

# **Animal Traction and Small-scale farming: A Stellenbosch Case Study**

George Munyaradzi Manjengwa

*Thesis presented in partial fulfilment of the requirements for the degree  
Master of Philosophy Sustainable Development Management and  
Planning at the University of Stellenbosch*



Supervisor: Candice Kelly

Faculty of Economic and Management Sciences  
Department of Public Leadership

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**Supervisor: Candice Kelly**

**Proposed date of award for degree: March 2011**

## **DECLARATION**

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## **ABSTRACT**

The main aim of this case study was to research the impact of the introduction of oxen for draught power on Eric Swarts' Stellenbosch farm. The research objectives were designed to find out if the oxen helped to improve the quality of the soil, to determine their cost-effectiveness (compared to a tractor) and other social and managerial constraints and benefits associated with using them and also to make recommendations for small-scale farmers in developing countries.

The literature review revealed that human society faces many serious sustainability challenges from ecosystem degradation and global warming, to massive poverty and social inequality. The global population is growing against a background of decreasing agricultural productivity due to degraded soils and the increased costs of farming. The adoption of farming methods that enhance ecosystem services and depend less on external inputs is therefore essential. Animal traction is still widely used among small-scale farmers in developing countries, but lacks policy and investment support to make it more efficient. There are currently widespread negative opinions about animal traction which regard it as a backward or old-fashioned technology. This research investigated the possibility of animal traction emerging as an affordable, environmentally-friendly and appropriate technology for small-scale farming.

The research is a case study with a qualitative, ethnographic research design in which participant observation was key in gathering research data. A cost-benefit analysis (CBA) was carried out to compare the cost-effectiveness of using oxen to either hiring or buying a tractor.

The findings showed that oxen were a more cost-effective means of draught power than a tractor, not only in terms of capital costs but also maintenance and operational costs. The manure from the oxen was both an effective way of supplying crops with essential nutrients and improving soil biodiversity. The introduction of the oxen presented some challenges to the farmer concerning knowledge about how animals work and other managerial challenges, but these were overcome by learning through practice. It was found that the farmer will be able to make significant savings in soil-amendment costs and he can control the quality of the manure to suit

his needs. It was concluded that small-scale farmers who choose animal traction over tractors as a means of draught power will realise many advantages in return.

## OPSOMMING

Die hoof doelwit van dié gevallestudie was om die impak van die ingebruikneming van osse as trekkrag op Eric Swarts se plaas te Stellenbosch na te vors. Die navorsingsteikens was ontwerp om uit te vind of die beeste gehelp het om die kwaliteit van die grond te verbeter, om hul lonendheid vas te stel (in vergelyking met 'n trekker) asook ander sosiale en bestuursbeperkings en -voordele wat met hul gebruik geassosieer word en ook met voorstelle vir kleinskaalboere in ontwikkelende lande voorendag te kom.

Die literatuuroorsig navorsing het ontbloom dat die menslike samelewing met vele volhoubaarheidsuitdagings vanaf ekosistemiese agteruitgang en aardverhitting, tot swaar armoedigheid en sosiale ongelykhede gekonfronteer word. Die wêreld bevolking groei steeds ten spyte van die afname in landboukundige produktiwiteit as gevolg van verlaagde grondkwaliteit en die toenemende landboukoste. Die ingebruikneming van landboumetodes wat ekosistemiese dienste verhoog en minder staatmaak op eksterne insette is dus noodsaaklik. Dieretrekking word steeds algemeen in ontwikkelende landebenuit, maar dit ontbreek beleids- en beggingsondersteuning om dit meer doeltreffend te maak. Daar is tans algemeen verbreide negatiewe sienswyse oor dieretrekking wat dit as agterlike en oudmodiese tegnologie beskou. Dié navorsing het ondersoek ingestel om die moontlikheid van dieretrekking as 'n bekostigbare, omgewingsvriendelike en passende tegnologie vir kleinskaalboerdery vas te stel.

Die navorsing is 'n gevallestudie met kwalitatiewe, etnografiese navorsingsontwerp waarin deelnemerwaarneming kern is tot die insameling van data. 'n Kostewinsteanalise (KWA) was uitgevoer om die lonendheid van beeste te vergelyk met dié van of die huur of die koop van 'n trekker.

Die bevindings het getoon dat beeste 'n lonender wyse van trekkrag as trekkers is, nie net in terme van kapitale koste nie, maar ook onderhoude en bedryfskoste. Die beesmis was beide 'n doeltreffende manier om die gevasse van nodige voedingstowwe te voorsien asook om grondbiodiversiteit te verbeter. Die ingebruikneming van beeste het sekere uitdagings vir die boere ingehou in verband met die kennis van hoe diere werk en ander bestuursuitdagings, maar

dié was oorkom deur onderrig uit ondervinding. Daar was bevind dat die boer beduidende besparings kan maak aan grondaanvullingskoste hierdie jaar en dat hy die kwaliteit van die beesmis kan beheer om sy behoeftes dien. Die slotsom is dat kleinskaalboere wat kies om dieretrekking eerder as trekkers as trekkrug te gebruik, sal vele voordele hê.

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## **LIST OF ACRONYMS AND ABBREVIATIONS**

ATNESA	Animal Traction Network for Eastern and Southern Africa
CBA	Cost-Benefit Analysis
FAO	Food and Agriculture Organisation
GDP	Gross Domestic Product
IAASTD	International Assessment of Agricultural Knowledge Science and Technology for Development
IEA	International Energy Agency
IPCC	Inter-governmental Panel on Climate Change
MDGs	Millennium Development Goals
MEA	Millennium Ecosystem Assessment
NGO	Non-governmental Organisation
SANAT	South African Network of Animal Traction
SI	Sustainability Institute
SRG	Stellenbosch Research Group
TDAU	Technical Development Advisory Unit
UFHATC	University of Fort Hare Animal Traction Centre
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme

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## CHAPTER ONE: INTRODUCTION

### 1.1 BACKGROUND AND MOTIVATION

Global population has increased exponentially during the past century and is expected to increase to 9 billion by the year 2050 (UNDP, 2007). This means that demand for food is going to increase and agricultural production must also increase in pace with the growing demand. Agriculture needs to avail itself of technologies that are relevant, affordable and environmentally friendly for farmers to improve food security (IAASTD, 2008a). Such technologies should be appropriate and contextually relevant to small-scale farmers considering that they comprise the majority of the farmers in the world (Pretty *et al.*, 1995). There are currently about 1.6 billion small-scale farmers globally and of these approximately 1.2 billion are in developing countries (IAASTD, 2008a). The small-scale farmer traditionally farms for subsistence although some make surpluses which are sold on the food market and their success can bring food sufficiency for many people (Pretty *et al.*, 1995).

Many different approaches have been suggested as possible ways of increasing food production to cater for an increasing world population (Madeley, 2002). The conventional way has been through Green Revolution methods which prescribe greater use of external inputs such as fertilisers and pesticides. Genetically modified crops and livestock have been advocated as options but both present possible sustainability problems (Pretty *et al.*, 1995; Shiva, 1995) such as a breakdown of ecosystem services and pollution leading to global warming and climate change, poverty and inequality (MEA, 2005). Agricultural solutions for small-scale farmers should include technologies which are affordable to purchase and maintain in light of increasing global oil prices (IEA, 2007). Whether or not one agrees with the concept of peak oil, we have reached a time when there will be no more cheap oil (IEA, 2007). Technologies and production systems that depend on oil are expected to get more expensive so that reducing our dependence on them is important.

Sustainable agriculture asserts that the way forward is to embrace farming methods that “work with nature rather than against nature” (Mollison, 1998:17). It calls for the adoption of farming



methods that mimic natural systems by making use of innovative agricultural knowledge, science and technology policies. These are important for building natural, human and physical capital for social and environmental sustainability (IAASTD, 2008b). Some of these sustainable agricultural systems are organic farming, biodynamic farming, nature farming and permaculture. These are polycultural systems which produce wide varieties of crops and usually promote the integration of plant and animal systems. Diversity and interdependency are key components of sustainable agriculture which benefit farmers as well as the natural environment (Bowler, 2002).

I grew up in a farming community where agricultural activity was central to human life as a form of sustenance. Animals which included donkeys, mules and cattle were used to provide much needed draught power. The availability of a pair of working animals was so important that it made the difference between food sufficiency and lack of it in a household. Animal traction was a versatile form of draught power used for ploughing, harrowing, weeding and transportation of produce to the market. Animals were not only important for the provision of draught power, but they provided manure for crops and people related to them with love. The major challenge in maintaining animals as a source of draught power was feeding them during dry years. Many of them would die due to starvation during severe droughts such as the 1992-93 rainy season.

The national government (in Zimbabwe), through the department of agriculture, tried to assist by providing subsidised tractors for hire to the farmers for the provision of draught power. Farmers were happy with such assistance because tractors were perceived to be a sign of 'progress' but the tractors were never sufficient for the needs of individual farmers. The main challenge was giving each farmer an equal opportunity to use the tractor when needed. In rain-fed agricultural systems, all farmers need draught power at once because ploughing has to be done while the ground is still wet. There was not a single season when the draught power needs of small-scale farmers were adequately met by hired tractors. Farmers struggled to acquire new sets of work animals and they had to hire them from others if they could not afford to buy.

After doing courses in sustainable development and sustainable agriculture, I became aware of the serious challenges of unsustainability facing the world. Reflecting back on the situation in my home country I felt that government could have done better to subsidise animal traction as

opposed to tractors because the latter were perhaps unsustainable not only economically but in view of other challenges such as environmental unsustainability. Animals would not only assist farmers to achieve draught-power sufficiency but they would be an important source of valuable manure and also reduce farmer dependence on external inputs and the oil economy.

Through the Sustainability Institute (SI), an NGO based in Stellenbosch, I met Eric Swarts, a small-scale organic farmer who produces vegetables for the market with assistance from the SI. I got more acquainted with him from June 2008 when I joined a team of researchers tasked by the SI to do some investigations on his farm. Some of the major problems he faced were identified as low soil fertility and the unavailability of draught power. More background information, including the challenges faced by Eric, is given in Section 4.1. When the SI decided to buy oxen for Eric for the provision of manure and draught power, it presented me with an opportunity to investigate, from a sustainable development perspective, the suitability of a technology I had worked with for some time. I decided to investigate the suitability of animal traction for small-scale farming through a Stellenbosch case study.

The research was also done in part fulfilment of the requirements of the MPhil degree for which I am registered at Stellenbosch University. The SI funded the oxen project as well as this research. The SI wanted to evaluate the project through this research. The research will hopefully show whether the project is worth replicating with other farmers.

With the rise in oil prices the price of agricultural inputs based on petrochemicals are set to increase possibly pushing them well beyond the means of the small-scale farmer. This research is an attempt to show that animal traction, applied with the appropriate technology, could re-emerge as a benefit and answer to small-scale farmers. This is key to African agriculture where most of the farmers struggle with costs and generally find the demands of conventional agriculture prohibitive (Altieri, 1989).

## **1.2 RESEARCH PROBLEM AND OBJECTIVES**

Oxen were introduced to help Eric acquire draught power and manure so that the research questions were formulated to help determine whether the project has achieved its aims. It was also anticipated that insights could be gained from this case study to offer recommendations to other small-scale farmers. The following research questions were formulated to set boundaries for the research:

- 1) Did the oxen improve the quality of the soil?
- 2) How cost-effective were oxen in relation to a tractor?
- 3) What managerial and social challenges and benefits emerged as a result of the introduction of oxen?
- 4) What general recommendations can be made regarding the use of draught animal power by small-scale farmers in developing countries?

## **1.3 SIGNIFICANCE OF THE STUDY**

The study will assist the SI in assessing the success of the oxen project and inform their decision as to whether or not it is worth replicating. The project was initiated to assist Eric Swarts with a cost-effective source of draught power and manure for soil fertility. This research will help assess whether these aims were achieved. On a broader level, I hope that the research will provide insights into the use of draught power from which recommendations can be made for small-scale farmers.

## **1.4 INTRODUCTION TO RESEARCH DESIGN AND METHODOLOGY**

The research was conducted through a qualitative ethnographic research design and it made use of sub-designs such as case studies and participant observation. Research tools used included interviews and field diaries. These were used to document my perceptions and those of the farmer, as well as other informants whose views were considered important to the research. The tools were also used to record on-site data which was then used to answer the research questions.

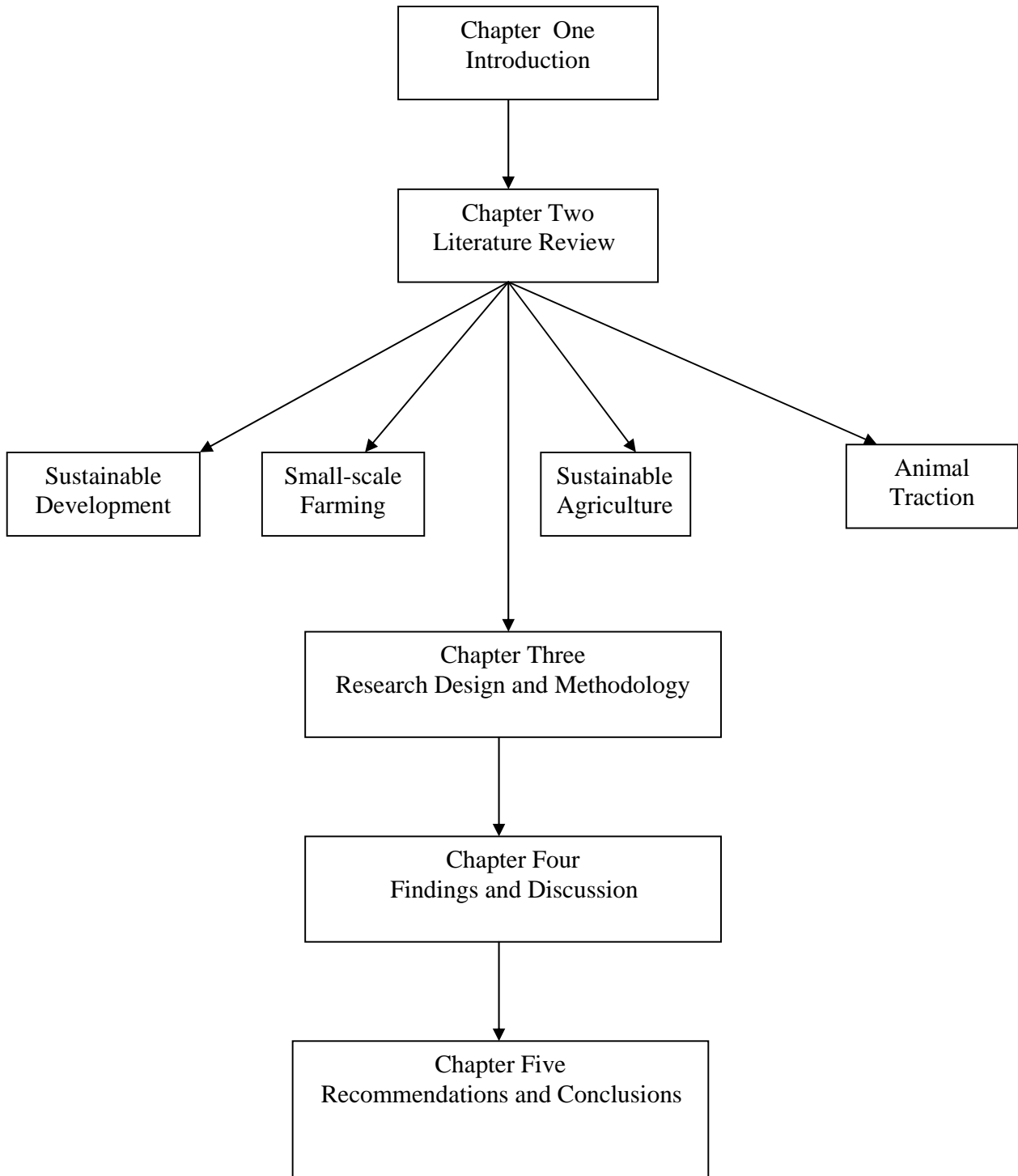
A case study was used to thoroughly describe and document all the changes and impacts oxen had on Eric's farm. Much information was gathered during the time spent on the farm while participating in the processes which involve the work of the oxen. I was on the farm for four days each week between February and August 2009. Through participation in working with the oxen, manure preparation and application, I was able to gather data about the efficiency of animal traction and the social and managerial changes they brought to the farm. I was also able to observe changes in crop growth rate and quality. I carried out several formal interviews with Eric and numerous informal discussions during work in which he revealed earnings from sales as well as costs incurred in maintaining the oxen project. I was also able to capture his feelings and perceptions during the interviews. The information was useful to determine the social and managerial changes that occurred as well as to perform a cost-benefit analysis (CBA).

Qualitative research methods were sufficient to answer research objectives one, three and four. For research objective two (comparing the cost-effectiveness of the oxen to that of hiring and buying a tractor) a quantitative method, cost-benefit analysis, was used. The use of quantitative data was necessary to show the costs of the project and the level of benefits derived from it. A CBA was quite useful in determining how profitable or not (in economic terms) the project was. However, it was not helpful in measuring the social and environmental impacts of the project, both of which are important considerations in sustainable development. The conclusions and recommendations based on the CBA were discussed with other social and managerial aspects in mind. The final product was a result of methodological triangulation, because purely qualitative or quantitative methods could not sufficiently address all the demands of the research. Triangulation was a way of ensuring that the conclusions are well-grounded.

## **1.5 OUTLINE OF THE THESIS**

The diagram below summarises the outline of the thesis.

**Figure one: Outline of thesis**



## **CHAPTER TWO: LITERATURE REVIEW**

### **2.1. INTRODUCTION**

The literature review in this chapter is presented in four sections. The section on sustainable development (2.2) provides the theoretical framework in which the research is grounded and gives a holding space for the other three sections; namely small-scale farming (2.3), sustainable agriculture (2.4) and animal traction (2.5).

The sustainable development review discusses the major challenges of unsustainability which human society faces in the world today and how these threaten present and future generations. It also exposes the major role that agriculture plays both as a contributor and a victim of an unsustainable system. An alternative system, sustainable agriculture, which offers solutions to the current crisis is discussed next by pointing out the various ways of responding to the sustainability crisis in agriculture. The section on small-scale farming is used to demonstrate that it is a system that can work using sustainable agriculture principles which promote diversity and local self-sufficiency in food production. These three sections provide a context in which animal traction as a technology becomes relevant, particularly for small-scale farming. The review of animal traction literature presents the major trends and debates on the use of animal traction.

### **2.2 SUSTAINABLE DEVELOPMENT**

This section summarises evidence showing how unsustainable the world has become and then defines sustainable development. This overview introduces the major aspects of the crisis that are discussed in detail later. A working definition of sustainable development is given so that possible solutions can be reflected in the light of that definition. In particular, the contribution of animal traction as an appropriate technology is measured against the definition.

#### **2.2.1 Introduction**

The world today is faced with numerous challenges that have necessitated a development pathway that can be termed 'sustainable'. The gravity and extent of the issues are shown by the evidence that 60 percent of ecosystems on which human beings depend for survival have been

degraded according to the Millennium Ecosystem Assessment (MEA, 2005). The consumption of fossil fuels has released greenhouse gases into the earth's atmosphere which have and will continue to lead to rising temperatures in a phenomenon known as global warming. This will have some destructive consequences, especially for the world's poor (IPCC, 2007). Excessive use of resources that drive the world's economies has not only brought environmental dangers but it has also pushed their prices up and the world's growing economies will need new forms and sources of energy to continue operating (IEA, 2007). The United Nations' *Human Development Report* (UNDP,1998) states that one fifth of the world's population in the developed world consume 86 percent of the world's income, while the poorest 20 percent have access to only 1.3 percent. This shows that the world has some very rich but few people who consume most of the income while the majority share very little among themselves. Such a situation is socially unsustainable.

Collectively, the problems summarised above reflect "...a highly unequal urbanized world dependent on rapidly degrading ecosystem services, with looming threats triggered by climate change, high oil prices and declining agricultural yields, which is marked by extreme inequality between rich and poor" (Swilling, 2008:10).

The notion of sustainable development has been defined variously. For some, definitions were born of the need to strike a balance between economic needs and environmental considerations (Dresner, 2002). Defining sustainable development in economic and environmental terms is not sufficient because that omits social aspects of human life which are equally important, as reflected by the challenges outlined above. Many organisations have defined sustainable development in ways that reflect the sectarian interests of those organisations. A seminal and more encompassing definition is given by the Brundtland Report (WCED, 1997: 50) which states that, "sustainable development is development that meets the needs of the present generation without compromising the ability of future generations to meet their needs". This definition emphasises inter-generational equity. In seeking to improve our lives, the current generation must consider that the earth's resources are finite and exploiting them should be done in a way that protects them from depreciation, degradation and extinction.

The absence of a clear-cut and universally accepted definition of sustainable development has led to further disagreements on the ways of achieving it. Organisations such as the World Bank and the United Nations assert that all forms of development must lead to progressive transformation of economies and societies ultimately improving the quality of life as measured by economic indicators (World Bank, 2002; UNDP, 1998). However, economic indicators have the limitation that they do not measure social, political or environmental aspects of development. Bringing sustainability considerations into the development discourse is not an attempt to derail economic gains in a capitalist-driven world: the one does not necessarily have to suffer at the expense of the other. Hattingh (2001) has pointed out that sustainable activities can be maintained indefinitely and sustainable development leads to a sustainable economy. A sustainable economy takes care of the natural resource base and the environment upon which it depends by continuously adapting to changes, improving in knowledge, organisation, technical efficiency and wisdom.

The following six sub-sections examine the various challenges of sustainable development and draw some conclusions as to how agriculture generally can contribute towards a more sustainable world.

### **2.2.2 The importance of the environment for economic growth**

Bartelmus (1994) identifies two major functions of the global ecosystem. It is a source of the economic sub-system from which vital resources are extracted and it is also a sink into which wastes are deposited and recycled through the living systems in it. As a source it is limited by the finite nature of its resources and as a sink it needs a regulated flow to absorb and recycle wastes. The rate of flow of natural resources and energy from the ecosystem into the human economic subsystem as well as the inflow rate of heat energy, wastes and materials from economic operations such as industries are determined by economic considerations with little or no regard for the environment (Clayton and Radcliffe, 1996). As a result, the regenerative and assimilative capacities of the environment are currently strained (Goodland and Daly, 1996). This has created problems of unsustainable exploitation of resources and deposition of wastes into the global ecosystem.



The Millennium Ecosystems Assessment (MEA, 2005) outlines the benefits of the ecosystem services to the socio-economic system. At the first level these include: food, fibre, genetic resources, bio-chemicals, minerals and fuels. On the second level: regulation of air, climate, water, erosion and water purification, waste treatment, disease and pest control, pollination and natural hazard regulation feature, with nutrient cycling and soil formation at the third level. The fourth category is aesthetic and cultural value and ecotourism. The MEA (2005) continues that human activities have impacted on ecosystems by:

- 1) Changing ecosystems to meet human needs thereby causing largely irreversible loss in the diversity of life on earth
- 2) Increasing economic growth at the expense of ecosystem services.
- 3) The Millennium Development Goals (MDGs) as outlined by the United Nations will not be achieved due to persistent degradation of ecosystems.
- 4) Reversing ecosystem damage can only be attained through policy changes.

Having said this, the MEA concludes that the unsustainable exploitation of ecosystems is likely to persist even if population growth stabilises, as countries race to increase gross domestic product (GDP) and this may lead to a total collapse of ecosystem services (MEA, 2005). A balance needs to be sought between economic growth and sustaining ecosystem services because the importance of the latter goes beyond economic considerations. To achieve sustainability, development projects should ensure that they protect and enhance ecosystems.

