in the last month?		Y – Yes N – No		X – Don't know Q – Query		
12) If (11) = Yes, how often in the last month did your household not have enough to eat?	Very often (15-30 days)	Often (8-14 days)	Sometimes (2-7 days)	Rarely (1 day)	Never	
13) Has your household not had enough food to eat in the last year?		Y – Yes N – No		X – Don't know Q – Query		
14) If (13) =Yes, in which season? (You may select more than one option)		1 – Summer 2 – Winter				
15) If (13) = Yes, for what reasons? (You may select more than one option)		1 – No money available at home 2 – Did not receive pension/ grant/ food aid on time 3 – Did not receive expected money from other family members 4 – Food did not grow in homestead / poor harvest 5 – Unexpected new household members 6 – Other				
If other, specify:						

		Number of times (1,2,3 etc)	Per day (D) Per week (W) Per month (M) Per year (Y)
16) How regularly does your household eat the following?	1 – Chicken		
	2 – Fish		
	3 – Red meat		
	4 – Eggs		
	5 – Vegetables		
	6 – Fruit		
17) How many meals does your household normally take in a day?	Maximum number of meals for male adults	Maximum number of meals for female adults	Maximum number of meals for children
18) How many meals did your family take yesterday?	Maximum number of meals for male adults	Maximum number of meals for female adults	Maximum number of meals for children

19) How do you expect the amount of food available to your household to change in the coming year?		1 – We will have more food 2 – Same amount of food	3 – We will have less food 4 – Don't know

APPENDIX TWO

Food Security Status Form

CEN-FDSCY-R13-V2

AGINCOURT Health & Population Unit

Village:
Dwelling:
Fieldworker:
Visit Date: Y Y Y Y M M D D

1	How has your household obtained Maize (Mealies / Mealie meal) over the last year? (Fill in all that apply)	Grown in own garden or homestead plot	1.1
		Grown by household members outside of own garden or homestead plot	1.2
		Purchased	1.3
		Borrowed	1.4
		Get it free (Food Aid/Food Parcel)	1.5
		Other	1.6
	If Other specify: 1.7		
2	What staple foods other than Maize (Mealies / Mealie meal) does your household often consume? (Fill in all that apply)	Rice	2.1
		Bread	2.2
		Potatoes	2.3
		Other	2.4
	If other specify: 2b		
3	Has your household grown food crops other than mealies in a **garden on your homestead plot** over the last year?	Y = Yes; N = No	3
4	**If Q3 = "Y"** which crops? (Fill in all that apply)	Fruit	4.1
		Vegetables	4.2
		Other	4.3
	If other specify 4.4		
5	Has your household grown food crops other than mealies in a **field outside of your homestead plot** over the last year?	Y = Yes; N = No	5
6	**If Q5 = "Y"** which crops? (Fill in all that apply)	Fruit	6.1
		Vegetables	6.2
		Other	6.3
	If other specify 6.4		
7	Have your fields/gardens produced enough crops to feed all the members of your household over the whole of the last year?	Y = Yes; N = No	7
8	**If Q7 = "N"** Why do your fields/gardens not produce enough crops to feed all the members of your household? (Fill in all that apply)	Our fields/gardens are not large enough to produce enough food	8.1
		We do not have enough fertilizer	8.2
		We do not have enough water/rainfall	8.3
		No-one available to work on the field/garden	8.4
		Other	8.5
	If other specify 8.6		
9	**If Q7 = "N"** How do you supplement your food requirements? You may select more than one option. (Fill in all that apply)	Buy food from the market	9.1
		Relatives, friends or neighbours bring food	9.2
		Food aid from the government	9.3
		Gather food from the bush	9.4
		Gather wild foods from plot or field(e.g. guxe, mice, locusts)	9.5
		We manage with the food we have	9.6
		We sell household goods e.g. furniture to buy food	9.7
		We sell livestock to buy food	9.8
		Borrowed money to buy food	9.9
		Other	9.10
	If other specify 9.11		

