An analysis of the financial implications of different tillage systems within different crop rotations in the Swartland area of the Western Cape, South Africa.

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Declaration

By submitting this thesis electronically, I declare that the entirety of the work contained therein is my own original work, that I am the authorship owner thereof (unless to the extent explicitly otherwise stated) and that I have not previously in its entirety or in part submitted it for obtaining any qualification.

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Abstract

The pressure on the world's natural resources is increased by an expanding global population. The majority of the growth is expected to take place in Africa and Asia. This creates the need for sustainable agricultural practices. To sustain food security, the limited natural resources must be utilised efficiently to optimise agricultural productivity.

Conservation agriculture (CA) is one of the most holistic sustainable agricultural practices yet. It reduces environmental degradation, and concurrently it could enhance farm profitability. The practice of CA is able to improve food security while sustaining the environment for the benefit of future generations of both consumers and producers. A large proportion of the commercial grain producers in the Western Cape have adopted CA to varying degrees. A purer form of CA practice is continually pursued to realise its full benefits. Adoption has taken place in the absence of any policy support framework directed to CA, and thus, has been market driven. The reasons for and rates of CA adoption in other regions of the world differed, but was mostly successful, which highlights the driving forces behind adoption of CA in the Middle Swartland.

The physical/biological benefits of CA are well known. The financial implications of the various systems within CA, at farm-level are still unknown. This study implements trial data from Langgewens experimental farm to evaluate the financial implications of various farming systems over an extended period.

Farm systems are complex, consisting of numerous interrelated components. A whole-farm budget model is developed within a systems approach to compare various farming systems designed within CA principles. A trustworthy whole-farm model providing an accurate representation of a real life farm requires insight across many scientific disciplines. Multi-disciplinary group discussions are used to bridge the gap between scientific knowledge. To serve as a basis for comparison, the whole-farm model was based on a typical farm within the Middle Swartland relative homogeneous farming area. Trial data on crop rotations and tillage systems from Langgewens experimental farm served as starting point for the research. The data was fitted for use in financial analysis and as input to the typical farm model. A key role of the inter-disciplinary expert group was to ensure that data and the model design accurately reflect the underlying physical/biological processes of CA.

The financial evaluation of the various farming systems showed that conventional agricultural practices of monoculture and deep tillage are financially unsustainable. Farming systems under conventional tillage returned negative net present values (NPV) and an internal rate of return on capital investment (IRR) lower than the real interest rate. This implies that investment in conventional tillage will ultimately lead to financial losses. The

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financial benefits of CA are directly related to improved soil health, lower weed and pest stress and improved yields. The CA farming systems were less susceptible to variations in external factors, highlighting the resilience of the system that incorporates crop rotation and no-till. The farming systems operated under conventional practices are expected to be unsustainable over a long-term period of 20 years.

Opsomming

Die druk op die aarde se natuurlike hulpbronne word verhoog deur ŉ groeiende wêreld populasie. Die meeste van die groei word verwag in Afrika en Asië. Dit skep die nodigheid vir volhoubare landboupraktyke. Om voedselsekerheid te volhou moet die beperkte natuurlike hulpbronne doeltreffend benut word om landbouproduksie te optimeer.

Bewaringslandbou is die mees holistiese volhoubare landboupraktyk tot op hede. Dit verminder omgewingsdegradasie terwyl boerderywinsgewendheid kan verbeter. Die praktyk van bewaringslandbou is in staat om voedselsekuriteit te verbeter terwyl die omgewing onderhou word tot voordeel van toekomstige generasies van beide produsente en verbruikers. ŉ Groot gedeelte van kommersiële graanprodusente in die Wes-Kaap het bewaringslandbou teen verskillende intensiteit aangeneem. ŉ Suiwer vorm van bewaringslandbou word deurlopend nagejaag om die volle voordeel daarvan te benut. Die aanneming van bewaringsboerdery het sonder regeringsbeleid plaasgevind en was dus markgedrewe. Bewaringsboerdery is in ander wêrelddele vir verskillende redes aangeneem, maar was meestal suksesvol. Dit beklemtoon die beweegrede vir die aanneming van bewaringslandbou in die Middel Swartland.

Die fisies/biologiese voordele van bewaringslandbou is wel bekend. Die finansiële implikasies van verskillende stelsels binne bewaringslandbou op plaasvlak is nog nie bekend nie. Hierdie studie gebruik proefdata van Langgewensproefplaas om die finansiële implikasies van verskillende boerderystelsels oor die langtermyn te evalueer.

Boerderystelsels is kompleks en bestaan uit interafhanklike komponente. ŉ Geheelplaas begrotingsmodel is binne ŉ stelselsraamwerk ontwikkel om verskillende stelsels wat binne bewaringslandboubeginsels ontwerp is, te evalueer. ŉ Geloofwaardige geheelplaasmodel wat ŉ akkurate weerspieëling van realiteit verskaf benodig insig van verskeie wetenskaplike dissiplines. Multidissiplinêre groepbesprekings is gebruik om die gaping tussen die verskillende dissiplines te oorbrug. Die basis vir vergelyking wat gebruik is, is ŉ tipiese plaas in die relatief homogene boerderygebied van die Middel Swartland. Proefdata van verskillende gewasrotasie- en bewerkingstelsels is as die vertrekpunt vir die studie gebruik. Die data is pasgemaak vir finansiële ontledings en om te dien as inset vir die geheelplaasmodelle. ŉ Kern rol van die interdissiplinêre ekspert groep was om te verseker dat die data en die model-ontwerp die onderliggende beginsels van bewaringslandbou reflekteer.

Die finansiële evaluasie van die verskillende boerderystelsels wys dat konvensionele landboupraktyke met monokultuur en diepbewerking nie finansieel volhoubaar is nie. Boerdery stelsels onder konvensionele bewerking genereer ŉ negatiewe netto huidige waarde en ŉ opbrengs op kapitaal investering wat laer as die inflasie vlak is. Dit beteken dat

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investering in konvensionele uiteindelik tot finansiële verlies kan lei. Die finansiële voordele van bewaringslandbou is direk geassosieer met verbeterde grondgesondheid, laer onkruid en plaag-druk en beter opbrengste. Die bewaringslandbou boerderystelsels is ook minder blootgestel aan veranderinge in eksterne faktore wat die gehardheid van die stelsels wat gewas-wisselbou en geenbewerking inkorporeer, beklemtoon. Die boerderystelsel onder konvensionele praktyke sal na verwagting nie volhoubaar wees oor ’n langer periode van 20 jaar nie.

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List of Abbreviations

CA: Conservation Agriculture

CT: Conventional tillage

No-till or NT: No tillage

SSA: Sub-Saharan Africa

USA: United States of America

EU: European Union

USDA: United States Department of Agriculture

UN: United Nations

FAO: Food and Agriculture Organisation

CAP: Common Agricultural Policy

WWWW: Wheat, wheat, wheat, wheat crop rotation system

WCWL: Wheat, canola, wheat, lupin crop rotation system

WMWM: Wheat, medic, wheat, medic crop rotation system

CWWW: Canola, wheat, wheat, wheat crop rotation system

IRR: Internal rate of return on capital investment

NPV: Net present value

CAWC: Conservation Agriculture Western Cape

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Chapter 1: Introduction

1.1 Background

Earth has limited natural resources in the form of land, water, and air. Never before in recorded history has the demand on these resources been so great or the resources so fully utilised.

The global population has doubled over the last 40 years from 3 billion to more than 6 billion people, and is projected to exceed 9 billion by the year 2050. In order to provide sufficient food for this population, it is estimated that current food production must increase by 70 percent over the next 35 years (Bruinsma, 2003). Gardiner and Miller, (2007), estimate that 10 to 20 percent additional new land can be put under cultivation by 2050. At current rates of consumption the Earth's reserves of 'blue water' will be exhausted by 2025 (Vink et al, 2011 and Ragab & Prudhomme, 2002). Agriculture is also responsible for 30 percent of total greenhouse gas emissions and is directly affected by climate change (IPCC, 2007). These factors endanger our continued existence on Earth, therefore, impetus should be on how to utilise the available natural resources in the most sustainable and efficient manner possible.

The green revolution, where fertilisers, herbicides, crop chemicals, improved seed materials, and scientific expertise was combined, brought some developing nations out of poverty and aided in establishing food security. Although this was in part successful, agricultural intensification in both developing and developed nations has been marred by negative effects to the natural resources of soil, water, and biodiversity resulting in declining crop yields and quality (Derpsch & Friedrich, 2010).

Current projections estimate 95 to 97 percent of population growth to occur in developing nations, primarily Asia and Africa. Increased food production in these regions is thus paramount. The predicament is complicated in the light of increasing urbanisation and industrialisation, which competes with agriculture for the diminishing resources of land and fresh water. The concentration of activities that characterises commercial agriculture tends to deplete soil fertility, water quality and increase the adverse effects of climate change (Derpsch & Friedrich, 2010). Agriculture must consequently focus on intensifying and optimising crop production to cater for the expanding demand. Focus should be on sustained production through responsible use of the limited natural resources available.

While sustainable forms of agriculture are designed to maintain the natural resource base, the livelihood of the producer should not be overlooked. The producer (farmer), can be defined as the human element at the centre of food production, and forms an interdependent relationship with the natural resources to generate the capacity for food production. Food security depends

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on sustained and responsible production by farmers, with population growth and continued urbanisation. Production methods based on best practice must be appreciated and maintained by the market to ensure sustainable use of natural resources for present and future generations.

Conservation agriculture (CA) is promoted as the most holistic practice of sustainable agriculture and has experienced high adoption rates across the globe since the mid 1990's (Derpsch & Friedrich, 2010). Conservation agriculture rests on three guiding principles; continuous minimum soil disturbance, permanent organic soil cover, and diversified crop rotations (FAO, 2013). The practice of CA promotes sustainable management of natural resources while increasing agricultural productivity and sustaining the farmer's livelihood, resulting in poverty alleviation and food security (Friedrich & Kienzle, 2007). Conservation agriculture, however, is not a set recipe to sustainable production. Every farm has a unique set of ecological characteristics. The guiding principles of CA provide a foundation from which the producer can build according to their unique environment.

Two key drivers steered South African farming practices towards CA. Firstly, following the deregulation of marketing and the consequential abolishment of the different commodity control boards, farmers were forced to find ways to reduce input costs and remain viable (Vink et al, 2011). Secondly, the prevalence of herbicide resistant ryegrass compelled farmers to adopt crop rotations so they could use grass herbicides in the broad leaf cropping phase. No-till planting equipment enabled farmers to spray one effective herbicide, Trifluralin, to combat ryegrass weeds (Strauss, personal communication, 2014).

South Africa has a broad range of ecological and climatic regions, from Mediterranean, to subtropical, to semi-desert. Conservation agriculture has been successfully adopted to varying degrees throughout South Africa. The Western Cape, a typical Mediterranean climate region is for winter cereal production. The Swartland area forms one of the main wheat producing areas of the Western Cape. Known for particularly dry and harsh summers, the adoption rate of CA in the Swartland since the new millennium has been relatively high.

Technical data on trial plots dedicated to CA has been collected from 2002 to 2013 at Langgewens experimental farm (Strauss, 2013 and Labuschagne, 2013). The trials consist of four tillage practices; Zero-till (ZT), No-till (NT), Minimum–till (MT), and Conventional-till (CT), across three crop sequences (rotations); wheat monoculture (WWWW), wheat-canola-wheat-lupin (WCWL), and wheat-medic-wheat-medic (WMWM) (Labuschagne, 2013). All crop sequences are subjected to the same production activities. The trials have been analysed for the purposes of plant and soil properties, the financial implications of the various systems, especially at farm level is still unknown. (What are the financial implications of adopting CA as a farming approach in the Middle Swartland area, Western Cape?)

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1.2 Problem Statement and research question

Conservation agriculture has been adopted at varying degrees around the world. Why have some countries adopted CA with greater success than others? What are the reasons for and rate of adoption of CA in other parts of the world? In some instances CA may be promoted through policy intervention. However, are there sufficient financial benefits from CA and market pressure to motivate producers to shift agricultural practices of their own accord? Thus, the question is what are the financial benefits of CA?

There is a lack of knowledge on the financial costs and benefits of adopting CA as a practice over the long-term in the Middle Swartland area. Many farmers appreciate the ecological and economic value of adopting crop rotations. However, the on-farm financial benefits of adopting a CA specific tillage practice are not as well known or thought to be as pronounced. What are the fundamental reasons for adopting CA? What are the financial implications of adopting CA? What are the implications on whole-farm level, over an extended period of time, and can the farm business afford to invest in costly CA specific machinery? Are the additional earnings derived from adopting a CA specific tillage practice (No-till), sufficient to validate the capital outlay for the required machinery?

1.3. Objectives of this study

The previous paragraph highlighted the need to progress from current agricultural practices to a more sustainable and productive system by optimising the use of natural resources such as soil and water.

The main objective of this study is to assess the financial implications of adopting a CA farming approach on a grain production farm in the Middle Swartland.

The specific goals of the research are to:

- Establish the context of CA in terms of its origins and progression globally and in the Middle Swartland of the Western Cape area.
- Financially assess existing trial data to compare the different tillage and rotation systems earmarked for use in the Middle Swartland.
- To illustrate the expected whole-farm financial implications of CA in the Middle Swartland area of the Western Cape.

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1.4. Methodology of the study

In order to fully understand the origins and progression of CA within the Western Cape, an overview of the literature will be conducted, tracing the history and implications of conservation agriculture worldwide, placing its adoption in South Africa within a global context. The literature review will be undertaken in conjunction with group discussions with the pioneering and continued conservation agriculturalists within the region.

To develop a clear understanding of the financial implications of adopting CA by evaluating the financial and technical results of on-going CA trials in the Middle Swartland area. Using the data from the past twelve years of differing tillage practices and crop rotations from the Langgewens experimental farm, this study intends to evaluate the costs of the eight possible alternatives using a typical farm model to interpret the most profitable approach.

Using financial and economic indicators, the research will seek out the best-fit scenario for the Middle Swartland area.

1.5. Outline of this study

The study begins with an overview of sustainable agriculture focusing on CA as the most holistic sustainable practice to date. Having defined CA, the historical development and progression of the practice, as well as the benefits and challenges associated with CA will be established.

Chapter 3 focuses on the complexity of agricultural systems and the decision making environment. The systems thinking approach is established as a method to evaluate the whole-farm implications of CA. Systems thinking is discussed, incorporating the multi-disciplinary discussion technique used to promote creative thinking and validate data from multiple disciplines. The concept of model simulation is outlined with particular focus of budget modelling, the method of evaluation in this study. Chapter 4 elaborates on the findings from the analysis on trial data from Langgewens experimental farm. Combining this data with expert opinions during group discussions, the dynamics of the whole-farm model is laid out.

A description of the characteristics and parameters of the whole-farm model developed form the first part of Chapter 5. The results of scenarios run through the model form the second. Chapter 6 contains the conclusions of the study, summary, and ends with some recommendations.

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Chapter 2: Overview of conservation Agriculture

2.1 Introduction

Conservation agriculture (CA) has its origin in no-tillage and conservation tillage. Initially it was in response to the Mid-West dust Bowl in the USA in the 1930's. Conservation tillage gained momentum as other regions of the world experienced similar degradation of natural resources. The combined factors of; growing consumer concerns of environmental degradation, the development of pre- and post-emergent herbicides, heavy mechanisation, and the price-cost squeeze, drove farmers to adopt economically and environmentally sustainable practices. By this time the practice had evolved to encompass a more holistic approach to sustainable farming, focusing not only on conservation tillage but also incorporating the practices of crop rotations, and the use of cover crops and straw mulch. The Food and Agriculture Organisation of the United Nations (FAO) and the European Conservation Agriculture Federation (ECAF) started to promote the practice under the label of conservation agriculture (Knowler & Bradshaw, 2007).

Today, CA has expanded to address not only soil erosion, but also to improve soil moisture retention. This is particularly important to dry land farming (Friedrich & Kienzle, 2007). As water is an essential resource to agricultural production, the optimal use of this resource is important, especially seeing that at current rates consumption will outstrip reserves of 'blue water' by 2025 (Vink et al., 2011 and Ragab & Prudhomme, 2002).

Global agricultural markets are becoming increasingly competitive and consumer driven. Producer prices are kept low with high levels of competition on the world market. The consumer is more discerning, emphasizing their desire for ethical and environmental standards on agricultural resource management to protect the rural environment.

There are two interconnected aspects driving CA. The first being the ecological and biological benefits from the improved soil fertility, moisture retention, and reduction in erosion. Live crop cover or dead mulch provides food for soil biota, which acts as biological tillage replacing the need for conventional tillage (Knowler & Bradshaw, 2007). These benefits grow annually, providing the farmer with long-term sustainability. The second aspect is the financial benefits of reduced input costs and reduced exposure to production risk. As the soil structure and fertility increases, the requirements for certain inputs, such as fertilisers, decline. Improved moisture retention of the soil reduces risk associated with climate change, and a diversified cropping system spreads the risk across the various enterprises.

Essentially, CA is a sustainable practice promoting optimised yields and profit margins while simultaneously offering environmental benefits to both the farmer and society. As CA incorporates best practice management across a variety of system components, it forms a knowledge-intensive practice (Kassam et al., 2009). In some instances the net social benefits outweigh the individual farmer benefits, such as reduced river and dam sedimentation resulting in improved downstream fishing and reduced dredging costs (Knowler & Bradshaw, 2007).

For both economic and environmental reasons, agriculture is seeing a shift both in developed and developing countries from conventional agriculture to CA (Dumanski et al., 2006). There is a renewed understanding of mankind's symbiotic relationship with the environment, with greater emphasis being placed on efficient use of natural resources, reducing environmental pollution and greenhouse gas emissions through limited use of external inputs and fossil fuels (Vink et al., 2011).

Conservation agriculture is a knowledge-intensive practice operating within the high risk business of agriculture, with unpredictable weather and varying ecological regions. There is need and scope for research to fully understand and disseminate the technical and financial implications of the process involved in adopting the novel system. Conservation agriculture is a long-term commitment, not a quick fix; it requires a change in the mind-set and the perseverance to push through the learning curve to enjoy the economic, ecological and biological benefits.

Since the 1990's, CA has expanded rapidly through much of the North America, Australia and New Zealand, and most dramatically South America. Currently over 116 million hectares are under conservation tillage practices (Derpsch & Friedrich, 2010).

2.2 The origins of sustainability and sustainable agriculture

The term 'sustainable' first appeared on the international scene in 1987 as the Brundtland Commission defined Sustainable development as "…development that meets the needs of present generations without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development (WCED), 1987). Later the definition was enhanced for the United Nations Conference on Environment and Development at the Earth Summit, Rio de Janeiro. Today that definition forms the guiding principles for sustainable development, defined as:

> *…the management and conservation of the natural base, and the orientation of technological and institutional change in such a manner as to ensure the attainment and continued satisfaction of human needs for present and future generations. Such sustainable development (in agriculture, forestry and fisheries sectors) conserves land, water, plant and animal genetic resources, is environmentally non-degrading, technically appropriate, economically viable and socially acceptable* (FAO, 1989).

Sustainable development is based on concerns for intergenerational equity. Therefore, agriculture and the productive capacity of the natural resources used therein form an integral

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part of the concept. According to John Ikerd, as quoted by Duesterhaus (1990), in terms of agricultural production, sustainable implies the use of farming systems that are "capable of maintaining their productivity and usefulness to society indefinitely. Such systems… must be resource-conserving, socially supportive, commercially competitive, and environmentally sound".

The concept of sustainability is not new and was pioneered by the likes of Aldo Leopold, Lady Eve Belfour, and Edward Faulkner in "Ploughman's Folly", 1943. The concern over sustainability was based on issues of food insecurity, environmental degradation, and food safety. The post-World War II era, along with expanding populations, saw the development of industrialised agriculture or conventional farming, resulting in increased food production and subsequent over supply. This primarily took place in the Western World as the less developed nations continued to experience famine and poverty. International organisations, such as the Word Bank, IMF, WHO, were established to try to provide worldwide food security and alleviate poverty. The 1960-70's saw the green revolution achieve food security for a number of developing nations through the aid of pesticides, herbicides and high yielding hybrid seeds. At the same time developed nations continued to industrialise agriculture with the extensive use of agrochemicals, high yielding hybrid seeds, continuous cropping, and mechanisation. This led to high labour efficiency and large-scale farms benefiting from economies of size.

By the late 1980's the adverse effects of over cropping, excessive continuous soil tillage and pollution of water sources from agrochemicals became increasingly apparent. This, combined with a growing consumer voice, brought the concerns for the environment to a head. Scientists warned of health concerns from pesticide residues on food products, and irreversible soil degradation. The paradoxical oversupply of food in the developed nations and famine in the developing world led the United Nations (UN) to usher in a new era of sustainability at the Earth Summit, in 1992.

In line with the UN and FAO definitions, the United States Congress' "Farm Bill" (1990), defines sustainable agriculture as:

…an integrated system of plant and animal production practices having a site-specific application that will, over the long term:

- *Satisfy human food and fibre needs;*
- *Enhance environmental quality and the natural resource base upon which the agricultural economy depends;*
- *Make the most efficient use of non-renewable resources and on-farm resources and integrate, where appropriate, natural biological cycles and control;*
- *Sustain the economic viability of farm operations; and*
- *Enhance the quality of life for farmers and society as a whole (Gold, 2009).*

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Sustainable agriculture could involve two approaches: the first considers a closed farming system. Agriculture should sustain itself over a long period of time by conserving and optimising the use of productive resources such as; fertile soil and ground water. It should also develop renewable energies and farming systems to mitigate climate change. The second approach considers the sustainability of large areas and social communities by incorporating the goals of rural and urban areas. Agriculture would assist urban goals by recycling urban sewage, developing rural employment, and maintaining a rural landscape for urban people (Lichtfouse et al., 2009).