### **2.2.3 Resource consumption patterns and inequalities**

Poverty in developing countries can be directly linked to over-consumption of the earth's finite resources and ecosystem services in developed countries (Enrilch, 2008, in Swilling and Annecke, Unpublished). The over exploitation of the earth's resources has led to depletion of those resources and the power relations in the world limits access to the remaining stock to the rich minority. The 1998 *Human Development Report* further demonstrates the relationship between poverty and inequality by stating that since 1990 consumption per capita has risen by 2.3 percent in the developed countries while during the same period it dropped by as much as 20 percent in sub-Saharan African countries (UNDP, 1998). The ever-widening gap between the

rich and the poor disproves the notion that if the rich get richer, some of their wealth will trickle down to the poor (Swilling, 2008). Capital accumulation by the world's wealthy minority through unsustainable means should not be allowed to continue under the pretext that the world's poor will eventually benefit.

There is literature which paints a more positive picture by claiming that the actual numbers of the world's poor have decreased in the past 20 years. A World Bank report claims that the number of the world's poor has decreased by 200 million people between 1980 and 1998 (World Bank, 2002). However, using a more realistic standard of US\$2 per day researchers from the same institution found that there were actually more poor people in 1998 than in 1980 (Swilling, 2008). Concomitant with this rise in poverty is the increase in inequality over the same period. The richest 20 percent of the world consume 45 percent of all meat and fish while the poorest fifth consume only 5 percent (UNDP, 1998). Concerning energy, the richest 20 percent, consume 58 percent of total energy while poorest 20 percent use less than 4 percent (IEA, 2007).

As human populations grow, levels of consumption will increase to enable human development (Swilling, 2008). However, consumption trends need to change given the urgent need to reduce inequality, conserve ecosystem services and protect the interests of future generations in our finite resources.

#### **2.2.4 Energy consumption and peak oil production**

Oil is the main resource from which the global economy derives energy, accounting for up to 60 percent of total global energy needs (IEA, 2007). Although the primary use of oil is to fuel motor vehicles, it has other multiple uses in the modern economy including the generation of other forms of energy such as electricity. Other important uses of oil are as a polymer derivative for making plastics, the manufacture of antibiotics and as energy for cement production. Oil is also used in agriculture and food production as a fuel and oil-derived pesticides and fertilisers (Swilling and Annecke, Unpublished). Oil also plays a central role in the movement of goods and people in commerce.

The problem of relying on oil is that it is a non-renewable resource and global oil reserves will eventually run dry. There is a strong opinion that we have already passed peak oil production (IEA, 2007; Swilling, 2008). The oil peak is based on interpolation and experience in the discovery of oil in the United States. Trends show that oil discovery peaked in the 1930s and that production peaked 30 to 40 years later (IEA, 2008). Based on these time frames, there is an indication that we are moving toward a point where oil will only be available at a higher price (IEA, 2008). Considering how important oil is to the world economy as demonstrated by the above examples, a rise in oil prices will trigger rises in the prices of goods and services across the global economy because it is basically an 'oil economy'.

The possibility of demand for oil outstripping supply is made more realistic by growing world economies such as India, Brazil and China which have substantially increased their demand for oil (IEA, 2007). Demand for oil is pushed by industrial needs including power stations, as well as by a growing middle class with disposable incomes which raise the demand for goods and services in their economies. The IEA identifies two challenges regarding the world's energy system. First, it needs a reliable, secure and affordable source of energy and second the energy must be low carbon, efficient and environmentally safe (IEA, 2007). This recommendation points to a need for an energy revolution but such a revolution requires an institutional framework within which it can occur. Such an institutional framework does not yet exist but instead of investing in oil exploration and setting up of new oil infrastructure, oil companies can invest in alternative, cheaper, safer and environmentally friendly fuels (IEA, 2007). Creating a framework for global cooperation on these issues is crucial and a probable starting point is to use the time of the expiry of the Kyoto protocol in 2012 as a foundation for new and better cooperation. One must agree with the IEA (2007:73) that "it is within the power of all governments, of producing and consuming countries alike, acting alone or together, to steer the world towards a cleaner, cleverer and more competitive energy system." The way for the world to go should be the promotion of alternative technologies that reduce dependence on the oil economy as much as possible.

### **2.2.5 CO<sub>2</sub> emissions, global warming and climate change**

Closely related to the issue of energy consumption is the issue of high carbon dioxide emissions, global warming and the resultant climate change whose effects are already being felt (Goodland and Daly, 1996; IPCC, 2007)

Burning of fossil fuels has released and continuously increased the concentration of greenhouse gases in the earth's atmosphere. Carbon dioxide is the main gas, but nitrous oxides from oil-based fertilisers and methane from melting permafrost are important contributors to global warming (IPCC, 2007). The gases trap heat radiation in the atmosphere causing temperatures to rise. Emissions of greenhouse gasses are expected to increase by 30 percent between 2005 and 2030 (IEA, 2007). During the past century an average temperature increase of 0.74 degrees Celsius has been recorded and 11 of the last 12 years have been the hottest since 1850 (UNDP, 2007). If carbon dioxide is released slowly into the atmosphere, earth's ecosystems can absorb and recycle it into carbon through carbon sequestration, but the rate at which it is currently being released has surpassed the absorption capacity of the global ecosystems (Bartelmus, 1994).

Some of the signs of global warming are the reduction in sea-ice cover, melting permafrost and mountain glaciers, frequent heatwaves and sporadic and recurrent droughts. The impacts already being felt include food insecurity, the spread of waterborne diseases and the non-availability of safe water (IPCC, 2007). Climate change poses a threat to the attainment of the Millennium Development Goals as it will not only stall but also reverse the gains achieved in the past in education, health, nutrition and other areas (UNDP, 2007).

### **2.2.6 Species extinction and biodiversity loss**

A rich biodiversity is an important element of global ecosystem services and its loss is a threat to human development. Biodiversity is vital in agriculture for the regulation of biological processes such as soil formation, pollination and nutrient cycling. Biodiversity has spiritual and aesthetic benefits as well as amenity values in ecotourism. Examples of the economic importance of biodiversity are that plant pollination by bees is worth US\$2 billion globally and the fishing

industry generates US\$58 billion annually (UNEP, 2006). These are 'free' services yet human activities continue to irreversibly alter the distribution and functioning of ecosystems. A reduction in species diversity means less agricultural genetic diversity. Bartelmus (1994) estimates that due to the current unsustainable exploitation of plant and animal species, and pollution to the environment, the earth is losing between 5000 and 15 000 species each year. Agricultural systems and technologies should promote biodiversity to achieve sustainability.

### **2.2.7 Agriculture and food insecurity**

During the early 1990s the world experienced some reductions in the number of hungry people, but the numbers have increased since 1995 (FAO, 2008). The number of hungry people has continued to grow annually since 1995 and in 2007 it increased by 75 million to reach 923 million (FAO, 2008). One of the main causes of increased food insecurity is severe weather (droughts, floods) which may be as a result of human-induced climate change. Soil degradation is also a key contributor to global food insecurity (Bartelmus, 1994; Swilling, 2008). About 23 percent of the world's agricultural soils are degraded and this may lead to further increases in food insecurity (IAASTD, 2008b). Agricultural systems need transformations that will not only halt but reverse soil degradation so as to achieve global food security. The IAASTD maintains that agricultural activities have, in many cases, caused negative environmental outcomes, such as soil degradation, groundwater pollution and reductions in biodiversity and it recommends that agricultural production should be focused on agroecological approaches to avoid these outcomes in the future (IAASTD, 2008a).

Production methods need to particularly limit dependence on the oil economy because we have reached an era where oil prices are expected to increase continually (IEA, 2008). Many small-scale farmers in the developing countries may not be able to afford oil-based inputs yet these small-scale farmers are indispensable players in the fight against global food insecurity (FAO, 2008; IAASTD, 2008a) One way of limiting dependence on the oil economy is to minimise the use of conventional fertilisers and chemicals because a high percentage of these are oil-based and oil is dominant in production and distribution processes. Increased food demand is expected due

to population growth, especially in developing countries where a growing middle class in countries like China, India and Brazil may worsen global food insecurity (IAASTD, 2008b).

### **2.2.8 Summary**

The sustainable development literature establishes that human society on earth needs a paradigm shift in the way it deals with the challenges of unsustainability which affect us. All these challenges affect agriculture: from soil degradation, species extinction, global warming and the rise in oil prices to population growth. Agriculture is not merely the victim of an unsustainable world but is also an active contributor. However, it can make its contribution toward a more sustainable world through the adoption of technologies that are environmentally safe and enhance ecosystem services and reduce dependence on oil and minimise greenhouse gas emissions while promoting greater equality for the world's poor. It is with this idea in mind that this research argues for the promotion of animal traction as a sustainable technology. It is a technology that can empower small-scale farmers in the struggle against hunger, poverty and malnutrition.

## **2.3 SMALL-SCALE FARMING**

This section discusses the characteristics and advantages of small-scale farming and the major challenges confronting these farmers. It serves to demonstrate that the contribution and significance of smallholder agriculture should not be overlooked in a world struggling with food insecurity. Agricultural policies and technologies that promote small-scale farming should be sought and promoted (IAASTD, 2008a).

### **2.3.1 Introduction**

Of the three billion people who live in rural areas of the developing world, 2.5 billion practice agriculture and 1.5 billion are on small-scale farms averaging two hectares or less in size (Altieri, 2008). Large-scale mechanised farms total only twenty million worldwide (World Bank, 2002). These statistics show that global efforts to improve food production and end hunger, poverty and

malnutrition, should necessarily take on board the activities of small-scale farmers. It is highly unlikely that any attempts to increase global food availability will achieve much without promoting small-scale agricultural production.

### **2.3.2 Characteristics of small-scale farming: a historical perspective**

The small-scale farm is traditionally a family farm which provides for the family's food needs. It is a mixed farming system combining livestock rearing with crop production in a way that promotes interdependency (FAO, 2008). Animals feed on crop residues and animal wastes are used as manures for crop production. A wide range of crops are grown under this system and a variety of animals are reared indicating a system rich in diversity (Altieri, 2008). The idea of feeding crop residues to farm animals whose wastes are ploughed back into the soil shows an understanding of the concept of nutrient recycling and keeping the production system sustainable. Indigenous farming knowledge and skills are passed on from one generation to the next together with an understanding of the animal species raised and crop varieties that are grown (McMichael, 2006). These have been maintained for generations which means they are well adapted to their environment and they give good returns in the form of milk, meat, wool and other products derived from them. Very few if any external inputs are used on the traditional small-scale farm (Altieri, 1989).

### **2.3.3 Advantages of small-scale farming**

Small-scale farms promote self-sufficiency in food, fodder, fibre and medicines. They also feed some of the urban population apart from being the main source of food for rural populations in developing countries (Reijntjes, 2009). In some countries they contribute significantly both to national and export food needs. For example, in Zimbabwe, small-scale farming used to contribute up to 60 percent of local food needs and up to 20 percent of food exports (Rukuni and Eicher, 1994). In Latin America, small farms produce 51 percent of maize, 77 percent of beans and 61 percent of potatoes consumed nationally (Altieri, 2008). The polycultural nature of small-scale farms produces more output than large-scale monoculture farms in terms of total output and

not yield from one crop. For example an acre on which maize and beans are planted produces more yield than an acre of either maize or beans alone (Altieri, 2008).

The severe contribution of conventional agriculture to climate change is not only due to the high use of fossil fuels, but also due to the high loss of biodiversity both in the soil and above it. Much can be gained by promoting the sustainable practices of small-scale farming that are well informed by indigenous knowledge systems (IAASTD, 2008b). Traditional production methods have proved to be efficient, reliable and richly diverse. They show how agriculture can contribute to biodiversity rather than become a threat to it (Reijntjes, 2009). Cuba has demonstrated that diverse and nutrient-efficient small-scale farms can be more productive than large-scale monocultural farms (Reijntjes, 2009). Polycultural farms are also more resistant to the hazards of climate change and they can survive without agrochemicals (Altieri, 2008). During periods of economic hardship when jobs outside agriculture are lost, people return to the land (Rukuni and Eicher, 1994). From the view point of poverty reduction and employment creation, smallholder farming should be supported. The advantages go beyond food production and sufficiency it is a system which merits support from governments and from non-governmental organisations dealing with food production and poverty reduction. Small-scale farming provides livelihoods, conserves agro-biodiversity and can reduce the dependence on food imports in developing countries (Altieri, 2008).

#### **2.3.4 Challenges facing small-scale farming**

One of the major challenges facing small-scale agriculture is lack of investment by national governments in the sector and the absence of policy instruments to promote it. This is the situation in most developing countries despite the importance of small-scale farmers in these countries. The following observation encapsulates the situation: “in many developing countries, underinvestment in the agricultural sector, the dismantling of public support programs and the impacts of trade liberalisation have undermined the small farm [sic] sector, and national food production capacity, leaving those countries even more vulnerable to price volatility. Investment in the agricultural sector has focussed largely on export crops to generate foreign exchange, forcing countries to rely on continued low international food prices to meet national food



demand. That strategy has failed” (IAASTD, 2008b:53). The food riots of 2008 can be viewed in the light of increasing lack of self-sufficiency.

Most small-scale farmers in the developing countries are yet to benefit from research and extension services as current structures favour commercially orientated large-scale farming (Rukuni and Eicher, 1994). Education systems do not support the improvement or the sustainability of family farms: they promote industrial agriculture. In many cases, modern technology is not available, either because it is too expensive or because it is not appropriate for the system (Altieri, 2008). It is therefore imperative to promote technologies that are more readily available and appropriate to the circumstances of the small-scale farmer. A prime example of such technology is animal traction, the focus of section 2.5. But first, the contextual relationship with sustainable agriculture needs to be set.

## **2.4 SUSTAINABLE AGRICULTURE**

The literature on sustainable development demonstrates that the world’s agriculture system in its current form is largely unsustainable, promoting inequalities in food availability as well as failing to promote intergenerational equity regarding resource use. Ecosystem services are under severe strain and new ways of production are needed. The above description of small-scale farming showed that the polycultural practices of small-scale farmers are suitable for the attainment of sustainability in agriculture. This section presents and discusses the main characteristics of sustainable agriculture and the advantages to be gained from adopting these alternative or sustainable forms of production which include the integration of plant and animal systems. It also helps to understand Eric’s farm where he uses many sustainable agriculture techniques, including the use of animal manure. The next section presents some of the main negative aspects of conventional agriculture as a departure point.

### **2.4.1 Challenges of conventional agricultural systems**

Conventional farming methods have brought considerable success especially through Green Revolution methods where intensification of the production process was achieved through use of

more inputs (Bowler, 2002). However, the increased use of synthetic fertilisers, pesticides and heavy mechanisation has brought problems of affordability and environmental damage resulting from the oil-based inputs (Altieri, 1989; Bowler, 2002). Many small-scale farmers cannot afford the high external inputs and technologies of conventional agriculture hence it is an unviable option for them (Pretty *et al.*, 1995). Ecosystems have suffered strain as soils have degraded and soil biodiversity has been destroyed through increased use of chemicals in agriculture and as a result the productivity of soils has declined (Bowler, 2002). Industrial agriculture is also a contributor to species extinction and global warming. The fact that many farmers cannot afford conventional technologies points to social inequalities and poverty. This means that alternative ways of production, which are more affordable, maintain soil productivity and are environmentally friendly are needed to avoid the adverse effects of conventional agriculture (Pretty and Hine, 2001).

The next section discusses some of the main forms of sustainable agriculture and the technologies they use. This serves to demonstrate that sustainable agriculture can positively respond to the challenges of conventional agriculture and that it can overcome many of the sustainability challenges presented earlier. The focus then moves to information gleaned from the sustainable agriculture literature on the integration of plant and animal systems as well as the value of manure in order to set the scene for promoting animal traction.

#### **2.4.2 Sustainable agriculture systems**

The challenges discussed earlier of decreasing agricultural productivity and global food insecurity may be addressed by the adoption of alternative production systems that are sustainable. These farming methods are driven by a philosophy of working with and enhancing natural systems upon which agriculture depends (Mollison, 1998). They promote self-reliance by maximising use of farm-derived renewable resources and the management of ecological and biological processes and interactions to provide acceptable levels of crop, livestock and human nutrition (Lampkin, 2001). Sustainable agriculture systems remove or minimise the use of pesticides and synthetic fertilisers to prevent soil degradation and environmental pollution (Bowler, 2002). Lesser use of fossil fuels means a reduced contribution to the problems of greenhouse gas emissions and global warming.

The soil and soil health are crucial in sustainable agriculture systems and nutrient recycling is done to ensure that nutrients taken up from the soil during plant growth are returned and soil fertility is maintained. The soil supports a diversity of life forms that include macro and micro fauna and plants which interact in mutually beneficial ways (Pretty *et al.*, 1995; Dibbits and Wanders, 1995). The addition of composted organic materials to soil increases organic matter content which increases the availability of plant nutrients locked in soils (FAO, 2008). Use of composts improves seed germination, promotes plant growth and results in sustainable increases in biological soil health. Composting and curing of animal wastes and plant materials increase the bulk density of resultant manure, reduces weed seed viability and destroys plant and human disease-causing organisms (Rosenberg and Linders, 2004). Research has adequately demonstrated that the use of vermicompost can increase both biomass and marketable yields in crops. The humic acids from composts promote root development and growth in plants (Jack and Thies, 2006). Inoculations of liquid manures cultured by fermentation can be done to enhance nitrogen fixation in soils (FAO, 2008).

Another major aspect of sustainable farming systems, such as organic farming, is that they are low external input farming systems (Altieri, 1989; Bowler, 2002). External inputs are kept to the minimum and are only used as supplements or adjuncts to the system. This results in affordability and farmers can increase farm yields without negatively impacting on the environment (Lampkin, 2001). Such systems provide greater resilience for the farmer who is not subjected to price increases for external inputs.

Clearly, sustainable farming systems address not only the economic concerns of the farmer but also environmental sustainability and the needs of future generations. There is agreement that a variety of advantages are to be derived from the adoption of alternative or sustainable production methods. Among these are affordability, little or no requirement for external inputs, environmental suitability, meeting of local needs, provision of farmers with nutrition from a variety of produce and protection from dependence on external markets.

### **2.4.3 Integration of plant and animal systems**

Conventional farming systems generally separate livestock and crop systems, yet bringing them together gives efficient and maximum utilisation of local resources (Kate, 2008). Fallow fields can provide grazing for livestock and the grazing process shortens grass before ploughing is done. Ploughing becomes much easier resulting in a good seedbed. Grazing animals on fallow fields is an incentive for the land to continue to regenerate (Wardle, 2004). Energy losses can be minimised through composting plant and animal wastes together to give a rich source of nitrogen and organic matter thereby restoring soil fertility which leads to increased productivity (Pell, 2006). Composting plant and animal wastes enhances nutrient recycling which is a key component of sustainable agriculture. Livestock can be used for pest control in crops, for example ducks can reduce snail attacks on vegetables by their feeding on the snails (McMichael, 2006). Crop residues can also provide feed for livestock, particularly during periods when grazing is not good enough or be used to improve the quality of manure.

In addition to manure, nutrient recycling and the interdependency of crop animal systems there are further advantages of having animals on farms. Animals can alter soil microbial populations which are important in making nutrients available to plants and they can positively alter soil pH and reduce compaction (Wardle, 2004; Ritz, 2004; Pell, 2006). These important functions of manure are usually ignored, mainly because they are less apparent. In integrated systems manure is locally produced and widely available compared to outsourced fertilisers. Livestock usually represent the most valuable, easily-convertible assets owned by rural communities where they can buffer against inflation and crop failures (Wardle, 2004). In some cultures, livestock have religious and social significance and therefore their importance goes further than the provision of food or economic considerations (Pell, 2006). The work done by animals such as ploughing, weeding and transportation is important and saves human labour costs. Animals are used to till more than half of the cultivated land in the world (Wardle, 2004).

Traditional farming systems which have kept animals (cattle, goats, sheep, chickens) and a variety of plants on farms as a system of interdependent components are consistent with sustainable farming principles (Altieri, 1987; Bowler, 2002). This means that the integration of

crops and animals on farms is not a new phenomenon but rather a well established agricultural practice with documented benefits.

#### **2.4.4 The value of animal manure**

Animal waste is the most commonly used form of manure in many parts of the world. More than 34 million tonnes of nitrogen and nine million tonnes of potash are provided from farm or domestic animal manure globally every year (Sheldrick, Syers and Lingard, 2003). It is also an important source of soil organic matter whose amounts vary depending on the diet of animals, the storage conditions of the manure and amount of bedding included with the faeces and urine (Pell, 2006). Cow manure collected from Spanish farm composts was found to contain between 25 and 67 percent organic matter while goat and sheep manure contained less variable amounts of 55 and 51 percent respectively. In Nepal, composted animal manure accounts for more than 80 percent of nitrogen applied to amend soils (Thorne and Tanner, 2002). Farms with many animals and a relatively small area under cultivation usually attain better soil fertility and quality than those with extensive cropping but no complementary animal husbandry. Farms with extensive crops and fewer or no animals are prone to suffer serious soil degradation (Pell, 2006).

Soil comprises three main components: the biological, chemical and physical components. Inorganic fertilisers give quick results when applied to crops but they address soil chemistry at the expense of soil biology and physical structure (Lampkin, 2001). Organic manure, on the other hand, feeds soil biology and improves its structure as well as soil chemistry (Abbott, 2009). The soil is a system made up of a network of interdependent organisms with food chains representing complex energy flows between animal and plant species (Abbott, 2009; Madge, 2003). Attempts to improve soil productivity should therefore take into account this nature of soil as much as possible. Manure is a conditioner of soil which works both in the short and long term (Fernandez-Rivera *et al*, 1995; Madge, 2003).

The advantage of inorganic fertilisers is that they contain plant food elements in the right proportions but their major disadvantage is that they address soil chemistry at the expense of soil biodiversity and structure. Their effectiveness is therefore, even at best, short term (Lampkin, 2001). All commercially prepared fertilisers are expensive in Africa, costing as much as six

times more in sub-Saharan Africa than in Europe or North America (Sanchez, 2003). Locally produced alternatives to inorganic fertilisers are not only attractive but essential, especially to small-scale farmers.

One of the major advantages of animal manure is that it adds to soil organic matter. Soil organic matter is both a source and a sink for plant nutrients from which plants can extract nutrients when needed or deposit some which are later taken up as the need arises (Pell, 2006). Soil organisms such as earthworms, termites and micro-organisms feed on the soil organic matter and they in turn improve soil productivity by breaking down organic matter into usable elements for plants (Abbott, 2009). The quantity of manure that a farmer uses on his crops is important but its quality is equally important. Two important factors affecting manure quality are the diet that is fed to the animals and the conditions of storage of the manure before it is applied to crops (Pell, 2006). Changes in the type and quantity of food result in large differences in the extent of nitrogen mineralisation following manure incorporation into the soil (Sanchez, 2003; Scheldrick, Syers and Lingard, 2003). The nitrogen content of animal manure can vary from 0.5 to 2 percent of dry matter while potash levels can differ by as much as four times (Murwira, Swift and Frost, 1995).

#### **2.4.5 Conclusion**

The literature agrees on the need for urgent reforms in our systems of agricultural production. In particular, the over-reliance on petro-chemicals as inputs has led to ecosystem degradation and should therefore be minimised. External inputs are costly and many small-scale producers cannot afford them. Farmers need production modes that are accessible, familiar and applicable to them. The adoption of sustainable agriculture methods will help to address the global challenges posed by hunger, poverty, inequality, species extinction, degraded soils and agriculture's contribution to global warming. They also promote long-term sustainability and inter-generational equity by building soil fertility and biodiversity and conserving the ecosystem services on which life depends. The discussion on sustainable agriculture has demonstrated that efficient recycling of farm wastes can increase production and reduce costs. Sustainable systems lead to soil carbon sequestration and they minimise carbon dioxide emissions into the

atmosphere thereby reducing agriculture's contribution to global warming. Sustainable agriculture methods unquestionably have a crucial role in addressing the productivity challenges faced by small-scale farmers and the world's environmental concerns. The literature on sustainable agriculture is, however, relatively silent about which forms of draught power technology are appropriate or how they can be adopted. The following section takes a closer look at animal traction as a component of sustainable agriculture.