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2007.11.14

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10	**If Q9.4 or Q9.5 marked** What do you gather and how regularly in season?			Number of time (1, 2, 3, etc.)	**W** = Week; **M** = Month; **Y** = Year
		Wild Herbs (e.g. Guxe)	**10.1**		
		Wild Fruit e.g. (Marula)	**10.2**		
		Wild insects etc. (e.g. locust, flying ant, mopani worm)	**10.3**		
		Bush meat (e.g. Rabbits,mice, birds etc.)	**10.4**		
		Other	**10.5**		
	IF other specify **10.6**				
11	Has your household **not** had enough food to eat in the last month?	**Y** = Yes (hunger); **N** = No	**11**		
12	**If Q11 = "Y"** How often in the last month did your household **not** have enough to eat?	**V** = Very Often(15-30 days); **O** = Often(8-14 days; **S** = Sometimes(2-7 days); **R** = Rarely(1 day) ; **N** = Never	**12**		
13	Has your household **not** had enough food to eat in the last year?	**Y** = Yes (hunger); **N** = No	**13**		
14	**If Q13 = "Y"** In which season (Fill in all that apply)	Summer	**14.1**		
		Winter	**14.2**		
15	**If Q13 = "Y"** For what reason(s) (Fill in all that apply)	No money available at home	**15.1**		
		Did not receive pension / grant / food aid on time	**15.2**		
		Did not receive expected money from other family members.	**15.3**		
		Food did not grow in homestead / poor harvest	**15.4**		
		Unexpected new household members	**15.5**		
		Other	**15.6**		
	If other specify **15.7**				
16	How regularly does your household eat the following?			Number of time (1,2,3, etc.)	**W** = Week; **M** = Month; **Y** = Year
		Chicken	**16.1**		
		Fish	**16.2**		
		Red Meat	**16.3**		
		Eggs	**16.4**		
		Vegetables	**16.5**		
		Maize(Mealies / Mealie meal)	**16.6**		
		Bread	**16.7**		
		Potatoes	**16.8**		
		Edible wild herbs and fruits(e.g. guxe, marula)	**16.9**		
		Rice	**16.10**		
17	How many meals does your household normally take in a day?	Maximum number of meals for male adults	**17.1**		
		Maximum number of meals for female adults	**17.2**		
		Maximum number of meals for children	**17.3**		
18	How many meals did your household take yesterday?	Maximum number of meals for male adults	**18.1**		
		Maximum number of meals for female adults	**18.2**		
		Maximum number of meals for children	**18.3**		
19	How do you expect the amount of food available to your household to change in the coming year?	**1** = We will have more food; **2** = Same amount of food; **3** = We will have less food;	**19**		
20	Comments:				

CEN-FDSCY-R13-V1

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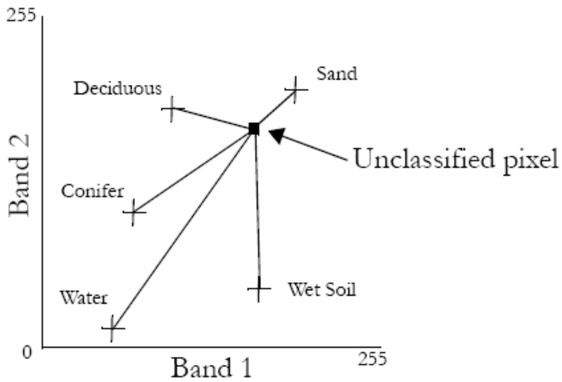
APPENDIX THREE

Remote Sensing – Image processing classifiers used in the study.

The ***hard classifiers*** were used to classify images after the signature development had been completed. The hard classifiers use a hard (i.e., unequivocal) decision about the class to which each pixel belongs. They are all based on a logic that describes the expected position of a class (based on training site data) in what is known as *band space*, and then gauging the position of each pixel to be classified in the same band space relative to these class positions (Eastman 2003; De Roeck, 2008).

Minimum-Distance-to-Means (MINDIST)

MINDIST characterized each class by its mean position on each band based on training site data. For example, if two bands were used, the positions of known classes, determined from the training site data would be derived based on the mean reflectance of the bands. To classify an unknown pixel, MINDIST examined the distance from that pixel to each class and assigned the identity of the nearest class, see Figure below.



.

Classifying a pixel using MINDIST (Eastman, 2003)

This technique, despite its simplicity performed well, was reasonably fast and could use maximum distance thresholds, thus classifying all pixels on an image. A problem associated with this method is a lack of recognition of signature variability between classes, which can result in misclassification of some pixels (Eastman, 2003). A way of addressing this problem is by changing the distance to standard scores using an equation:

Standardised distance = (original distance - mean) / standard deviation

The MINDIST procedure in IDRISI offers the option of using standardised distances, which is highly recommended (Eastman, 2003).