With this in mind, the concept of sustainable agriculture is primarily concerned with four main principles:

- Worldwide food security
- Environmental degradation
- Conservation and optimal use of natural resources
- Economic viability and the maintenance of farmer livelihoods

The relative vagueness of the concept of sustainable agriculture (Lichtfouse et al., 2009) is referred to as a ‘strength’, as it leaves the subject open for scientists to think creatively about it. This is critical considering that over 80 percent of the required growth in agricultural production until 2050 needs to come from yield improvements on currently cultivated soils (FAO, 2010).

Conservation agriculture forms the base for sustainable intensification of agricultural production. The guiding principles of sustainable agriculture are incorporated into CA by:

- Promising to enhance biodiversity and natural biological processes within the soil
- Reduce environmental degradation
- While at the same time maintain the economic livelihood of farmers through reduced costs of external inputs and increased yields (FAO, 2013).

2.3. The concept of Conservation Agriculture

Conservation agriculture is not a single specific technology, rather it is a concept developed to encompass a number of technologies directed to improved land husbandry in a sustainable manner. These embodied technologies have undergone continued development and have been enhanced through research and development. The concept originated from the practice of no-till followed by, Conservation tillage. These concepts are still practiced, however, over time the systems have evolved to encompass a more holistic approach, incorporating crop rotations and the specific importance of residue cover. For the purposes of this study, the main concepts involved in sustainable agricultural production will be defined and clarified.

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2.3.1. No-Tillage

No-tillage has been practiced since the dawn of agriculture by ancient cultures such as the Egyptians and the Inca's. This is simply because of the lack of sufficient physical strength to till large areas of land by hand. These ancient civilisations used a stick to make a hole in the ground to place seed below the soil surface in untilled land. In more modern times, the practice of no-tillage gained momentum with the advent of herbicides to control the plague of weed infestations.

Today's No-tillage, synonymous with direct-drilling, direct-seeding, and disc-drilling, is defined as "…the sowing of seeds into soil that has not been previously tilled in any way to form a 'seedbed" (Baker et al., 2007). No-till consists of no soil tillage other than the disturbance to the soil caused by the specific planting technique. Initially no-till planters used a tine to open the soil where the seed would be placed below the surface. Modern no-till equipment uses discs in place of tines, to further reduce soil disturbance.

2.3.2. Conservation Tillage

Conservation tillage is concerned with minimising disturbance of the soil and maintaining a residual cover of the soil, usually from previous crops. Conservation tillage can be defines as follows:

> *… the collective umbrella term commonly given to no-till, direct-drilling, minimum-tillage and /or ridge-tillage, to denote that the specific practice has a conservation goal of some nature. Usually, the retention of 0-30% surface cover by residues characterises the lower limit of classification for conservation-tillage, but other conservation objectives for the practice include conservation of time, fuel, earthworms, soil structure and nutrients. Thus residue levels alone do not adequately describe all conservation tillage practices (Baker et al., 2007).*

The FAO defines conservation tillage as a practice that reduces soil erosion and enhances water infiltration. The practice essentially focuses on three tillage practices; No-tillage, Ridge-tillage, and Mulch-tillage that contribute to soil fertility.

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2.3.3. Conservation Agriculture

Conservation agriculture is an amalgamation of various sustainable agricultural practices. It forms the foundation of a paradoxical shift in a farmers mind set. CA promotes the benefits of physical and biological structure of soil, obtained through three guiding principles, rather than seeing the soil as simply a medium in which plants grow.

- *Continuous minimum mechanical soil disturbance.*
- *Permanent organic soil cover.*
- *Diversification of cover crop species grown in sequence and/or associations* (FAO, 2013).

Confusion exists surrounding the different tillage practices that result in inconsistencies in academic research on CA (Derpsch et al., 2013). In some instances mulch tillage, reduced tillage, and minimum tillage are incorporated into CA experiments. This often renders inconsistent and sometimes contradictory research results. The variation in the definition of CA (Derpsch et al., 2013), necessitates need for a well-defined tillage practice for CA to reduce future confusion in research. For the purposes of this study, the definition of CA will encompass both zero tillage and no-tillage. Tillage practices that disturb the soil such definitions as in 2.3.1 and 2.3.2 (minimum till and conventional tillage) will be deemed outside the definition of CA.

The adoption of novel technology is mostly for economic gains. With production cost savings and increased yields gained from successful CA practice, the line between conventional and conservation agriculture seems to blur. The main difference between the conventional and conservation farmer is in the mind-set. The conventional farmer would increase tillage if economically possible, while the conservation farmer questions the need for tillage at all (FAO, 2001).

Terms such as conservation tillage, no-tillage, zero-tillage, direct sowing, and resource conserving technologies all form sub types of CA systems. There is growing evidence of large-scale adoption of CA systems worldwide whatever the specific terms (Derpsch, 2005). The type of actual CA practices used in diverse agro-ecological and socio-economic environments is highly variable, and frequently departs from simultaneous and rigorous local application of the three generic CA principles (Harrington & Erenstein, 2005).

Only in limited areas, such as Southern Brazil (Bolliger et al., 2006) and other areas in South America (Scopel et al., 2004) are all three principles applied simultaneously. Concern was raised over the consistency of scientific data and therefore the need arose for common standards in tillage systems experiments (Derpsch et al, 2013).

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2.4. The benefits of Conservation Agriculture

From a technical point of view, CA has a number of proven environmental and economic benefits. Each will be discussed briefly.

2.4.1. Reduced erosion and environmental degradation

Soil erosion and environmental degradation occur through the impact of raindrops on bear soil surface as well as when rainfall fails to infiltrate into the soil, but instead flows over the soil surface (Benites, 2008). By minimising soil disturbance and maintaining a permanent cover on the soil, the effects of rain drop impact and crusting or compaction of the soil surface is removed. The erosive effects of wind are equally detrimental to topsoil left dry and bare on the surface. Cover crops form a protective blanket over the surface to secure topsoil in place.

2.4.2. Improved soil structure and biology

The traditional concept of soil fertility refers to the quantity and concentration of nutrients available in the soil. The modern concept emphasises maximised access of plant roots to soil nutrients and focuses on interactions occurring in the soil-water-plant system (Benites, 2008). The practice of CA increases the amount of organic matter in the soil through crop rotation and cover crops. Soil aggregate stability is further improved as plant matter decomposes naturally in the soil under no-till. This creates a biologically rich zone of activity and diversity. There are more earthworms and beneficial insects in soil where tillage is minimised and groundcover and mulch is present. Mulch cover acts as an insulating barrier between the sun and soil, and aids in moderating the soil temperature (Hobbs, 2007). Organic matter provides low to medium concentrations of nutrients, but more importantly, these nutrients are available over several months or years in well-balanced quantities, via a slow-release mechanism. Conservation agriculture, incorporating no-till has sometimes been coined biological tillage, and serves to gradually improve soil structure.

2.4.3. Improved soil moisture retention

There are certain inherent physical soil qualities, such as soil type, that cannot be changed (Swanepoel, 2014). Other physical qualities, such as density, compaction, and microstructure can however, be changed. This can alter the water holding capacity of the soil. Soil moisture retention improves because the permanent cover on the soil reduces evaporation from the surface. No-till systems and permanent ground cover have shown increased moisture levels in the soil profile throughout the growing season. Improved water infiltration and reduced water runoff is also associated with no-till and cover cropping (Hobbs, 2007). The main reason is reduced compaction by vehicles and natural drainage from higher levels of biological organisms present in the soil (Derpsch, 2005).

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2.4.4. Higher soil carbon levels

No-tillage and mulch cover on the soil surface results in more biotic diversity in the soil, which leads to higher soil organic carbon levels than that found in tilled soils (Hobbs, 2007). Reduced nitrogen fertiliser efficiency, due to microorganisms tying up nitrogen in the residue, has been recorded. This is observed in the initial period of adoption following continuous tillage. Soil structure and health stabilises after a number of years of CA practice, creating a reservoir of microbial activity and nutrient recycling that supply plant life with nutritional requirements (Hobbs, 2007).

2.4.5. Increased yields

In a CA production system planting can be done closer to optimal planting time. There is no need to wait for ideal weather conditions to till and prepare the land (Hobbs, 2007). Soil fertility is improved by using legumes in the crop rotation which fixes nitrogen in the soil. Yield variations are reduced, and crops can better withstand a drought through increased and consistent soil moisture and structure. These factors all lead to higher yields over the long term that cannot be achieved through conventional agricultural practices.

2.4.6. Reduced input costs

Input costs such as fuel and repairs and maintenance on tractors and implements are reduced in a no-till production system. This reduces CO_2 emissions and reliance on fossil fuels (Derpsch, 2005). By incorporating crop rotation and residue cover in the production system, the producer can optimise labour use, and simultaneously reduce agrochemical application levels over the long-term. Incorporating legumes into the crop rotation system fixes nitrogen in the soil and, combined with increased organic matter, improves soil health. Through rotating differing plant species, specific herbicides can be used to target competing weeds in alternating crops. In the long-term this reduces the use of herbicides and reliance on specific herbicides. All these practices fall under CA and reduce input cost and increase the profitability to the cropping system.

2.4.7. Reduced CO_2 emissions (reduced use of fossil fuels)

Disturbing the soil surface accelerates organic matter mineralisation; this converts plant residues into carbon dioxide (CO_2). Greater intensities of tillage result in higher relative mineralisation of organic matter and subsequent release of CO_2 into the atmosphere (Benites, 2008). Total losses of carbon from ploughed wheat fields compared to no-till fields, were up to five times greater 19 days after ploughing (CTIC, 1996).

Fewer passes with machines over the land reduces CO_2 emissions and dependence on fossil fuels. In a broader sense this step will reduce the negative environmental impact, seeing that agriculture is responsible for 30 percent of total greenhouse gas emissions.

2.5. Challenges of Conservation Agriculture

For a producer to change his mind-set and adopt a foreign concept that is contradictory to past wisdom, also requires that he forfeits economic value of current assets such as knowledge and machinery. This is known as path dependence. The effects of switching agricultural management practices can be costly and daunting. Change is risky and producers need assistance to calculate the expected financial impacts of change and to soften the impacts of acquiring the necessary technology (Friedrich & Kienzle, 2007).

The transition from a conventional farming system to a conservation system often has an expensive learning curve. The initial capital expenditure to no-till planting equipment is high and affects the cash flow of the business. The difference in gross margin, between crops grown on two identical plots, is insignificant in the first few years (FAO, 2004). After several years the difference becomes more evident. Figure 2.1 shows the transitional phases of adopting CA.

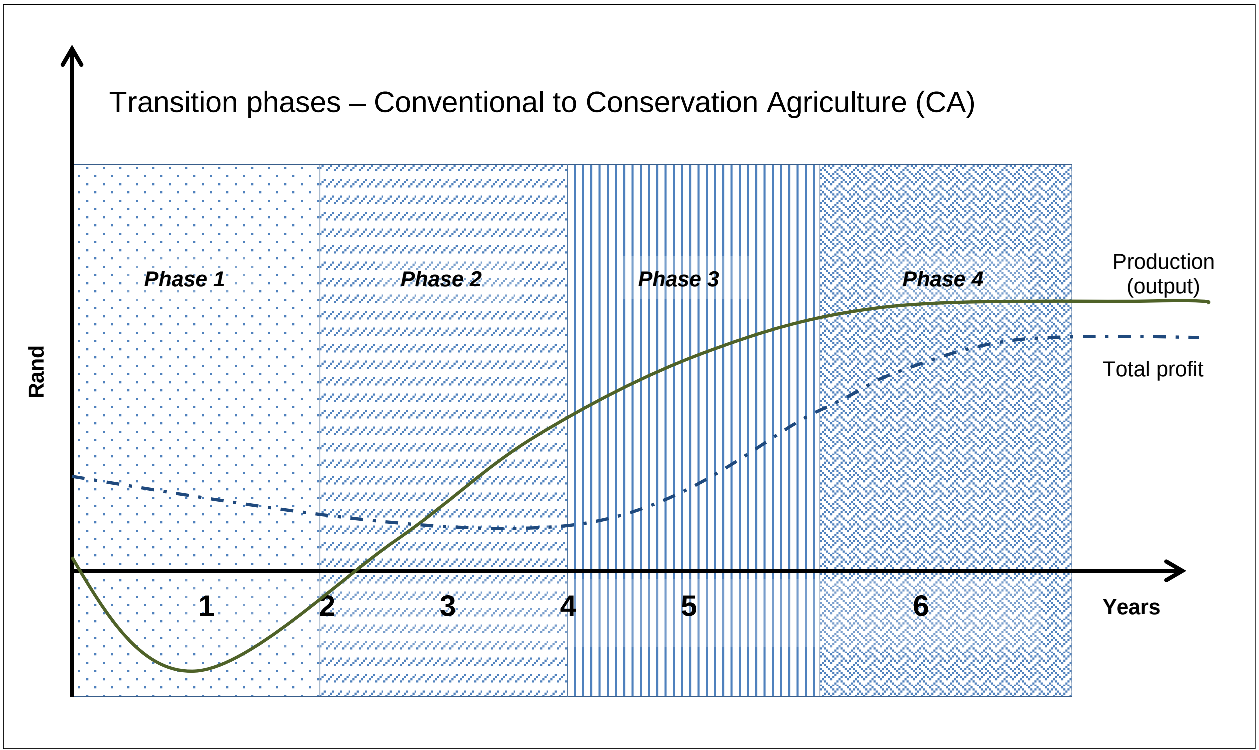

Figure 2.1: Transitional phases – conventional to conservation agriculture. Source: FAO, 2004

Adopting CA practices should be seen as a gradually shifting process. It cannot be undertaken as a ‘flip of the switch’. Producers should experiment on their farm within their specific ecological conditions to formulate a viable and sustainable system on the foundations of the CA principles.

A producer should thus be prepared that the benefits of CA will only become apparent after a lag of time. It is a clear case of invest now to reap benefits at a future date.

A further challenge for the producer is that of changing the mind-set to accommodate new ideas. Producers usually form tight networks of people they trust. Primary producers are mostly price takers operating in a high risk environment with volatile weather and markets. Traditionally, they view the world outside their network with scepticism, rendering new technologies difficult to implement. In the case of CA participatory approach has proved more successful (Abrol et al., 2005).

Conservation agriculture is a knowledge-intensive practice. Producers need continued support in training, flow of information, and supply of necessary inputs, such as herbicides, throughout the adoption phase. They need assistance to soften the financial impact of acquiring and implementing the necessary technology. Assistance in the form of special term financial arrangements, machinery pools, and extension services can aid the adoption process (Friedrich & Kienzle, 2007). Support is often provided but then funding runs out before the communities are adept and self-sufficient in the new practice.

Local institutions as well as climatic conditions differ for every region or area; as such they have unique requirements. Gender issues play an integral role, as women in most developing countries make up a large part of the labour force. Each individual locality has its own unique set of circumstances that affect the adoption of any new and foreign concept.

2.6. The progression of Conservation Agriculture

It was only during the 1970’s that the adoption of Conservation tillage, under the umbrella of CA, began to accelerate. In 1973/74 CA was practiced on 2.8 million hectares worldwide, growing to about 45 million hectares in 1999 (Derpsch, 2001), 72 million hectares in 2003 (Benites et al., 2003) and to 127 million hectares by 2011 (FAO, 2014). The area under CA for each continent for 2011 is shown in Table 2.1. The fastest adoption rates have been in South America where some countries are using no-tillage permanently on more than 70 percent of the total cultivated area, in contrast to the USA where fields are often tilled occasionally (Derpsch & Friedrich, 2010).

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Table 2.1: Area under CA by Continent, 2011

Continent	**Area (Ha)**	**% of Total**
South America	55,464,100	43.4
North America	43,090,000	33.7
Australia & New Zealand	17,162,000	13.4
Asia	4,742,200	3.7
Europe	6,451,900	5.0
Africa	993,740	0.8
World Total	127,903,940	100

Source: FAO, Aquastat 2014.

Figure 2.2 depicts the proportion of land under conservation agriculture by continent as of 2011 (FAO, 2014). The main continents to successfully adopt the practice have been South America, North America, and Australia and New Zealand.

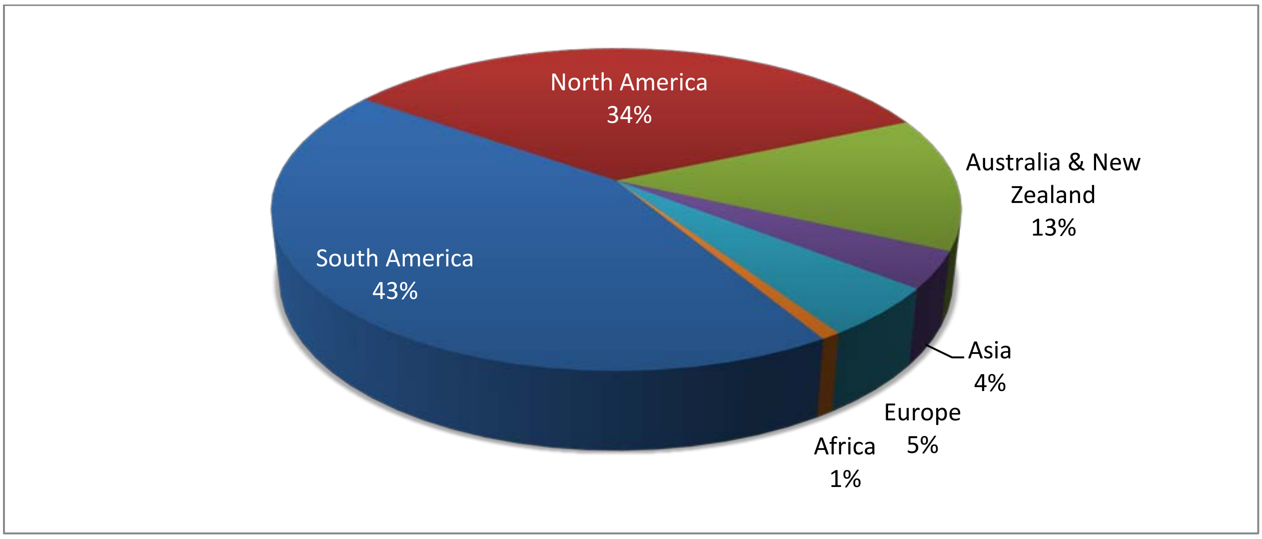

Figure 2.2: Percentage of cultivated area under CA by continent: Source: FAO, Aquastat 2014.

2.6.1. USA

26,500,000 hectares under CA (FAO, 2014).

In the 1930's, soil erosion in the United States reached crisis proportions. The 'Great Dust Bowl' in the Mid-West of the USA, was a result of excessive tillage and successive droughts, resulting in millions of tons of topsoil being blown away by the wind or washed into rivers. The US Government responded by establishing the 1933 Soil Erosion Service, under the Department of Interior, later to be transferred to the US Department of Agriculture (USDA) and consolidated into the Soil Conservation Service, 1935.

In 1917, the USDA initiated research programs on experimental plots to measure losses from erosion. With this knowledge, and government support, US producers started abandoning traditional practices of ploughing, and begun planting directly into the previous crop stubble.

Initially adoption of the new practice was slow, mainly due to weed infestations. The 1960's brought a wave of change in agriculture. Post-emergent herbicides such as Atrazine were released on the market, and farmers began renewed experiments with no-tillage and minimum-till systems. Concerns over the environmental impact of agriculture surfaced around the same time. Consumers were concerned over health and environmental scares from agricultural pesticide use. In the early 70's both the US and Europe acknowledged the adverse impact agricultural policy was having on the environment. The rising levels of pollution from increased use of fertilisers in agriculture was no longer acceptable.

The Federal government provided various financial incentives for farmers to adopt conservation practices, and most who tried the system continued with it (Reeder, 2000). Tillage is still incorporated occasionally, for example, one year in five, if returns are increased. Of the current 26.5 million hectares under no-tillage, only 10-12 percent is permanently not being tilled. It should be noted that the 26.5 million hectares only constitute 22.6% of all cropland in the USA (Derpsch, 2008).

2.6.2. Canada

16,590,000 hectares under CA (FAO, 2014).

The combination of climate and farming practices in Eastern Canada at the turn of the century fostered good land management and improved soil fertility. Western Canada, on the other hand, has been farmed for less than 100 years and the degradation of soils from continuous ploughing has adversely impacted the arid Prairie soils. Prolonged droughts and the depression of the 1930's bankrupted many Western Canadian farmers (Blackshaw, 2002).

Canadian agriculture, similar to that of the USA, expanded production in response to growing demand from new markets post World War II. This period was followed by the advancement of pesticides, fertilisers, and high yielding seed varieties. Consequently, producers' switched to monoculture, as the effects of soil degradation, was compensated for by the readily available fertiliser and agrochemicals.