## **2.5 ANIMAL TRACTION**

The literature on sustainable development, sustainable agriculture and small-scale farming has demonstrated the importance of production methods in agriculture that promote sustainability. This section traces the historical development of animal traction, its current use and challenges it faces. Finally it argues for its promotion, especially among small-scale farmers, as a suitable source of energy and soil fertility.

### **2.5.1 History of animal traction**

Man has had a long relationship with animals since the domestication of animals in the Iron Age period (Child, 1967). Not only have they provided meat, they have also provided draught power for transporting goods and people as well as for the cultivation of crops. The most commonly used animals have been horses, mules, oxen, donkeys and buffalos (Starkey, 1995).

Recorded history shows that draught animal power was in use in Southern Africa before the 17<sup>th</sup> century (Joubert, 1995). The use of draught animal power by African communities before the coming of European settlers is largely not recorded, but it is known that the Khoi-khoi used animals for riding, packing and waging war (Joubert, 1995). When early European settlers arrived in the 1650s, they began to use oxen and later imported horses and donkeys. It took the imported animals up to a 100 years to adapt to the African environment before they could be widely used (Child, 1967). By 1900, animal traction was an important source of power in all sectors of the economy and it was used by all sections of the population (Bosman, 1988; Burman, 1988). In commerce they were used to carry goods and people between cities while in agriculture they were used for ploughing and carrying produce to markets.

After the first World War, there was a rapid development in fossil-fuel-powered engines and a major shift to tractor-powered machinery occurred (Blackwell, 1991). Within a period of 50 years, draught animal power almost disappeared from most commercial farms but many small-scale farmers continued to use it (Sieber, 1996). In 1994, the South African Network of Animal Traction (SANAT) conducted a survey which revealed that only a small number of commercial farmers used animal traction on their farms, and that it was more common among the small-scale and subsistence farmers in the rural areas (Joubert, 1995). This is discussed in the next section.

### **2.5.2 Current use of animal traction**

Despite its fall from global eminence after the invention of motorised transport, animal traction is generally on the increase in African and some Asian countries, but the adoption pattern has been patchy rather than large scale (Sieber, 1996). In sub-Saharan countries donkey use has increased 300 percent in the last 50 years (Starkey, 1995). It is in decline in the European Union and North American countries, due to increased motorised transport in these countries. The formation of animal traction networks in Eastern and Southern Africa in the last 20 years is a signal of a technology that is on the rebound. These include the Kenyan Network for Draught Animal Technology, the Tanzania Association of Draught Animal Power, the Ethiopian Network for Animal Power, the Animal Power Network for Zimbabwe and SANAT. These are formal networks which promote animal traction within their respective countries while linking up national activities to the regional body, the Animal Traction Network of Eastern and Southern Africa (ATNESA). To date, animal traction is one of the major sources of power in smallholder agriculture as reflected in Table 1. The proportional contribution is given by the percentage of total power use for agriculture in selected developing countries. It is quite dominant in the Southern Africa region.



**Table 1: Draught power use in agriculture for selected countries and the sub-Saharan region**

<b>Country/Region</b>	<b>Human power %</b>	<b>Animal power %</b>	<b>Tractor power %</b>
<b>Sub-Saharan Africa</b>	80	16	4
<b>Botswana</b>	20	40	40
<b>Kenya</b>	84	12	4
<b>Tanzania</b>	80	14	6
<b>Zimbabwe</b>	15	30	55
<b>South Africa</b>	10	20	70
<b>India</b>	18	21	61
<b>China</b>	22	26	52

Source: COMSEC (1992:71)

Since the invention of the agricultural tractor which was later popularised by the Green Revolution as the panacea for global agricultural draught power needs, animal traction has lost its significance in conventional agriculture. Industries promoting tractor-powered technology have merged with subsidiary companies across the world. Animal traction is still being used in the world's developing countries and to a much lesser extent in developed countries.

For the small-scale farmer faced with economic constraints, owning a tractor and its implements remains a pipedream. Tractor-powered agricultural interventions in sub-Saharan Africa have never served the needs of smallholder farmers, yet there is generally no official recognition of the need to promote animal traction as an alternative to the tractor (Kaumbutho, Pearson and Simalenga, 2000). Only Uganda has developed a policy at national level to promote and finance animal traction (Oram, 1996).

Farmers using animal traction have been left to their own devices and agricultural extension workers currently do not receive training in draught animal technologies (Starkey, 1995). There is a strong indigenous knowledge system which includes animal traction that is passed on from

one generation to another. Surveys conducted in South Africa's rural areas reveal conclusively that there is still widespread use of animal traction by rural communities and to some extent also by commercial farmers (Joubert and Kotsokoane, 1999). A nationwide survey commissioned by SANAT in 1994 revealed that between 40 and 80 percent of rural farmers use animal traction for both agricultural and transport purposes (Starkey, 1995). At that time it was estimated that about 400 000 small-scale farmers were making use of animal traction (Starkey, 1995).

Tractors have failed to meet the needs of small-scale farmers (Blackwell, 1991). There are some small-scale farmers who only use tractors and others who use tractors and draught animal power. However, due to the high cost of tractors up to 80 percent of the small-scale farmers who use tractors hire them (Joubert and Kotsokoane, 1999). A small number of commercial farmers use animal draught power and they have reported significant financial savings from using horses and oxen for ploughing, cultivation and transport on their farms (Jansen, 2003; Jolly and Gadbois, 1996).

In South Africa, the use and type of draught animals vary from one province to another. In North West, Limpopo and Mpumalanga donkeys are more common while in the Eastern Cape and KwaZulu-Natal oxen dominate (Starkey, 1995). On average, oxen are more often used than donkeys or horses. "Oxen remain the most important draught animal in the country, they are powerful, accessible and the trek-gear [sic] needed to in-span [sic] them is cheap, durable and readily available" (Kaumbutho, Simalenga and Pearson, 2000: 12). Oxen appreciate in value over their working life and their owners can realise appreciable profits at the end of their working life (Starkey, 1995). Elsewhere in Southern Africa, there are farmers using digging sticks and hoes to till the land, old and traditional techniques which are labour intensive. Most of these farmers fail to produce enough food for their families (Panin, 1989; Van der Lee, Udo and Brouwer, 1993; Kaumbutho, Pearson and Simalenga, 2000). This group of farmers would benefit immensely from draught animal power. Individual ownership of tractors is not a viable option for most small-scale farmers because their farms have arable plots of three to five hectares (Carruthers and Rodriguez, 1992). It has been calculated that about 40 hectares of land are needed to support the costs of a 20-kw tractor (Carruthers and Rodriguez, 1992). When a farmer buys such a tractor and uses it for less than 100 hours of work per annum, they have more fixed

costs than they can justify (Kaumbutho, Pearson and Simalenga, 2000). The costs of operating tractors are likely to go up as fuel costs increase so that animal traction would be an important way of cushioning farmers against the challenges of an oil economy.

### **2.5.3 The contribution of livestock to soil fertility**

Many disadvantaged farmers around the world have problems maintaining soil fertility. For those who own livestock the traditional way has been the composting of animal waste and bedding together with crop residues to give valuable manure for crop production (Ritz, 2004).

This practice enables nutrients from the fields and those imported from the pastures to be ploughed back into the farm system. Changes in the type and quantity of food result in large differences in the extent of net nitrogen mineralisation following manure application to the soil (Diver 1999; Sanchez, 2003). Well-composted animal manure can significantly improve soil fertility and overall productivity (as detailed in section 2.4.4). Farmers require more knowledge on how they can maximise benefits from animal manure.

### **2.5.4 Constraints on the use and promotion of animal traction**

It has been easy for the agricultural tractor to be popularised because a whole range of supporting infrastructure and technology was introduced. Extension courses and agricultural lessons in schools incorporated the use of the tractor. Courses in agricultural engineering were introduced that trained and promoted agricultural specialists in tractor-powered technology. The availability of supportive infrastructure and technology explains why tractors are popular even among farmers who have no access to them (Joubert and Kotsokoane, 1999). Perceptions were created that the tractor was the agricultural machine for the 20th and even the 21st centuries.

Farmers who continued to use animal traction did so, not because they believed in it as a viable power option, but because they could not afford tractors. There is therefore a major challenge for the 21st century to strategically promote animal traction despite the negative perceptions of it among some farmers (Kaumbutho, Pearson and Simalenga, 2000, Mbata, 2001). There is no extension support for animal draught power users in South Africa. At least three generations of agricultural extension workers have graduated without learning about animal traction (Joubert and Kotsokoane, 1999). There is a need for research and extension services to support animal

traction in the same way that the tractor has been supported. Extension services should be availed to farmers to enable them to properly feed their work animals particularly during drought periods as many farmers lose work animals due to starvation. Agriculture courses at school and college level should include animal traction to end the marginalisation that it is presently suffering.

The non-availability of modern animal drawn implements in South Africa is another major setback for the promotion of animal traction. “The biggest challenges in the animal traction business have been on availing effective quantity volume sales of quality implements or services at affordable prices and still make profit to sustain the business” (Kaumbutho, Pearson and Simalenga, 2000:63). The contribution of mechanisation by both tractors and animal traction to agricultural development has been disappointing because of the inadequate promotion of entrepreneurship in developing the technology. Farmers who are using animal traction and those willing to adopt it have not been assisted by sufficient availability of the necessary implements (Joubert, 1995; Fernandez-Rivera, 1995). The support of manufacturing industries is important where implements such as ploughs, harrows and cultivators are manufactured specifically to meet the needs of small-scale farmers. Even where implements exist, they need to be improved by further research to enhance their utility (Kaumbutho, Pearson and Simalenga, 2000).

Sufficient support for smallholder farmers will help address the dualistic system that has long characterised South African agriculture. The commercial sector has had effective support services while the smallholder farming system has been neglected as far as support is concerned (Starkey, 1998). Lack of government recognition and a National Policy on animal traction is also a major constraint to the adoption and use of animal traction (Joubert, 2010). Research by Sieber (1996) has revealed that agricultural officials at both provincial and national level were not aware of the degree to which animal traction was used in their areas with the result that they would report it as negligible even in areas where 80 percent of the farmers used it. The common picture that has been painted about animal traction is one of an outdated and backward technology rejected by western countries (Oram, 1995). This poor image and status can become a major constraint in the future drive and promotion for draught animal power in South Africa (Starkey, 1995). Planners need to work closely with end-users (farmers) to ensure that agricultural interventions meet the needs of the intended beneficiaries.

### **2.5.5 Summary on animal traction**

The preceding discussion has demonstrated that tractors have failed to meet the draught power needs of small-scale farmers. The cost of acquiring and maintaining tractors is too high for many small-scale farmers. Animal traction provides a viable option to tractors because it is much cheaper to acquire and maintain. Many small-scale farmers in developing countries use animal traction but they face a number of constraints which include negative perceptions and lack of support. The constraints can be overcome through the efforts of farmers and animal traction associations with the support of governments. Animal traction also has some environmental and social benefits which farmers can realise from using it. It is a sustainable power option for farmers. The future of animal traction, and ways to improve it, are discussed in Chapter Five. Most of the literature reviewed was conference papers put together by ATNESA and SANAT. It is hoped that this research will make a small contribution to building a body of knowledge on the subject of animal traction and that the findings can stimulate debate on the way towards the provision of appropriate draught technologies.

## **2.6 CONCLUSION**

The literature provides incontestable evidence that we live in a world where our food is being produced in largely unsustainable ways. The debilitated state of the soils and ecosystem services upon which we depend for agricultural production, needs new agriculture methods which promote intra- and intergenerational equity. The promotion of small-scale agriculture and the adoption of sustainable agriculture methods are central to efforts aimed at achieving this. Simple low-cost, affordable and environmentally-friendly technologies such as animal traction have an important role in the promotion of sustainable agriculture. The interdependency of plant and animal systems on a farm can be beneficial both to the farmer and the farming system. The affordability of animal traction and its simplicity and versatility can allow individual farmers to benefit from it in ways that can promote household and national food security. It is imperative that the government recognises animal traction as an appropriate power source for agriculture in South Africa and that a National Animal Traction Policy be developed and implemented as a matter of urgency (Joubert, 2010).

## CHAPTER THREE: RESEARCH DESIGN AND METHODOLOGY

### 3.1 INTRODUCTION

In this chapter the practical approaches to gathering the required information and its analysis are presented. The chapter states the research objectives and explains how the literature search was done. It also discusses the research design, the tools used, the contributions made by peers, the limitations of the research design and how the data were analysed. The chapter outlines and justifies the research tools and procedures followed and considers the constraints encountered in using these particular methods. The chapter highlights the challenges and opportunities presented by the choice of the research methodology. A research design is concerned with the kind of results aimed at and the means by which they are to be accomplished (Mouton, 2001). Methodology refers to the tools and procedures used in the research process (Mouton, 2001) or to the history of the research process which identifies the decisions made during the research process (Silverman, 2005) or to the epistemological home of an enquiry (Henning, 2004).

This research combines qualitative and quantitative methods so as to adequately address the demands of the different research questions. This combination of approaches is called 'triangulation' (Mason, 1996). Triangulation is a way of striking a balance between the desirable and the practical as one engages different issues in research (Singleton *et al.*, 1998). The research design is most closely related to 'ethnography'. An ethnographic research design was chosen because research in similar fields shows preference for ethnographic or qualitative research. Ethnography is a research design that provides descriptions of human societies (Halloway, 1997). However, some of the methods used for the data analysis are quantitative and therefore fall outside ethnography. For example, one of the research questions required a comparison of the costs of using the tractor to those of using oxen which required a formula to be derived.

### **3.2 RESEARCH OBJECTIVES AND QUESTIONS**

The purpose of this study is to document the processes around the introduction of oxen on a particular farm, that is to do a case study of Eric Swarts' farm. The formulation of research questions was important in delineating the boundaries of the research (Clough and Nutbrown, 2002). In this case, oxen were introduced to Eric's farm for two main reasons, namely, the need for manure to improve soil quality and the need for a cheap and cost-effective power source as opposed to tractor power. It is imperative to measure the improvement and cost-effectiveness to determine whether the introduction of the oxen has achieved its aim. This informed the formulation of the first two research objectives.

The third objective aimed at understanding any other benefits and limitations the oxen might have brought to the farm. Given my experience of qualitative research, I was aware that the introduction of a new 'technology' would impact on the farmer, his workers as well as the processes on the farm and potentially even people outside the farm system. These impacts would not be measurable in quantitative terms, yet they are important to the overall success or failure of the project. It was necessary, for example, to find out how much time Eric spent tending and using the oxen including any other extra demands made on him by the oxen, so as to determine whether it was really cheaper to have them or not. It is possible too that the monetary benefits of the project would be outweighed by added stress resulting from using oxen.

The fourth research objective was informed by the need to relate findings from literature on animal traction to Eric's experiences to make recommendations about the use of animal traction by small-scale farmers in developing countries. To guide data collection and analysis, four research questions have been formulated:

- 1) Did the oxen improve soil quality on the farm?
- 2) How cost-effective is the use of oxen in relation to the use of a tractor?
- 3) What managerial and social challenges and benefits did the oxen bring about on the farm?

- 4) What general recommendations can be made regarding the use of draught animal power by small-scale farmers in developing countries?

“Knowing what you want to find out leads inexorably to the question of how you will get that information” (Miles and Huberman, 1994: 42). The research methodology followed and the methods chosen to address each of the research questions as adequately as possible are discussed in the following sections.

### **3.3 THE APPROACH TO LITERATURE REVIEW**

Literature reviews are important in that they “provide an overview of scholarship in a certain discipline through an analysis of trends and debates” (Mouton, 2001: 179). This helps the researcher to see where and how the intended research fits into the gaps and how it will contribute to filling the lacunae (Silverman, 2005). A review of scholarship on draught technologies and animal traction, gave direction to the contribution this research should make. It also provided insight into how research is normally done in the field of sustainable development.

Ideas from the literature review were helpful in shaping what to do and how to do it. Hart (1998: 13) asserts that a literature review is done “to justify the research topic, design and methodology.” It directs one’s thinking before and during the search for data and in this case it also informed my data analysis. What scholars say about small-scale farming, animal traction and the use of manure provided an appreciation of Eric’s situation. Interpretation of data and the making of inferences were done by relating research data to literature findings (Halloway, 1997). In a way, literature is a source of data and some of the recommendations made in Chapter Five were drawn from literature.

In order to use the literature review for an understanding of the broad debates and trends in the field of animal traction, it was necessary to concentrate the literature search on the relevant focus areas. Since I am pursuing a master’s degree in sustainable development, and this is the field in which I have training, the sustainable development literature was a fitting starting point because it allowed me to draw from my disciplinary training and clarify my approach to the subject. I



turned next to agriculture viewed through the sustainable development lens which led me to concentrate on the sustainable agriculture literature. The focus was then narrowed to small-scale farmers in developing countries and finally on the literature on animal traction.

Theories from the fields (sustainable development, small scale farming, sustainable agriculture and animal traction) directed my observation and data collection on the farm. As Silverman (2004: 52) puts it, any observation is theory saturated and denying it would amount to “simplistic inductivism”. This is important because we award meaning to data depending on what we already know (Silverman, 2005). It deepened my understanding of the observations I made in the field because as I collected data, I had to find out whether the benefits of animal traction observed in my case agree with those described by other scholars. As observed by Henning (2004:71) “we should bring to them (data) the full range of intellectual resources, derived from theoretical perspectives, substantive traditions and research literature and other sources.” I had to revisit literature to integrate it with my findings in the field. Literature reviews give us the tools needed for comprehensive data treatment.

The literature review also seeks to answer the following questions:

- a) What is the history of animal traction use?
- b) What challenges constrain its adoption among farmers?
- c) How can farmers benefit from the promotion of animal traction use?

Finding the answers to these questions helps to combine knowledge with critical thought (Silverman, 2005).

For literature on sustainable development and sustainable agriculture, I used core readings provided in my courses in 2008 and my supervisor provided some important documents on the two subjects. The review of the key sustainability issues facing human society (in Section 2.2) was based on key globally accepted documents usually drawn up by large groups of scientists (for example MEA, 2005). The documents were informative and they were sufficient for my purposes. Dr Tarak Kate whose courses on biodiversity and sustainable agriculture I attended in 2008 as part of a BPhil degree programme provided useful documents on the effectiveness of animal manure. Dr Kate runs an NGO in India which has helped small-scale farmers convert

from inaffordable conventional to affordable sustainable agricultural methods and to make use of their oxen's dung and urine to improve soil fertility.

The major limitation for my literature search and review was that there was only one book (Kaumbutho, Pearson and Simalenga, 2000) provided to me by my supervisor on animal traction. I had to rely on conference proceedings edited and compiled by members of ATNESA. These documents were given to me by Bruce Joubert, who manages the UFHATC. Stellenbosch University's J S Gericke Library had no books on the subject. An online search for peer reviewed journal articles produced papers already provided by Mr Joubert and five other articles which I found quite useful. The literature was the source of insight used to make recommendations on Eric's situation and for small scale farmers generally.

### **3.4 RESEARCH DESIGN: ETHNOGRAPHY**

Ethnography has been described as "...studies that are usually qualitative in nature, which aim to provide an in-depth description of a group of people or communities" (Mouton, 2001: 148). Ethnographies are studies based on observational work in particular settings where researchers immerse themselves in a culture to enable them to see it from the point of view of those practising it (Halloway, 1997). Silverman (2005) agrees that the initial thrust in favour of ethnography is anthropological. For example, anthropologists who want to understand the life of the San people can go into the Kalahari Desert to live with them. Ethnography makes use of research designs such as participant observation and case studies.

This research is not truly ethnographic because it does not solely study human life. It is a study of a farm and the work done by oxen on the farm and it includes quantitative research methods. However, it is closely linked to ethnographic research because it makes use of qualitative research methods, case studies and participant observation. Maycut and Morehouse (1994) emphasise the importance of observation in ethnographic research while Mouton (2001) sees ethnographic research more as investigative participation. They agree that research must take place within a particular setting for the researcher to be able to articulate it. In this case I spent a

substantial amount of time participating in activities involving oxen on the farm. The procedures are detailed in Section 3.4.2.

Two methods used in this study which are part of ethnographic research design are interviews and participant observation. Methodology goes beyond the selection of appropriate research tools as it is an “ongoing task of justification” (Clough and Nutbrown, 2002:22). Ethnographic research is qualitative and the immersion of the researcher in the research setting produces rich data. It enables the researcher to make detailed descriptions of the situations being researched. The following section describes case study research.

### **3.4.1 Case study**

The overall research aim was to document the changes, benefits and challenges brought about by the introduction of oxen on Eric’s farm. Because the research is bound to a particular farm or case, case study as an ethnographic research instrument is an appropriate tool to conduct the study.

Stake (1995: 437-8) has identified three different types of case studies, namely:

- 1) The intrinsic case study where the case is of interest in all its particularity and ordinariness. In the intrinsic case study, no attempt is made to generalise beyond the single case or even to build theories.
- 2) The instrumental case study in which a case is examined mainly to provide insight into an issue or to raise a generalisation. Although a case is selected and studied thoroughly, the main focus is something else.
- 3) The collective case study where a number of cases are studied in order to investigate a general phenomenon.

In this case, the research contains aspects of the first two types. The Sustainability Institute, which funded the introduction of the oxen on the farm, is also funding this research project because it wants to assess the impacts of the oxen on the farm. This characterises the research as

an intrinsic case study. The research also aims at getting insight into animal traction as a technology that may be appropriate for small-scale farmers generally, thus making it an instrumental case study.

“Case studies are defined not only by their boundedness regarding the unit of analysis of the topic, but also by their methodology” (Henning, 2004: 15). Thus it is not enough to just identify the unit of study, in this case Eric Swarts’ farm, and then proceed to describe data and make conclusions without giving a detailed description of the events on the farm during the period under study that is January to July 2009. For example, I could not just gather information on animal traction from anywhere, but I had to thoroughly describe processes of animal traction on Eric’s farm which is the ‘case’. A case study is meant to give an in-depth understanding of the situation and meaning for those concerned. The interest is in the process rather than just the outcomes, in context and not just specific variables. Before arriving at a conclusion on whether animal traction or tractor use is an appropriate technology for Eric, it was necessary to give a description of the work of oxen and tractor and details of how the two differ to underpin such a conclusion. The process is as much a part of the outcome as the context is a part of the case (Henning, 2004).

Certain ‘how’ and ‘when’ questions have to be answered before answering the ‘why?’ questions. A detailed description of events precedes the analysis. In this case, I had spent six months on the farm prior to commencing research for the thesis. I was asked in June 2008 to be part of a team of researchers which included the thesis supervisor, whose work was to investigate Eric’s farm thoroughly to identify ‘blockages’ and then assist in putting forward possible solutions. My brief was to spotlight the farm’s production process. Between February and July 2009, I spent four days a week working on the farm and gathering data through interviews and noting down observations. This was done to assess the oxen’s performance during their first six months on the farm having arrived in January 2009. By July 2009, I had completed almost a year on the farm. From the large amount of data gathered during this period information relevant to the thesis had to be selected. The taking of field notes was one of the methods used to collect data.

Spending time on the farm was a good way of getting in-depth data on the research topic. The prime disadvantage of case studies is that the results from a single case are not necessarily generalisable to other cases. The next section discusses participant observation.

### **3.4.2 Participant observation**

Observing and gathering on-site data is known as participant observation (Henning, 2004). Although data can be collected in a few days of participation, the ethnographer needs to spend sufficient everyday time in the setting where participants carry out their daily tasks and conversations. This eventually renders a detailed description. The research story therefore includes many of my own personal experiences resulting from spending time in the setting. Singleton *et al.* (1998:11) contend that, “field research is essentially a matter of immersing oneself in a naturally occurring set of events in order to gain firsthand knowledge of the situation.” It is an unstructured exposure to the situation.

The processes of participation and observation started in middle January 2009 when I was asked to accompany Piet Smit, one of the newly hired oxen handlers, to the University of Fort Hare for training. The course covered the basics of in-spanning oxen, the various tools used and the fundamentals of working with animal-drawn implements. When the oxen arrived on the farm at the end of January 2009 I knew how they were supposed to work and I was ready to participate and observe.