Maximum Likelihood Classifier (MAXLIKE)

The Maximum Likelihood procedure (MAXLIKE), based on Bayesian probability theory applied information from a set of training sites. It used the mean variance/covariance data of the signatures to estimate the posterior probability that a pixel belonged to each class. MAXLIKE accounts for inter-correlation between bands and by incorporating information about the covariance between bands and their inherent variance, produced what can be conceptualised as an elliptical zone of characterisation of the signature (Eastman, 2003). MAXLIKE procedure is similar to MINDIST, both using the standardised distance option, except that MAXLIKE accounts for inter-correlation between bands (Eastman, 2003; De Roeck, 2008).

Linear Discriminant Analysis (Fisher Classifier)

The FISHER classifier conducted a linear discriminant analysis of the training site data to form a set of linear functions that expressed the degree of support for each class. The assigned class for each pixel was then that class which received the highest support after evaluation of all functions (Eastman, 2003). These functions had a form similar to that of a multivariate linear regression equation, where the independent variables were the image bands, and the dependent variable was the measure of support. The equations were calculated such that they maximised the variance between classes and minimised the variance within classes. The number of equations was equal to the number of bands, each describing a hyper-plane of support. The intersections of these planes then formed the boundaries between classes in band space (Eastman, 2003).

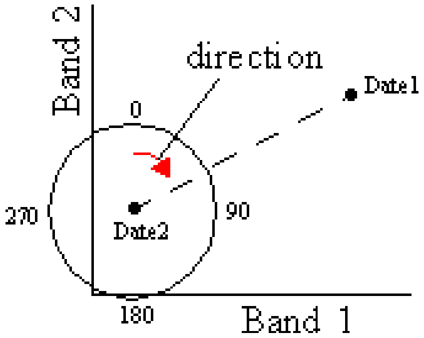
When training sites are strong (i.e., well-defined with a large sample size), the MAXLIKE procedure would be ideal. However, if the quality of the training sites (particularly their uniformity) is questionable, the MINDIST method with standardized distances should be applied (Eastman, 2003). The Fisher Classifier can perform exceptionally well when there are not substantial areas of unknown classes and when the training sites are strongly representative of their informational classes (Eastman, 2003).

Of the four hard classifiers used, MAXLIKE and FISHER were clearly the most powerful and also, not surprisingly, the slowest to calculate. However, with high-quality (i.e., homogenous) training sites, they were both capable of producing excellent results (Eastman, 2003).

APPENDIX FOUR

CALCULATION OF THE DIRECTION OF CHANGE AND MAGNITUDE OF CHANGE FOR THE CHANGE VECTOR ANALYSIS PROCESS

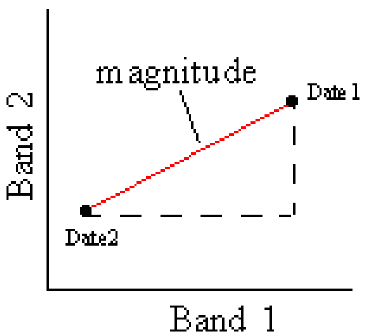
To indicate the direction of change, the coordinate for the pixels for the bands to be used are plotted, with Band 1 as the X axis and Band 2 as the Y axis. The two points at the beginning of the Date 1 and the beginning of date 2 are joined using a line. The azimuth is then the angle from a position directly above Date 1 and in a clockwise direction to the line (see Figure below), indicating the change that has happened (Eastman, 2003).



Direction of Change (CVA) (Eastman 2003)

In terms of the magnitude, of change, the line between the two points described above indicates the magnitude of change (see Figure below) and is derived using the Pythagorean Theorem:

$$magnitude = \sqrt{(date2band1 - date1band1)^2 + (date2band2 - date1band2)^2}$$



Magnitude of Change (CVA) (Eastman, 2003)

If the CVA is used with the red and infrared bands (as in the same process with the NDVI) the CVA direction of change can highlight areas of vegetation growth or deforestation.

APPENDIX FIVE

DEMOGRAPHIC DATA ANALYSIS – CORRELATION, SPEARMANS RANK AND REGRESSION ANALYSIS

Correlation Analysis

Correlation analysis was used to determine the extent to which different variables, either dependent or independent are linearly related, and if such a relationship was identified, the strength of the relationship was ascertained and measured (Anderson *et al*, 1994). It is important to note that correlation analysis does not however establish a cause and effect relationship, highlighting instead how and to what extent the relationship between variables, with the cause and effect relationship being left to the discretion of the analyst (Anderson *et al*, 1994). The correlation coefficient, which is the output of the correlation analysis, is always depicted as a number between – 1 (negative 1) and + 1 (positive 1), with a value of + 1 indicating a perfectly related linear sense between two variables and a value of -1 indicating a negative relationship between variables (Anderson *et al*, 1994). Correlation coefficients close to zero show that the variables are not linearly related.