The successive droughts of the late 1970's and 80's, combined with declining farm prices, and growing concerns of soil erosion and salinity, resulted in a renewed interest in soil conservation techniques, both by farmers and various levels of government (Blackshaw, 2002). Rising production costs and declining yields demanded increased efficiency of farmers to remain viable.

In Canada the adoption of no-till and minimum-till systems was aided by government policies, availability of appropriate sowing implements, and the decrease in the price of glyphosate. More than 50 percent of Canadian crop production is currently under minimum or no tillage systems.

2.6.3. Latin America (55,464,100 hectares under CA (FAO, 2014))

The first concerns over environmental degradation in South America were after a dramatic soil erosion event. In the late 60's the Brazilian government introduced policies to stimulate producers in southern Brazil to switch from a livestock based agriculture system to cropping. The area is just south of the Amazon rain forest and is hilly with high rainfall. The result was large tracts of land were cleared and tilled to plant soya beans, the main crop being promoted. This resulted in soil erosion to the extent that producers' yields decreased sufficiently that they defaulted on loans. The initial theory of restoration promoted the use terraces. At the same time, a splinter group of academics and producers promoted CA, adapted from Kentucky, and by the 1990's commercial farms were successfully cropping soya beans under these practices. The alternative system was initially opposed by universities and was mainly promoted by local agro-chemical, implement, and technical assistant agencies. The main impact was gained through the maintained practical assistance of skilled agronomists.

Conservation tillage has increased rapidly in South America, since the 1970's. Figure 2.3 shows the expansion of the practice since the 1970's for the MERCOSUR countries (southern common market comprising of Argentina, Brazil, Paraguay, Uruguay, Venezuela, and Bolivia) compared to the USA (Derpsch, 2008).

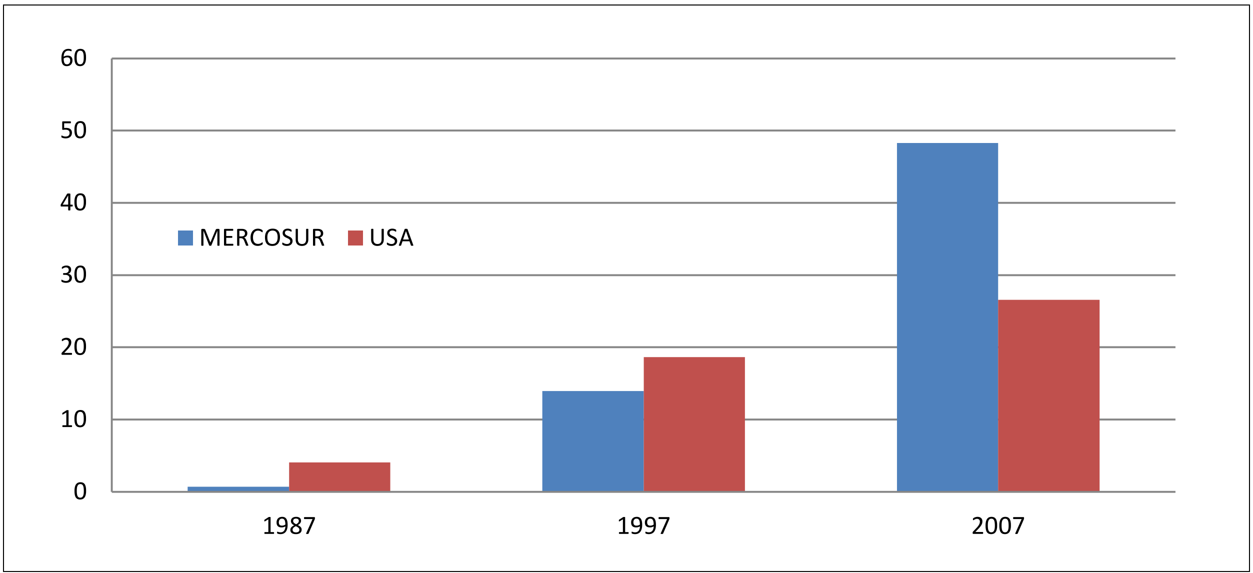

Figure 2.3: Area of land under no-till Farming practices in MERCOSUR countries:
Source: Derpsch, 2008.

The Latin American region continues to expand in the practice of conservation tillage. Table 2.2 shows farm land under conservation tillage in various South American countries, reaching a total of 55,464,100 hectares (FAO, 2014).

Table 2.2: Hectares under conservation agriculture, Latin America 2011

Country	**CA Area (ha)**
Argentina	25,553,000
Bolivia	706,000
Brazil	25,502,000
Chile	180,000
Colombia	127,000
Mexico	41,000
Paraguay	2,400,000
Uruguay	655,100
Venezuela	300,000
Total	**55,464,100**

Source: FAO, 2014

In 1987, The Latin American Conservation Agricultural Network (RELACO) was founded. The spread of conservation agricultural practices in South America can be attributed to the efficient diffusion of the technology through farmer organisations. Implement manufacturing companies, seized the opportunity, and further contributed by developing and distributing no-till equipment. Brazilian no-till implements are highly competitive in the world market. Most of the Latin American countries have formalised no-till farmer organisations that transfer knowledge and information efficiently.

2.6.4. Australia

17,000,000 hectares under CA (FAO, 2014).

Australia's premium white wheat areas are characterized by a Mediterranean climate of winter rainfall and low fertility soils with low moisture retention. The summer months are hot with high solar radiation and nearly or completely absent rainfall (Anderson & Garlinge, 2000). This harsh environment is similar to a few regions of the world, namely the Mediterranean in Europe, California, South Western and Southern Australia, the Western Cape in South Africa, North Africa, and western Middle East.

In terms of CA adoption, Australia follows a similar trend to the USA, with similar environmental concerns arising in the 1960's. Initially, concerns were for the urban pollution problems from litter and transport. At this time rural degradation was regarded as normal in Australia, naturally

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consisting of a mostly uninhabitable harsh environment. By the 1970's wind and water erosion to the rural lands gained recognition questioning agricultural practices. The shift from conventional agriculture to CA was incentivized by three main negative consequences of conventional tillage; erosion (both wind and rain), a lack of soil moisture retention, and delayed planting opportunities (Jat et al., 2014). The resultant negative impact of conventional tillage on yield was a gradual process. Adoption of CA required a paradigm shift in the attitudes of farmers and uptake was relatively slow.

The Australian government has tried to stimulate economic development and sustain the environment. Three rural policy programs are currently in place directed at conservation farming. The first, 'Care for our country', includes a multi-year budget directed at sustainable farm practices. With an objective of improving land management practices, this initiative focuses on reduced tillage, maintained ground cover and the build-up of soil organic matter. The second, Carbon Farming Initiative (CFI), focuses on providing producers access to domestic and international carbon markets. The third, Conservation Tillage Refundable Tax Offset, incentivizes the producer to purchase depreciating assets specific to conservation tillage, by entitling the producer (taxpayer) to a refundable tax offset of 15 percent of the cost of the asset (Jat et al., 2014).

In all States of Australia, producers use varying aspects and degrees of minimum tillage and are constantly experimenting with what is most suitable for their own situation. No-till adoption began in the 1990's with the major growth phase taking place between 1996 and 2003. By 2008, approximately 90 percent of farmers had adopted no-till practices in Western Australia; refer to Figure 2.4. Other regions have recently increased to levels of between 46 percent, in New South Wales, and 78 percent, in Southern Australia (Llewellyn & D'emden, 2009).

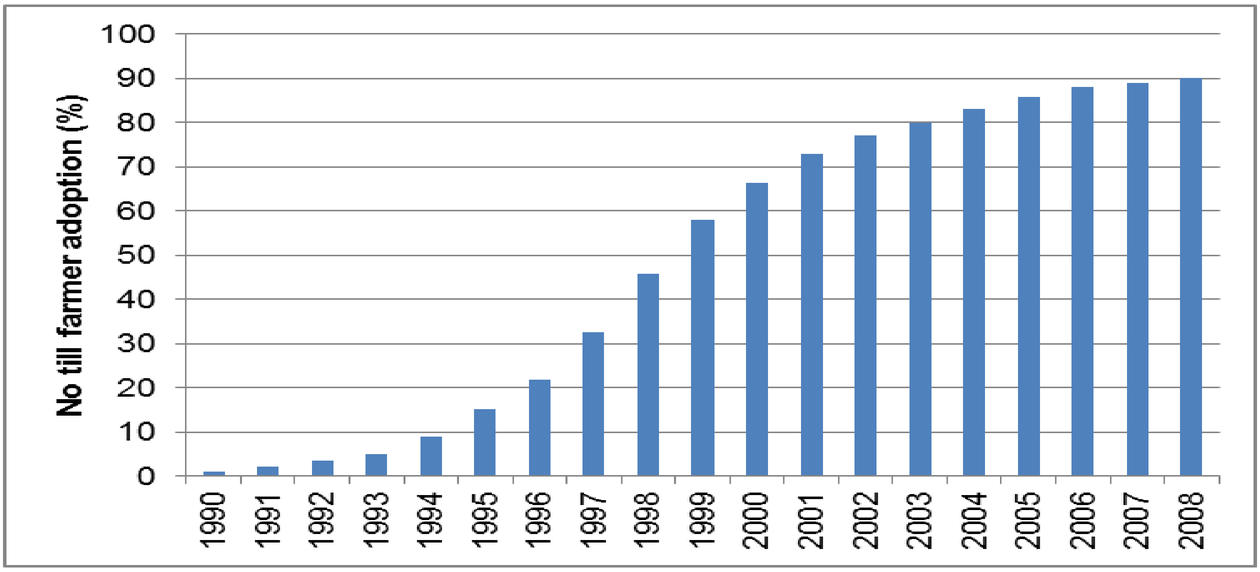

Figure 2.4: Percentage of farmers practicing No-till in Western Australia, 1990-2008:
Source: Grain Research and Development Corporation, Australian Government [July 2014]

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Adoption of no-till is lower in South Eastern Australia. This is due to a differing environment characterised by low winter rainfall, alkaline soils, high levels of nematodes, and frequent summer rains that encourage summer weed growth. In spite of this, the proportion of producers using no-till is expected to exceed 80 percent in most regions by 2013.

The main drivers for Australia's transformation in tillage practices has been the benefits experienced by producers, such as; reduced fuel and labour costs at seeding, soil conservation, and soil moisture management. Government rural policy has played a significant role by incentivizing and supporting producers through the adoption phase of CA.

2.6.5. Europe

6,451,900 hectares under CA (FAO, 2014).

Europe remains a high production zone for winter wheat under Mediterranean climatic conditions. The adoption of CA remains low in contrast to similar areas. Figure 2.5 shows the extent of Mediterranean climate zones worldwide, the largest area is in Europe. The highest adoption rates of CA in Europe are associated with the Mediterranean climatic regions. High adoption rates are also found in the Mediterranean climatic regions outside of Europe.

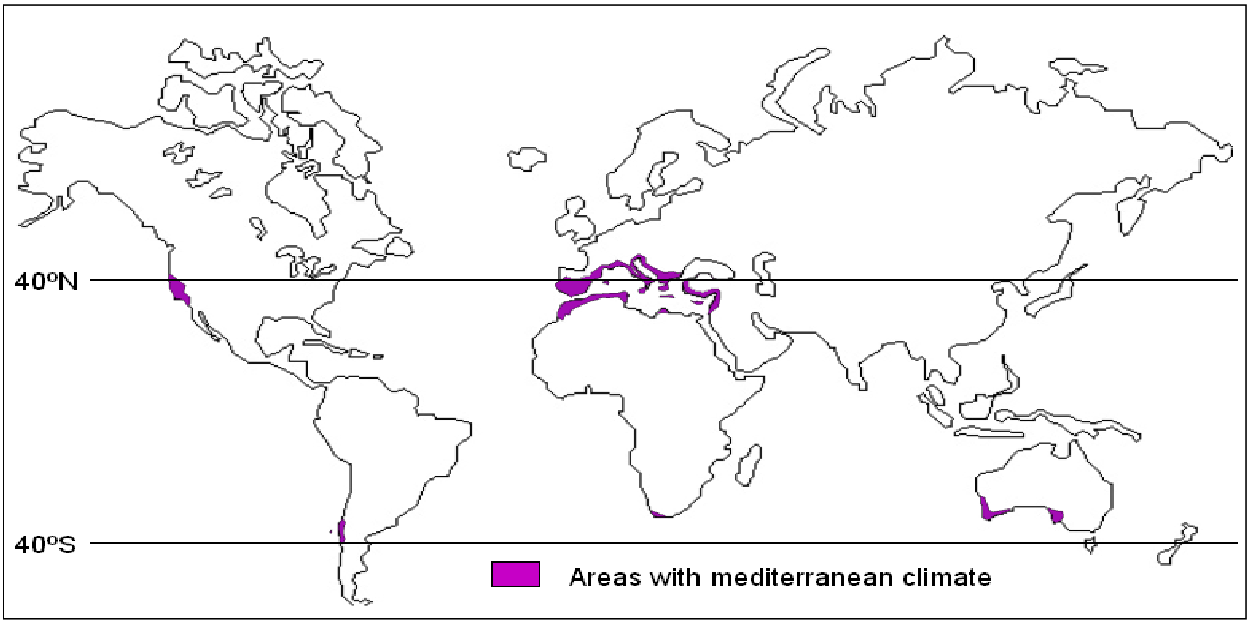

Figure 2.5: Areas with Mediterranean climate in the World:
Source: Wikipedia, 2014

Agricultural Policy in Europe functions through the Common Agricultural Policy (CAP) that all EU member states adhere to. The introduction of agro-environmental schemes in Europe began in 1985 with the Agricultural Structures Regulation. Since 2000, The EU has increasingly shifted

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focus away from production-orientated policies towards the promotion of countryside stewardship by the producer.

Research on CA in Europe started as early as the 1970s in France and Germany. The European and national administrations are still not fully convinced that the concept of CA is the most promising one to meet the set requirements of environmentally friendly farming. The reliance of CA on the use of chemicals for weed, disease and pest control, are the main constraints for the acceptance of CA (Basch, 2005).

The CAP has two headings under budgetary expenditure; market price support and direct income payments. Cross-compliance became compulsory in the 2005 CAP reforms. This led to a greater role of soil protection and conservation, as well as EU environmental directives that now include the Nitrate Directive. The CAP is increasingly focused on keeping agricultural land in good agricultural and environmental condition, (Burrell et al., 2009).

Spain is the leading country in terms of no-till adoption in Europe (Derpsch & Friedrich, 2010). Other countries that are researching and adopting CA include; Finland, France, Switzerland, Ukraine, Germany and Russia.

2.6.6. Asia

4,742,200 hectares under CA (FAO, 2014).

Conservation agriculture in Asia originated in Pakistan in the 1980's when the first zero-till planters were imported from New Zealand. Research began with the intention to advance wheat sowing dates in an effort to increase yields. The basis was the importance of timely wheat sowing and the costs to prepare paddy rice fields for wheat sowing (Harrington, 2008). In South Asia, no-till wheat is grown in a double cropping system with rice. However, for rice production, farmers plough the land or use intensive tillage practices (Derpsch & Friedrich, 2010).

In India farmer interest and adoption was slow as the seed drill was not well adapted to sowing wheat into standing rice stubble (Harrington, 2008). By 1994, a locally adapted model of a seed drill had been developed. At this time, farmer adoption of no-till accelerated, with the crisis of herbicide-tolerant *Phalaris minor* plaguing the wheat crop. This combined with good extension services, and the reduction in production costs assisted the diffusion of CA as a technology and practice.

The adoption of zero till in South Asia's wheat industry can be traced to numerous factors including:

- Input costs

- Access to reasonably priced, high quality implements
- Substantial technical support from extension officers (especially India)
- Favourable policy environment, including some subsidies for drill purchase,
- Good understanding from research on how to make zero-tillage work;
- Travelling seminars in which stakeholders from different states and countries shared their experiences (Vink et al., 2011).

Adoption of no-tillage in China has been a recent phenomenon and can be traced back to the development of no-till seeding equipment for small farmers. In Northern China wheat and maize are double cropped. Most of the maize is produced under no-till practices, but, after the maize harvest, fields are ploughed to sow wheat. As a result this area cannot be considered CA (Derpsch, 2008). Government policy in China favours the adoption of no-till technology, with clear goals for up scaling conservation agriculture (Li, 2010).

In Kazakhstan, CA has developed quickly in recent years as a result of producer interest, government policies, and an active input supply sector. Kazakhstan is among the ten countries with the biggest area under no-tillage in the world (Derpsch & Friedrich, 2010).

2.6.7. Sub Saharan Africa

993,740 hectares under CA (FAO, 2014).

Over 65 percent of the population in sub-Saharan Africa (SSA) live in rural areas and depend largely on subsistence farming to meet their livelihood needs (Vink et al., 2011). The agro-ecosystem in SSA is harsh with light textured, thin soils of low fertility and an erratic rainfall distribution usually of high intensity and a good chance of early or late seasonal drought. Producers often spread risk by integrating livestock into the farm system, which competes for crop residues after the harvest. The lack of soil cover results in a hard, weathered, compacted, dry soil medium to plant into, for the coming summer.

Conservation agriculture is popularly considered to hold the answer to the problems of erosion and food security in SSA. However, Giller et al. (2009) argue that despite strong advocacy of CA by international research and development organisations, the evidence is mixed, and largely based on experience in the America's where "…the effects of tillage were replaced by heavy dependence on herbicides and fertilisers" (Giller et al., 2009). The empirical evidence lacks clarity on; increased yield, reduced labour requirements, improved soil fertility, and reduced erosion. Increased labour requirements, when herbicides are not used, had an effect on the gender shift and the labour burden to women. This is held as the main reason for slow adoption among small-scale farmers in Africa. (Vink et al., 2011)

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Conservation agriculture emerged in a number of countries in SSA in the 1990's. In Zimbabwe, experiments with zero-tillage and direct seeding led to the recovery of degraded soils as well as the financial recovery of enterprises. These lessons have been expanded to small-scale farmer training by NGO's (Oldreive, 2009).

In Zambia a dedicated extension unit, supported by donor funds, diffuse knowledge on CA to producers. Here, farmers found that CA worked on small-scale farms too. More than 100,000 small-scale farmers in Zambia are currently converted to CA (Friedrich & Kienzle, 2007)

The Africa Conservation Tillage Network (ACT) was established in 1998 to promote CA in Africa as a sustainable means to alleviate poverty, use the natural and human resources more effectively, and reduce environmental degradation.

Large-scale farmers in South Africa, Kenya, and Namibia have, in the last decade, shifted towards CA. The practice of CA has spread more recently to neighbouring countries Zambia, Zimbabwe, and Mozambique, being promoted by donor organisations (Kassam et al., 2009). Sub-Saharan Africa (excluding South Africa, Namibia, and Botswana), have experienced an influx of investment and institutional changes that have allowed agriculture to grow. With the proverbial 'clean slate' it has been easier for commercial farmers to adopt CA practices, as they are not 'Path Dependent'.

2.6.8. South Africa (368,000 hectares under CA (FAO, 2014))

South African producers were initially hesitant to adopt CA despite on-going trials and experimentation underway on research farms in the 1980's and 1990's. The main constraints to CA adoption are:

- Inadequate tillage equipment,
- Build-up of diseases and subsequent drop in yields and quality,
- High price of herbicides, such as glyphosate,
- Lack of passion and commitment to the concept,
- Farmers often tried no-till on problem fields (Vink et al., 2011).

Deregulation and liberalisation of the agricultural sector in the 1990's, particularly wheat and maize, resulted in commodity prices declining to world price levels (Sandrey & Vink, 2007). Producers were faced with high and increasing input costs. To remain competitive at global commodity prices and sustain their livelihoods, producers focused on reducing quantities of inputs, the only variable under their control. Conservation agriculture, extensively adopted in other parts of the world, provided the ideal components to achieve sustained production while steadily reducing input costs, and conserving the environment.

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The pioneers of CA adoption in South Africa were predominantly in the Western Cape, which is a typically Mediterranean climate. Inspired by examples in Western Australia, producers searched for an effective method to reduce soil erosion. The knock on effect of soil moisture retention and increased yields led to the spread of the concept. Problems with grass weeds were resolved with the introduction of broadleaf and/or pasture crop rotations (Vink et al., 2011).

In the late 1990's summer rainfall areas began to adopt no-till practices from examples and experience of the Brazilian farmers. The idea was to increase soil fertility and conserve soil moisture and it resulted in an average increase in 1 ton per ha in maize yields.

Tillage practices in South Africa vary between regions, areas and farmers. There is a wide range of practices varying from conventional tillage to no-till. It is estimated that only 20 percent of farmland in South Africa is still under conventional tillage, the remaining 80 percent falls under variations of minimum tillage and no-till (Vink et al., 2011). This is set to grow as knowledge of the concept is more readily transferred through farmer communities. Technological development continues to drive production in this sustainable direction. South Africa, as a whole, lags behind other regions of the world as seen in Figure 2.6.