From Monday to Thursday each week between February and August 2009, I spent six hours a day on the farm working with three other workers to inspan the oxen, plough, harrow and cultivate the fields. I recorded all these activities including the time spent on each and any constraints encountered. I also recorded other functions such as planting, harvesting, collection and composting of manure as well as the preparation and application of *sanjeevak* (explained in Section 4.2). The response of crops to applications of manure was an important area of observation. A main advantage of participant observation is that by being involved it is relatively easy to understand the processes being researched (Yin, 1994). It allowed me to capture feelings, values and perceptions.

An essential disadvantage of using observation as a research method is that there is a limit to what can be observed. Apart from observing earthworms as an indicator of improving soil biodiversity, there was no comprehensive method of measuring soil health (a challenge detailed in Section 3.6). Observation also has the pitfall of getting caught in the daily routine without questioning it (Miller and Brewer, 2003). The following section discusses cost-benefit analysis, a quantitative technique used to complement the preceding qualitative methods.

### **3.4.3 Cost-benefit analysis**

A cost-benefit analysis (CBA) was used to determine the profitability and cost-effectiveness of the project in order to answer the second research question. This is done by expressing benefits as a proportion of the costs of the project (Gittinger, 1980). CBA is a tool which helps to evaluate the impacts of investment decisions (Atkinson, Dietz and Neumayer, 2007). It is a tool for financial analysis which is not an end in itself but it provides a framework within which a project can be evaluated systematically (Gittinger, 1980). A comparison was also made to determine which of the farmer's options between a tractor or oxen as a means of draught technology was more remunerative. This was important for the second research question.

The CBA required a large amount of information about the work of oxen and tractors because it was essential to capture all the costs and benefits to ensure that the CBA results would be as truly representative of the real situation as possible, making it a reliable measure. However, CBAs by their nature measure quantifiable costs and benefits and this is a limitation because oxen have environmental and social values which are difficult to quantify. So, at best, a CBA is only a close estimate. I have tried to carefully explain the assumptions of CBA to allow readers to follow the reasoning, behind the technique. I will now detail the actual tools used to collect research data.

### **3.5 RESEARCH TOOLS**

This section identifies the tools used in data collection and explains how each of the tools was used including the advantages and limitations. The use of a diary, interviews and peer contributions are discussed in the following sections.

#### **3.5.1 Diary**

The decision to do a case study and participant observation which are ethnographic and qualitative methods meant that specific tools for gathering data in the field had to be chosen (Halloway, 1997). As a means of collecting data, I diarised my findings from the literature and my observations on the farm. By recording Eric's responses to interview questions it was possible to trace how his perceptions were maintained or changed over time. The research diary showed the development of my thinking and reflections on the research. Substantial parts of the research methodology and data chapters (Chapters 4 and 5) were developed from this diary. The use of a primary source of data helps address concerns of validity and objectivity (Silverman, 2005). The data collection and analysis results were products of a variety of techniques.

In ethnographic research, the researcher is the main research tool because what is observed and recorded is interpreted by the researcher (Halloway, 1997). This implies that what is recorded is already an interpretation and a selection from many other things happening in the research setting. I only recorded what I thought was relevant to my study hence motive colours content (Miller and Brewer, 2003). This is obviously a disadvantage in that some useful information may be overlooked for being considered irrelevant. The next section discusses the role of interviews in gathering research data.

### **3.5.2 Interviews**

An interview is a narrative collectively assembled. It is a conversation with a purpose in which the interviewer and the interviewee 'construct' the narrative (Holstein and Gubrium, 1995). In qualitative research, researchers conduct qualitative interviews which can be structured, semi-structured or unstructured (Halloway, 1997). Structured interviews have questions that give a range of options or answers from which a respondent chooses and this includes questions that need a 'yes' or a 'no' answer. In this research, asking the farmer if he uses inputs from outside the farm is an example of a structured question. Semi-structured interviews ask open-ended questions about specific subjects. Asking the farmer a question like -where do you get your fertilisers?- is an example of a semi-structured question. I used all these types of questions in the four formal interviews and during informal discussions I carried out with Eric from June 2008 to July 2009.

My key informant was Eric Swarts but I also interviewed other knowledgeable people about animal traction. These were Bruce Joubert, lecturer and manager of the UFHATC, John Snyed an animal traction consultant, the three animal handlers I worked with on the farm, Gareth Haysom from the SI who was responsible for setting up the oxen project, and Dr Tarak Kate, who is well informed about animal traction and the use of ox dung and urine.

Discussions held with my supervisor and other lecturers made it apparent that interviews were to be the primary way of collecting data about the farm. During my initial visits to the farm in 2008 I identified certain farming problems which Eric hoped would be solved by owning and using oxen. During informal discussions I gathered a wealth of information about how Eric sees the 'reality' of his farm. On 20 February 2009, I conducted a structured interview with Eric and again on 15 July (the interview questionnaire is included as appendix five). The questions I asked in the interviews were geared to find out from the farmer how the introduction of the oxen was impacting his activities such as ploughing, cultivating and planting. I also intended to discover from the farmer how the project was affecting his finances. I managed to get some written records for some aspects of the farm but generally they were not up to date.



The questions asked during the interviews were intended to obtain detailed information necessary in answering my research questions and reach the study's objectives. Answers to these and other questions helped to draw a comparison between what the farmer said and what I saw when making observations. As Silverman (2005) observes, ethnographers who fail to use their eyes and ears are neglecting a crucial source of data.

There are advantages to using interviews, the major one being that they are a flexible data-gathering mechanism (Miller and Brewer, 2003). They allow the interviewer to digress and probe the interviewee further to gain important insights on the responses (Feagin, Oram and Sjoberg, 1991). I experienced that the interviews were rich sources of information which was relevant in answering all the research questions. Disadvantages of interviews are that interruptions can occur during discussions as experienced twice, interviews tended to take longer than planned and digressions are difficult to manage. It is also important to establish trust between the interviewee and the interviewer before interviews can bear useful information (Yin, 1994). Since I had been on the farm for six months before the research began, a good rapport had been established between Eric and myself. The next subsection looks at the contribution of a peer research group to information gathering and analysis.

### **3.5.3 Peer contributions**

Analysing the data and writing up the research findings were not done in isolation. My supervisor and other student researchers, particularly those in the Stellenbosch Research Group (SRG)<sup>1</sup>, were important sources of insight and inspiration. I learnt from listening to other students talk about their research processes and findings. We had fortnightly meetings where we shared ideas and at times each one of us made a presentation and received feedback from the others. I presented my own findings on 22 June 2009 and I received useful comments especially regarding my data analysis. Professor Mark Swilling was present at most of these meetings and he assisted us with incisive criticism and insightful ideas about our research.

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<sup>1</sup> This is a group of fellow MPhil students doing research focussed on the Stellenbosch area.

In order to attend to the second research objective, I needed to do a CBA and this required agricultural economics skills. Erik van Papendorp, an agricultural economist graduate was consulted to identify the considerations for a CBA and then Silant Taurayi, a trained agronomist, assisted with the completion of the CBA. Their contributions were vital because during one of the meetings of the SRG, brainstorming produced advice on how to improve the presentation of the research data. The following section discusses how data analysis was done.

### **3.6 DATA ANALYSIS**

Data analysis is the presentation and discussion of the data or information collected during research (Mouton, 2001). It involves searching the research data for information which helps to answer the research questions and this involves making interpretations and inferences about the data. The discussion of the data means that the researcher has to ask key questions about the data (Silverman, 2005). Some such questions are:

- 1) What are the main units in the data and how do they relate to one another?
- 2) What story emerges from fitting the units together?
- 3) Which categories are used by the people in the context being studied?
- 4) What constraints and opportunities were encountered and how did this impact on the research findings? (Silverman, 2005)

In this research, the main units of data were inputs, processes, outputs, costs and income. The analysis involved drawing relationships between inputs and processes (for example oxen manure and productivity). Questions such as: How does ploughing and cultivation with oxen affect the farmer, his costs and ultimately profitability on the farm? And, Which constraints were encountered and what do they tell us about the farm, or the farmer or his oxen? These questions were important because generating answers to them helped in attaining the research objectives.

All categories of information were used to answer the four research questions. Conclusions summarising the findings and detailing some insights and inferences drawn from the experience of the introduction of oxen on Eric's farm were made.

I needed to answer the question as to how my research findings speak to the broader issues of sustainability and sustainable agriculture. It involved asking myself if the findings fitted existing theory in the discipline or if a new theory was emerging from the findings. Extrapolation is a typical procedure in qualitative research (Alasuutari, 1995). I had to reflect on how my findings agree or disagree with ideas from literature and my personal experiences with animal traction.

Data analysis was not done at a later stage but early in the research so that it was an on-going process (Henning, 2004). Even during the data collection stage, I used categories into which I classified data, which is the task of coding (Silverman, 2005). I found that tackling data piecemeal was better than dealing with large volumes at once. Working with data during the analysis made me revisit many areas of my research design. For example, I had to go back to literature to find out what the environmental and financial costs are of soil compaction caused by ploughing with a tractor. This assisted in comparing tractor use with oxen in the CBA.

In answering the first research question, my initial plan was to do a soil quality test in January 2009 and then another one in July 2009 to assess any improvement in soil quality but the soil scientist I contacted, Johann Lanz, advised against it. He maintained that the scientific soil test only tests changes in soil chemistry and these would only be evident at a much later stage. His e-mailed recommendation reads:

*“My response to this is that it would be a difficult thing to measure and that getting any real meaningful quantitative data will be difficult, maybe impossible. You are wanting to test whether the oxen are affecting soil quality or health in some way. Measuring changes to soil health is exactly what I am trying to do for my PhD. There are a number of reasons why this would be difficult in your particular case.*

- 1. Measuring and showing differences in soil health generally as a result of some management impact is difficult and complicated. There are many measures that can be used but all have limitations, difficulties and complications to them. Generally the useful measurements in terms of soil health are not done by labs. Labs just do the standard chemical analysis which tells you very little about soil health.*

2. *The naturally occurring variation in most soil parameters makes comparison difficult and requires rigorous sampling and a number of replicates.*
3. *Six months is a very short period to expect measurable change in soil conditions. Those things that can be measured reliably like organic carbon take longer to show significantly measurable change.*
4. *The different sampling seasons will make comparisons of any measurements related to soil biological activity, difficult because the seasonal variation is likely to influence it.*
5. *We do not really know what kind of effect the oxen will have on the soil so we do not know what parameters to target for measurement.”*

Ultimately, full technical information will require that specialist agronomists, soil scientists and economists cooperate to assess the impacts of the animal traction project over a longer period. Bringing these people together on Eric’s farm for the purposes of evaluating the project was not feasible. My evidence of change was mostly derived from my observations and what the farmer said, as well as the comments and observations of other people, especially those knowledgeable about animal traction and animal manure. The research process, particularly the data analysis was beset with some constraints which are discussed below.

### **3.7 CONSTRAINTS**

Some constraints were encountered during the research process. The oxen only arrived at the end of January 2009 and the SI asked me to review the first six months of the project. Six months is quite likely too short a period to get reliable results and draw informative conclusions. The other constraint was methodological. While my research design was qualitative and closely linked to ethnography, it was not possible to sufficiently address the demands of the research questions through purely qualitative means. One must agree that, “No matter how elegant your original research proposal, its application to your first batch of data is always salutary” (Walcott 1990: 20). I needed financial techniques, for example the CBA, which are quantitative, even though initially I had intended to follow a purely qualitative approach. The final product was thus a balance between the desirable and the practical (Silverman, 2005).

Quantitative techniques helped to show how the processes at the farm were changing. An analysis of the costs involved in the use of a tractor and oxen was made to show the differences. It helped to make the qualitative descriptions clearer. I agree with Kirk and Miller (1986: 10) that "...by our pragmatic view, qualitative research does imply a commitment to field activities. It does not imply a commitment to innumeracy." In answering the second research objective (about the cost-effectiveness of the oxen versus the tractor), I needed to do a CBA (a quantitative technique), but I lacked the requisite skills and so to overcome this constraint I sought the assistance of the relevant people. My supervisor introduced me to an agricultural economist who assisted with the general guidelines for carrying out a CBA and he recommended some informative literature, particularly the book by Gittinger (1980). Nonetheless the task remained a challenge.

Feelings of anxiety dominated my thinking for some time but I finally completed the CBA with the help of a fellow student who is an agronomist. I discovered that the original data I had was insufficient to complete a CBA so I had to go back to the farmer to get more information and to have various financial facts verified. The CBA took more effort and much longer than planned. Record keeping is seemingly a major challenge to small-scale farmers. Figures on amounts of fertilisers used during the early years were estimates as were those on the expenditure on labour. Figures, tables and graphs enabled me to test and revise my conclusions and generalisations and they helped to make the storyline clearer to the audience of the research.

### **3.8 CONCLUSION**

This methodology chapter has explained how the research was carried out through a qualitative ethnographic research design and it has discussed the research methods used, including interviews and participant observation. It also recounts the constraints encountered in the research process and describes how the data analysis was done. The next chapter (Chapter 4) presents and analyses data from the research findings.

## **CHAPTER FOUR: RESEARCH FINDINGS AND DISCUSSIONS**

In this chapter the research data is organised into categories, analysed and presented as answers to specific research questions. The four main categories into which the data has been grouped include data relating to soil fertility used to achieve the first research objective (Section 4.2); costs and benefits for the second objective (Section 4.3); and managerial and social benefits and challenges for the third research objective (Section 4.4). The fourth research objective is treated in the recommendations section in Chapter Five. Before paying attention to answering the research questions, a picture is sketched of the baseline farm before the introduction of the oxen (Section 4.1). It is a description of Eric's work and the constraints he faced which necessitated the introduction of oxen. A brief overview of the background to the oxen project is given to provide the context for the case study.

### **4.1 THE BASELINE FARM**

#### **4.1.1 Introduction**

The baseline study comprises information collected from June 2008 to January 2009. It presents the situation on the farm before the arrival of the oxen on 27 January 2009. The information was gleaned from the works of BPhil and MPhil students who previously conducted research on the farm, by interviewing the farmer and from on-site observations. Background information on the farm is given including how the farmer started working the land, his relationship with the SI, some of the main features of his work and the constraints he faced before the introduction of the oxen. The purpose of this section is to provide a benchmark against which to compare the changes that have occurred subsequent to the arrival of the oxen.

#### **4.1.2 Background**

Eric Swarts is a 39-year-old black farmer who has lived in the Western Cape all his life and trained at Kromme Rhee Agricultural College as a farmer. He has a small-scale (10 hectares) vegetable farm along the Annandale Road connecting the R310 to R44 near Stellenbosch in the

Western Cape province of South Africa. The Western Cape experiences a Mediterranean type climate with hot dry summers and cold wet winters. Eric's farm is part of Stellenbosch municipality's commonage property. The farm is leased to Spier Holdings who have allowed Eric to grow produce with support from the SI. The crops grown on the farm are lettuce, spinach, carrots, onions, broccoli, leeks, gem squashes, beans, cucumbers, sweet-corn, beetroot, butternuts and baby marrows, among others. There is a ready market for these vegetables, especially for lettuce and carrots.

Eric has been on the farm for ten years. He and four other farmers, some of whom now farm conventionally on neighbouring farms, started working the land in 1999 under Spier's Go Organic programme. The programme envisaged getting people back onto the land through land reform and black economic empowerment (Swarts, 2008). Spier intended to empower the five farmers by giving them access to land and capital to enable them to use their farming skills to earn a living off the land. After three years it became clear that organic farming was not an appropriate option because it would take too long to build the fertility of the soil. Consequently, Spier abandoned the project, which had operated at a loss for all three years. The other farmers decided to leave the farm and continue farming conventionally across the road, while Eric chose to stay on the farm and to continue farming organically.

Asked why he has chosen organic farming, Eric gave a number of reasons. He wants to provide healthy vegetables to his customers and it gives him great satisfaction when customers express their appreciation of the quality or taste of his produce, which they buy from him specifically for these attributes (Swarts, 2008). He wants to contribute to building an environmentally-safe farming system that will assist future farmers who will work the land after him. He says for him it just feels like the natural way to farm. Eric has been trained formally as a farmer in conventional agriculture and he appreciates the usefulness of conventional practices but quickly adds that he found some gaps in the industrial agriculture system, such as its negative impacts to the environment, years back when he was being trained. He says that soil that has been farmed using chemicals does not show signs of life forms in it and synthetic fertilisers do not provide biomass for soil micro-organisms which are important to crops (Swarts, 2008). Eric displays an

understanding that his farm is part of a bigger ecosystem, the biodiversity of which farmers should protect for the mutual good of the ecosystem and farmers.

#### **4.1.3 Relationship with the Sustainability Institute (SI)**

Eric's relationship with the SI started in 2002 when he had started farming on his own. Since then he has been receiving financial support from the SI, especially towards the purchasing of organic manure. The support has averaged R20 000 per annum (Swarts, 2009a). The SI has also paid Eric a stipend because he teaches BPhil and MPhil students and allows them to interview him for their projects. The SI has also paid for the farm's water and certification costs for a number of years.

In 2003 the SI sent Eric to India to learn from the experiences of farmers there who had successfully converted their farms from conventional to organic farming. He says his experiences in India broadened his horizons in many ways. He learnt about on-farm preparation of organic manures which he hoped to do once he could collect manure when the oxen arrived on his farm. One of the manure preparations is *sanjeevak*, a mixture of fresh dung, urine and molasses left to brew for two weeks. Eric says it has a high nitrogen content. Composted animal manure is an effective fertiliser and can be used to make 'compost tea' by adding water to a portion of compost and collecting the water that filters through the compost (Kate, 2008). Compost tea is both an effective fertiliser and a biological pesticide in much the same way as cow urine (Swarts, 2008). Indian small-scale organic farmers are good at observing changes in soil fertility by using certain biological indicators. Eric has already developed this expertise on his farm. The presence of earthworms, termites and other macro-organisms indicates high levels of fertility as well as the presence and activity of useful micro-organisms that are beneficial to plants (Kate, 2008). Other indicators of soil fertility used in India are soil colour and smell. The SI has funded the oxen project in order to assist Eric in his quest to farm sustainably. Details of this arrangement are given in section 4.1.5.



#### **4.1.4 Constraints faced by Eric**

This section introduces the major challenges faced by Eric before the arrival of the oxen on the farm. It provides a baseline to assess whether the introduction of oxen relieved any of these constraints. The information in this section was gathered through interviews with Eric and Gareth Haysom, a member of the SI staff who has worked with Eric for over two years and who helped facilitate the oxen project, and from my own observations on the farm since June 2008. Eric was asked to order the constraints from the most to the least severe and they are reflected in the following sub-sections in the order given by him.

##### **4.1.4.1 Soil fertility on the farm**

The soils on the farm are sandy and had been impoverished by years of conventional tobacco cultivation before Eric took over the land. Tobacco cultivation requires a lot of chemical additives such as fertilisers and pesticides which, in his view, were responsible for impoverishing the soil and giving it a poor structure (Swarts, 2008). As a trained and experienced farmer, Eric can, by merely looking at the soil or by picking some up and smelling it, tell how productive it is. When he took over the farm, soil tests revealed that it contained insignificant organic carbon levels and the pH was too low indicating an acidic soil that needed attention before any meaningful organic production could take place (Swarts, 2008). He observed that there were no visual signs of microbial activity, a certain sign of an unhealthy soil. There were also no earthworms, termites or insect activity noticeable in or on the land, all of which are important signs of productive land.

Significant strides have been made toward building the organic carbon content of the soil since Eric's taking over the farm. The SI has been instrumental in providing funding for the purchase of manure and towards certification costs. Eric's records show that the average annual expenditure on organic fertilisers and cow manure has exceeded R20 000. When he took over the farm organic carbon content was insignificant but current soil tests show that the organic carbon content is now slightly above one percent (Swarts, 2008). Good soils have a carbon content of between three and five percent (Madge, 2003). This signifies that there is much work to be done

in adding manure to the soil. During an interview on 23 September 2008, Eric acknowledged that, “I have realised that farming organically has no short-cuts, it is a gradual take-off by building soil fertility through natural processes.” Despite having heavily invested in the soil over the past ten years, some crops will only do well when the levels of fertility are higher than they are now. Carrots and potatoes are occasionally grown but they are ‘heavy feeders’ requiring very fertile soils. Hence, the challenge to build the fertility of the soil is central to Eric’s work. Lettuce is by far the dominant crop, mainly because it matures fast and has a ready market. He observed that winter temperatures are often too low to sustain the growth of most crops and that is the time he relies mostly on lettuce

One of the important aspects of an organic farm is nutrient recycling to reduce the need for externally-sourced fertilisers (Lampkin, 2001). Weeds and crop residue should be composted so that they decompose sufficiently before they are ploughed back into the soil to restore nutrients which are taken up from the soil during growth (Madge, 2003). It is evident that before the introduction of the oxen this was an area that needed improvement because there was not much evidence of recycling.

Eric noted that the manure he bought was usually a poor quality product and there was no time to compost it before application. The latest batch received comprised 25 percent wood chips. Manure that has not been composted takes up nitrogen from the soil as decomposition takes place before plants can access the nutrients (Swarts, 2008). The small compost heap on the farm which had been made from plant residues was decomposing quite slowly. The composting process took too long to produce fully-decomposed manure -on average six months for material to be sufficiently decomposed for application as manure. This meant Eric could only apply sufficiently decomposed manure twice a year.

Organic manures used to build soil fertility over the years were Sea-gro, guano, chicken manure and some horse manure. During the 2002 and 2003 seasons Eric used chicken manure, which he applied three tons to a hectare. It appeared to work well but later it caused excessive levels of phosphates in the soil. Plants need nutrients in balanced proportions (McMichael, 2006). From 2002 to the present Eric has been using guano which is rich in nitrogen and does not result in

excessive phosphates in the soil. Guano is made from wastes deposited by birds on artificial islands made at sea by organic fertiliser companies. The guano has been applied at the rate of 300 kg per hectare per crop. Apart from chicken manure and guano, the farmer has also used Sea-gro which is a by-product of the fishing industry (Swarts, 2008).

A major challenge of using commercially-prepared organic manures has been that it is difficult to get a well-balanced organic fertiliser. The companies manufacturing them are in the process of developing these fertilisers which need to be tried and tested over time (Swarts, 2008). To achieve a nutrient balance for his crops, Eric has been using combinations simultaneously and this is done at great cost to him. The cost of externally-sourced organic fertilisers has been increasing significantly annually. Table 2 summarises the quantities and costs of organic manures which Eric has been using over the last nine years. It shows that the price of fertiliser has been rising by an average of ten percent per annum. This forced Eric to progressively reduce the quantities bought and applied with each year. For example, while he applied 16 tons per hectare in 2000, in 2004 he only managed five tons per hectare. In 2007 he achieved an application rate of 20 tons per hectare only as a result of increased support from the SI. While in 2000 a ton was costing only R300, by 2008 it was R489 which shows a difference of 57 percent.

**Table 2: Quantities and costs of manure used by Eric, 2000 to 2008**

<b>Year</b>	<b>Quantity in tons</b>	<b>Cost</b>	<b>Year-on- year price per ton</b>	<b>Application rate: tons per ha</b>
2000	160	R60 000	R375	16
2001	120	R38 000	R317	12
2002	120	R38 000	R317	12
2003	120	R38 000	R300	12
2004	53	R20 000	R377	5
2005	3	R1 500	R500	1
2006	103	R43 000	R417	10
2007	125	R60 000	R480	20
2008	92	R45 000	R489	18
Nine-year averages	99.6	R37 944	R397	11.8

Source: (Swarts, 2008)

Eric has been investing heavily in the soil, but he contends that if he had enough financial resources, he would have bought 120 tonnes of cow manure each year to enable him to build sufficient nutrient reserves in the soil over a period of 10 years. Cow manure is his preferred soil amendment, but it is difficult to obtain cow manure which meets organic certification standards (more detail on this in section 4.1.4.5). Since 2006 he has reduced the area under cultivation to four hectares to increase the amount of manure he could apply per hectare.