Spearman Rank Coefficient

The Spearman's rank coefficient was developed to test the correlation coefficient of ordinal or rank order data. Spearman's Rank Correlation Coefficient is a method which can be utilised to discover the strength of a link between two sets of data.
The formula for Spearman's rank is expressed as:-

$$(R^2) = 1 - \frac{6\sum d^2}{n^3 - n}$$

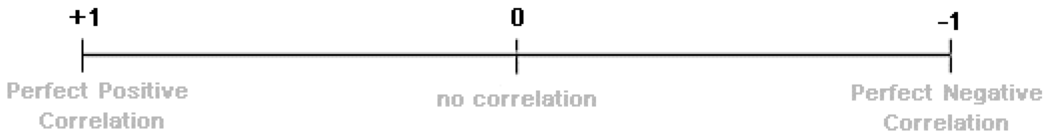
Where: n = number of items of individuals being ranked

x_i = the rank of item i with respect to the variable

y_{i} = the rank of item i with respect to one variable

$d = x_{i\,=}\,y_i$

The result, the statistic R is always between 1 and – 1 (see below)



(http://geographyfieldwork.com/SpearmansRank.htm)

Regression Analysis

Regression analysis is a statistical method that is used to develop a mathematical equation showing the relationship between two or more quantitative variables. The variable that is being predicted by the mathematical equation is the dependent variable, while the variable that is being used to predict the value of the dependent variable is the independent or explanatory variable of which data is available (Anderson *et al*, 1994; www.ec.europa.eu, 2003). A regression analysis involving two variables is termed a simple linear regression while the regression involving more that two variables is known as a multiple regression analysis. A simple regression analysis can show that the relation between an independent variable X and a dependent variable Y is linear, using the simple linear regression equation $Y= a + bX$ (where a and b are constants). Multiple regression will provide an equation that predicts one variable from two or more independent variables, $Y= a + bX_1+ cX_{2+} dX_3$ (www.ec.europa.eu, 2003).

Regression analysis in this study was primarily utilised to establish and understand the statistical dependence of one variable on the other variables, by highlighting the proportion of variance between the dependent and independent variables usually depicted as a graph (www.ec.europa.eu, 2003).

Logistic regression

Logistic regression is a variation of the ordinary regression and is usually applied when the dependent variable is a binomial, (only taking two answers 1/0 or yes/no) and is usually presenting the occurrence or non occurrence of an event. In this case the occurrence would be hunger. The independent variables are continuous, categorical or both. The difference between linear or ordinary regression and logistic regression is that logistic regression does not assume the relationship between the independent and dependent variable to be linear; neither does it assume that the error terms are normally distributed (http://www.resample.com). The form of the model is

$$\log\left(\frac{p}{1-p}\right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_k X_k$$

where p is the probability that Y=1 and X_1, X_2,.. .,X_k are the independent variables (predictors). β_0, β_1, β_2, ... β_k are known as the regression coefficients, which have to be estimated from the data. Logistic regression estimates the probability of a certain event occurring (www.resample.com, 2008). Logistic regression thus forms a predictor variable (log (p/(1-p)) which is a linear combination of the explanatory variables. The values of this predictor variable are then transformed into probabilities by a logistic function. Such a function has the shape of an S. On the horizontal axis we have the values of the predictor variable, and on the vertical axis we have the probabilities (www.resample.com).

Logistic regression also produces Odds Ratios (O.R.) associated with each predictor value. The ‘odds’ of an event is defined as the probability of the outcome event occurring divided by the probability of the event not occurring. In general, the ‘odds ratio’ is one set of odds divided by another. The odds ratio for a predictor is defined as the relative amount by which the odds of the outcome increase (O.R. greater than 1.0) or decrease (O.R. less than 1.0) when the value of the predictor variable is increased by 1.0 units. In other words, (odds for PV+1)/(odds for PV) where PV is the value of the predictor variable. Logistic regression ultimately expresses both the magnitude and direction of the association between the outcome and explanatory variable(s) by calculating the odds ratio (OR) and corresponding 95% confidence interval (CI) of the association. When one dichotomous explanatory variable is included in the model, the OR obtained from the logistic regression is equivalent to that obtained from the Chi-squared test of the explanatory and outcome categorical variables (www.reasample.com, 2008; SPSS Manual, Crowther, 2008).

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