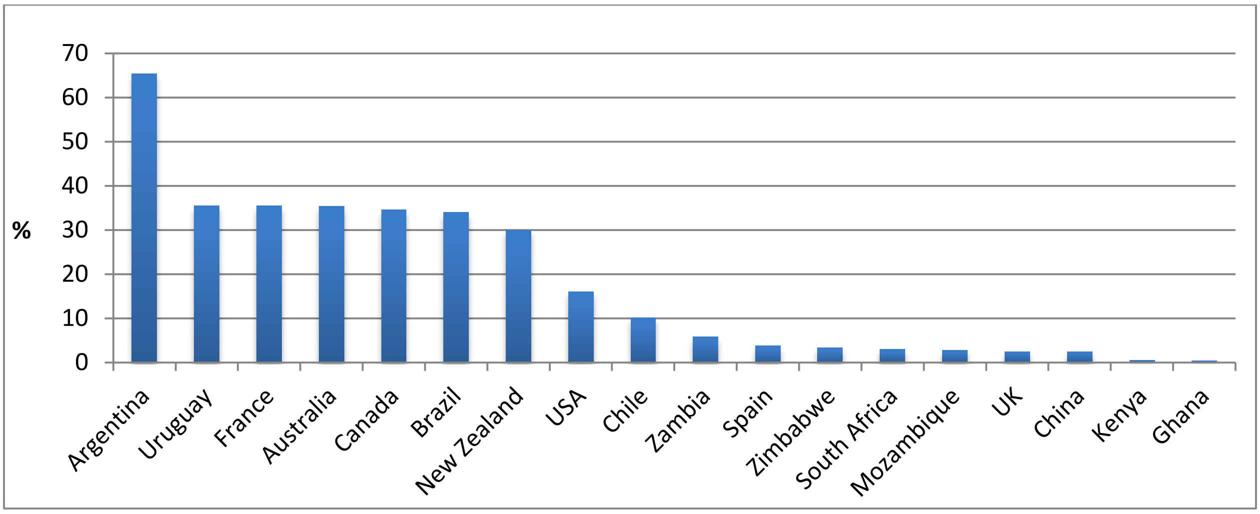

Figure 2.6: Percentage (%) of Arable Land under Conservation Agriculture 2011: Source: FAO AquaStat, 2014.

2.6.9. Swartland area of Western Cape

The Swartland area was named after the *renosterbos* (rhinoceros bush) that turns black after the rain, a word of Dutch origin meaning 'black land'. The Swartland is a farming region within the Western Cape region of South Africa and typically characterized as a Mediterranean climate. It receives winter rainfall averaging 400mm from March to mid-October and hot dry summers. The Swartland differs from the rest of the Western Cape in that the summer months are extremely hot and dry with a complete absence of rainfall, shown in Figure 2.7. Other wheat producing areas of the Southern Cape receive up to 40 percent of annual rainfall in the summer. The soils are dominated by what's known as Malmesbury shale, shallow sandy-loam soils, with low clay content, and are generally rocky (Wiese, 2013). As a result, there are no summer rain fed crops grown in the Swartland and crop residues do not decompose due to the lack of moisture. The Swartland is most similar to the cereal production areas of Western Australia and North Africa. The homogeneous area known as the Middle Swartland is expressed in Annexure A. Also contained in Annexure A are maps of the rainfall distribution and soil type for the Middle Swartland homogeneous area.

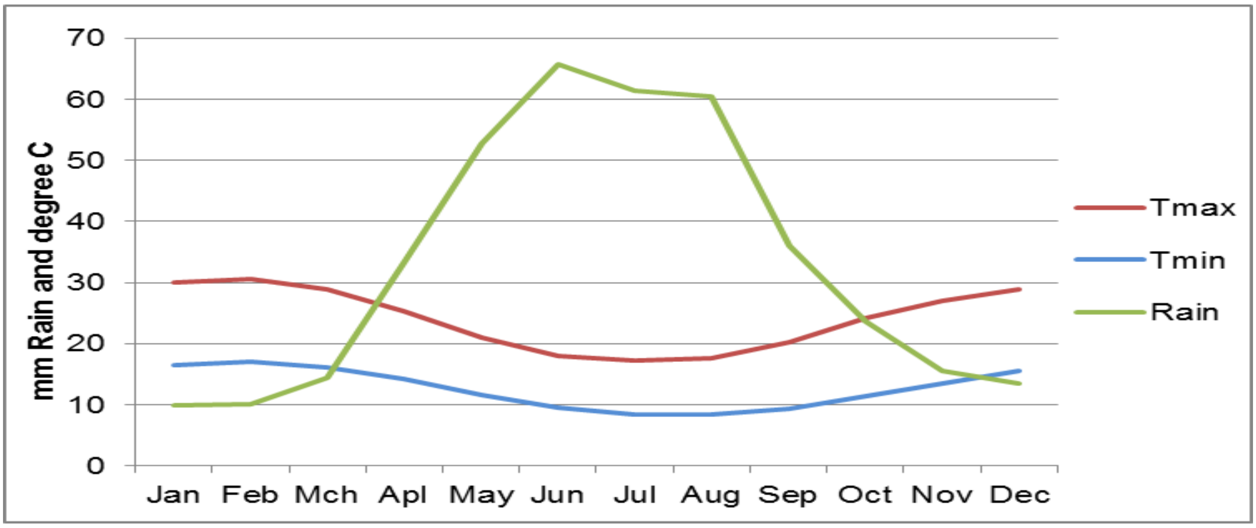

Figure 2.7: Swartland Average Annual Rainfall and Max-Min Temperatures, 1964-2006: Source: Labuschagne, 2013

The Middle Swartland area has traditionally been a wheat monoculture area. No-till was adopted as a result of two events. Firstly, the decline in domestic wheat prices to world market levels in the 1990's (Vink et al., 2011). Secondly, as ryegrass became increasingly resistant to herbicides, no-till machines enabled producers to spray pre-emergent herbicides such as Trifluralin (Strauss, 2013).

The motivation for the adoption of CA in the Middle Swartland area differed from the rest of the Western Cape, in that it aimed at improved soil fertility, rather than conserving soil moisture (Vink et al., 2011). This is because of the shallow soils that characterise the Swartland. Producers experienced declining yields with no further price support. They were forced to find alternative cost saving production systems. These factors combined with increased soil fertility and a strategy to combat grass weeds such as rye grass with the use of rotations of canola, lupin and medics, led the adoption of CA in the Swartland.

In the Swartland land use is gradually changing from wheat to grape vine production. Wheat reduced from 92 percent in 1977 to 80 percent in 2010. Grape vines cover 8.55 percent of the

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Swartland. This was due to squeezed profit margins in the wheat industry and growing exports of SA wines from 1991 to 2001 (Halpern & Meadows, 2012).

2.7 Conclusions

Conservation agriculture is seen as the most holistic approach to sustainable agriculture as the practice contributes positively to the natural resource stock, the environment, and the farmer's profitability. Conservation agriculture incorporates three main principles; minimal soil disturbance, permanent organic soil cover, and diversified crop rotations. Incorporated successfully into the farming system, CA offers improved soil health and moisture retention, increased soil carbon levels, reduced soil erosion and degradation, increased yields, and reduced inputs costs. This allows the producer to remain viable in a competitive environment. The process of adopting CA comes with challenges. Initially the producer may have difficulty in adapting a new weed management system. There may be higher input costs during this learning phase, as CA equipment requires large capital investment. In time, as the system settles and the farmer is able to generate higher margins through increased yields and reduced input costs, the benefits of CA are realized.

Conservation agriculture has been adopted throughout the world with varied success. Latin America has experienced the most dramatic adoption since the 1990's with 43 percent of land cropped under CA. North America and Australia also have large proportions of land being cropped under CA. In all instances the reasons for adopting are similar and include a combination of environmental concerns, the development of herbicides, and economic benefits to the producer. Africa, with much of the rural areas still under subsistence agriculture, shows the lowest growth rate in adoption of CA. Conservation agriculture in South Africa was pioneered in the Western Cape, predominantly a winter rainfall Mediterranean climate, it started in the wheat producing areas in the 1980's. As the word spread of the financial benefits of CA and planting equipment became more readily available, the summer rainfall areas began to adopt. Today South Africa has over 368 000 hectares under CA.

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Chapter 3: Overview of systems theory and farm simulation models

3.1 Introduction

Chapter 2 outlined various concerns related to agricultural intensification over the past century. These include; climate change, exhaustion of natural resources, pollution, rapid urbanization, and unequal distribution of food and income. Although agriculture has shown impressive yield increases, but there is a concern that at current production levels and the availability of natural resources, a global population increase of 40 percent by 2050 may not be supported. Agriculture is becoming increasingly complex and faces productive, environmental and socially interconnected problems. In order to solve these complex problems, research must develop to incorporate trans-disciplinary, integrative and innovative perspectives (Rodriguez & Sadras, 2011).

The traditional scientific approach to understanding complex problems has been reductionist, whereby one component is isolated and analysed within the context of an individual scientific discipline (Hirooka, 2010). This approach has contributed greatly to our current knowledge-base. However, understanding the implications of a single component is insufficient to comprehend the interrelated impacts of multiple components.

When dealing with large and complex systems, a multi-disciplinary approach is required to incorporate specialized knowledge and bridge the gap between disciplines. Computer software can efficiently calculate the multitude of equations required to cross-compare interrelated components within a system. This has allowed further development of the systems thinking approach. A system can be studied experimentally because it can be modelled. The use of models and simulations to mimic real life operations allows for the use of emerging and immature concepts to explore their possible future impacts. Essentially, system models and simulation allow the researcher to explore questions regarding the future of farming (Schiere et al., 2004).

Considering CA within a whole-farm systems approach, the impacts of many varying interrelated components have to be addressed. These include; soil structure, rainfall, commodity prices, machinery costs, yields, input quantities and costs. To analyse each component in isolation is possible, however, especially in CA, components are delicately intertwined within the farming system. The implications of adopting CA will thus be evaluated from a whole-farm perspective. A typical farm in the Middle Swartland area will be financially modelled by a 25-year budget simulation adapted around potential impacts of the practice.

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3.2 Systems approach in agriculture

Scientific research in agriculture has evolved towards a systems thinking approach as agriculture developed over the 20th century. Research techniques or methods used in the early 1900's were not wrong, but the increasing complexity of agricultural systems left the results obtained lacking in explanation. During the Green Revolution in the late 1960's early 1970's, scientists experienced variable results from experimental trials to field crops in uncontrolled settings, as well as unexpected trade-offs within the system. This led to the development of Farming Systems Research (FSM) (Schiere et al., 2004).

Prior to FSM, research was focused on a reductionist approach whereby the problem was broken down into individual components and each component studied in isolation. In order for this analytical approach to work, two assumptions hold. Firstly, interactions between individual components within the object of study have to be absent or extremely weak. Secondly, relationships between the differing components must be linear (Hirooka, 2010 and Strauss, 2005). The knowledge derived from this approach has formulated the foundation of current scientific knowledge. The quest for greater understanding of systems increased consequent to the increase in the complexity of systems. This led to the development of a more holistic approach. The innovation of computer technology and software programs, able to compute multiple equations in manageable time frames, have further facilitated the development of systems approaches using models and simulation.

Agriculture is based on many interrelated systems such as biological systems, mechanical systems, economic systems and management systems. Within all these systems there are interacting subsystems and components. These have unique characteristics and behaviour while simultaneously contributing to an overall form and function of an entire system (Peart & Curry, 1998). Understanding how these interactions impact on the system as a whole enables us to make better informed decisions concerning the future in an environment of risk and uncertainty.

Agricultural systems consist of many complex interrelated components, such as; the ecological region, the diversity and interrelatedness of crops and livestock, mechanical processes, fertilization, pest and weed management systems, product and input price and marketing systems, consumerism, and sustainability issues (Hoffmann, 2010). For the producer to make informed decisions, the entire system must be evaluated.

Modern agricultural systems thinking can be classified into hard, soft, and complex methodologies (HSM, SSM, and CSM) (Scheire et al., 2004). Hard System Methodology (HSM) refers to a *systematic* approach of objective measurements, quantification and reductionist thought. The principle of *"if you can measure it, you can control it"* (Knott, personal communication, 2010). The Soft System Methodology (SSM) refers to a *systemic* approach incorporating more qualitative aspects as well as hard factors. It takes into account the non-physical aspects of farming, those of consumer opinions or perceptions of policy makers. It assumes that farming systems are ever changing and learning, and the observer operates from within the system by setting the boundaries. Complex System Methodology (CSM) focuses on an integrated approach to problems, incorporating trans-disciplinary methods and knowledge bases, to develop dynamic systems prepared for continuous learning across science domains. This system recognizes the 'knock-on' effects of policies within and across differing sectors, highlighting the interrelatedness of modern systems.

The challenges that producers face require short-term tactics as well as medium to long-term strategies. These challenges span across disciplines, knowledge bases, and value systems. It requires the involvement of various role players including; researchers, producers, agribusinesses, advocacy groups, and private consultants, to collectively describe the problem and identify actionable solutions (Power et al., 2011). The use of multi-disciplinary discussion groups will be addressed later in this chapter.

3.3 Modelling and simulation

Models are designed as a description or representation to aid in visualising something that cannot be observed directly (Daellenbach & McNickle, 2005). By using a model to represent the real world situation, certain events that occur due to factor variations or over time, can be evaluated. For the purposes of this study a real world farm, with its interconnected systems, will be represented in a model.

3.3.1. Modelling

Farming operations are conducted outdoors, usually over a large area and under location specific climatic and environmental conditions. It is expensive and time consuming to conduct field research when considering the manipulation of large complex systems. To overcome this problem a life-like smaller, more manageable version of the system can be developed. This is termed a model. A model is defined as a simplified representation of the real world, based on an ordered set of assumptions and observations. In farm systems research, models where the real world is represented by symbols are commonly used (Nuthall, 2011 and Hirooka, 2010).

A model is also an ideal research tool due to its practical use and relative ease of understanding by the farmers (Hoffmann, 2010). Modelling organizes available knowledge within a farming system and highlights research gaps and areas of limited understanding for further study (Hirooka, 2010). A symbolic model of a farming system has the capacity to evaluate possible outcomes by manipulating input data and system parameters. This requires multiple calculations and was made possible by the advancement of the computer and software technology.

3.3.2. Simulation models

Once a model, representing a system has been built, experimentation can be done. This attempts to reproduce, or mimic, the relationships between objects and persons in the real world. This process is called simulation. By simulating specific scenario's the observer can predict or understand the likely behaviour or outcome of the objects or persons within the system or that of the whole system.

In the field of agricultural economics, model simulation incorporates both physical models and economic models. In the case of natural sciences, it is often possible to build a physical model to scale to represent the real world. In economics it is virtually impossible to build a physical model of for instance a whole farm model. Most experiments are conducted using computerised models. In the case of this research, a model of typical Middle Swartland cropping systems has been built, based on data collected over the last seven years on Langgewens experimental farm. This data is captured in a computer model to simulate the financial implications in the real world.

There are many different approaches to simulating agricultural systems, however the logic remains the same and is depicted in Figure 3.1 (Strauss, 2005).

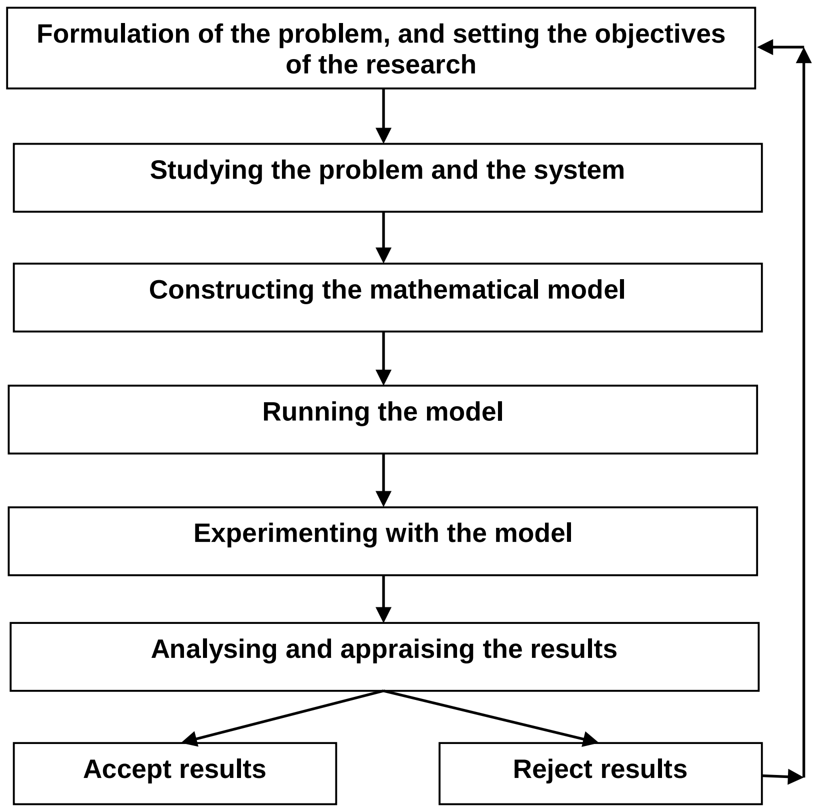

Figure 3.1: The order of implementation of simulating economic problems:

Source: Strauss, 2005

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3.3.3. Types of models

There are two basic types of models, deterministic and stochastic models. The type of model to use depends on the type of system being modelled and the purpose of modelling or simulating the system (Strauss, 2005). For the purposes of this research, a deterministic model will be used, as the model will analyse a specific set of variables (inputs) to simulate a specific outcome.

Deterministic models are aligned to a systematic approach, as they contain no random variables, do not deal with probabilities of different model variables, and all relationships within the system are constant. All of the input values to be used in this model are fixed and known, and the element of risk will be incorporated only through scenarios. The deterministic model is best suited to this research. The main purpose of the modelling is to evaluate various systems in terms of profitability.

3.3.4. Approaches to modelling

In model design and simulation it is important to consider what is to be achieved. There are two main approaches to modelling, a normative or positive approach.

A positive approach is concerned with '*what is'*, *'what was'* or *'what will be'* (Hoffmann, 2010). Positive models use current and historical variables to predict a specific outcome. This approach is well suited to a deterministic model, which describes the nature of the system as it is, rather than exploring what the nature of the systems should be. In describing observable situations, positive models provide empirical evidence to prove the problem statement either correct or incorrect. Positive models are used to run a number of simulations to ascertain the influence of specific variables or parameters within certain scenarios.

The purpose of this research is to establish the current situation of a typical whole-farm in the Middle Swartland and simulate the impacts to the business of a variety of scenarios. The positive approach is well suited to this purpose.

3.4 Budgeting models

Budgeting is a simple form of simulation that can be used to evaluate future plans in both physical and financial terms. Their relative simplicity and recognition across all disciplines including producers, researchers, and policy makers, makes them an ideal tool in bridging the gap between academics and the producer. Most farm businesses require and use basic budgets for estimating profits. Larger farms, with greater potential gains from improved planning, may afford more sophisticated techniques (Nuthall, 2011). With the development of computer and software technology, budgets can be adapted to more complex systems. Though multiple simulations, budgeting can provide a dynamic tool to decision making. This classifies the budgeting technique as simulation based on accounting principles (Hoffmann, 2010).

Budgeting requires experience and insight in developing the physical dimensions of the farm system being modelled. Estimating costs and returns expected from the farming system depend on the accuracy with which the physical dimensions are interconnected. This ensures the feasibility of the modelled system components and system as a whole. With budgeting certain principles are prerequisites including that; prices and costs have fixed values and input-output coefficients are valid. The dependence on the trustworthy physical dimensions of the model requires that economists depend on other scientific disciplines involved in the broader focus area. To validate these, researches can use inputs from other scientific disciplines, or use a range of parameter values, to generate conservative estimates.

Budgets can be used to forecast financial performance of the farm measured in criteria such as expected cash surplus. It is a useful tool for planning purposes to predict taxation, as well as day to day control mechanism or blueprint for the farmer to follow (Nuthall, 2011). Budgets provide a valuable decision making tool with the comparison of alternative systems. Such budgets include; partial budgets, which compare different parts of the farming system either looking at a conventional partial budget or a gross margin analysis of a technical unit, for example 1 hectare and developmental budgets which analyse one or many future time periods (Nuthall, 2011).

Gross margin budgets are useful when comparing the performance of different enterprises that make up the entire farming system. With this information the decision maker can observe the implications of manipulating the components of the system, with the aid of model simulation, on expected financial performance. Budget simulation can also be used to predict the impacts of adopting novel technologies.

Gross margin of a product is defined as the total income less the variable costs per unit of production, which is usually 1 hectare (1 Ha) for crops and a stock unit (SU) for livestock (Nuthall, 2011). The fixed and overhead costs of the system are incorporated in the whole-farm budget. The gross margin is only concerned with the variable costs attributable to the specific product. Fixed costs remain fixed irrespective of the level of output for example, rent; variable costs however vary according to farm system parameters, such as intensity, scale of production, and natural production circumstances. Individual gross margins are incorporated into a whole-farm budget and can be projected over a number of years to simulate expected performance.

Farm planning is often long-term future oriented. It may be necessary to invest capital to promote growth and change. Capital budgets can be integrated into budgeting simulation to answer the questions of ‘how much capital investment’, ‘when’, and ‘for how long’. In the current, dynamic, decision making environment, there is need to plan for change as technological

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developments progresses at such a rapid pace, and the need for intensified agricultural production also increase. Capital flow budgets provide the decision maker with the ideal source of data to base investment decisions on (Barnard & Nix, 1979).