#### **4.1.4.2 The need for draught power**

The absence of readily-available draught power is a major constraint on Eric's farming activities. He uses a tractor, which he borrows from Spier, for ploughing. The tractor is not always available because it is lent to other farmers too and it has to be serviced at certain times. Eric could not use it for about three weeks in November 2008, when it broke down and was sent for repairs. In farming, timely cultivation and planting is important so that the unavailability of a

tractor can be quite costly for a farmer. If crops are planted three weeks late because the land is not prepared, it means losing income for three weeks and on average it amounted to R12 000 in Eric's case (Swarts, 2008). A new or second-hand tractor is quite expensive and Eric said he could not afford it.

A tractor ploughs and discs quite quickly, but it is difficult to achieve a level seedbed using a tractor (Swarts, 2008). On average, Eric spends two days each week on the tractor because ploughing is a continuous function. This is done to keep the plots in good condition and to eradicate weeds. Eric observed that the tractor also causes soil compaction especially after repeated use and literature asserts that compaction can seriously affect soil structure and productivity (Sanders, 1988). Using a tractor costs R500 per hour and it takes about 30 litres of diesel to plough a hectare in two hours. Hiring rates generally include fuel costs so if the price of fuel goes up, hiring costs are likely to increase too. At a usage rate of eight hours per week it costs R4000 and up to R16 000 per month. These amounts are estimates arrived at after interviewing the farmer and having a telephone conversation with a salesperson at Agrimark, the local tractor dealers. These estimates serve to make comparisons with the use of oxen. Eric does not currently pay for the use of the tractor as he borrows it when it is available.

#### **4.1.4.3 Farm operates at a loss**

The current expenditure on farm operations is quite high: in fact it is operating at a loss. Eric's books for 2007 record an annual expenditure of R460 000 against an income of only R410 000- a deficit of R50 000 (Swarts, 2008). Turning the farm from a loss making venture into a profitable business is one of Eric's major challenges. Closely related to the issue of profit-making is the productivity of the soil. Improving the soil organic carbon from an insignificant content to one of one percent at present is good but not enough (Swarts, 2008). Eric believes that the farm output is affected and significantly reduced by weeds. Increasing the number of workers to do weeding has in the past raised farm expenditure to economically unsustainable levels so that he has had to find a way of making the best use of the minimum number of workers that the farm can sustain (Swarts, 2008). I have observed that the farm also experiences water logging caused in part by

leaking pipes and by poor drainage of storm water. This affects plant growth and can reduce the harvest.

#### **4.1.4.4 Labour and labour costs**

The operations on the farm are labour intensive and Eric said that 70 percent of the total farm expenditure was for labour. He spent R6 400 per month in salaries for his workers as of October 2008. An organic farm does not use herbicides or pesticides so that the removal of weeds and some insect pests is done manually, making the farm more labour intensive than conventional farms (Madge, 2003). There are currently four hired workers on the farm who plant, weed and harvest produce. These operations are continuous on the farm, taking place daily and demanding constant supervision to ensure maximum productivity. The number of workers varies from time to time depending on the nature of the labour demands. At times workers are hired temporarily to assist with urgent labour needs, particularly weeding. The SI also provides some labour for an hour in the mornings when students come to do community work.

#### **4.1.4.5 The organic certification process**

Eric's farm has been certified as organic for the previous years but is not certified any longer due to some restrictions faced in the process. These include limitations in sourcing manure and the cost involved. The organic certification process requires that Eric buys manure from certified farmers only and he reports that regulation has meant there are very limited sources of manure and at times he has had to go without manure when supplies ran out. Spier offered some horse manure but he could not use it. Horses are dosed with de-worming medicines so that their manure contains chemicals that kill earthworms, hence the horse manure can only be used in limited quantities in conjunction with other manures. One of the certification reports also discourages the intensive use of chicken manure which causes excessive phosphate levels (Swarts, 2009a). Cow manure has always been a best option but even this is sometimes a less than optimal choice because cattle farmers use various materials for bedding and these affect the quality of the manure. The conditions under which manure is stored also affect its quality (Pell, 2006).

The farm was first certified organic in 2002 and it has been certified annually since then until 2007. Organic certification is an expensive and rigorous process. The initial certification was charged at R3 400 but the cost has been rising sharply over the years and the last certification in 2007 cost R8 000. The certification costs more than doubled in five years and Eric is now finding the fee unaffordable. It is a requirement of the certification process that the farmer keeps record of all the inputs used on the farm including fertilisers, seeds and water. This is done to ensure that no synthetic fertilisers or chemicals get into the system.

In 2009 Eric decided not to certify due to the exorbitant cost of certification which he contends is not much of a benefit to him. He believes that he has built a sufficient clientele base over the years who now trust him and always buy from him without insisting on organic certification. Eric and other small-scale organic producers in the area have decided that they will not certify again because the process favours the certifying agents at the expense of the farmer (Swarts, 2009a). Organic certification has the advantage that it can open up bigger and better-paying markets including some foreign markets, however in view of the exorbitant costs farmers can act jointly and market their produce under their own brands.

#### **4.1.5 Conclusion**

Eric's ordering of the constraints facing him agreed with that of Gareth and my own observations that the need to improve soil fertility is his biggest challenge. He believes that once the soil fertility is satisfactory, he can take up all the other challenges to which he gives an equal weighting. The only difference in how the constraints were ranked was on the importance of the certification process which Eric sees as one of his least concerns for the present. I would argue that certification should be given greater priority because it could open up new markets for Eric especially in the light of an anticipated increase in production.

At the time of introducing oxen on the farm it was assumed that it would assist Eric in a number of ways, namely

- a) The costs of fertilisers keep on rising and the farmer has no control over it. The oxen would present an opportunity for him to harvest his own manure at no extra cost.
- b) Using manure from his own oxen would do away with some of the certification problems, such as the need to justify buying manure from some farmers.
- c) Manure will be available throughout the year.
- d) Eric will have readily-available traction power.
- e) The oxen would reduce the labour burden by using them to help weed the fields.
- f) Self-sufficiency on the farm would be improved and less outsourcing would be done.

From the point of view of the SI, the oxen project would assist their efforts to empower an emergent, previously disadvantaged organic farmer. It would also help as a case study to see if it can be replicated with other small-scale farmers. The oxen would provide research opportunities for SI students of sustainable agriculture (Haysom, 2009), this research being such an example.

#### **4.1.5 Background of the oxen project**

Prior arrangements were made to facilitate the introduction of oxen on Eric's farm. Eric's SI-sponsored trip to India, was a key step in the preparations (although this was not the original intention of the trip) because he had the chance to see how effectively cattle were being used and how to handle them. Eric was impressed by what he saw in India concerning the work of cattle on small-scale farms (Swarts, 2008). He was, however, concerned about a possible strain on his operations especially regarding the handling of the oxen and his finances if the oxen were introduced on his farm (Haysom, 2009). Consequently, the SI introduced the oxen as a research project which they would fund. Gareth Haysom travelled the country to interview people having animal traction skills and in Eastern Cape he was introduced to SANAT and UFHATC. Gareth arranged for the head of UFHATC, Bruce Joubert, to visit the SI. An agreement was then



reached and a memorandum of understanding signed in which the UFHATC agreed to source and train the oxen for Eric for which the SI paid and budgets were drawn up (Haysom, 2009). Apart from paying for the purchase and training of the oxen, the SI also agreed to pay for the labour needed to handle the oxen on the farm. Piet Smit, one of the handlers, and myself travelled to Alice for a week-long training at UFHATC in January 2009.

One of the major costs funded by the SI in preparation for the coming of the oxen was the construction of a standard kraal with a handling facility as well as feeding and watering points for the oxen. Part of the kraal floor has been concretised and it has little channels through which ox urine can flow to collection points outside the kraal. This is something Eric learnt in India. The Indian farmers construct kraals in this way because urine is needed to make *sanjeevak* (defined and explained later in this chapter).

The oxen had to undergo two months of training at the UFHATC and the training was paid for by the SI. UFHATC advised that training is an ongoing process and when the oxen were brought to the farm on 27 January 2009, both John Snyed (an animal-training consultant) and Bruce Joubert (lecturer and head of the UFHATC), together with some of their handlers, came along so that they could practically assess Eric's situation and give guidance on the handling and welfare of the animals. They returned to Fort Hare after three days but later sent two experienced handlers to the farm to help Piet and Vuyo (the other handler) for three months. It was hoped that after that period Eric's handlers would be confident enough to work on their own. It is difficult to get people who have experience and are willing to work with oxen. The SI had to hire Piet and Vuyo even though they did not have any experience in handling oxen. These two helpers expressed that they were willing to learn so they were hired.

## 4.2 DID THE OXEN HELP IN IMPROVING SOIL FERTILITY?

For the purposes of this study, soil fertility is defined as the endowment of the soil with food nutrients enabling it to produce crops (Abott, 2009). The concept of fertility also comprises Eric's view that it includes availability of biomass in the soil and an increase in observable biodiversity such as earthworms (Swarts, 2009a). If crops grow faster in one season after another and if more earthworms are available in the soil it can be assumed that soil fertility is increasing. As a trained organic farmer and through his experiences in India Eric is familiar with measuring soil fertility organically.

Initially, I intended to do a soil fertility test before the arrival of the oxen and then another one six months later to assess the effectiveness of oxen manure in improving soil fertility. My supervisor assisted with the arrangements for the soil test and the SI offered to pay for the service. The soil scientist who was consulted advised by email (recall his response in Section 3.6) that for various reasons, it would not be possible to do tests that would give informative and reliable results. In the absence of scientific tests of soil fertility I have had to rely on Eric's comments as well as viewpoints from literature about cow manure and my own observations about soil fertility. This means that the findings about this research objective are based on qualitative information, primarily Eric's subjective views, about how the oxen have helped soil fertility. Eric's personal feelings about his soil are thus the most valid 'measurements' for assessing the success of the oxen project. Farmers have a deep understanding of measurements of their farms which may not rely on scientific formulas but this does not mean that their knowledge is inappropriate. The findings are presented below starting with an exposition on manure preparations (namely *sanjeevak*, composting and vermiculture) to show how Eric has attempted to cater for the different needs of crops by diversifying manure preparations. This is followed by a section on Eric's opinions on the effectiveness of the manure and another on my field observations on the topic. Section 4.2 ends with some comments on self-sufficiency and seeds and some concluding remarks.

#### **4.2.1 Animal manure preparations**

Eric makes some manure preparations on the farm which he believes are quite effective and which will assist in improving soil quality and which, in turn, improve the rate of growth of crops, their health and quality. During his trip to India, Eric learnt about the animal manure preparations he is now putting into practice. The preparations are *sanjeevak*, composting and earthworm compost. The following discussions on manure preparations are given to demonstrate how different aspects of soil quality are catered for through a variety of manures. They exemplify Eric's efforts to improve soil quality in a sustainable way. Eric's ideas about the need to improve all soil components correspond with those in the literature (Lampkin, 2001). On average Eric collects 40 litres of ox urine daily and 200kgs of dung daily.

##### **4.2.1.1 *Sanjeevak***

Eric prepares *sanjeevak* from dung and urine from the oxen, mixed with molasses and allows the mixture to ferment for about two weeks. He uses 45 litres of urine which is mixed with 125 kg of dung and water plus two kilograms of molasses to make a *sanjeevak* brew which is used as a fertiliser. Eight 200-litre drums are stationed at various points in the field for this purpose. The first *sanjeevak* application was done on 19 February 2009. Application is done by hand using watering cans, the *sanjeevak* being sprayed just beside the plants so that roots can access it. Direct application to crops may damage leaves. From February 2009 up to the present, Eric has been applying *sanjeevak* to some of his crops especially lettuce, spinach and cabbage.

The crops have shown such marked improvements in growth rates and size of harvests that Eric now uses half the manure that he collects for making *sanjeevak*. Only a few selected plots are fertilised with *sanjeevak*. This has been done to draw comparisons at the time of harvesting of the total mass of plants that were given *sanjeevak* as opposed to those that had not. Comparisons also enable Eric to note any observable changes. Records are being kept of the manure applications and the results they bring about. Unfortunately the results are as yet inconclusive until a longer period of trials has been accomplished.

#### **4.2.1.2 Composting**

There is enough manure left over after making *sanjeevak* to do composting so that every week more than 200 kg of dung are added to the compost. In total, Eric adds about one tonne of manure to the compost heap every month which will add up to twelve tonnes for a year. Considering that some more organic waste goes to the worm farm and the making of *sanjeevak*, Eric is handling a considerable amount of manure (Swarts, 2009b).

The composted dung is mixed with weeds and crop residues, including some harvested crops which cannot pass quality-control tests. Eric contends that biomass that is composted alongside ox manure decomposes much faster than biomass alone as he was doing in the past. Animal wastes already have decomposing microbes and these assist in breaking down plant residues when they are mixed with waste materials (Kate, 2009). Eric is able to harvest sufficiently decomposed manure for application to his crops within six weeks of starting the composting process. Mixing animal wastes with crop residues and grasses which are used as bedding for the oxen brings variety and richness to the quality of manure. When Eric did not have oxen, it took six months before composted crop residues were decomposed enough for application to crops.

Eric closely monitors the composting processes and sometimes turns the compost over to ensure uniform and complete decomposition. Aeration control is important to allow micro-organisms to perform well. Thoroughly composted manure is essential for the elimination of pathogens so that diseases are not returned into the soil (Madge, 2003). Thorough composting also ensures that food elements are immediately available for plant use (Swarts, 2009b). On 15 March 2009, Eric had the first batch of composted ox manure ready for application. Ox manure has made it possible for Eric to apply sufficiently composted manure eight times a year compared to only twice a year previously.

#### **4.2.1.3 The worm farm**

As an organic farmer, Eric recognises the importance of promoting soil-biological processes. A rich soil ecosystem is one in which macro- and micro-organisms are actively interacting among

themselves and with the plants (Swarts, 2008). As a way of promoting a rich farm ecosystem and healthy biological processes, some of the dung and crop residues, especially those of lettuce, spinach, cabbage and carrot leaves are fed into the worm farm.

Eric considers earthworms to be important soil conditioners. This is supported by the literature. Earthworms work the soil and aid organic decomposition in various ways (Madge, 2003). The availability of ox manure seems to have created a conducive environment for the earthworms; consequently they are multiplying fast and some of them are already being transferred into the plots. Compost from the earthworm farm is considered to be the best, even better than that from compost heaps or *sanjeevak*. Eric uses most of the vermicompost to produce seedlings, a move he has made to cut operating costs and build self-sufficiency (Swarts, 2009a).

#### **4.2.2 Eric's opinions**

According to Eric, the whole question of the productivity of the farm hinges on soil fertility and quality. He has been battling to improve soil fertility for nine years and he believes that well-prepared cattle manure is the best fertiliser for an organic farm. He is grateful to the SI for sending him to India for an important learning experience which his training in conventional agriculture had not given him. He now harvests manure daily and he expects to significantly increase the rate at which soil organic carbon builds up from now on (Swarts, 2009b).

The preparation and application of different forms of manure are meant to address many needs at the same time. *Sanjeevak*, which is rich in nitrogen, sufficiently provides plant requirements for nitrogen. Soils on the farm usually lack the required amount of nitrogen, especially in winter, and this causes stunted growth and a pale yellowish colouring of plant leaves. Eric feels that this year (2009) he has been in a much better position to deal with these deficiency symptoms through the use of *sanjeevak* and it has also given rise to a rapid growth response (Swarts, 2009b). The woody substances or organic matter (from dung) in *sanjeevak* feed soil organisms which are important in making food elements available to plants. A fellow student, Richard Orendo-Smith, is doing his soil science doctoral studies on the efficacy of organic manures on Eric's farm. He has carried out laboratory tests to determine the chemical content of *sanjeevak*. Results have

showed that it is rich in nitrogen and contains other important nutrient elements such as potassium and phosphorous. It is less balanced regarding the proportion of the elements compared to those in conventional fertilisers but it is closer to ammonium nitrate in nitrogen content (Orendo-Smith, 2009).

One of Eric's reasons for applying well-composted manure is that it is a rich source of nutrients for plants. Manure restores nutrients taken up by plants during growth. Enriching compost with crop biomass and grasses from the ox kraal helps to create a balance in the nutrient content of the manure. When applied in the right amounts, compost also gives a rapid rate of plant growth. Good compost is a source of organic matter which feeds soil organisms such as earthworms, termites and beetles that are important for improving soil structure. Good compost promotes change in the number and type of organisms present in soil including essential bacteria and fungi (Swarts, 2009b). Eric's assertions agree with those reported in the literature (see section 2.4). Improved soil structure means a better water-holding capacity of soil, reduced irrigation needs and less nutrient leaching (Madge, 2003). Unlike commercially prepared fertilisers which address particular deficiencies in the soil for a growing season, Eric contends that his composted manure is building a long-term base for productivity. He expects to gradually build soil organic carbon to levels above two percent (currently they are just above one percent). This knowledge is a result of courses he has attended on organic farming and wise counsel by Dr Tarak Kate (Swarts, 2009a). Eric's views agree with those expressed in the literature about the value of animal manure (see Section 2.4).

Eric's earthworm farm produces the best manure in terms of levels of decomposition and the worms produce 'anti-bodies' that are important for organic farming (Swarts, 2009b). 'Anti bodies' is Eric's term for substances used to inoculate the soil or protect it from disease. A water solution that drips down on the inside of the containers housing the earthworms is used as a fertiliser and as a pesticide. The biodynamic philosophy from which the practice is adopted avers that the solution contains growth hormones which improve plant growth. Nothing could be found in the literature to support this idea but it appears to work for Eric. The earthworms have multiplied so prolifically that thousands of them have been transferred into plots where they work to improve soil quality. Eric feels that the phenomenal multiplication of the earthworms is

a direct response to the presence of animal manure which is a rich source of food for them. The earthworm farm has been enlarged by adding more containers. The importance of earthworms and other soil organisms in maintaining biodiversity and improving soil quality is documented in the literature (see Section 2.4).

The availability of more manure has made it possible to start and maintain a nursery and Eric believes that the seedlings it produces are better than those bought from the nursery at the SI. The best quality manure comes from the earthworm farm, and it is used on a plot for seed production. Crops that are being tried for seed production include: green pepper, two types of lettuce, egg plant, tomatoes and beans. They appear to be doing very well. Crops meant for seed production should be grown under the best possible conditions which include sufficient moisture, optimum temperatures and highly fertile soils so that the seeds have enough vigour to reproduce. In the past (before the introduction of the oxen) Eric could not produce his own vegetable seeds, primarily because he lacked the required levels of soil fertility to do so (Swarts, 2009a).

Eric has noticed a significant increase in earthworm activity and a change in soil colour, texture and smell in the plots where animal manure has been applied consistently over the years (Swarts, 2009b). He believes that soil colour and smell are major indicators of soil fertility.

#### **4.2.3 My observations**

During the research period (February to August 2009), I had the opportunity to observe and participate in the processes of collecting ox waste, composting it, preparing *sanjeevak* and applying it to crops. I also managed to observe changes in plant growth in response to manure applications and compare them to the plant growth I had observed before the introduction of the oxen.

When I learnt that Eric had decided to make three pathways through which animal waste would be prepared before applying it to the crops, I felt that it was not going to work. In my opinion the waste was insufficient for four hectares of land. Splitting the manure into three forms would weaken its effectiveness. I argued that all that was necessary was to compost all the waste and apply it as soon as it was ready. Eric was adamant that he wanted to prepare *sanjeevak*, feed the

worm farm and compost the remainder. Two weeks later the first batch of *sanjeevak* was ready and two of his workers and I applied it to lettuce plots. After one week, a significant improvement in the growth rate of crops had occurred. The response was much better than I had expected. During winter months, the lettuce crop tended to turn yellow due to too much water caused by persistent rainfall. I observed that regular *sanjeevak* applications restored a brilliant green colour to the crop. There was a remarkable difference between crops that received the *sanjeevak* fertiliser and those that did not.

After an initial testing period of two weeks, Eric appeared to have been encouraged by the spectacular response of the crops. More drums (eight compared to the initial two) of *sanjeevak* were posted all over the farm and more crops received *sanjeevak* doses. The fermentation time was also reduced from two weeks to ten days. It appeared though that the responses were not similar for all the crops, some responding better than others. Onions, leeks and carrots did not show the almost immediate responses shown by lettuce, spinach and tomatoes. Eric asserted that the year's (2009) winter crop was the best ever and he attributed it to *sanjeevak* applications. I was convinced that his leafy vegetable crop (lettuce, spinach and cabbage) was better in the winter of 2009 than the previous year's winter crop.

Before Eric had oxen on the farm, he used to buy up to ten tonnes of guano, a commercially prepared organic fertiliser applied for lettuce production during winter months. The price of all externally sourced fertilisers has been increasing rapidly. In 2009 Eric only bought three tonnes of guano and he contemplated discontinuing its use because of the positive results produced by on-farm manure. There were some plots in which a combination of guano and *sanjeevak* was applied and it appeared that the fertilisers performed very well as combinations. Perhaps, the best combination might be that of compost and *sanjeevak*. It will be worthwhile for Eric to continue experimenting with combinations to find an optimum solution. Seedlings planted with manure from the worm farm are growing well and full grown plants from the seedlings gave good quality crops.

In Section 4.1 reference was made to soil fertility being the greatest constraint to the farm's productivity and profitability. The lack of sufficient levels of fertility has made the production of



what Eric calls 'heavy feeders,' like carrots and potatoes, a difficult job. In March 2009 he grew both carrots and potatoes, the carrots doing significantly well. The potato crop was disappointing with a harvest of less than half the expected quantity being realised. The crops were fertilised with Eric's best composted animal manure and a combination of guano and *sanjeevak*. Although the harvested quantity was low, the quality of the potatoes was good and one can assume that as the soil is given more manure and improves in quality, harvests will improve. The small potato harvest probably indicates that compost and manure are soil amendments which build soil fertility slowly. It might take two or more seasons before the carbon levels of the soil become sufficient to promote potato growth.

A predicament for Eric is that the manure preparations he is making are still at an experimental and learning stage. Issues like how concentrated the *sanjeevak* should be or what should be fed to the oxen to improve manure outcomes, cannot be learnt overnight. Eric's knowledge and expertise as well as the manures he prepares will improve overtime. These issues were raised in the literature review where it was revealed that farmers could improve the benefits derived from animal manures through various methods, including feeding animals rich diets, thorough composting and ideal storage conditions (Pell, 2006). Reliance on animal manure as the sole source of soil amendments can present problems of unbalanced food elements for crops as the ratio of nitrogen to phosphates in manure is typically lower than that required by plants (Pell, 2006). Eric is aware of this and he has resolved to combine animal manure with green manures such as lupine, grass and oats. According to the literature the most promising response to animal manure by crops has been obtained when the manure is supplemented by inorganic fertilisers or used in combination with green manures (Pimm and Raven, 2003).

Eric's major advantage now that he is producing his own manure is that he can control what is fed to his oxen, so as to produce the quality of manure that suits him best. He is feeding them bean plants to get manure rich in nitrogen and mixed crop residues to give manure rich in organic matter. This is supported by findings reported in the literature (Sanchez, 2003). To control nitrogen and potash losses due to poor storage, the manure is composted daily after collection and never allowed to dry out; Eric applies it to the crops as soon as he feels it is ready

(Swarts, 2009b). Eric reports that apart from providing him with more manure than he was buying in previous years, the oxen are giving him better quality manure.

#### **4.2.4 Farm self sufficiency and seed production**

One of Eric's aims as an organic farmer is to be self-sufficient not only in terms of manure but also seeds. This is in line with sustainable agriculture ideals of limiting dependence on external inputs as much as possible (Lampkin, 2001). Reliance on external inputs exposes farmers to pricing systems that are unfavourable to them and small-scale farmers who rely on external inputs often fail to break even (Pretty *et al.*, 1995). Manure and seeds have been major items of expenditure in Eric's operations in the past. The increased fertility of the vermicompost has allowed Eric to produce his own healthy seedlings for the first time.

#### **4.2.5 Conclusion**

The above findings confirm that which was highlighted in the literature review about small-scale farmers being able to improve productivity by using animal waste as fertiliser for crops and as a soil amendment. Animal waste contains the necessary food elements for crops, it improves soil structure and feeds soil fauna, which in turn further benefit the crops. It has a cumulative effect which cannot be obtained by using externally sourced and commercially prepared fertilisers such as guano. However, effective preparation of manure before it is applied to crops is essential.

The impact on soil fertility was measured for only a short period (January to July), but the cumulative effect of continuous application of animal manure is likely to be greater because building natural fertility of the soil is a slow process. Eric now has more manure for use than before the arrival of the oxen. He contends that the major advantage is the quality of the manure rather than the quantity (Swarts, 2009b). The availability of manure has enabled him to use skills learnt in India to his advantage as he now makes *sanjeevak*, vermicompost and worm-tea. As he gains experience in making these fertilisers, they can replace externally sourced ones which currently strain his finances. Soil fertility has not yet reached Eric's desired levels, but many of

his customers compliment him on the quality of his vegetables as evidenced by their good taste (Swarts, 2009b).

Manure benefits the farm as a system that has to be maintained sustainably in the long run. It is better than commercially prepared fertilisers which are only effective for addressing particular deficiencies for short periods. Animal manure not only contains the essential food elements needed for plant growth, it is also a soil conditioner containing organic matter that feeds soil fauna to the benefit of the crops. The oxen are giving Eric a better quality fertiliser and at the same time saving the ever-increasing costs of externally sourced organic fertilisers. Eric's opinions and observations confirm that animal manure is improving the condition and quality of the soil as suggested in the literature on the effectiveness of animal manure.

Section 4.2 has discussed how ox manure improved soil fertility. The next Section 4.3 discusses cost-effectiveness.

### **4.3 HOW COST-EFFECTIVE ARE OXEN COMPARED TO A TRACTOR?**

This section investigates the second research objective which sought to establish which of the farmer's options, that is using a tractor or oxen, is more cost-effective. While buying oxen is cheaper than buying a tractor, working with oxen involves hiring labour and spending time caring for the oxen making it necessary to find out how those extra responsibilities affected Eric. The qualitative approach established that Eric is satisfied with the benefits of the oxen but it was necessary to quantify the benefits and costs of using oxen before comparing them to those of a tractor. Section 4.3 will cover how cost-effectiveness is measured, the assumptions and steps that were taken to complete the CBA, the comparison of the different scenarios' costs and benefits and an explanation of the salvage value.

### **4.3.1 Introduction**

To measure cost-effectiveness, a comparison of the costs of the project and its benefits needs to be made. This can be done by means of a cost-benefit analysis which expresses the net value of benefits as a proportion of the net value of costs of a project. A project that is implemented after careful analysis using such a tool has an improved chance of yielding the expected benefits (Gittinger, 1980). It is especially important where two alternatives exist, as in Eric's case, to show which of the two will give better returns by comparing costs with benefits for each of the two draught technologies (oxen and tractor).

Farmers use draught technologies under varying circumstances, for example, some who can afford them will buy tractors, while others who cannot afford to buy tractors will hire them. My experiences as a small-scale farmer and information gathered from literature show that many small-scale farmers do not own tractors. They hire them for use on their farms. Hence, a scenario is created in which the cost of hiring a tractor is compared to that of buying oxen. Eric's circumstances, which represent the main scenario, is unique in that his project is fully funded by the SI so it is not representative of the typical small-scale farmer. A scenario of a typical small-scale farmer was generated so that the results of its CBA could be used to make general recommendations as required by the fourth research objective (the assumptions made for this 'typical' small-scale farmer scenario are expounded later). Tables and graphs have been used to show the various components of a CBA. The CBA compares capital and operational costs for oxen to those of a tractor as well as the probable benefits over a period of ten years. A short explanation of how the cost-benefit ratio is calculated is followed by a listing of the general assumptions. Tables comparing costs and benefits are presented followed by explanations of how the values for the costs and benefits were obtained.

### **4.3.2 The cost-benefit analysis (CBA)**

This section introduces the CBA, gives the general assumptions that guide the calculation of the CBA, presents tables of costs and benefits for the various scenarios of the draught technologies and sets out the specific assumptions relating to these costs and benefits for each scenario. The

salvage value is considered separately from other costs and benefits because it is only realisable at the end of the project's life. It cannot be enjoyed during the lifetime of the project.

#### **4.3.2.1 Introduction**

There were three categories of costs considered in the calculation of the CBA: capital costs, operational and maintenance costs and production costs. Capital costs include costs of purchasing a technology plus all other costs incurred to make it ready for use. Operational and maintenance costs are those brought about by using a technology on the farm such as labour, fuel, and maintenance. Production costs are those for producing crops on the farm, for example the cost of seedlings, fertilisers and effective microorganisms. The choice of draught power affects production processes on the farm and therefore production costs. Benefits included in the scenarios are income from sales of produce and food for Eric and his workers. The values were provided by Eric and for comparison purposes it was assumed that a typical small-scale farmer farming four hectares would have the same income as Eric. Both technologies provide draught power for ploughing but the oxen have the extra benefits of aiding weeding and producing dung and urine. The value of dung is based on what Eric paid for the last batch delivered to his farm in 2008 and he also estimated the value of urine per month.

All costs are converted to their net present value which is their current year's cost adjusted for future inflation at 10 percent per annum. All benefits are also converted to their net present value. To calculate the cost-benefit ratio for the oxen, the net present value of benefits is divided by the net present value of costs. Ratios greater than 1.0 indicate profitability while those less than 1.0 indicate unprofitable investment projects (Gittinger, 1980). Tables showing the conversions of both costs and benefits into net present values are attached as appendices.

#### **4.3.2.2 General assumptions**

I made nine general assumptions to guide the calculation of the CBA. It was necessary to ascertain the values of the various technologies and processes associated with them so that a

basis for comparison could be created. The numbering of the assumptions does not imply ordering.

1. The 'typical' scenario for oxen represents a small-scale farmer whose costs are R18 000 for the purchase of four oxen and basic equipment. It was assumed that a 'typical' small-scale farmer would farm four hectares – this is not unrealistic given information obtained from the literature and is easily comparable with Eric's operation with ten hectares available to him of which he actively farms four. The farmer buys oxen from neighbouring farmers, trains the oxen and uses family labour to work them so that the only operational costs are for basic medicines for curing minor wounds or cuts or for treatment of ticks when government's dipping services become infrequent. The only capital costs incurred are for the purchase of nails, bolts and other off-farm materials necessary for building the kraal and handling facility. While it is a good idea that farmers insure their animals, from experience I know that the 'typical' small-scale farmer does not, so there are no insurance costs included in the scenario. It is assumed that the prices of the oxen and the implements are the same as those in Eric's case, while the income generated from these four hectares is the same as Eric's. (This allowed for ease of comparison and avoided the almost impossible task of trying to calculate a 'typical' income for a small-scale farmer).

2. The different projects were analysed for a period of ten years. This is considered to be the valid life cycle of a tractor and working life for oxen. Consultation with Bruce Joubert confirmed that oxen generally gain weight and condition after working for ten years after which time they can be sold for 3.5 times the price paid for them originally. A tractor could last longer, but (for ease of comparison and calculation), it was assumed that the farmer would want to sell the tractor at this juncture before repairs become too costly.

3. To determine the monetary value of projects over the ten year period, the interest is charged at ten percent (which is close to the current 2009 inflation rate in South Africa), depreciation ten percent and appreciation ten percent per annum where applicable.

4. The value of the tractor depreciates over ten years where as the value of cattle appreciates.

5. All the monetary values for costs and benefits are subject to inflationary conditions which are factored in at ten percent.

6. The capital costs for Eric's oxen are the actual costs incurred including purchase price of six oxen, the construction of handling facilities, purchase of tillage equipment, training of the oxen, conveying oxen from the stockfair, transportation and delivery of the oxen to Eric's farm, transport and accommodation for UFHATC staff, the UFH retainer for service and information and veterinary costs.

7. The capital costs for the scenario of purchasing a tractor are the purchase of a 25-kw tractor and tillage equipment. The operation and maintenance cost are repairs and maintenance and expenditure on fuel and oil. It is assumed that the small-scale farmer drives the tractor himself and so no further labour costs are added.

8. The production costs include all the operational costs involved from land preparation to harvesting and marketing.

9. There is also a subsidy from the SI for Eric.

The listed assumptions provided a basis upon which the comparison of costs and benefits was made for the four scenarios.

#### **4.3.2.3 Comparisons of scenario costs and benefits**

This section compares costs and benefits for each scenario, explains where the figures were obtained, states the assumptions made and points out the key differences in each scenario. Table 3 presents a comparison of the capital costs involved.

The cost of buying the tractor and associated cultivation implements was provided by Gail Archer, from the Agricultural Development Support Services Directorate in Durban. Capital costs for Eric's oxen were given by the SI and the 'typical' oxen scenario costs are based on costs paid for Eric's oxen and equipment. Under typical conditions a small-scale farmer farming

four hectares of land will need four oxen and not six as in Eric’s case (Kate, 2009). There are no capital costs for hiring a tractor. Capital costs for buying a tractor are almost four times higher than those for Eric’s scenario and almost 25 times higher than the ‘typical’ oxen scenario.

**Table 3: Comparisons of capital costs of oxen and tractors**

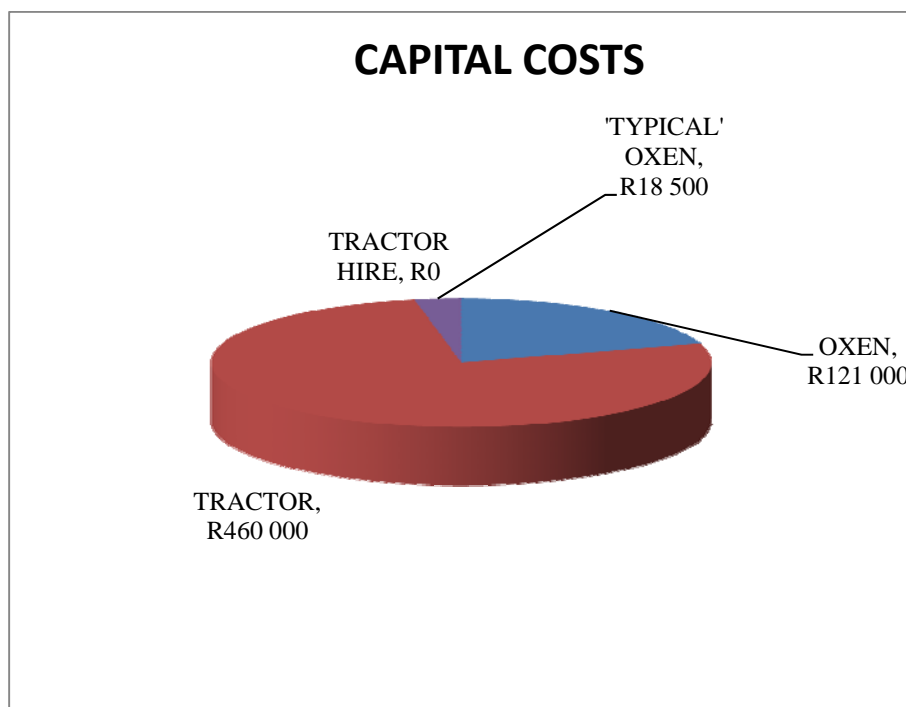
Cost category	Cost item	Amounts in ZAR			
		Eric’s oxen	‘Typical’ oxen	Buying a tractor	Hiring a tractor
Capital	Purchase of oxen or tractor	18 000	12 000	300 000	-
	Construction of handling facilities	6 000	500	-	-
	Purchase of equipment	15 000	6 000	160 000	-
	Cost of training	15 000	-	-	-
	Conveying oxen (from stock fair)	2 000	-	-	-
	Transportation and delivery of oxen to Eric’s farm	25 000	-	-	-
	Transport and accommodation for UFHATC staff	10 000	-	-	-
	UFH retainer for service and information	30 000	-	-	-
	<b>Total</b>	<b>121 000</b>	<b>18 500</b>	<b>460 000</b>	<b>-</b>

Capital costs for buying a tractor with basic ploughing equipment attracts about R460 000, hiring a tractor has no capital costs. Eric’s oxen brought R 121 000 capital costs for purchasing them, paying for training, transporting them to the farm from UFHATC and the construction of the kraal. The ‘typical’ scenario has much lower capital costs for buying four oxen and basic equipment at R18 500. It can be assumed that the ‘typical’ farmer’s family will use mainly their own materials to build a handling facility and they will most likely purchase oxen from a neighbouring farmer (if they do not breed their own).

Figure 2 presents the differences in pie-chart form.



**Figure 2: Capital Costs Associated with Oxen, Buying a Tractor or Hiring a Tractor**



If prices for tractors increase on the market, the difference will be bigger. The high initial costs such as those needed to acquire a tractor are likely to make the technology unaffordable for the average small-scale farmer. These differences are explained further in Section 4.3.5 where the four scenarios are compared.

The costs of operating and maintaining oxen and a tractor are compared in Table 4.

**Table 4: Comparison of operational and maintenance costs of oxen and tractors**

Cost category	Cost item	Amount in ZAR per year			
		Eric's oxen	'Typical' oxen	Buying tractor	Hiring tractor
Operation and maintenance	Labour costs	27 000	-	-	-
	Veterinary cost estimate	6 000	500	-	-
	Maintenance	-	500	12 000	-
	Insurance	-	-	15 000	-
	Fuel and oils	-	-	12 520	-
	Hiring	-	-	-	60 000
	<b>Total</b>	<b>33 000</b>	<b>1 000</b>	<b>39 520</b>	<b>60 000</b>

The cost for hiring a tractor is R500 per hour and is regarded as an operational cost. A tractor is hired only when needed and it works 10 hours per month on average (based on Eric's experience). Operational and maintenance costs refer to fuel, servicing and insurance. Eric's oxen have a total operational cost of R33 000. This is a high cost compared to the 'typical' oxen scenario where a much smaller cost of R1 000 is incurred but it is still cheaper than the operational costs of a bought tractor by R6 520 and by R27 000 compared to a hired tractor. The labour cost in Eric's case takes into account the fact that oxen handlers spend 60 percent of the time working with oxen and 40 percent of the time on other work on the farm. It also takes into account the fact that weeding costs have been reduced by R6 000 per annum. The tractor has no hired labour costs needed to work with it. Labour costs of R27 000 have to be met annually for three workers and the veterinary surgeon's fee of R6 000 per annum.

**Figure 3: Operational and maintenance costs for four scenarios**

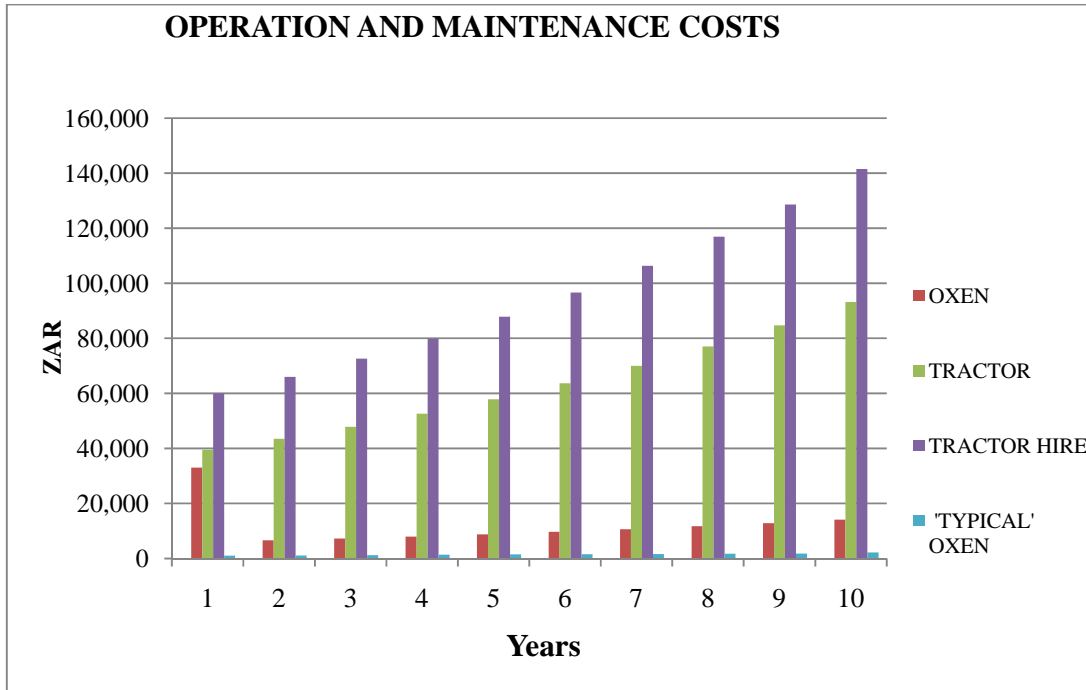


Figure three shows operational and maintenance costs for buying a tractor, hiring a tractor, Eric’s oxen and ‘typical’ oxen. Please note that the ‘typical’ oxen scenario costs are so low that they do not show up on this graph. Hiring a tractor attracts the highest costs over 10 years followed by buying a tractor while buying oxen remains the cheapest power option of the three. Eric’s salary bill will be reduced in the second year as he pays two workers only compared to four at the beginning of the project thereby significantly lowering operational costs from the second year onwards. There are much lower operational or maintenance costs for the ‘typical’ oxen scenario because the farmer trains the oxen and uses family labour to handle them. Farmers in the communal areas benefit from government’s dipping, immunisation and treatment programmes. Costs increase each year due to inflation which is estimated and factored in at ten percent per annum.

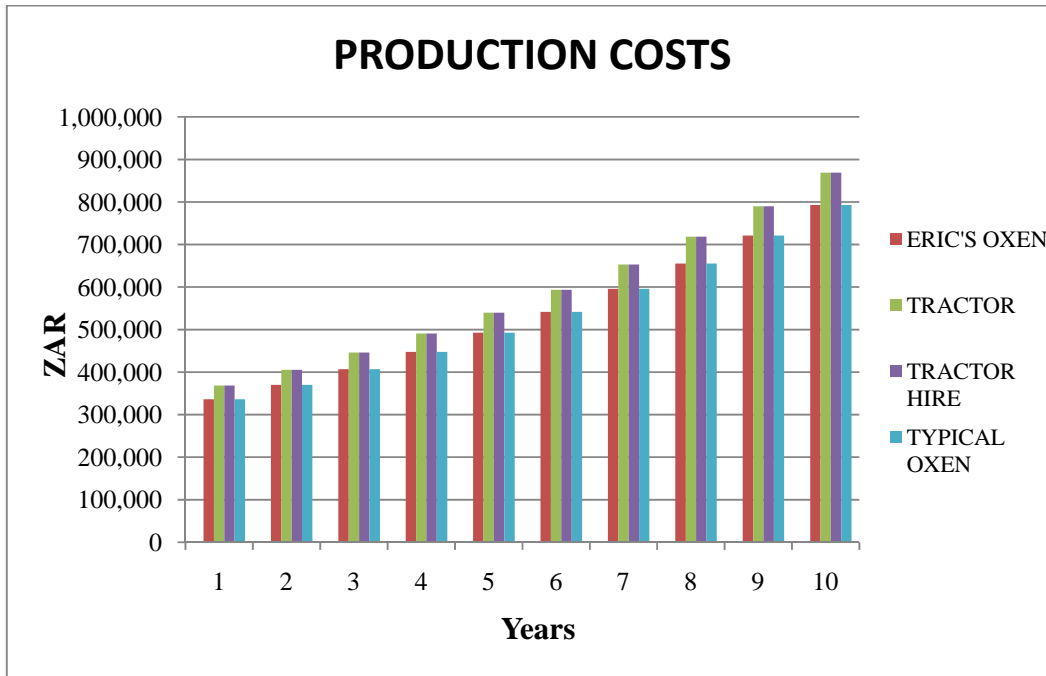
The production costs for the four scenarios are set out in Table 5.

**Table 5: Comparison of production costs**

Cost category	Cost item	Amount in ZAR per year				
		Eric's oxen	'Typical' oxen	Buying tractor	Hiring tractor	
Production	<b>Land Preparation</b>					
	Ploughing and Harrowing	33 000	-	57 600	57 600	
	Fertiliser	-	12 000	48 000	48 000	
	labour	4 800	4 800	4 800	4 800	
	<b>Seedlings &amp; Planting</b>					
	72000 plants per hectare	50 880	50 880	50 880	50 880	
	labour	70 680	70 680	70 680	70 680	
	<b>Crop Management</b>					
	Weeding 48 labour days	7 680	7 680	26 000	26 000	
	Pest and disease management	30 080	30 080	46 080	46 080	
	Effective microorganisms 2 litres per ha	160	160	160	160	
	Irrigation per annum	1 500	1 500	1 500	1 500	
	Harvesting 25 labour days	9 600	9 600	9 600	9 600	
	Packaging	24 000	24 000	24 000	24 000	
	<b>Total</b>		<b>232 380</b>	<b>211 380</b>	<b>329 700</b>	<b>329 700</b>

The costs of production were obtained from Eric and for comparison purposes it was assumed that a typical small-scale farmer farming on four hectares of land would have the same costs as Eric. Ploughing and harrowing is cheaper at R33 000 per annum for Eric than for using a tractor which costs R57 600 per annum, it is higher due to costs of fuel, depreciation and insurance while the 'typical' oxen scenario incurs no ploughing and harrowing costs because it uses family labour. Crop management costs also differ significantly. Eric and the 'typical' oxen scenario have R7 680 while the tractor scenarios have R26 000 weeding costs per annum. The use of oxen urine as an organic pesticide reduces costs for pest and disease management from R46 080 to R30 080. The total production costs are lowest for the 'typical' oxen at R211 380 and highest for the tractor scenarios at R329 700. Figure 4 displays gross production costs over a 10 year period.

**Figure 4: Comparison of production costs for four scenarios**



The costs go up every year as a result of inflation factored in at 10 percent per annum. Eric's production costs can be significantly reduced by limiting the number of oxen-handlers. A rise in fuel and service costs above inflationary increases could increase production costs for the tractor even further.

**Figure 5: Comparison of gross costs for four scenarios**

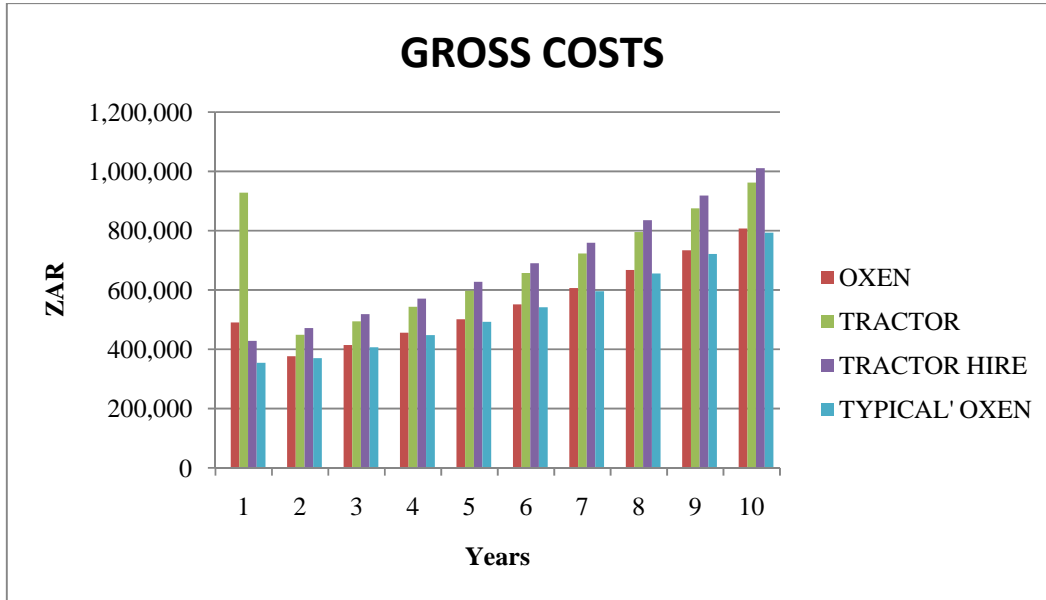


Figure 5 compares gross costs over 10 years, which includes all capital, operation and production costs. It shows the total cost for each technology. Typical oxen scenario has the lowest while buying a tractor has the highest total cost. Hiring a tractor has the second highest total cost. For the tractor, operation and maintenance costs typically increase as it ages so total costs of using it are expected to increase. The CBA did not factor that into the calculations because it would be difficult to determine how much the increase would be and in that case the costs for the tractor may be underestimated.