3.5 Multi-disciplinary group discussion techniques

It has been established that farming systems are complex and span across various disciplines. The business of farming has evolved from a lifestyle to an unforgiving business environment. Focus is on the performance of the business to maintain the lifestyle. Farmers consequently have to master many of the trades. In contrast, researchers narrow their focus of study to specialize in a specific field. As a result, knowledge is compartmentalised into separate specific fields and a barrier of scientific language and pride remains. It is thus increasingly important to undertake research accounting for the various aspects of the agricultural system, and to have a thorough understanding among the participants involved. A useful tool to combine the skill set of role players involved in the industry is to facilitate a focused discussion with all parties present. This technique, with its origins in World War II military tactical decision-making, is termed a multi-disciplinary group discussion (Hoffmann, 2010).

There often is a gap in interest and understanding between the researchers and the producer. There are three forms of knowledge, lay, scientific and met-science knowledge. Lay knowledge is gained from; experience, learning, and reflection, and is used in everyday life. Scientific knowledge comes from the systematic and analytical study of real life problems. Meta-science is concerned with conceptualization, thus the selection of theory and research approach (Hoffmann, 2010 and Myers & Yearwood, 2012). Each of these forms of learning constitutes what may be considered, their own world and language. Agriculture spans all three disciplines and some parties may be intimidated and/or disinterested in complex research. There is however a real need for the relevant information to reach the necessary participants and decision makers within the system, for the production system to operate at its optimal level. Multi-disciplinary discussions provide a platform for this gap to be bridged. It is important for the researcher to understand the dynamics of the whole farm business to contrast and generate a realistic model and simulate real world scenarios.

Figure 3.2 shows a schematic representation of the three forms of knowledge, highlighting the importance of multi-disciplinary discussions in bringing together the opinions of scientists and producers from their relative fields of knowledge, in the development and validation of the budget model.

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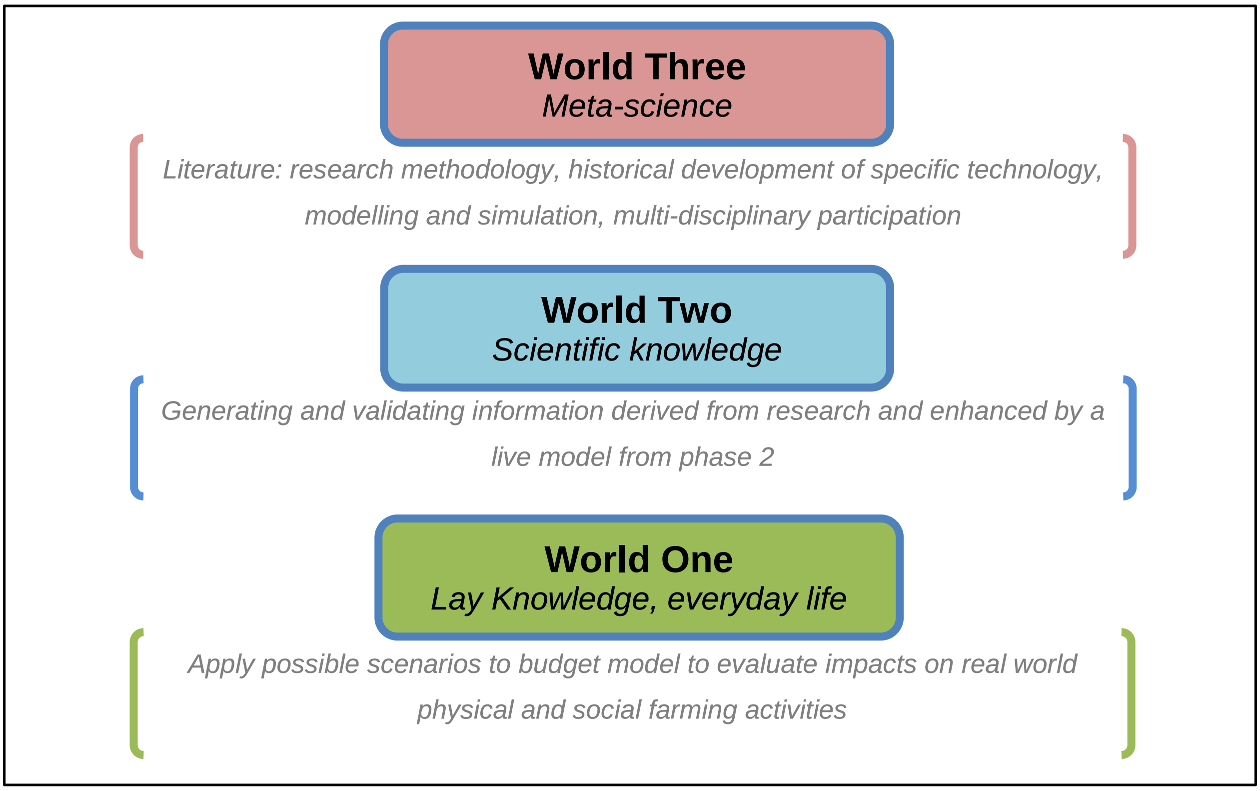

Figure 3.2: Schematic representation of the role and impact of scientific knowledge:
Source: Adopted from: Hoffmann, 2010

Multi-disciplinary group discussions stimulate creative thinking, as participants are able to challenge cross-disciplinary perspectives (Hoffmann, 2010). Farmers can challenge the theoretical application of novel technologies from a practical, in-field perspective. Vice versa; scientists can challenge farmer's 'conventional wisdom' with research based knowledge. The group discussion provides a platform to enquire and validate trends in data and applied knowledge. Understandably, with participants from various backgrounds and holding different perspectives, there is likely to be opposing opinions and resulting disagreements. Disagreements confront experts with alternative perspectives, which is the core advantage of expert group discussions. Based on the level of expert knowledge and the disagreement, alternatives can be invented and formulated. There is a risk that some participants may overshadow other's views, due to the nature of human interaction and varying characteristics. Therefore, an important role of the researcher is to mediate the discussion to avoid deviations and attain an objective outcome. The multi-disciplinary group discussion attempts to funnel the opinions of experts from various fields to obtain consensus on an assumption that can be used in research. Figure 3.3 depicts the process of funnelling expert opinions.

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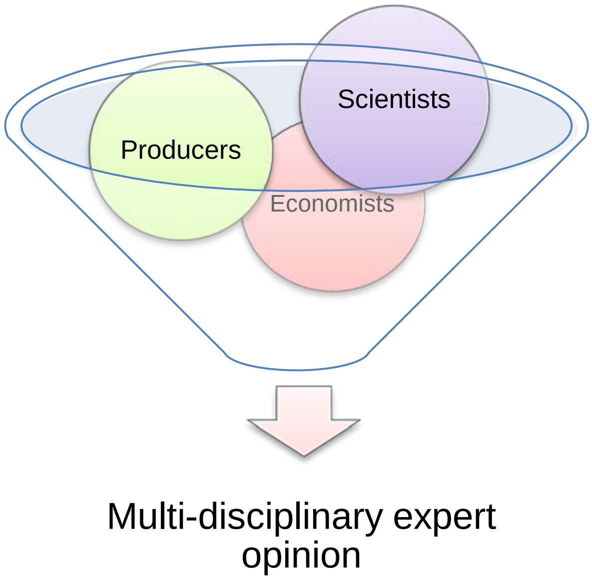

Figure 3.3: Depicted process of obtaining expert opinion from multi-disciplinary group discussion

Agricultural research is traditionally divided into sub-sectors by commodities for example, maize, wheat, soya, beef, dairy, sheep, oats, and barley, etc. Researchers specialize in specific disciplines where they tend to develop independent languages and indicators specific to their field. This fragmentation of knowledge and lack of compatibility between indicators can create confusion for the end user, the farmer. Researchers should thus try to pool together information to make decisions on a whole-farm level, taking into account the diversification of farming operations. The challenge for the researcher is to incorporate and deliver applicable knowledge across multiple, interrelated disciplines of physical-biological, socio-economic, and management dimensions that make up a farm system (Hoffmann, 2010).

By design, group discussions allow for a number of processes that enhance research output and decision-making. By grouping together participants of different disciplines and encouraging an environment of discussion and debate, individuals may come to realize there alternative perspectives. Bridging disciplinary boundaries encourages the exchange and fusion of knowledge. The sense of competition is removed and greater scope for knowledge sharing exists. The result is a merging of perspectives, collective learning as participants interact, and the opportunity to foster continued working relationships towards a common goal.

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3.6 Theory of a whole-farm model

Farming is an inherently risky business dealing with unpredictable climatic conditions. To minimise the exposure to risk, farm systems are often diversified. This causes the business of farming to be an increasingly complex operation and best analysed from a systems approach. An alteration in one component of the farm will impact other components and the farming system as a whole. The whole farm may also be impacted by attributes independent of the enterprises (Hoffmann 2010; Hammond, 2003; and Hardaker et al., 2004). It is therefore wise to conduct studies in a whole-farm context, rather than analysing individual components independently (Hardaker et al., 2004).

Whole-farm budgeting views the farming system as a whole, quantifying and subtracting fixed costs from the whole-farm gross margin to arrive at a net farm income value. Through the use of computer spreadsheet programs, whole farm budget models can handle complex calculations and express relationships, yet are adaptable and user-friendly. By adapting the model to incorporated multi-period budgets, the whole-farm model can be used to calculate returns on capital invested as well as profitability indicators such as Internal Rate of Return on capital investment (IRR) and Net Present Value (NPV) (Hoffmann, 2010).

The attraction of whole-farm budget models is that they are relatively simple to explain and understood by participants. Whole-farm budget models have the capacity to accommodate a large number of variables and relationships, and their performance indicators can be set by participants or according to the goal (Hoffmann, 2010).

Whole-farm budgeting is a form of simulation modelling. It is not designed to generate an optimal solution as mathematical programming models do. This is a common criticism of the whole-farm budget approach. A core requirement is a need for an intensive understanding of the system being modelled. This may be an initial drawback as not all researchers have such broad knowledge of the system. If the modeller is capable, then it will however increase trust in the model and method. If the modeller is prepared to learn it will build valuable relationships between participants.

There is often a separation between research knowledge and the producer due, essentially, to a lack of common understandable language. The use of whole-farm budgets breaks down this barrier and allows all disciplines to participate in a common goal. In combination with expert group knowledge it also is not necessary for everyone to understand the principles by which certain data and inputs are generated. The accuracy of the impact of inputs in terms of the farm system is however important.

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3.6.1. 'Typical farm'

The 'typical farm' forms the basis of normality as representative farm within a homogeneous area. The concept of a 'typical farm model' was introduced in the 1930's in the USA. As the importance of the relationships between variables, and within systems, became more apparent, the focus shifted from a production-cost approach to a whole-farm approach. The aim is to reduce the effect of outliers for example the exceptionally good and poor farms. The goal is to achieve the mode of, rather than the average, of the farms in a homogeneous area. This is with respect to size, profitability, management quality, access to markets, cropping systems, and cultivation practices (Hoffmann, 2010). A typical farm is defined as a farm representing what a group of farmers do within an essentially homogeneous area (Feuz & Skold, 1992).

The typical, whole-farm, approach can be used as a tool to assess farm profitability and evaluate the impact of changes in variables on farm-level profitability. The typical farm model should therefore able to effectively compare and evaluate the implications of specific managerial decisions and options, for instance capital investment. As a typical farm model operates hypothetically, it cannot be used to direct managerial decisions on a specific farm. However, it is possible to adapt the model to a specific farm to guide managerial decisions on that farm. The purpose of using a typical farm model in this research is to provide a basis of comparison for the expected impacts of specific scenarios. The main advantage of a typical farm model over farm surveys is that it is cheaper and less time consuming to undertake.

No two farms are exactly the same. As a result, the impact of the exact same set of factors on profitability for one farm may not mirror the impact on another. The typical farm model highlights the impacts of trends, strategies, and policy options on farm-level profitability (Hoffmann, 2010). General assumptions of available technology, market access, and management have to remain valid for a typical farm model to maintain its integrity (Carter, 1965).

A typical farm model is not derived from a specific set of data and is consequently devoid of personal information. The model components have to be established by incorporating the knowledge and opinions of producers and agribusinesses from within the homogeneous area. The typical whole-farm model and its individual components should then be validated by expert stakeholders such as scientists, producers, and economists.

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3.7 Conclusion

The farm is a complex system, comprised of many interrelated components, such as; the ecology, diversity of crops and livestock, mechanical processes, agrochemical management, financial and marketing systems, and issues of sustainability. A model is an ideal tool to simulate and evaluate such a complex system. In order for the producer to make an informed decision, an analysis of the entire system must be undertaken to understand the implications of decisions within certain assumptions. By using models to replicate the farm system in a computer program, complicated formulas can be designed to manipulate the data within the system parameters. It can also be used to evaluate the impact of specific possible changes on farm profitability by using scenarios.

To assess the implications of changes to a farm system, a typical farm is developed. The typical farm forms the basis of normality, the farm that would be the most common place, or the representative farm, within a homogeneous area. This forms the basis for comparison for differing farming systems to be evaluated.

A budget model has the ability to simulate a complex system, to evaluate future plans in both physical and financial terms, and is relatively easy to understand across various disciplines. By incorporating a multi-period budget, an extended period of time can be evaluated and the cash flow budgets provide the decision maker with the ideal source of data to base decisions on capital investment.

The agricultural system entails a variety of disciplines. It is important to incorporate expert knowledge from each specific related discipline. Multi-disciplinary discussion groups provide the ideal platform to generate knowledge on complex systems and to validate data and opinions across a broad field. There is often a gap in the understanding of knowledge between disciplines. Producers may not appreciate the relevance of meta-scientific and scientific knowledge and scientists may not grasp the complex interrelationships between the system components. By bringing together the various experts in varying fields, the gap between disciplines can be bridged to more fully comprehend the complexity of the system and validate data to generate comparisons within the system.

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Chapter 4: Financial analysis of Langgewens research data

4.1 Introduction

The complexity of a whole-farm system has been discussed in Chapter 3, highlighting the need to evaluate whole-farm profitability from a systems approach. The theory of systems thinking and modelling, as a means to effectively replicate and express the interrelatedness of the farming system, is then reviewed.

Chapter 4 will begin with a description of the Langgewens trials and a financial analysis of the trial data. Two sets of data were used, from trials conducted on Langgewens experimental farm by the Directorate Plant Sciences, Western Cape Department of Agriculture. The data was entered into a model that was developed to capture trial data and express it in enterprise budget format. Gross margins for the enterprises operating under differing cropping systems and tillage practices were developed and analysed to identify trends within the systems. This information was used as a basis for the expert group discussions attended by various experts with indigenous knowledge of the Middle Swartland area.

The last part of this chapter will explore the theory behind multi-disciplinary discussion groups describe how the budget model was built combining scientific data with knowledge from local agribusiness, extension officers, and producers operating in the Middle Swartland, and validated by experts in the group discussions. The various components of the model will be explained and the parameters of the typical Middle Swartland farm will be laid out.

4.2 Description of Langgewens research trials

For the purposes of this research, combinations of two research trial data sets have been selected for use. The combination is necessary as the trials used are not specific to economic research. However, by combining the data from the trials, it is possible to gain a more accurate simulation of practical farming systems taking place in the Middle Swartland and the costs involved. Thereby the derived gross margins can be simulated in a typical farm model to evaluate the implications of the differing systems.

Langgewens experimental farm is situated halfway between Malmesbury and Moorreesburg (-33.27665º; 18.70463º; altitude 191m) in the Western Cape Province of South Africa. Soils are predominantly Malmesbury and Bokkeveld shales, with a long-term average rainfall of 396.9mm (Wiese, 2013). The experimental farm experiences a typical Mediterranean climate; hot dry summer months followed by winter rainfall from April to mid-October.

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Both sets of trial data are taken from trials conducted on Langgewens experimental farm. The first trial is conducted with the aim of: *The identification of soil parameters as indicators of sustainable dry-land crop production systems for the shale derived soils of the Western Cape: tillage practice, soil quality and crop production*. The goal of this trial is to quantify the effects of tillage practice and crop sequence on soil physical and chemical properties, and soil biological activity towards gaining a better understanding of soil parameters that will promote sustainability in crop production systems on the shale derived soils of the Western Cape (Labuschagne, 2013). The trial started in 2007.

The experimental design and treatments applied to the trials consist of;

Gross plot size – 60 meters x 20 meters

On each plot there are 3 crop sequences, each in a four year cycle;

1. Continuous wheat: WWWW
2. Wheat/medic/wheat/medic: WMWM
3. Wheat/lupin/wheat/canola: WLWC

All crop sequences are fully represented each year (i.e. seven whole plots per replication), and four replications of each whole plot in a randomized plot design, as shown in Annexure B.

There are four sub-plots on each whole plot, of size – 30 meters x 10 meters. Each sub-plot consists of a different tillage practice, namely;

1. Zero-Till – soil left undisturbed and planted with a Star wheel planter (planter places seed with minimal soil disturbance),
2. No-till – soil left undisturbed and planted with a tined planter that results in a maximum of 20 percent soil disturbance to a depth of 100mm to 150mm in the planting row,
3. Minimum-till – soil is scarified to a depth of 100mm to 150mm in late March/early April and then planted with the no-till planter described in 2, above,
4. Conventional-till – soil is scarified to a depth of 100mm to 150mm in late March/early April, then ploughed to a depth of 150mm to 200mm just before planting, and planted with a no-till planter described in 2, above.

All straw, chaff and stubble remain on the soil surface in all tillage treatments.

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Since the main aim of the trial is to evaluate long-term effects on soil parameters it is important that the same inputs are made to all replicates of each of the individual treatments.

The second trial is conducted by Dr. Strauss of the Department of Agriculture, Western Cape, titled: *An investigation into the production dynamics of eight crop rotations systems, including wheat, canola, lupins and pasture species in the Swartland, Western Cape*. This trial, also conducted on Langgewens experimental farm, has the specific aim of determining the short-term and long-term effects of eight of the most feasible crop and crop/pasture rotation systems identified for the Swartland on; crop yields, weed control, disease suppression, soil production potential, sheep production, and economically sustainable land use.

The experimental design encompasses eight crop rotation treatments, fully represented each year and replicated twice, in a random block design. The whole experiment operates under a No-tillage practice. With a total experimental area of 50 hectares divided up into 38 camps, each camp comprising a minimum or maximum size of 0.5ha or 2.0ha respectively. Each year there are 10 medic camps with a grazing herd of 66 sheep, divided over the medic camps according to each of the pasture system requirements.

The eight rotations selected for the experiment are:

- System A – Wheat, Wheat, Wheat, Wheat
- System B – Canola, Wheat, Wheat, Wheat
- System C – Wheat, Canola, Wheat, Lupins
- System D – Wheat, Wheat, Lupins, Canola
- System E – Wheat, Medic, Wheat, Medic
- System F – Wheat, Medic/Clover, Wheat, Medic/Clover
- System G - Medic, Wheat, Medic, Canola
- System H – Wheat, Medic/Clover, Wheat, Medic/Clover (With saltbush pastures)

No-tillage is the only tillage practice used in the experiment, as defined above no-till is - soil left undisturbed and planted with a tined planter that results in a maximum of 20 percent soil disturbance to a depth of 100mm to 150mm in the planting row.

4.3 Formulation of trial data to financial budgets

Data from the Langgewens trials are captured in the form of excel spreadsheets. The data listed crop rotation and yield achieved in a particular year on each specific trial plot. A separate excel spreadsheet comprised the activities related to each year and the specific plots, these activities would include land preparation, planting, applications of fertilizer, pesticides, fungicides, and

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herbicides, harvesting and their relevant dates. The relevant prices of inputs used in each year were also made available.

This data was then organized into a single excel workbook to evaluate the costs of production and the relative gross margins of the differing systems from 2007 to 2013. The initial stage of the gross margin model development was to capture the yield data for all the years on a single spreadsheet named ‘crop systems’ as shown in Annexure C. This spreadsheet records the yields achieved under different tillage practices (zero-till (ZT), no-till (NT), minimum-till (MT), and conventional-till (CT)) in the years 2007 to 2013 shown in the columns, the rows express the rotations each of which consist of four repetitions (Rep1, 2, 3, 4), and finally the averages for the four repetitions are surmised at the bottom, these calculated average yields are used in the gross margin analysis.

For clarification purposes, some accounting terms will be briefly defined. The gross margin (GM) of an enterprise is defined as the gross production value less variable costs. The gross production value (GPV) is defined as the total value of production from that enterprise derived from only the marketable output. Variable costs represent the proportion of total costs that vary in proportion to changes in the scale of the enterprise. The variable costs are subdivided into directly allocatable and non-directly allocatable costs. Directly allocatable costs refer to variable costs that can be realistically allocated to the enterprise without having to keep detailed records, for example; fertiliser, chemical, and seed costs. Non-directly allocatable costs in contrast refer to variable costs that can be realistically allocated to the enterprise if detailed records are kept, for example, machinery costs (Department of Agriculture, 2005).

The gross margin model comprises a number of spreadsheets to capture the necessary data to calculate the total production income, directly attributable costs, and the non-directly attributable costs for each year and specific crop rotation under individual tillage practices. These spreadsheets included:

- Mechanisation – this data was derived from the ‘Guide to machinery costs’ released annually by the Department of Agriculture, forestry, and fisheries (DAFF), South Africa. For each annual gross margin analysis the respective year of guide to machinery costs was used. Refer to Annexure D.
- Crop Systems – Derived from Langgewens trial data as described above.
- Prices of commodities, fertilisers, and chemicals – all the prices of the inputs and sales of produce were recorded and captured by the Langgewens farm management team on an annual basis.

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- Gross Margins – calculated gross margins of each crop rotation under each tillage practice, as shown in Annexure E.

- Summary of costs and margins – calculated from the gross margin analysis, as shown in Annexure F.

On analysis of the yields harvested from the Langgewens trials conducted by Dr. Labuschagne, from 2007 to 2013, it was seen that there were very erratic results from the zero-till trials. On consultation with Dr. Labuschagne and Dr. Strauss, it was decided that the data be omitted, although it is a viable practice under the climate experienced in the Middle Swartland, the equipment used is outdated. The reason for the erratic results is that the planter used for the zero-till trials was a star wheel planter and, as there is minimal disturbance of the soil, the herbicide 'Trifluralin' could not be applied at planting, resulting in rye grass weeds out-competing the wheat and drastically reducing yields. In practical terms under zero-till, the wheat seed is placed into the ground when one end of the star spike on the star wheel planter makes a hole in the soil. As there is minimal soil disturbance, if Trifluralin was applied at planting, the seed would come into contact with the herbicide and die. Figure 4.1 depicts the reduced yields experienced under zero-till, shown by the red bar (ZT).

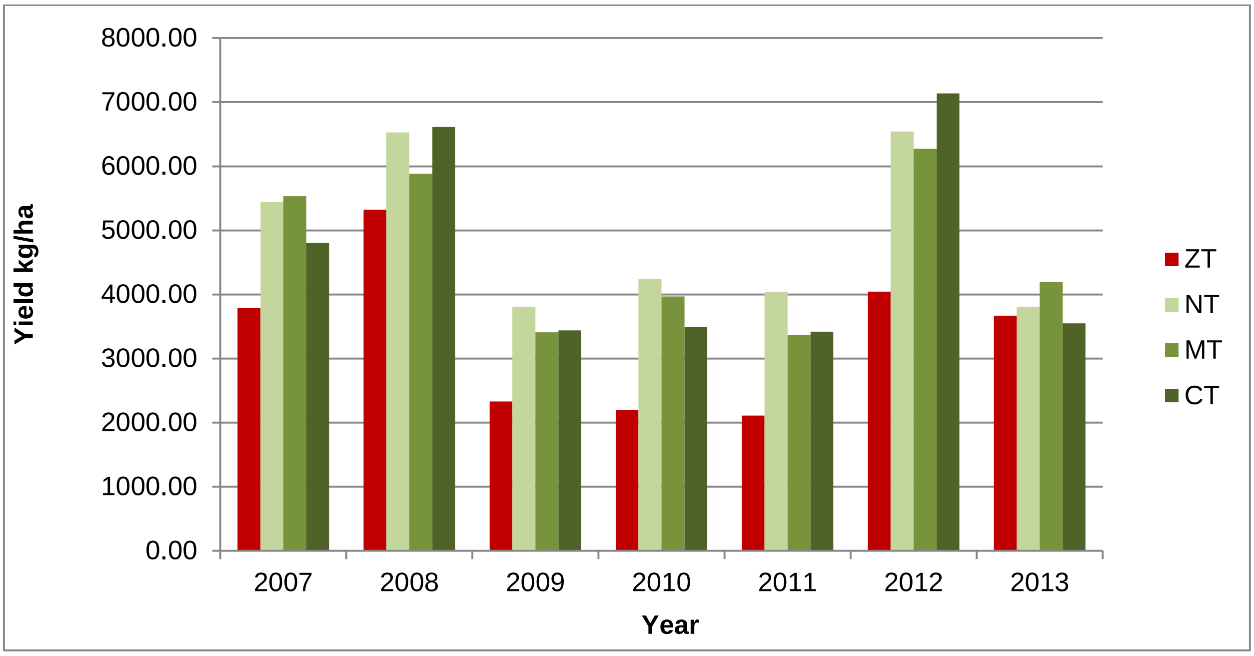


Figure 4.1: Wheat yields under differing tillage practices, 2007-2013

4.4 Analysis of differing tillage systems within differing crop rotations

The trials conducted at Langgewens are specifically designed to measure the effects of tillage and rotation systems on the soil health. As such, the trials require a blanket effect of all activities above the surface. As a result, the crop yields are very erratic and in some instances, where weeds have out-competed the wheat, yields were not recorded. This makes it very difficult to directly analyse the financial outcomes of the cropping systems as the trials were not designed or intended for economic analysis. What does stand out from the financial analysis is the evidence of reduced input costs and increased yields under crop rotations. This is in line with the principles of CA.

Figure 4.2 shows the average non-directly allocatable costs for the three tillage practices; no-till (NT), minimum-till (MT), and conventional-till (CT), under the three rotation systems, based on the Langgewens crop trials. There are two sets of data for the rotation of wheat, canola, wheat, lupin (WCWL). The two graphs depict wheat following canola (LWCW), and wheat following lupin (CWLW). Below the non-directly allocatable cost graph, is the corresponding average gross margin for the same crop within the crop rotation and tillage practice. It is clear evidence of a reduction in non-directly allocatable costs. This is because CA tillage practices constitute lower mechanical costs due to less movement over the field.

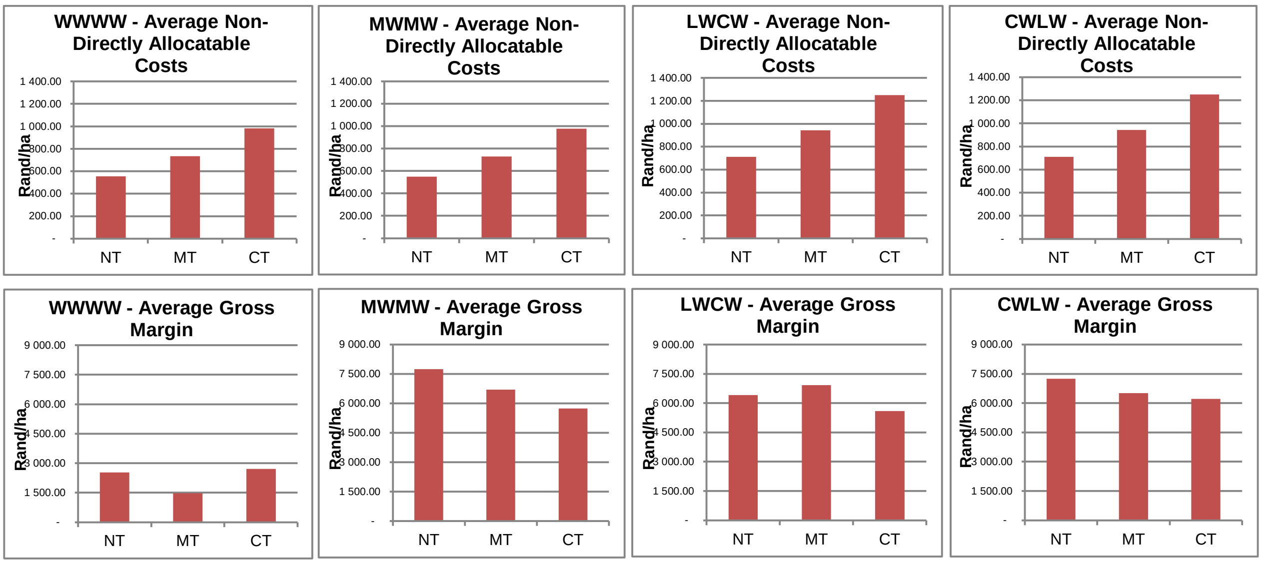


Figure 4.2: Trends in the non-directly allocatable costs and the gross margins of crop systems

The effect of the introduction of crop rotations into the system is increased yields experienced on wheat followed by legumes crops, such as medics and lupins, and also canola. Wheat monoculture achieved the lowest and most erratic yields through the years 2007 to 2013. It also performs the worst on the gross margin analysis as shown in Figure 4.3.

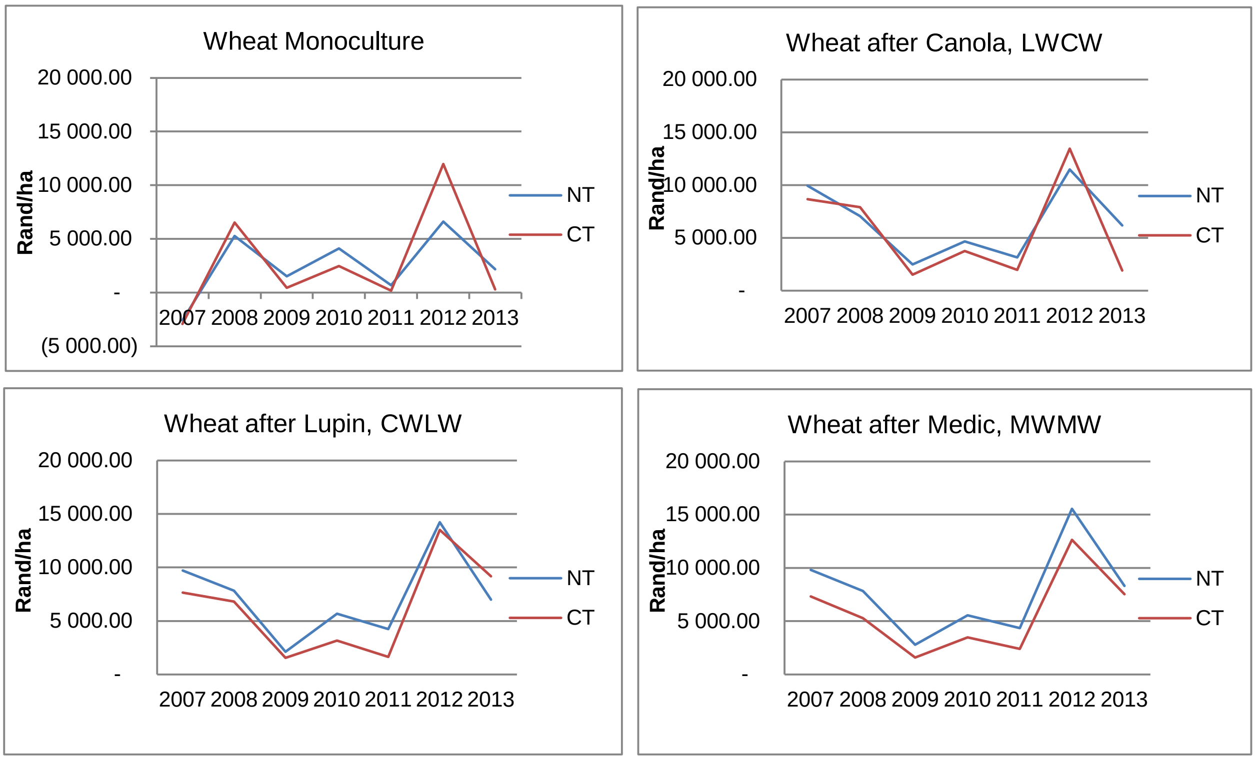


Figure 4.3: Gross margin for wheat in different systems as calculated on the Langgewens trial data

Wheat, under the monoculture system in 2007, showed a negative gross margin due to no yield data as wheat was out-competed by rye grass weeds and was not harvested. Rye grass is a grass variety that is prevalent in the Middle Swartland area and competes with wheat. Both wheat and rye are grass varieties, there are subsequently no herbicides that can control one without affecting the other.

The increased crop yields from rotations, combined with the reduced non-directly attributable variable costs, experienced under no-till, generate a significantly higher gross margin for the CA system than that of a conventional system of wheat monoculture and conventional tillage. It should also be highlighted that no-till consistently achieves a higher gross margin during the low rainfall seasons, as experienced from 2009 to 2011.

Conservation agriculture advocates increased production through rotations by suppressing weeds with the use of alternating herbicides. During wheat production broad-leaf weeds can be targeted with specific grass herbicides. When the rotating broad-leafed crop (medics, lupins, or canola) is planted, herbicides can be used to target grasses such as rye grass. During the following year's wheat crop there is less competition from grass weeds such as rye grass, as the seed bank has been suppressed the previous year. In contrast, in a wheat monoculture system, there are few herbicides that are able to effectively control rye grass without negatively impacting wheat germination. 'Trifluralin', a pre-emergent herbicide, is designed for the control of rye grass in cropping systems. However, Trifluralin should be applied to the soil prior to planting and contact with the wheat seed should be avoided as the chemical has a negative effect on the seed germination.

When the same herbicides are used continuously weeds develop tolerance or resistance to the active ingredients in the chemical, and within a period of twelve years, some cases even quicker, can render the herbicide ineffective. By alternating herbicides with crop rotations, the effective period of herbicides can be extended and the gene pool of tolerant and resistant weed seed can be reduced during the rotation crop phase. Figure 4.4 shows the reduced yields experienced under wheat monoculture. The lack of yield data shown in 2007 is due to the crop being out-competed by rye grass and was subsequently written off.

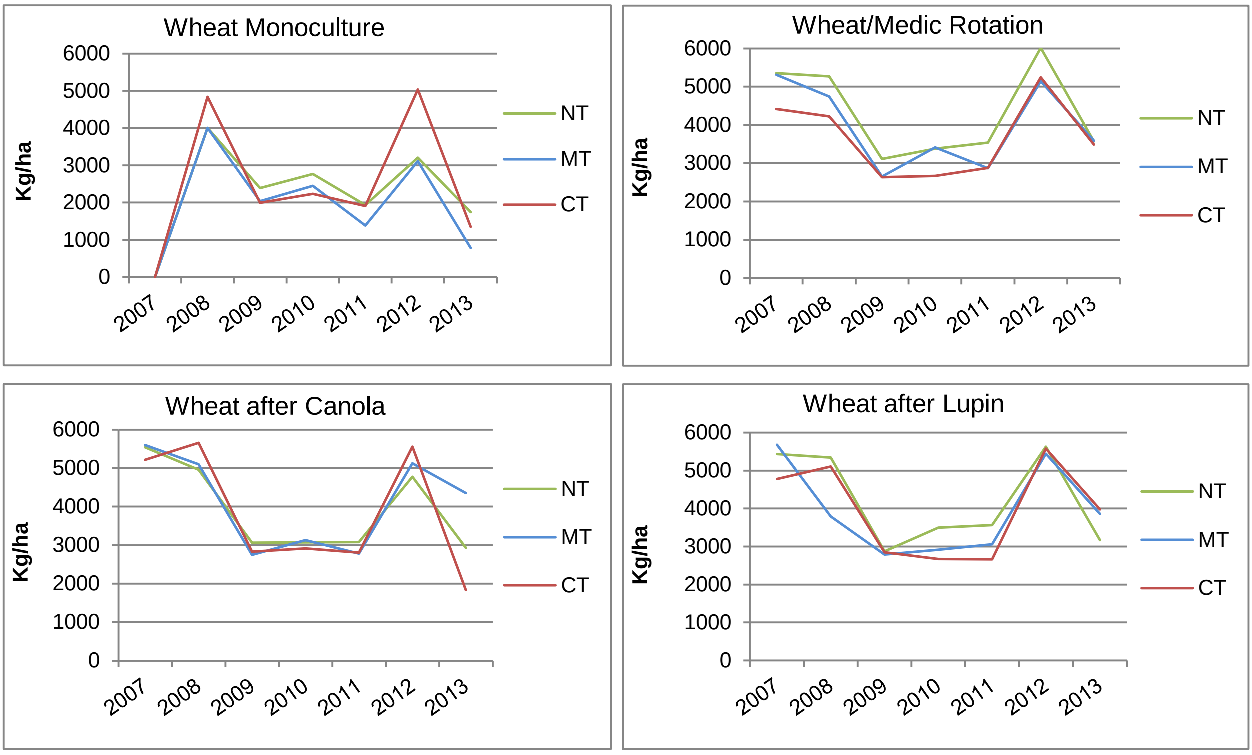


Figure 4.4: Wheat Yields from Langgewens Research Trials under crop rotations and differing tillage practices, 2007-2013.

Wheat after medics achieves the highest yields throughout the period with wheat after lupins also showing higher yields than wheat monoculture. Rotation systems also depict less erratic responses to poor rainfall seasons experienced from 2009 to 2011.

The concerns of loss in income, through incorporating crop rotations into the farming system, have been overcome with the introduction of broad-leaf crops such as canola and legumes such as lupins. Another alternative is livestock operations under pastures such as sheep on medics. The market for canola, initially introduced in 1996, has grown over the last eight years, establishing canola as a viable cash crop. Improved agronomic practices, suited to the specific environment in the Middle Swartland, and improved yields through better seed varieties, have increased the attractiveness of canola as a rotation crop and a cash crop.

Lupins initially gained popularity in Western Australia in the 1980's as a rotational crop through the proven benefits to following wheat crops. The market for lupin beans is limited and although the benefits to crop rotation are apparent the current production values are not viable (Sweetingham & Kingwell, 2008). Figure 4.5 depicts the yields achieved on Langgewens trials for both canola and lupins. In the case of lupins, some years resulted in no yields due to unfavourable conditions and lack of experience in cultivation of lupins.

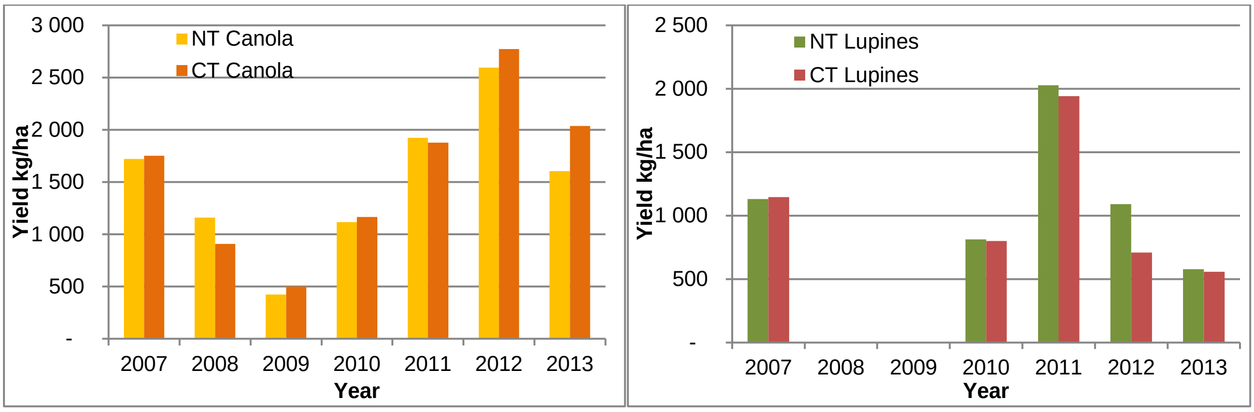


Figure 4.5: Canola and lupin yields from Langgewens Research Trials under differing tillage practices, 2007-2013.

The corresponding gross margins shown in Figure 4.6 highlight the potential gross margin from rotational crops such as canola and lupins.

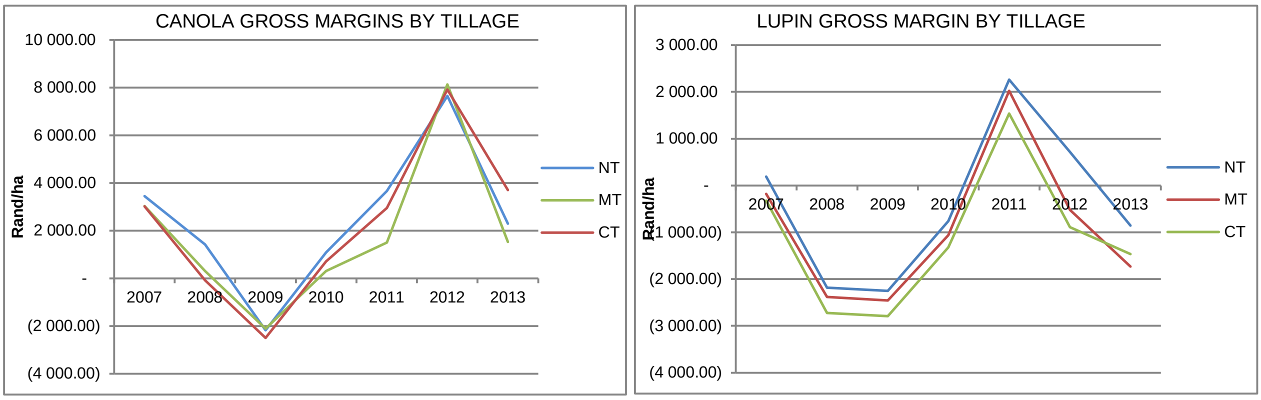
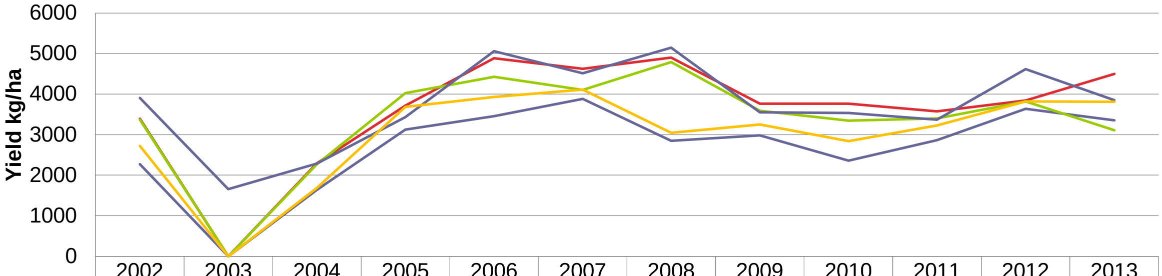


Figure 4.6: Canola and Lupin gross margin by tillage

The evidence of reduced non-directly allocatable costs related to tillage practice under CA is highlighted in Figure 4.2. This supports the literature reviewed in Chapter 2. Considering directly allocatable costs such as fertilizer and agrochemical applications, no allowance has been made in these trials according to the tillage and rotation system applied. The reason for this is the specific focus of the trials being on soil health and biology, which necessitated that all inputs accept tillage practice be kept constant. According to literature reviewed in Chapter 2, and the experience of producers expressed in the group discussions (Annexure G), there are grounds for adapting the applications of inputs according to both tillage and crop rotation practices. As expressed earlier the aim of these specific trials at Langgewens experimental farm was to measure soil health and not for the purposes of financial or economic evaluation. For this reason, it was necessary to incorporate the data from trials conducted with focus on the financial analysis of crop rotations under no-till.