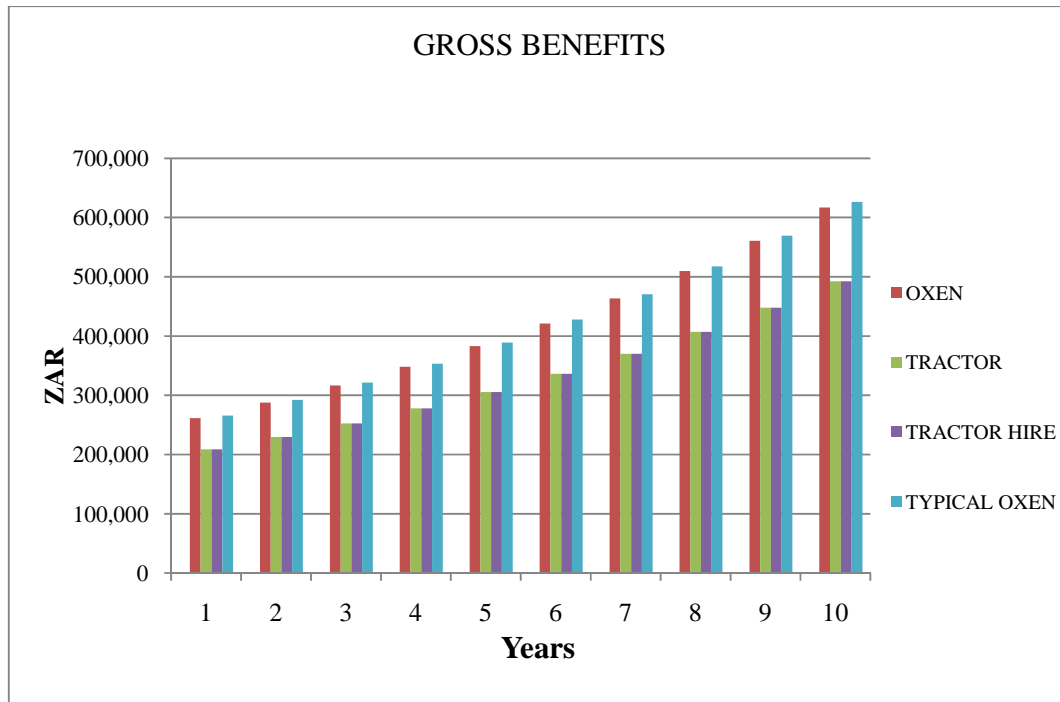
Table 6 sets out the benefits derived from using oxen and/or tractor

**Table 6: Comparison of benefits from farming**

Benefit item	Amount in ZAR per year			
	Eric's oxen	'Typical' oxen	Buying a tractor	Hiring a tractor
Sale of produce through weekly box scheme	48 000	48 000	48 000	48 000
Sale of produce at Jamestown market	96 000	96 000	96 000	96 000
Sale of produce at Sustainability Institute	19 200	19 200	19 200	19 200
Sale of produce to individual buyers	14 400	14 400	14 400	14 400
Staff and own consumption	7 200	7 200	7 200	7 200
Urine for <i>sanjeevak</i>	4 800	4 800	0	0
Cattle dung for compost and <i>sanjeevak</i>	48 000	40 000	0	0
Subsidy from Sustainability Institute	24 000	0	24 000	24 000
Hiring out of oxen	0	36 000	0	0
<b>Total</b>	<b>261 600</b>	<b>265 600</b>	<b>208 800</b>	<b>208 800</b>

Benefits of the project are derived from sales of produce to various markets plus a subsidy Eric receives. The farmer and workers consume some of the produce from the farm thereby deriving value from the project. Benefits also arise from ox dung and urine which is used as manure and from hiring out oxen for draught power to other farmers under the 'typical' small-scale farmer scenario. The major differences in benefits are that farmers who use tractors have no dung and urine benefits. While this factor increases their costs through having to acquire externally sourced fertilisers, it can also affect the quality of soil and produce and ultimately the amount of cash benefits (Fernandez-Rivera, 1995). Manure collected by a 'typical' small-scale farmer with four oxen is worth R40 000 while Eric collects more manure valued at R48 000 per annum and there are no costs for externally-sourced fertilisers. Benefits for the typical small scale farmer include hiring out the oxen to other farmers at R3000 per month and this brings in R36 000 per annum. The R3000 is an estimate provided by animal traction consultant John Sneyd. Figure 5 shows gross benefits accruing over a ten-year period for the four scenarios.

**Figure 6: Comparison of gross benefits of four scenarios**



The benefits shown on the graph go up every year as a result of inflation factored in at 10 percent. The typical oxen generate more benefits than Eric's oxen because they are hired out to other farmers bringing in approximately R36 000 per annum. Eric can increase the benefits from oxen by introducing a cart on the farm (Panin, 1989).



### 4.3.3 The cost-benefit ratio

The ratio of 1.02 indicates that Eric's oxen project will operate profitably. The project is ranked second after the 'typical' oxen scenario. With more training the oxen will become more obedient and easier to handle so they will need less workers which means less costs. The oxen can also bring more benefits by working longer than the current average of 15 hours per week. For example, they can be hired out to neighbouring farmers who need draught power and this will bring in more benefits. In light of this, it is expected that the oxen will give a more favourable cost-benefit ratio after a full year. The tractor's cost-benefit ratio of 0.58 indicates that there are more costs than benefits for the tractor and this ratio of less than one which means that the tractor would actually cause the farmer to incur losses. Buying a tractor is the worst option because it is the least profitable and thus is ranked fourth. According to the records Eric made available he has indeed been operating at a loss. Hiring a tractor has a cost-benefit ratio of 0.61 which also attests to operating at a loss and it is ranked third. The 'typical' oxen scenario where a small capital outlay is made during the first year with no operational and maintenance costs, gives the most favourable result of 1.23, this indicates that it is the most profitable option and thus it is ranked first.

**Table 7: Summary of cost-benefit ratios**

<b>Project type</b>	<b>Net present value of costs</b>	<b>Net present value of benefits</b>	<b>Cost-benefit ratio</b>	<b>Rank</b>
<b>'Typical' oxen</b>	R3 075 318	R3 786 732	1.23	1
<b>Eric's oxen</b>	R3 246 545	R3 319 858	1.02	2
<b>Tractor Hire</b>	R3 891 090	R2 371 488	0.61	3
<b>Tractor</b>	R4 112 909	R2 371 488	0.58	4

#### **4.3.4 Comparison of the cost-benefit analysis scenarios**

This section compares each scenario to the other three, identifies the differences in costs and benefits and explains why they occur.

##### **(i) Buying a tractor versus buying oxen (Eric's oxen).**

Capital costs, which are the initial costs incurred in acquiring the technology and getting it ready for use along with basic equipment needed to work on the farm, are highest for the tractor and implements (R460 000) while the cost for buying the oxen, training them and getting them to the farm are much lower (R121 000). It costs almost four times more to purchase a tractor (25kw) and its basic equipment than six oxen and basic equipment plus training. Operational and maintenance costs are much higher for the tractor than oxen as shown on Figure 3 because the tractor uses fuel, needs insurance and servicing while oxen have lower costs in Eric's case and much lower operational costs (about R1 000) under typical conditions. Figure 3 shows that in the tenth year the tractor will have operational costs of more than R1.6 million while Eric's oxen will have costs less than R200 000. This agrees with the literature which reports that oxen are up to 600 percent cheaper in their operations compared to a tractor (Starkey, 1995). The high operational and maintenance costs will have the effect of pushing up overall production costs for the tractor as shown in Figure 4. Eric's oxen scenario also incurs losses in the first year, but Eric manages to turn the loss around in the second year. Buying oxen is therefore much cheaper in terms of both capital and maintenance costs. Small-scale farmers, struggling to acquire enough inputs, will most probably find it harder to purchase expensive capital equipment such as tractors (Pretty and Hine, 2001; Jansen, 2003). In the case of Eric the SI met all the expenses towards the purchasing of oxen, their training and the equipment (Haysom, 2009).

It is well known in conventional economics, that machines become less efficient with time and therefore less economical. Human beings and draught animals generally become more efficient and effective at their work over time and therefore more economical. The CBA could not quantify or take this peculiarity into consideration but it is a distinctive difference between tractors and oxen. Eric's soil fertility is expected to improve gradually over the 10 year period as

a result of applying ox manure. It was not possible to determine how much production will increase as a result of the improvement in soil fertility so the CBA did not consider it. The benefits derived from the oxen were therefore underestimated.

**(ii) Hiring a tractor versus buying a tractor.**

The option of hiring a tractor is the cheapest one regarding capital costs as there are no costs at all. Farmers who hire tractors, or even oxen, do not incur capital costs. While buying a tractor involves a large initial capital outlay of R460 000, hiring will only need enough money to cater for the hours worked. Operational and maintenance as well as production costs are higher for buying a tractor than for hiring it as shown by figures 3 and 4. Buying a tractor will mean more costs for insurance and service while hiring does not incur such expenditure. Overall, it is better for small-scale farmers to hire tractors as it is cheaper than buying them. In both cases benefits derived from the technologies are low because no manure can be harvested and tractors can be used to weed but animals are preferable in terms of their accuracy and reducing damage to crops. Using a tractor also causes soil compaction which in some cases can significantly reduce yields. The cost-benefit analysis did not include the impacts of compaction because it could not be quantified. There can be major disadvantages from hiring a tractor typically not being able to plough, harrow, plant, weed or spray on time. Owning a tractor ensures the farmer is master of his situation and can do all his activities how and when he wants to.

**(iii) Eric's oxen versus hiring a tractor.**

Eric's oxen project invested more capital than would have been the case of hiring a tractor in the first year as shown on figure 2. The CBA shows that Eric's farm will operate at a loss for the rest of the first year because of the initial outlay but hiring a tractor results in losses for the full 10-year period. It is usually the case that animal traction is not profitable in the first year of adoption but becomes so later (Panin, 1989). Eric's oxen have earned extra benefits, for example weeding with draught animal power is more vegetation friendly than with a tractor. Manure-related benefits derived from the oxen translate to costs for a farmer who hires a tractor because a tractor cannot give manure so that it has to be sourced from outside the farm. If the price of fuel goes

up, which is quite likely, it has the effect of pushing production costs of the tractor even higher. Hiring a tractor will become less affordable and less cost-effective, especially for the small-scale farmer. Eric's oxen will realise more benefits than a hired tractor for the 10-year period earning a net present value of R3 319 858 compared to R2 371 488 for a hired tractor as shown on table 7. Figure 2 shows that the process of getting the project started was costly as it involved having the oxen trained, building a standard handling facility and hiring labour. This had the effect of raising operational costs to R336 000 as shown on figure 3, for the first year but by the second year the benefits from the oxen will enable Eric to pay off the initial costs. Operational costs for subsequent years actually become insignificant compared to the benefits.

#### **(iv) 'Typical' oxen versus Eric's oxen**

The highest value from a draught power option, as shown on the figures 2 to 5 is in the 'typical' oxen scenario where a farmer buys four oxen, and basic equipment for only R18 500. This is more than six times lower than Eric's oxen related capital outlay of R121 000. No labour is hired because the farmer trains his animals and works them on his own or with family labour. This scenario is reminiscent of my personal experiences at our small-scale family farm. The animals get used to people when they are still calves and this makes training easier when they are old enough to work. Older and experienced animals are used in training younger ones that eventually replace the older ones. Eric's scenario is second as shown on Figure 5 and Table 7 because some of his benefits had to pay for the cost of labour and training of the oxen. Eric's gross costs for the oxen will be significantly less if he reduces the number of paid handlers from the current three (2009) to two or one. If Eric were able to work with the oxen alone, he could accrue more benefits than registered by the 'typical' oxen scenario because of more manure being produced and the reality that six oxen can do more work than four. However, Eric's situation remains more beneficial than the cases of using a hired or purchased tractor.

#### **4.3.5 Salvage value**

The total worth of each agricultural project can be determined by investigating the salvage value of the project. This is the value of the assets at the end of the working life of the project (Gittinger, 1980). After working for an expected period of ten years the oxen can be sold at a price that is four times higher than their purchase price. For example, Eric's oxen were bought at R3 000 each but when they are fully grown at 12 years (having worked for 10 years) they can be sold at R8 000 to R10 000 each (Sneyd, 2009). At these prices Eric will have a total of up to R60 000 available of which he can use R20 000 to replace the six oxen and reinvest the remainder in the farm. A tractor, on the other hand loses value and if the depreciation rate is set at ten percent per annum, in 10 years it will have lost all its original value. However, if it has been well maintained and serviced it can be sold for about twenty percent of the purchase price (Archer, 2011). For example, a tractor bought for R300 000 can be sold for R90 000 if it is in good condition (Archer, 2011). While this is higher than the expected selling price of six oxen for R60 000, the oxen realised three times more at the end of their working life than the price for which they were bought. The second-hand tractor on the other hand will sell at three times less than the original price (Wium, 2009). The oxen increase in value while the tractor decreases and therefore have a positive and better salvage value than the tractor's negative salvage value.

#### **4.3.6 Conclusion**

The results of the CBA show that the oxen are more cost-effective than a tractor in Eric's case. This confirms the opinion widely raised in the literature (Section 2.5) that animal traction is a more affordable draught power option than tractors. The results also show that a farmer can gain more than just the oxen's draught power by using their waste as manure thereby minimising dependence on externally sourced fertilisers. The combined benefits of an appropriate, affordable draught power source and a reliable source of good quality manure can potentially turn a loss-making farming venture into a profitable one.

Because additional environmental and social benefits can be realised by farmers who choose to own oxen, the comparison of the two draught technologies (tractor and oxen) cannot be made

solely in monetary or quantitative terms. The oxen produce environmental and social benefits which are difficult to quantify, for example, the improvement of soil biodiversity due to the application of oxen manure, the timeliness of using oxen and the joys of relating to animals as one works with them. There is the potential for Eric to increase his clientele base as a result of the publicity he was given when the oxen arrived on the farm. All these factors can amount to significant benefits which a cost-benefit analysis cannot capture: for this reason the third research objective is investigated in the following section to determine the effects of these immeasurable elements.

#### **4.4 WHAT MANAGERIAL AND SOCIAL BENEFITS AND CHALLENGES DID THE OXEN BRING TO THE FARM?**

Section 4.4 investigates the challenges faced by Eric as a result of the introduction of oxen on his farm. Some of the challenges were social while others were managerial in nature and these are; knowledge of working with oxen, extra responsibilities and workers' attitudes. A description of benefits not covered by the previous sections is also provided.

##### **4.4.1 Challenges**

Section 4.4.1 discusses the challenges faced by Eric as a result of introducing oxen on his farm and these are; the knowledge of working with oxen, extra responsibilities and workers' attitudes. These challenges were identified through interviews with Eric and Gareth Haysom as well as my own observations.

##### **4.4.1.1 Knowledge of working with the oxen**

One of the main managerial challenges experienced by Eric was to acquire the know-how of working with oxen. The challenges of how to handle work animals were highlighted in the literature review (Section 2.5). This knowledge is not part of formal agriculture training and farmers usually acquire it through indigenous knowledge systems passed on from one generation to the next (Joubert and Kotsokoane, 1999). Eric is a formally trained farmer but he has confirmed that his training did not include draught animal technology (Swarts, 2009a). This probably accounts for the initial fears Eric had when he first tried to handle the oxen. Unfortunately, Eric could not attend the training at UFHATC in January 2009 with Piet Smit and myself. The UFHATC was developed through bringing together people with extensive experience in working with animals and having them train others (Joubert, 2009). They also rely on hired consultants like John Sneyd, yet these experts' indigenous knowledge is not recognised outside UFHATC because they have no formal qualifications.

It is not easy to find people who have the required knowledge and are willing to work with oxen. In the event that a farmer loses his current handlers he may have problems replacing them.

Working with oxen is hard work, to plough a hectare of land with a single furrow plough, oxen and men will walk about 44km (Joubert, 2010) and most people do not realise this until they start handling the oxen. Before the arrival of the two handlers from Fort Hare (Gideon and Sakumzi) we had to inspan the oxen on our own, but Eric was hesitant probably feeling that the week-long training that Piet and I underwent was inadequate. Eric was later persuaded that we could inspan and work the oxen on our own, something we managed to do twice.

There is need to develop proper work-rest cycles so that animals can work for definite periods and take rests when needed (Starkey, 1995). According to the literature each farmer just works the animals as best suited for him-or herself (Starkey, 1995). Presently, the oxen are working 2.5 hours per day on average. Eric feels that it is enough work for them but I feel that this is not enough because in my country (Zimbabwe) farmers work their animals for about six hours a day. This is the recognised maximum daily working time for oxen (Joubert, 2010). During a conversation with Gideon, one of the ox handlers from the Eastern Cape, he revealed that they work their oxen for five or more hours per day. When I was at Fort Hare in January 2009, I discovered that their younger animals work six hours a day but the older ones work half those hours. I could not find any standard in literature and this was confirmed by Joubert (2009) when we informally discussed the issue at Fort Hare. There is a distinct probability that Eric's oxen are being under-used and are therefore not giving him a maximum benefit for the investment. By acquiring a cart, he can improve the benefits and increase the cost effectiveness of the oxen around the farm: they can do more work by hauling inputs around the farm and produce to the market so increasing Eric's benefits from animal traction. The oxen could be hired out to neighbouring farmers who need draught power to earn more income for Eric.

#### **4.4.1.2 Extra responsibilities**

The oxen brought extra responsibilities to the farm. Someone has to take the oxen out of the kraal every morning, including weekends, to allow them to graze and also to fill the watering points before taking them back into the kraal later in the day. This means that the handlers have to take turns to work on weekends, as part of their employment conditions but sometimes they do



not arrive for work. Eric has to closely monitor this because if the worker on duty does not turn up then he has to do the work himself.

Eric was aware that feeding his oxen by grazing them on uncultivated patches of his 10-hectare farm might not be enough. Consequently, he approached Spier's management who agreed to help by giving the farmer an extra five hectares as pasture for the six oxen. Thus far the land has been adequate as it has for three weeks fed 70 cows belonging to Eric's neighbour for and there is still enough pasture on the farm for Eric's oxen. A neighbouring farmer, Angus MacIntosh, who also owns cattle, got in touch with Eric and they now share ideas on how best to look after their cattle.

Keeping draught animals can be challenging, especially during drought periods. Work animals need sufficient feed to maintain a healthy body and to sustain them during work. Eric was advised by Bruce Joubert to plant lupine and oats so that he could have green manures as well as reserves of fodder for the animals which he can rely upon in times of need. The constraint of insufficient animal feed was referred to in the literature review (Section 2.5.4). The kraal needs expanding so that it has sufficient space for the oxen.

#### **4.4.1.3 Workers' attitudes**

A dilemma Eric faced was that when the ox handlers came to the farm they knew that their salaries were paid by the SI and they did not feel obliged to take orders from Eric. On occasion they refused to carry out his instructions. The SI and Eric made an agreement that the ox handlers would provide labour on the farm when they were not working with the oxen. The handlers did not recognise Piet as the supervisor and this strained their working relationship. Gareth attempted to correct the situation but Sakumzi, one of the handlers from UFHATC, continued to have problems with Eric. He only worked a few hours a day with the oxen and did not want to do any other work on the farm. He was subsequently asked to leave and only three handlers remain.

Compared to a tractor, oxen have the disadvantage of needing training for sometime before they can perform best. Depending on how thorough the training is, it can take from six months to a year to fully train oxen as draught animals (Sneyd, 2009). A tractor normally needs one person to work it but oxen need at least two and in some cases three, the guide, the driver, and one handling the work implement (plough or cultivator). It took about 45 minutes for the oxen to plough 0.08 hectares of land (time recorded on 15 February 2009). It took 26 minutes for the farmer to plough the same area of land using a tractor (time recorded on 30 March 2009). The oxen showed an improvement when recordings were done in July 2009. The oxen managed to plough 0.08 hectares in 38 minutes on the 13 July and 39 minutes on the 14 July. Handling oxen can be quite challenging because oxen can be temperamental at times and can cause harm by headbutting. I knew this through my own experiences of working with them and this was confirmed when Piet Smit and I went for the handling training (Sneyd, 2009). Those who work with animals need to love them and exercise patience, knowing that training is a slow process requiring hard work that pays dividends later when the animals begin to work well with minimum supervision (Sneyd, 2009). This need for patience is especially true during the first two months of training. The following section exposes some of the benefits brought by the oxen so far.

#### **4.4.2 Benefits**

Section 4.4.2 discusses the labour, social, manure and environmental benefits of the oxen on Eric's farm. Social benefits were the provision of labour for ploughing and weeding, manure and publicity while environmental benefits were the achievement of a lower carbon footprint and promotion of biodiversity on the farm. Again these were identified through interviews with Eric and Gareth Haysom, as well as from my own observations.

##### **4.4.2.1 Labour and ploughing**

Eric reported that he realised some immediate benefits after the arrival of the oxen. Since Vuyo and Piet can work with the oxen, Eric has been released from the ploughing function. Previously he spent two days per week on the tractor but now he has more time to attend to other functions

on the farm. Cultivation by oxen is convenient because it is not only faster but also better than human effort. Cultivation by animals is better than that done by human labour because the hoe penetrates deeper to uproot weeds completely, improving soil aeration and mixing soil and organic matter added as manure more effectively (Swarts, 2009b).

The oxen and the handlers have improved their performance. It now takes just under 15 minutes to inspan the six oxen and get them ready for work. The harnessing tools, the skeys, leather riems, yokes, strops and the whips have given no problems so far. The handlers are getting used to the oxen and vice versa as shown by the oxen's obedience and quick response to commands and by the handlers' greater confidence in the way they handle and work with the oxen.

Eric was asked to name ways the oxen have impacted his operations. Primarily he has achieved timeliness in ploughing on the farm. Unlike the previous year when he was using a borrowed tractor, he now has a ready means of draught power available at all times. This means no more delays in planting and income losses.

#### **4.4.2.2 Weeding**

The oxen are becoming better and better in their performance of the various tasks they do on the farm. Ploughing and harrowing remain the major jobs but weeding by cultivation with the oxen has brought great relief to the farmer because in the past weeds have significantly decreased the harvest. Ox-performed cultivation reduced the need for more human labour, especially now that there are more than seven crops growing at the same time. During the first days of cultivation, Gideon was the only one who could skilfully handle the cultivator, but now all the workers, including the farmer, can do it well. It has saved Eric money because hiring three or four workers to deal with the extra workload for a month would cost him an extra R 6000.

In some areas of the farm ploughing with oxen proved difficult due to an overgrowth of weeds. Eric then grazed the oxen in those areas before ploughing, a ploy that worked well. Because it has become so much easier to plough the grazed fields, Eric now lets the oxen graze all plots that are due for ploughing. The prolific growth of kikuyu grass on the farm has caused a major weed

problem, however the vet who visited the farm soon after the arrival of the oxen commented that the grass is nutritious grazing for the animals. In the past it was difficult to pull up and compost kikuyu because it has tended to germinate on the compost piles instead of decomposing. Now it is useful in two ways in that it is an important fodder for the oxen and it is easily decomposed as dung.

#### **4.4.2.3 Manure**

Most of the benefits generated by Eric's oxen in the form of manure and soil fertility have been detailed in Section 4.2. The practice of grazing the oxen on the fields has the additional advantage that the urine and dung produced during the day is then deposited directly in fields where it intensifies the fertility of the soil. A neighbouring farmer, Angus MacIntosh, sent his 70 cows to graze on Eric's land for three weeks. The cows left large deposits of dung of which 32 cubic metres were collected for composting. Eric said this amounted to roughly 30 000 kg (Swarts, 2009b). A lot more was left on the ground for in situ composting. Measurement of quantities was done using the capacity of the trailer used for collecting the dung. This manure far exceeded the quantity Eric used to buy per annum (20 000 kg). Angus' cows also deposited large volumes of urine which benefited the soil directly although it could not be collected and quantified.