There is concern that yields achieved in small intensive trials are not always representative of a whole-farm environment. Certain losses involved in agronomic practices over a large area of land as well as varied soil types which cannot be compared to a plot of 0.12ha. As a result it is imperative to substantiate and validate the findings from the research trials. This was achieved with the expert group discussions that included experiences of farmers and academics from within the specific Middle Swartland area. The discussion group consisted of a multi-disciplinary group of experts including; producers, soil scientists, agronomists, agricultural economists, and mechanical specialists. The purpose of the group discussion was to analyse the data and give advice on its relevance according to their experience.

The Langgewens crop rotation trials began in 1996 and are still active. The data consists of eight crop rotations under no-till practices as expressed earlier in this chapter. For the purposes of this research only four of the rotations have been used, namely wheat monoculture (WWWW), wheat, lupin, wheat, canola rotation (WCWL), wheat, medic rotation (WMWM), and canola, wheat, wheat, wheat rotation (CWWW). Figure 4.7 highlights the impact of rotation on a cropping system. Wheat monoculture achieved consistently lower yields than wheat in rotation. In 2003 the Western Cape experienced a severe drought resulting in the wheat crops being abandoned. The only harvestable wheat crop was that of wheat in rotation with medics.



	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
WWWW	2270	0	1643	3124	3452	3879	2851	2979	2356	2859	3636	3355
CWLW	3393	0	2296	3716	4884	4625	4899	3761	3761	3573	3839	4501
LWCW	3371	0	2269	4024	4429	4100	4791	3591	3343	3402	3820	3109
MWMW	3907	1655	2291	3433	5061	4509	5147	3551	3536	3369	4613	3854
CWWW	2725	0	1687	3686	3930	4107	3045	3253	2839	3227	3821	3813

Figure 4.7: Wheat yields under no-till in different crop rotation systems from 2002-2013

The yield and input cost data was captured in enterprise budget models designed to relate the physical input/output quantities into gross margins. Figures 4.8, 4.9, and 4.10 depict the three main components that make up a gross margin; the gross production value, directly allocatable costs, and not-directly allocatable costs. The trend seen throughout is the reduced costs experienced in crop rotations as opposed to wheat monoculture. Figure 4.8 shows the gross production value of the three cropping systems. The GVP of wheat monoculture is relatively erratic compared to wheat rotated with medics.

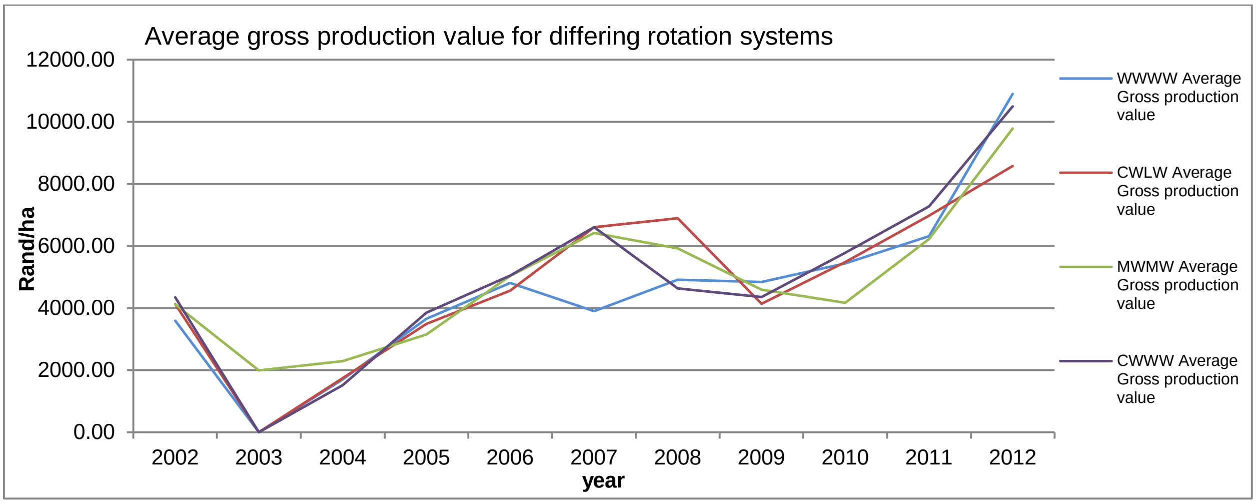


Figure 4.8: Average gross production value of different crop rotation systems from 2002-2012

Figure 4.9 shows the effect of crop rotation on directly allocatable variable costs for the four rotation systems, on a R/ha basis, over a period 2002-2011. The wheat medic rotation has consistently lower average directly allocatable variable costs. The gap appears to be widening the longer the time period progresses. The directly allocatable variable cost for the wheat in rotation with canola and lupins systems are marginally higher than wheat with medics. It is, however lower than that of wheat monoculture. Wheat three years in rotation with canola shows relatively high allocatable variable cost, similar to wheat monoculture. A contributing reason is that the canola year is used as a weed bank control year, whereby, effective and expensive herbicides are used to eliminate grass weeds.

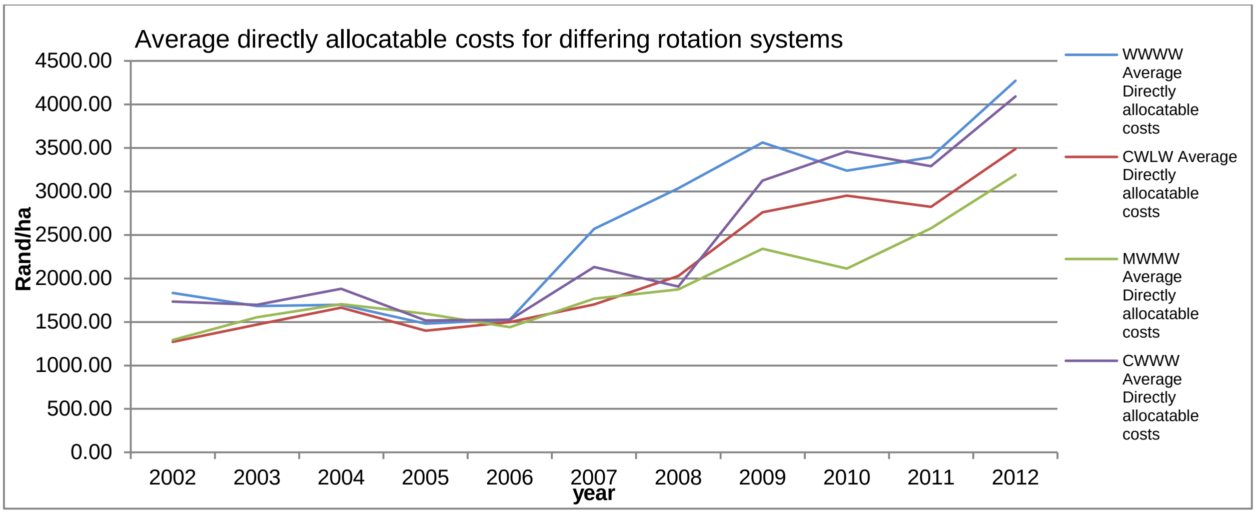


Figure 4.9: Average directly allocatable variable cost of different crop rotation systems from 2002-2012

The costs of machinery repairs and maintenance, activity of applying agrochemical, and tillage practices are represented by the non-directly allocatable costs. Figure 4.10 supports the trend already seen in trial results depicted in Figure 4.2 which also showed lower non-directly allocatable variable costs in wheat under rotation. Figure 4.10 shows the consistently reduced costs of wheat in rotation with medics.

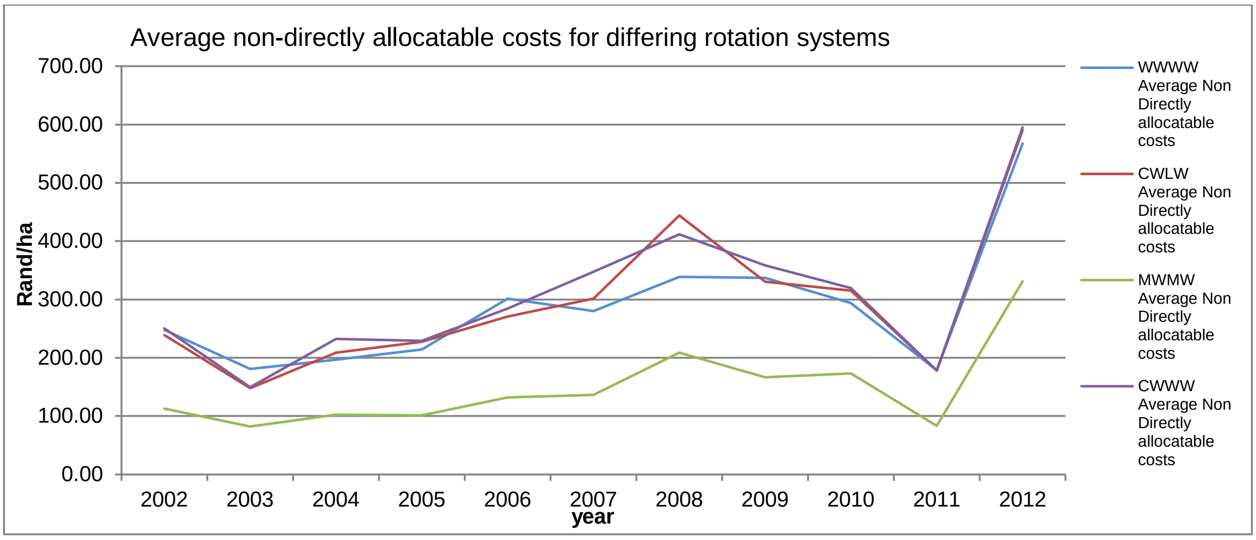


Figure 4.10: Average non-directly allocatable variable cost of different crop rotation systems from 2002-2012

Figure 4.11 shows the gross margins per hectare achieved under each crop rotation system. The consistent yields and low input costs of wheat in rotation with medics are depicted in a less erratic and more stable curve. Wheat monoculture is relatively more erratic with dips and peaks resulting in a lower cumulative gross margin as shown in Figure 4.12.

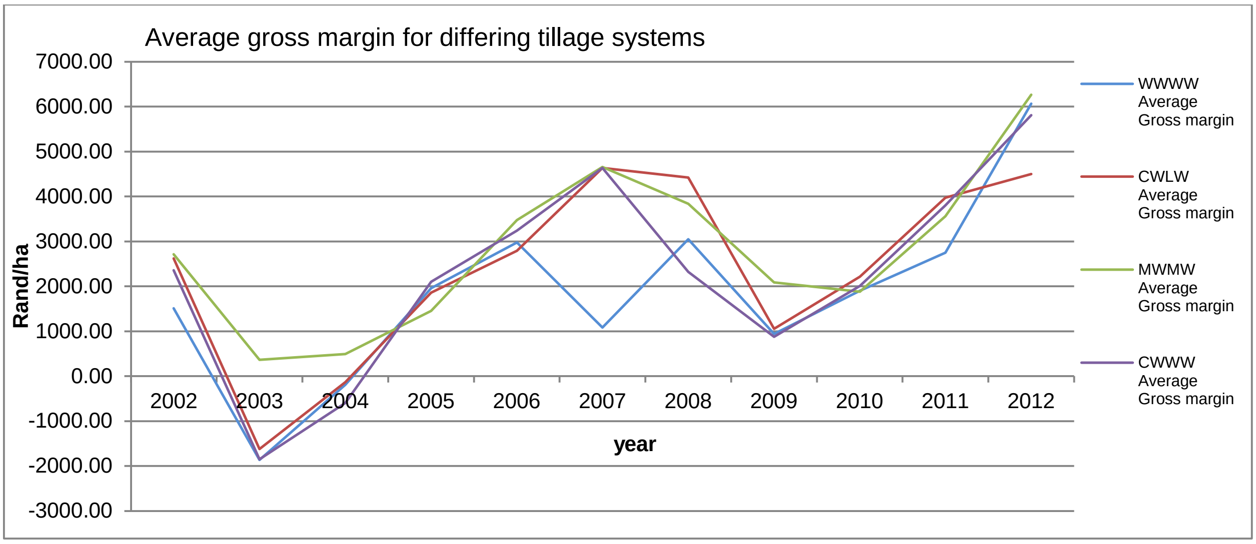


Figure 4.11: Average gross margins of different crop rotation systems from 2002-2012

Over the 10 years from 2002 to 2012, the cumulative production values of the three cropping systems are fairly similar with wheat monoculture being marginally lower. Figure 4.12 illustrates the trends, seen over the 2002-2012 period, of lower variable costs experienced under crop rotation systems and the consequent relative higher gross margins.

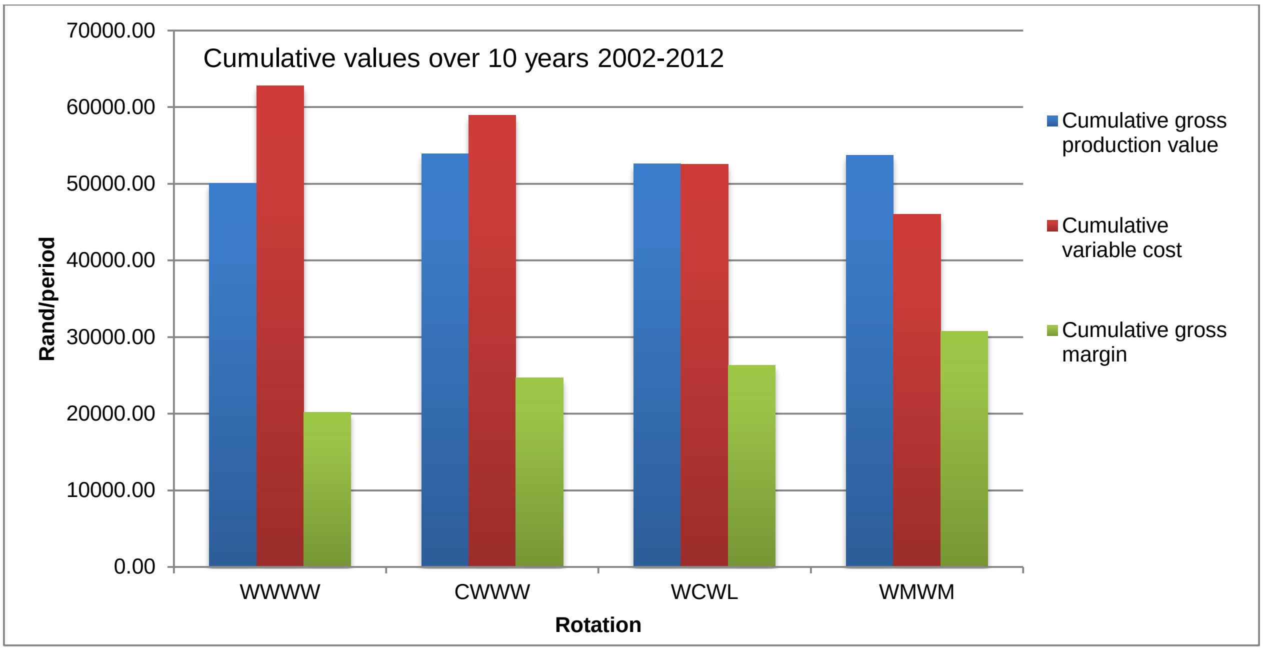


Figure 4.12: Cumulative gross production value, variable cost, and gross margin per system, for period 2002-2012.

4.5 Whole-farm level financial implications of the alternative systems for the Middle Swartland area

The complexity and number of interrelated processes, typically found on a farm, have been discussed in Chapter 3. The need was expressed for a combination of lay knowledge, in the form of practical experience, and scientific knowledge, gained through research. For this reason, a multi-disciplinary group discussion was used to comprehend the implications of individual components of the whole-farm budget model.

Figure 4.13 shows a schematic representation of the research process, highlighting the development and validation stages of the budget model. During all phases of model development expert knowledge from various domains was utilized, bringing together the opinions of scientists and producers.

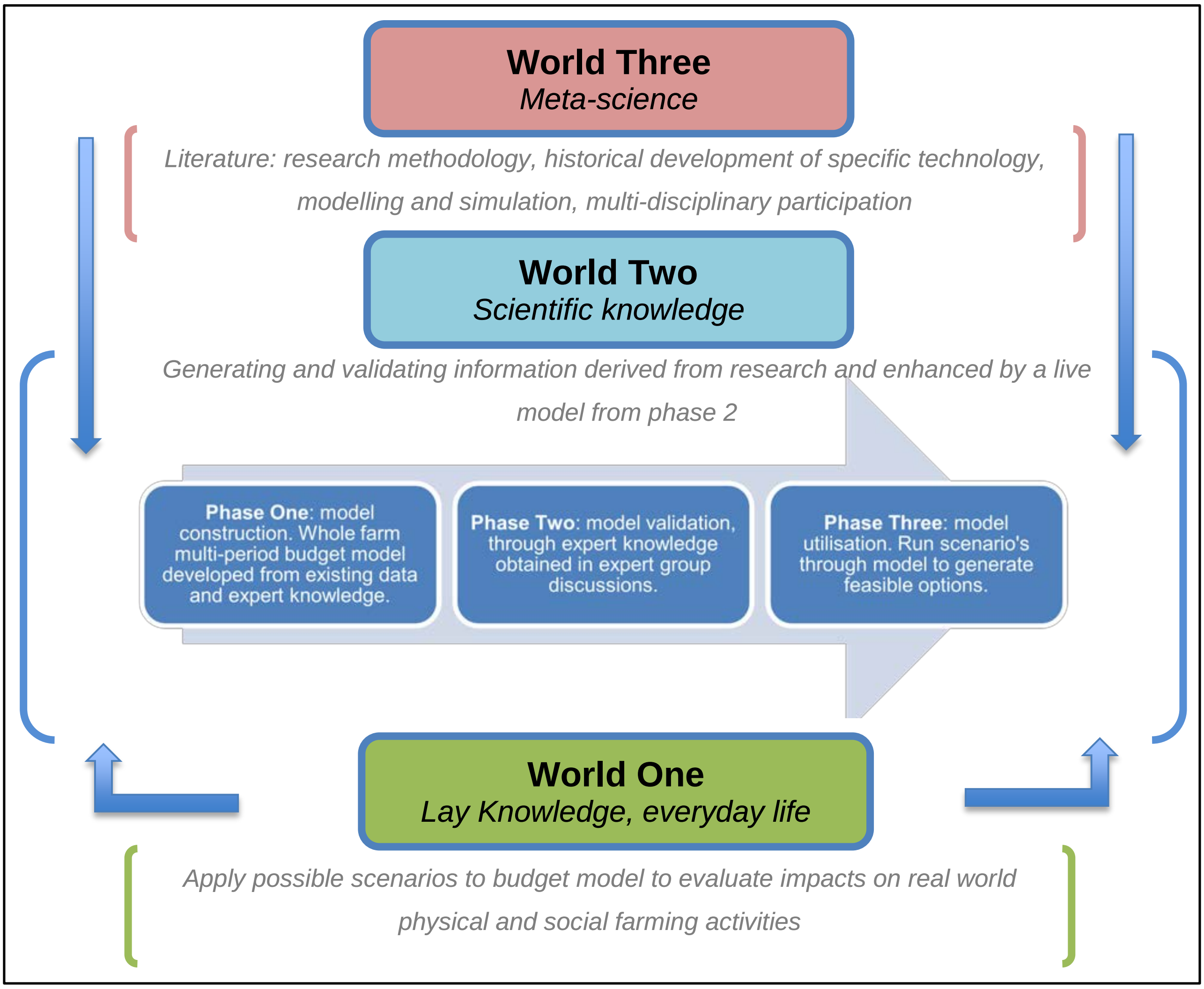


Figure 4.13: Schematic representation of research undertaken and model development: Source: Adopted from: Hoffmann, 2010

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To evaluate and compare the financial implications of alternative available options in terms of production systems on whole-farm profitability the current financial situation of producers is used as a benchmark. The complexity of the entire farming operation can best be expressed in a whole-farm budget model, which could incorporate both physical-biological factors and socio-economic factors, expressed in financial terms. The dimensions of the current whole-farm budget model serve as the basis for comparing alternatives. These dimensions were based on sources such as; national statistics, research data, producer study group data, and technical producer guides. The parameters of the budget model require validation, which was done through the expert group discussions.