#### **4.4.2.4 Social benefits**

The *Farmer's Weekly*, one of the most widely read agricultural publications in South Africa, published an account of Eric Swarts and the introduction of oxen on his farm. The story described how this small-scale organic farmer had managed to live through the hard times of converting a conventional farm to an organic farm and how the oxen project was being successful in providing an appropriate means of draught power and an important source of manure. The article reported that Eric's oxen project was an impressive example of how small-scale farmers facing many obstacles can benefit from simple technological innovations.

Following the publication of the piece in the *Farmers' Weekly*, a farmer in Gauteng contacted Eric and encouraged him to keep working hard and shared his own experiences of running an

organic farm for more than 35 years. The farmer, Mr van Zyl, also offered his 200-hectare organic farm gratis to Eric upon his retirement later in 2009 if Eric promised to keep the farm organic. Eric was delighted to receive such an offer as it was recognition of the good work he is doing. It was a source of motivation to him but he did not accept the offer because he felt that he would not be able to run two farms that are so far apart.

Spier, the holders of the lease on the land that Eric is farming, have allocated him an extra five hectares of land for grazing. There is a bountiful supply of biomass on this grazing land and Eric reckons his oxen will always have enough pasture there. The land is relatively fertile too and it receives animal wastes during the day when the oxen are grazing. It may be cultivated in future.

#### **4.4.2.5 Environmental benefits**

The manure Eric produces is not only better in quality but it also has a lower carbon footprint than that acquired from suppliers which needed to be transported for more than 100 km. By feeding macro-and micro-organisms in the soil, animal manure promotes biodiversity on the farm. Since the arrival of the oxen egrets have been common on the farm and they have a mutually beneficial relationship with the oxen in that they feed on the ticks that are a pest to the oxen. This is one of the food chain elements that have emerged on the farm, others being microbial. The hooves of the oxen actually improve soil texture (Abbott, 2009). The tractor, by comparison, has no environmental benefits but instead causes environmental damage by consuming a full tank of fuel for every two hectares ploughed thereby releasing carbon dioxide. The tractor also causes soil compaction on the farm which can substantially reduce yields if it occurs for prolonged periods (Abbott, 2009).

#### **4.4.3 Concluding remarks**

Most of the challenges faced by Eric are typical of those faced by farmers adopting animal traction for the first time. Fortunately they are not serious challenges, which could prevent farmers from benefiting from animal traction. The challenges represent areas that need attention or improvement to enable the farmer to realise the best benefits that animal traction can offer.

The oxen brought important benefits including the availability of a ready means of draught power and source of manure. There was also publicity and people around the farm and those who buy from Eric were generally content with and approving of his decision to introduce oxen to the farm. This can potentially increase his customer base as well as his revenue.

#### **4.5 CONCLUSION**

The baseline farm outlined the constraints on Eric's farming business and how he hoped the oxen would assist in relieving them. Key among his expectations were the need to improve soil fertility and for the availability of an appropriate draught power. According to the findings presented above in pursuit of the research objectives, the oxen have been a cost effective and appropriate technology. They have enabled Eric to harvest and prepare good quality manure which is effectively building soil fertility and at the same time saving him money previously spent on fertilisers. There were some constraints in the form of inadequate knowledge about how animals work but these were overcome in time as Eric and the handlers became accustomed to working with oxen. The oxen added some environmental benefits to the farm by improving soil biodiversity and reducing the consumption of fossil fuel. The testimony of the oxen project has received publicity which could assist the marketing of the farm's produce. The introduction of oxen has led to economic, environmental and social benefits for Eric's farm.

## **CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS**

### **5.1 INTRODUCTION**

This chapter makes some recommendations in view of the research findings. These are made according to the fourth research objective, concerning the use of animal traction as a means of draught power by small-scale farmers particularly in developing countries. In conclusion, a summary of research findings is made and some lessons that may be drawn from the findings are suggested.

### **5.2 CONCLUSIONS**

This section summarises the main findings of the research concerning the research questions and objectives. It also draws conclusions in light of these findings.

This research set out to investigate animal traction and small-scale farming with Eric Swarts' Stellenbosch farm as a case study. An ethnographic research design and methodology was used and through instruments such as interviews and participant observation, rich qualitative data was collected and used as the basis upon which answers to the research questions were built. Constraints were encountered in the data analysis and quantitative techniques had to be used to investigate the second research objective about the cost-effectiveness of the oxen project. Assistance was sought from experts to undertake the cost-benefit analysis. The final product of the research was therefore achieved through methodological triangulation of both qualitative and quantitative techniques.

The first research objective sought to find out if the oxen helped in improving soil quality. This objective was met by using the farmer's perceptions, my own observations and applicable ideas gleaned from the literature, in support of the perceptions and observations.

According to Eric's perceptions, wastes from the oxen (dung and urine) were quite important in giving high quality manure. The manure made significant improvements in soil quality as shown

by a faster growth rate in crops, greater quantities harvested and improved quality of produce. My observations agreed with the perceptions of the farmer that there was a faster growth rate of crops and better quality harvests which suggest an improvement in soil quality. Findings recorded in the literature support the practice that animal manures are effective organic fertilisers which could be relied upon to improve the biological, physical and chemical composition of the soil (Abbott, 2009; Madge, 2003; Pell, 2006; Sanchez, 2003). Animal manure is important as a long term soil conditioner and it is a more effective fertiliser and remains in the soil much longer than commercially prepared organic fertilisers. It is therefore concluded that the oxen did assist in improving soil quality and that they will continue to do so over the long term.

The second research objective intended to determine the cost effectiveness of oxen in comparison to a tractor. According to the results of the cost-benefit analysis, Eric's oxen are more cost-effective than buying or hiring a tractor. The costs of the project were high and caused a loss in the first year of operation but the losses will be significantly reduced by the second year. The substantial benefits from the work of the oxen and production and application of manure will potentially enable Eric to turn his farming business from a loss-making venture to a profitable enterprise by the second year if he reduces labour costs. If the oxen have a working life of 10 years, they will generate enough benefits to allow Eric to possibly sell some manure. The benefits of Eric's project are probably understated considering that the soil is expected to increase productivity with time. The estimates arrived at through the cost-benefit analysis can actually be surpassed if the farmer works the oxen for more hours and as the effects of the animal manure on soil quality become more evident. The valuable manure has cushioned the farmer from the vagaries of an external market over which he has no control.

The third research objective sought to examine what kind of social and managerial changes the oxen brought to the farm. The findings showed that there were both managerial and social constraints and benefits from the oxen project. The constraints included a lack of expertise to train the oxen and to handle them. Training the oxen had to be done at the UFHATC and the project incurred extra costs to cover this training. Two workers were hired to work with the oxen but they needed the assistance and guidance of two other experienced handlers which inevitably



increased the cost of labour on the farm. Issues of workers' attitudes and working relations tended to affect progress at times but these were resolvable.

Despite some constraints, the introduction of oxen on Eric's farm created an efficient nutrient-recycling system where the mixing of ox dung with crop residues produces ready compost within six weeks. This is a remarkable improvement because in the past it took about six months before ready compost could be harvested from plant residues only. Crop residues can be used as supplementary livestock fodder if the need arises, while wastes from livestock are used as manure for crops. Interdependency is good for the farm system as it affords many advantages which can be potentially increased. Social benefits netted by the oxen, included better relationships with neighbouring farmers and increased publicity for the farm and its products.

Eric found the oxen to be more useful than the tractor in that he is able to use them to weed and to spray crops using a boom sprayer. This suggests that in the context of a small-scale farmer oxen are more versatile than a tractor and therefore more beneficial. Working with oxen appears to have motivated the farmer highly and has released energies within him that were hitherto unseen. Eric has overcome his initial apprehensions about handling oxen by learning through experience and in future he might be able to work with the oxen like other small-scale farmers who do not hire any handlers.

The final research objective called for making recommendations for small-scale farmers in developing countries concerning animal traction. As demonstrated by the 'typical' small-scale farmers' CBA scenario results, animal traction is a viable draught power option particularly for small-scale farmers. It is a considerably cheaper technology than buying or hiring a tractor. Oxen appreciate in value and farmers can sell them at a substantial profit at the end of their working life as shown by their favourable salvage value. The full picture of the oxen's impacts will only be seen after some years but the preliminary results incontrovertibly demonstrate that the introduction of oxen on Eric Swarts' farm has empowered him in many ways. Apart from providing manure and much needed draught power on the farm, the animals are an integral part of a farm as a system under sustainable production methods, hence a farm without animals is incomplete.

In light of the benefits outlined in the body of findings and in the literature, it can reliably be said that the introduction of oxen has meaningfully empowered Eric Swarts. His commitment to organic farming is demonstrated by the fact that he has been farming with limited resources for the last nine years. The availability of the oxen is assisting him to realise his full potential as a farmer in view of the advantages that they have already brought. The results of this research also demonstrate that the draught power needs of small-scale farmers will not necessarily be addressed by high technology and large amounts of capital, but by simple low-cost technologies designed to specifically meet their needs. Farmers in developing countries who want to choose between buying or hiring tractors or buying oxen as a means of draught power should be advised about the full benefits of animal traction so that they make informed choices. Animal traction networks, non-governmental organisations concerned with agriculture and the FAO have a duty to educate farmers on the economic, social and environmental benefits of adopting animal traction. The adoption of animal traction can be seen as an effective way of reducing the dependence of small-scale farmers on an oil economy. This is particularly important in light of the peak oil challenges facing all economies currently. In view of the advantages of sustainable farming systems, the need for cost effectiveness and pressing environmental considerations, farmers who introduce animal traction technologies on their farms are choosing a sustainable farming method.

## **5.3 RECOMMENDATIONS**

This section introduces the recommendations, discusses the role of animal traction associations, the role of national governments, benefits for small scale farmers and recommendations for Eric's animal traction project.

### **5.3.1 Introduction**

Based on the findings on Eric's farm, which indicated that the oxen were quite beneficial to him, and findings from literature which supported this, it is concluded that draught animal power is a technology which should be promoted among small-scale farmers in developing countries. Animal traction is not only the most affordable option but it meets sustainability needs as well.

#### **Recommendations for Eric**

The results obtained from experimentation with various manure preparations have shown positive results but the trials need to be carried out over a number of seasons for more concrete results and this is an area for further research. If the research is done over three or more years it will produce more conclusive data. Eric needs improved record keeping to ensure that data on important findings on manure use is accurate and it can inform future decisions about the use and effectiveness of manure. Eric should seek more knowledge on working with animals and caring for them and on preparation of organic manure. Experts like Dr Tarak Kate can assist in this regard.

While the results from this study cannot justify generalisations to all small-scale farmers, they give insight into the needs of small-scale farmers in light of the technologies they use. The following sections therefore make general recommendations on the role of animal traction associations, the role of national governments and benefits for small-scale farmers.

### **5.3.2 The role of animal traction associations**

Animal traction as a draught power option for small-scale farmers can benefit from more research. Research on low-cost, simple animal-drawn technologies suitable for local manufacture can assist farmers access the technology and maximise the benefits derived from their use. Animal traction associations under the leadership of ATNESA and SANAT can lobby governments for policy formulation and implementation on animal traction. This will help eliminate the negative perception of animal traction among those who should promote it and those who should benefit from it. Associations can mobilise farmers to participate in and give valuable input into such policies. Farmers' active participation should precede policy formulation and implementation and they should be involved in farm implement design to ensure that the policies and implements serve the needs of the farmers in the best possible manner.

Institutions of higher learning, especially those concerned with agricultural engineering, can play a major role in designing implements and training farmers in animal traction, alongside the animal traction associations. Schools and agricultural colleges can include animal traction in their training courses and universities can offer undergraduate and postgraduate programmes on animal traction. Animal traction associations can help schools and colleges in the production of relevant literature. Currently, the University of Zambia's TDAU and the UFHATC offer advisory and technical support to small-scale farmers willing to use animal traction as a draught power option, but their roles can be enhanced to become centres of innovation and skills transfer into communities. This can be done through farmers' workshops and short-and long-term training courses in animal traction. Their services can be replicated elsewhere. Animal traction associations should be multidisciplinary in structure because they deal with issues ranging from engineering, animal health and nutrition to economics and social and cultural values. Their structures and the thrust of their operations should include all these aspects to ensure that some important issues do not suffer at the expense of others.

### **5.3.3 The role of national governments**

Governments have an important role to play. They can come up with policies designed to promote the use of animal traction as well as fund research in institutions of higher learning. So far only the government of Uganda has a national policy on animal traction but other governments can learn from their example (Oram, 1995). Through agricultural extension services, governments can carry out and coordinate farmer training in animal traction. The government of Zimbabwe has started a programme of training rural blacksmiths whose work is to repair and maintain animal drawn implements. Such training can be turned into formal training to empower farmers interested in animal traction. Findings of this research which corroborate the literature, demonstrate that farmers need knowledge about looking after their work animals, making of the trek gear, handling and veterinary management of the animals and establishing work and rest cycles on the farm. If farmers receive training in handling and maintaining work animals, they will not need to hire labourers to work with animals thus reducing costs.

In terms of cost it is more realistic for governments to empower farmers through animal traction than tractor power. Governments can advance credit to farmers wishing to adopt animal traction as well as technical support (Mbata, 2001). Support for farmers should be consistent with empowering them and government planners should work closely with the farmers so that they understand their needs. It is the duty of national governments to link the activities and needs of small-scale farmers to the FAO. This organisation can fund the training of farmers and research into animal traction technology. The current land reform programmes instituted in South Africa and other regional countries are likely to create more draught power needs among the newly resettled farmers and supporting them through animal traction will ensure that they have an appropriate and versatile technology that will serve their needs. This recommendation concerning government's role in promoting animal traction is based on the literature study (Oram, 1995; Kaumbutho, Pearson and Simalenga, 2000; Starkey, 1995).

This research has shown that empowering small-scale farmers through animal traction can help them increase production. Most developing countries have agro-based economies and they will

benefit directly from increased agricultural production among small-scale farmers. Attempts by national governments to provide draught power through tractors have not been successful partly because farmers only accessed tractors when they were available and not when they needed them. Farmers producing under rain-fed systems suffered most because they would get tractors when the land is too dry to cultivate. Animal traction will be a solution for these farmers as an ever-present and timely draught technology. Research can assist in generating knowledge about animal manures and how farmers can get the best out of them. Eric's case has shown that even conventionally trained farmers need advice on using organic manures.

### **5.3.4 Benefits for small-scale farmers**

Small-scale farmers can realise many benefits by adopting animal traction as a means of draught power. These range from economic, social and environmental benefits as demonstrated by the findings of this research and those reported in the literature. Chief among these benefits are the:

1. the creation of diverse farms where crops and animals are interdependent;
2. the availability of a versatile and appropriate draught power technology;
3. generation of 'free' manure for soil improvement; and
4. promotion of more sustainable farming systems.

Much can still be done to improve the quality and effectiveness of these benefits.

Many small-scale farmers who struggle to maintain soil fertility can benefit from keeping work animals and then using animal waste as soil amendments. Farmers who use animals also stand to benefit from the dung and urine which can be used as manure to support crop production. Crop residues can be used as animal fodder, especially in areas where grazing is insufficient. Feeding crop residues to farm animals can be a fast way of recycling nutrients on the farm if their waste is applied back into the farm as manure. An integrated crop-animal system will have more benefits for farmers over a system where farmers produce crops or animals only. Those who are currently relying on externally sourced fertilisers can reduce their dependence on inputs whose

prices they have no control over. In those areas where farmers use digging sticks and hoe cultivation, animal traction can help farmers increase the area under cultivation where land is available, and improve the quality of weeding thereby increasing food production.

Oxen appreciate in value over their working life and when they are finally sold, farmers realise significant profits and can easily replace the sold animals by purchasing younger animals at a much cheaper price. In the case of oxen in their final year farmers do not only get benefit from their work, they can receive premium prices for the sale of these work animals. If farmers have cows among their herd, they will not need to buy oxen to replace the ageing span, because cows will give calves which will be able to work once they are 18-24 months old and in this sense animal traction becomes a renewable power option.

There are a number of environmental benefits to be enjoyed by farmers who choose animal traction over tractors. Farmers need to be educated about these benefits through government extension services and through the work of animal traction associations. The use of animal manure is beneficial to the farm ecosystem which will in turn bring more benefits to the farmer. Less reliance on the fossil fuel economy will protect farmers from hikes in oil prices and it will also make their farming more carbon neutral. Small-scale farmers who do not love to work with animals and who have no grazing space for them can resort to hiring the services of other farmers who own oxen, but then they will forfeit the benefits of manure and urine. These proposals are mainly drawn from the literature study (Altieri, 1989; Pell, 2006; Sanchez, 2003). They are also reinforced by findings of this research.

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## APPENDICES

### Appendix one: Table showing costs and benefits for Eric's oxen

PROJECT TYPE		PROJECT COSTS						PROJECT BENEFITS		
	YEAR	CAPITAL ITEM COSTS	OPERATION AND MAINTENCE COSTS	PRODUCTION COSTS	GROSS COSTS	PRESENT VALUE	NET PRESENT VALUE	TOTAL VALUE OF PRODUCTION (GROSS BENEFITS)	PRESENT VALUE	NET PRESENT VALUE
OXEN	1	121 000	33 000	287 350	490 320	445 745	<b>3 246 546</b>	261600	-262 473	<b>261 600</b>
	2		6 600	369 952	376 552	311 200		223 560	-126 440	223 560
	3		7 260	406 947	414 207	311 200		247 716	-125 087	247 716
	4		7 986	447 641	455 627	311 200		274 288	-123 857	274 288
	5		8 785	492406	501 190	311 200		303 516	-122 740	303 516
	6		9 663	541 646	551 309	311 200		335 668	-121 724	335 668
	7		10 629	595 811	606 440	311 200		371 034	-120 800	371 035
	8		11 692	655 392	667 084	311 200		409 938	-119 960	409 938
	9		12 862	720 931	733 793	311 200		452 732	-119 197	452 732
	10		14 148	793 024	807 172	311 200		499 805	-118 503	499 805
	<b>TOTAL</b>	<b>121 000</b>	<b>122 624</b>	<b>5 360 074</b>	<b>5 603 699</b>	<b>3 246 545</b>	<b>3 246 546</b>	<b>3 319 858</b>	<b>-1 360 784</b>	<b>3 319 858</b>

**Appendix two: Table showing costs and benefits for tractor**

	PROJECT COSTS					PROJECT BENEFITS				
	YEAR	CAPITAL ITEM COSTS	OPERATION AND MAINTENCE COSTS	PRODUCTION COSTS	GROSS COSTS	PRESENT VALUE	NET PRESENT VALUE	TOTAL VALUE OF PRODUCTION (GROSS BENEFITS)	PRESENT VALUE	NET PRESENT VALUE
TRACTOR	1	460 000	39 000	320 600	868 060	842 745	<b>4 172 909</b>	208 800	-707 472	208 800
	2		42 900	404 822	448 866	370 018		163 680	-234 745	163 680
	3		47 190	445 304	493 753	370 018		180 048	-234 745	180 048
	4		51 909	489 834	543 128	370 018		198 052	-234 745	198 052
	5		57 100	538 818	597 441	370 018		217 858	-234 745	217 858
	6		62 810	592 700	657 185	370 018		239 643	-234 745	239 643
	7		69 091	651 970	722 903	370 018		263 608	-234 745	263 608
	8		76 000	717 166	795 193	370 018		289 969	-234 745	289 969
	9		83 600	788 883	874 713	370 018		318 966	-234 745	318 966
	10		91 960	867 771	962 184	370 018		350 862	-234 745	350 862
	<b>TOTAL</b>	<b>460 000</b>	<b>621 559</b>	<b>5 865 291</b>	<b>6 963 425</b>	<b>4 172 909</b>	<b>4 172 909</b>	<b>2 371 489</b>	<b>-2 820 181</b>	<b>2 371 489</b>

**Appendix three: Table showing costs and benefits for tractor hire**

	PROJECT COSTS					PROJECT BENEFITS				
	YEAR	CAPITAL ITEM COSTS	OPERATION AND MAINTENANCE COSTS	PRODUCTION COSTS	GROSS COSTS	PRESENT VALUE	NET PRESENT VALUE	TOTAL VALUE OF PRODUCTION (GROSS BENEFITS)	PRESENT VALUE	NET PRESENT VALUE
TRACTOR HIRE	1		60 000	320 600	428 020	389 109	<b>3 891 090</b>	208 800	-253 836	208 800
	2		66 000	404 822	470 822	389 109		163 680	-253 836	163 680
	3		72 600	445 304	517 904	389 109		180 048	-253 836	180 048
	4		79 860	489 834	569 694	389 109		198 053	-253 836	198 052
	5		87 846	538 818	626 664	389 109		217 859	-253 836	217 858
	6		96 630	592 699	689 330	389 109		239 644	-253 836	239 643
	7		106 293	651 969	758 263	389 109		263 608	-253 836	263 608
	8		116 923	717 166	834 089	389 109		289 969	-253 836	289 969
	9		128 615	788 883	917 498	389 109		318 966	-253 836	318 966
	10		141 476	867 771	1 009 248	389 109		350 862	-253 836	350 863
	<b>TOTAL</b>		<b>956 245</b>	<b>5 865 291</b>	<b>6 821 536</b>	<b>3 891 090</b>	<b>3 891 090</b>	<b>2 371 488</b>	<b>-2 538 363</b>	<b>2 371 488</b>

**Appendix four: Table showing costs and benefits for typical oxen**

	PROJECT COSTS						PROJECT BENEFITS			
	YEAR	CAPITAL ITEM COSTS	OPERATION AND MAINTENCE COSTS	PRODUCTION COSTS	GROSS COSTS	PRESENT VALUE	NET PRESENT VALUE	TOTAL VALUE OF PRODUCTION (GROSS BENEFITS)	PRESENT VALUE	NET PRESENT VALUE
TYPICAL OXEN	1	18 500	1000	354 350	355 320	322 109	3 073 818	265 000	-106109	237600
	2			369 952	369952	305 745		261 360	-89745	261360
	3			406 947	406947	305 745		287 496	-89745	287496
	4			447 641	447641	305 745		316 246	-89745	316246
	5			492 406	492406	305 745		347 870	-89745	347870
	6			541 646	541646	305 745		382 657	-89745	382657
	7			595 811	595811	305 745		420 922	-89745	420922
	8			655 392	655393	305 745		463 015	-89745	463015
	9			720 931	720932	305 745		509 316	-89745	509317
	10			793 025	793025	305 745		560 248	-89745	560248
	<b>TOTAL</b>	<b>18 500</b>	<b>1 000</b>	<b>5 360 075</b>	<b>5 378 075</b>	<b>3 075 318</b>	<b>3 075 318</b>	<b>3 786 732</b>	<b>-913 818</b>	<b>3 786 732</b>

### **Appendix Five: Copy of interview questionnaire for Eric**

1. For how long have you been farming on this land?
2. What land holding rights do you have?
3. When and where were you trained as a farmer?
4. What are your reasons for choosing organic farming?
5. What constraints do you face in your work as an organic farmer?
6. In what way do you think the oxen will assist in your work?
7. Did you receive training as an organic farmer?
8. How much dung and urine do you harvest a day?
9. How do you prepare manure for application into the soil?
10. What are the uses of manure in the soil?
11. How do you measure effectiveness of manure?
12. What are the differences between ploughing with a tractor and ploughing with oxen?
13. What constraints have you encountered so far in working with oxen?
14. What changes in your work have resulted from the introduction of oxen?
15. What sources of income do you have and how much do you make from each of them?
16. In 10 years' time, what will be the biggest impact that the oxen would have had on your farming operations?
17. What types of manure did you use before the coming of the oxen and where did you get them?
18. Why did you decide to harvest your own manure?