The research project drew on all three levels of knowledge, meta-science, scientific, and lay knowledge expressed in Figure 4.13, to evaluate feasible profitable, production options in the specified area. The methods and literature review draws on the meta-scientific knowledge base to comprehend the role of research. The construction and validation of the budget model through the use of research data and expert knowledge, forms the scientific research. The application and use of the model together with producers to specify the financial implication of various scenarios is based on lay knowledge. The aim of the research is application in a real world context.

The research data conducted at Langgewens experimental farm forms the basis of the scientific knowledge. The research data is limited in its application in the real world context as the experiments are carried out on a small scale, over a limited area and time and with specific soil health goal in mind. There is, therefore, need to validate the data generated from the research trials as well as information from producer guides. By bringing together experts from different disciplines a validated set of data can be generated to be used in the modelling and simulation. The group also establish and quantify the factors and interrelationships within the whole-farm system. Consensus within the group is the yardstick for validating a specific point. During this research project, two expert group discussions were held. The minutes of which are shown in Annexure G.

Simulation modelling, especially budget models, necessitates a thorough understanding of the object of study, in this case the typical farm. Irregular data entry will generate incorrect measurements of profitability and misinterpretation of the impact of factor variations, due to the interrelatedness and causality of the system components of the model. Therein lies the trustworthiness and level to which producers will associate to the model. In the case of this research, expert knowledge from producers and scientists were incorporated into the construction of the model. The group discussions, aimed at validating the findings of the trial research and the dimensions of the whole-farm model included: wheat producers from the Middle Swartland area, as well as scientists from various disciplines, such as agronomy, soil

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science, and mechanization. A list of attendance and minutes of the group discussions are shown in Annexure G.

The producers contributed to the physical description of the typical farm, farm inventory, and crop rotations. They also brought insight into factors, both internal and external, influencing farm level profitability. This influenced the choice of relevant scenarios applied later during the use of the model. Producers also imparted practical knowledge of the sequence of mechanical requirements for the different tillage and crop rotation systems.

The scientists provided valuable knowledge of input-output relationships as well as accurately quantifying the expected sensitivity of certain variables on whole-farm output. Scientists were selected from fields of soil science, agronomy, and plant pathology. They contributed on yield effects of specific cultivation practices, input levels within specific crop rotations, and the relationship between yield and rainfall. The scientists that were selected had previously conducted research in the Middle Swartland area. They consequently understood the whole-farm situation.

Agricultural extension officers from local agribusiness are exposed to broader industry-level issues and relate directly with a variety of producers on specific technical issues, challenges, and production methods. They also have access to producer study-group data which incorporates various producer profiles. Agricultural extension officers contributed to the construction of the typical farm inventory, field capacities of various machines and implements, identifying the relative homogeneous farm area of the Middle Swartland, and highlighting limitations in suggested strategies on an industry level.

The role of agricultural economists was to translate physical-biological and socio-economic data into financial data. The knowledge gained reviewing the experiences from other geographical areas that converted to CA production, described in Chapter Two, contributed towards suggestions and ability to point out possible flaws in suggestions. The agricultural economists also focused the group's discussions on factors that influence profitability. Such factors include; capital investment requirements, expected life and age of machinery, input costs associated with specific production methods, and crop yields. Agricultural economists also sensitises the group to a wider understanding of international trends, policy issues, and social responsibility both to rural development and the environment.

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4.5.1. Defining the homogeneous grain producing area

The expert group suggested that the point of departure for the description of a homogeneous production area should be the Langgewens experimental farm. The Langgewens experimental farm lies roughly in the centre of the Middle Swartland. Characteristics defining a homogeneous area include; climate, terrain and soil type, and farming practices. The climatic conditions in this area are characterized by rainfall between 250-450mm in the winter between April and mid-October, with typically dry hot summers. The soils are predominantly Malmesbury shale, consisting of shallow sandy-loam soils. The area is a traditionally wheat producing area with rotations of canola and lupins. Medic pastures for sheep are also rotated with wheat. The terrain is mainly rolling plains with moderate gradients.

Using a previously identified area of the Middle Swartland (Hoffmann, 2010), the expert group decided that the area of homogeneity should be extended. The area was extended to the west to incorporate an area west of the N7 highway and north to an area known for poorly cultivatable sandy soils. The agreed Middle Swartland area is depicted in the maps presented in Annexure A.

4.5.2. The structure of the whole-farm, multi-period budget model

Quantities and prices of inputs and outputs have the greatest impact on the profitability of a typical farm. On-farm management can influence quantities of inputs and yields, however exogenous factors are beyond the influence of the individual producer or even producer groups, and are typically determined by market and macro environments (Hoffmann, 2010). The potential impact of these factors on the profitability of the typical farm was achieved by developing a whole-farm, multi-period budget model. This model would firstly determine the current financial position of the typical farm. Secondly, be used to compare the financial implication of alternative production systems and thirdly evaluate the profitability impact of exogenous variables in the form of scenarios.

The budget model can accommodate numerous variables including; input costs, replacement of machinery, investment in new machinery, different crop rotation systems, farm size, and own versus borrowed capital ratios. The model follows a three-phase process in evaluating the data and calculating the output. Figure 4.14 illustrates these phases.

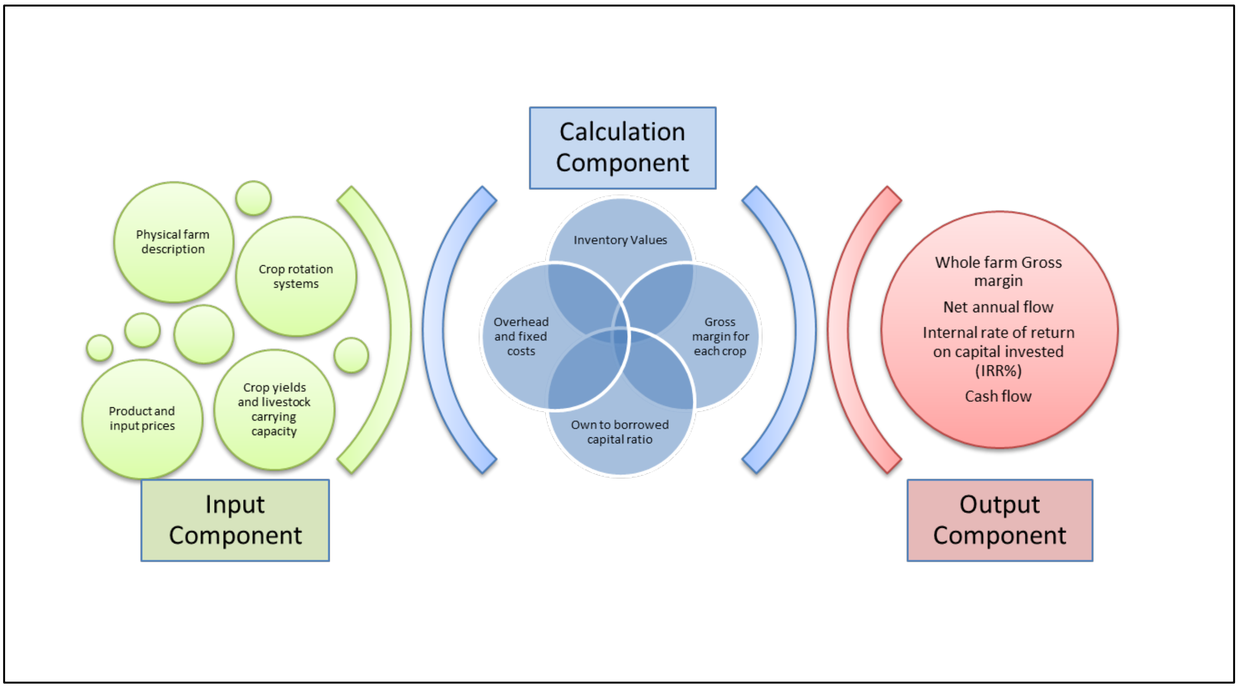

Figure 4.14: Graphic representation of components of a whole-farm, multi-period budget model: Source: Adapted from: Hoffmann, 2010

4.5.3. The input component

The input component includes data which forms the parameters of the whole-farm budget model. This includes; the physical farm description, farming practices and crop rotation systems, yield assumptions, and input and output prices. These factors can be modified which will immediately alter the output component.

4.5.3.1. Physical farm description

The aim of identifying a typical farm is to provide a basis to which farmers in a homogeneous area can relate. This is done by mimicking a farm on the most common physical farm parameters found in the area. Using the mode rather than the average of farm factors, gives the most frequently occurring farm and remove the misleading effects of outliers. The initial description of the typical farm was based on previous research studies (Hoffmann, 2010 and (ARC, 2014), and combined with producer study-group information. These assumptions needed to be validated as participants in study-groups do not always represent a true reflection of the broader producer population. These assumptions were presented to the expert group who, on the basis of consensus, agreed on the final descriptive parameters of the typical farm.

Within the whole-farm model, the typical farm size forms the basis for numerous other factors. These include, among others; area cultivated, land utilization, mechanization, labour requirements, and investment in fixed improvements.

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Other factors that affect the profitability of the typical farm include; the proportion of arable land and land is utilization. Farms have a portion of land that is not arable; this may include rocky areas, roads, riverbeds, steep inclinations and set-aside conservation areas. In the case of crop rotations the land utilization will determine the number of hectares under each crop or pasture. The budget model can be adapted to varying areas under each crop in the rotation A series of excel formulas automatically adjust the number of hectares under cultivation for each crop in the rotation on the whole farm. This calculates a whole-farm profitability result for a specific combination of crops within a given crop rotation system.

The typical farm is also described in financial terms in the form of an inventory or asset register. The farm inventory typically includes values for land, fixed improvements, machinery, equipment, and livestock, all of which are dependent on farm size. The relevant sizes and capacity of these factors of production, in respect to farm size, where initially derived from grower guides, and personal correspondence with manufacturers and producers. Later it was validated during the expert group discussions.

4.5.3.2. Crop rotation systems

Adopting crop rotation systems is one of the three pillars of CA and enhances sustainable land use. Wheat monoculture was the predominant cropping system practiced in the Middle Swartland until the late 1980's when rotation crops were introduced in response to declining wheat yields and land degradation (Heroldt, personal communication, 2014). The benefits of crop rotation systems have been well documented. Ultimately it lead to an increase in successive crop yields for a number of reasons including:

- Legumes such as alfalfa and medics are known to increase soil fertility through nitrogen fixation (Hoffmann, 2010).
- By alternating broad-leaf crops with grasses, weeds and diseases can be isolated and controlled with agrochemicals. This reduces the seed bank, as well as fungal and bacterial diseases in the soil. By alternating herbicides, weed tolerance to specific chemicals can be reduced, so prolonging the effective life of herbicides.
- Through diversification producers exposure to risk can be reduced, the cash flow can be stabilised by incorporating livestock, resulting in increased whole-farm profitability over the longer period (Hoffmann, 2010).

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The crop rotation systems that were initially proposed were based on experience from Langgewens experimental farm crop rotations trials, grower guides and personal communications with producers in the Middle Swartland. The rotation systems were proposed to the discussion group and accepted as the three most commonly practiced broad farming systems used in the Middle Swartland.

Wheat still forms the basis of the rotations used in the Middle Swartland. The three rotational systems used for comparison included; a wheat monoculture system, wheat in rotation with canola and lupins, and wheat in rotation with medic pastures for sheep.

- Wheat, produced mainly for human consumption, is the traditional and still the most common crop produced in the Middle Swartland. One of the principle benefits of introducing rotations to the system is to reduce weed infestations due to continuous cropping and to prevent weeds building-up tolerance to herbicides. Wheat monoculture, achieves poor yields in no-till and higher yields in CT, when compared to wheat in rotation. This is due to poorer weed control caused by mono-cropping, as herbicides are not alternated during a broad-leaf phase. In monoculture system weed control still depends on mechanical actions, which is less in no-till cultivations. These two factors contribute to less effective weed control which benefits CT in a mono-cropping system. This is against the principles of CA.

- Canola is a broad-leaf crop, originally introduced as a rotational crop. Oil, extracted from the seed is used in cooking and the animal feed industry, because of the high protein content of canola oilcake. The main benefits of canola in the rotation are increased yield in wheat crops following canola compared to wheat following wheat. Canola has lower input requirements compared to wheat. As a broad-leaf crop, alternative agrochemicals can be applied to limit build-up in tolerance to chemicals used in the wheat-growing phase.

- Lupin is a broad-leaf legume, and provides the rotation with similar benefits as canola. The increase in wheat yield following lupin is more dramatic because legumes increase soil fertility through nitrogen fixation. This results in potentially lower input costs for the wheat crop to follow. Lupin beans, with high protein content, form a nutritious component of animal feed and grazing.

- Medics, part of the clover family, are extensively used as pastures for sheep production in the Middle Swartland. Wheat following medics generates the highest yield response of all the rotational crops due to nitrogen fixation. The broad-leaf crop offers the same agrochemical benefits as canola and lupin. Medic re-establishes itself in years following wheat rotation if managed correctly.

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4.5.3.3. Tillage practices

Tillage can influence both yield and allocatable variable cost to the farm. The traditional form of tillage known as conventional tillage (CT) is compared with the increasingly popular No-till practice advocated by CA. No-till has a number of benefits, previously mentioned in Chapter 2. These include minimizing soil degradation, improving soil structure, organic matter, and moisture retention. All these factors contribute to higher yields. Reduced input costs are also achieved because there is less mechanical activity on the soil resulting in reduced costs to fuel, repairs and maintenance, and labour.

To identify the commonly used tillage practices and the potential yield under the differing tillage practices research data from ongoing trials at Langgewens experimental farm was used. This was supplemented with a review of the literature on tillage practices, and study group data from local agribusinesses. The tillage practices and their corresponding potential yield benefits were discussed and validated in the expert group discussions. Annexure H shows the yields that were validated during the group discussions. The main factors influencing yields, discussed during the group discussions include:

- Relatively lower influence on yield during a good year as the benefit of enhanced soil moisture retention is reduced due to good rainfall and rainfall dispersion. The positive effect of no-till is more prominent in average and poor years.
- The effect of tillage, that function as a mechanical weeding activity for wheat monoculture
- Reduced tillage results in better soil structure and microbial activity, and higher carbon levels in the soil, resulting in higher yields over the long-term.

These effects can be related to the figures generated by the discussion group shown later in Table 4.1 - 4.5.

4.5.3.4. Crop yields and livestock carrying capacity

Crop yields can vary from year to year due to seasonal variations. In order to incorporate this risk factor into the model, the prevalence of good, average and poor years needed to be identified. Rainfall patterns for the Middle Swartland area were obtained from local weather stations, along with personal communication with producers and local agribusiness extension officers. This was compared with a previous study that followed a similar method of identifying production yield (Hoffmann, 2010). It was found that even with a number of good seasons following 2011, the prevalence of good, average, and poor years would likely still follow the same pattern. A distinction can be made between good, average, and poor years on the quantity and dispersion of rainfall, through-out the season. The prevalence of good, average, and poor

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years would influence the profitability of the whole-farm over an extended period of time (Hoffmann, 2010). Each of the three seasonal variations can be defined as follows:

- A good year would represent the ideal rainfall conditions to provide the crop with sufficient water throughout the growing season. This would not only pertain to quantity of rainfall but also to dispersion of rainfall. Ideally, sufficient rain for planting and crop establishment, followed by increasing consistent rainfall during the growing phase, peak rainfall during seed filling stage, and a gradual decline of rainfall leading to harvest time.

- An average year would pertain to an adequate total annual rainfall, however the dispersion would be disruptive to plant growth, for example, there may be insufficient rainfall to establish the crop or at seed filling time, resulting in reduced yields.

- A poor year would entail both erratic rainfall dispersion and a low annual total rainfall, resulting in reduced yields. This would include the prevalence of droughts.

Yield data, presented during the expert group meeting for discussion, were derived from production guidelines combined with data from the Langgewens crop rotation trials (Strauss, 2013 and Labuschagne, 2013). Agribusiness representatives, scientists, and producers confirmed the expected yields in the Middle Swartland for good, average, and poor years. The group also confirmed on the frequency of the seasonal conditions within a ten-year period. The key reasons for yield assumptions provided by the expert group are highlighted in discussion of Tables 4.1 - 4.5.

Table 4.1: Wheat monoculture yield values and frequency validated by the expert group discussions

WHEAT YIELDS CROP SYSTEM	EXPERT GROUP VALIDATED YIELD VALUES/HA WHEAT MONOCULTURE (WWWW)		
TILLAGE PRACTICE	Frequency	No-till	Conventional-till
POOR YEAR	2	1,600	1,600
AVERAGE YEAR	7	2,500	2,600
GOOD YEAR	1	3,200	3,400

In Table 4.1 the yield for both NT and CT in a poor year is 1600kg/ha. The benefit of moisture retention in NT is traded off with the benefit of mechanical weed cultivation in CT. The effect of soil moisture retention is mitigated by rainfall volume and dispersion in average and good years, therefore wheat yields under CT outstrip yields under NT. CT has the benefit of mechanical weed cultivation.

Table 4.2: Wheat/Canola/Lupin rotation system wheat yield values and frequency validated by the expert group discussions

WHEAT YIELDS CROP SYSTEM	EXPERT GROUP VALIDATED WHEAT YIELD VALUES KG/HA FOR SYSTEM LUPIN, WHEAT, CANOLA, WHEAT (LWCW)		
TILLAGE PRACTICE	Frequency	No-till	Conventional-till
POOR YEAR	2	2,350	2,100
AVERAGE YEAR	7	3,400	3,100
GOOD YEAR	1	4,100	4,000

Table 4.2 shows higher wheat yields under a rotation system. Improved weed control through alternated herbicides in crop rotations results in benefits of no-till being realized. Those benefits include soil moisture retention and improved soil structure and fertility. The result is higher yields under NT than under CT. The benefit of soil moisture retention declines as seasonal rainfall patterns improve in average and good years. The main reasons for increased yields from a shift away from a wheat monoculture to crop rotation systems are; nitrogen fixation from legumes in the rotation, and more efficient weed control.

Table 4.3: Wheat/Medic rotation system wheat yield values and frequency validated by the expert group discussions

WHEAT YIELDS CROP SYSTEM	EXPERT GROUP VALIDATED WHEAT YIELD VALUES KG/HA FOR SYSTEM WHEAT, MEDIC, WHEAT, MEDIC (WMWM)		
TILLAGE PRACTICE	Frequency	No-till	Conventional-till
POOR YEAR	2	2,500	2,200
AVERAGE YEAR	7	3,600	3,200
GOOD YEAR	1	4,400	4,200

The benefits of the crop rotation system also apply to the wheat, medic rotation system shown in Table 4.3. The additional increase in wheat yield compared to LWCW system can be attributed to the enhanced nitrogen fixing properties of medics compared to lupin and canola. Medics have shallower root systems and re-establish themselves in the following year, thereby reducing traffic on the field and further exaggerating the effect of reduced tillage on soil structure and fertility.

Table 4.4: Wheat/Canola rotation system wheat yield values and frequency validated by the expert group discussions

WHEAT YIELDS CROP SYSTEM		EXPERT GROUP VALIDATED WHEAT YIELD VALUES KG/HA FOR SYSTEM WHEAT/CANOL ROTATION (WCWW)					
		CWWW 8%		WCWW 14%		WWCW	
TILLAGE PRACTICE	Frequency	No-till	Conventional -till	No-till	Conventional-till	No-till	Conventional -till
POOR YEAR	2	1728	1600	1824	1624	2350	2100
AVERAGE YEAR	7	2700	2400	2850	2550	3400	3100
GOOD YEAR	1	3456	3356	3648	3548	4100	4000

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Cropping canola in the rotation system shows similar increased yields in the following wheat crop as lupins and medics do, even though canola is not a legume. Canola offers a financially viable alternative cash-crop to rotate with wheat. As it is a broad-leaf plant variety, herbicides that control grasses such as rye grass can be used. Table 4.4 shows the consecutive wheat yields following canola. Increases in wheat yield directly following canola crops follow the same trend as seen in Table 4.2. The second consecutive wheat crop in the rotation records an increase in yield of 14 percent on a typical wheat monoculture crop. The third consecutive wheat crop should see an 8 percent increase on a typical wheat monoculture crop (Hoffmann, 2011 and Strauss, 2014). Thereafter, wheat yields begin to decline.

Table 4.5: Canola and lupin yield values and frequency validated by the expert group discussions

CANOLA YIELDS CROP SYSTEM TILLAGE PRACTICE	FREQUENCY	EXPERT GROUP VALIDATED CANOLA YIELD VALUES KG/HA FOR SYSTEM WHEAT, LUPIN, WHEAT, CANOLA (WLWC) No-till	Conventional-till
POOR YEAR	2	800	700
AVERAGE YEAR	6	1,400	1,300
GOOD YEAR	2	2,000	1,900

LUPIN YIELDS CROP SYSTEM TILLAGE PRACTICE	FREQUENCY	EXPERT GROUP VALIDATED LUPIN YIELD VALUES KG/HA FOR SYSTEM WHEAT, CANOLA, WHEAT LUPIN (WCWL) No-till	Conventional-till
POOR YEAR	2	700	600
AVERAGE YEAR	6	1,300	1,200
GOOD YEAR	2	2,000	1,900

Table 4.5 shows the yields of canola and lupin validated during the group discussions. The expert group agreed that these crops would follow similar trends under the different tillage practices as the wheat crop with higher yields under no-till as compared to conventional tillage..

Livestock was brought into the crop production systems of the Middle Swartland area for diversification purposes. This achieved, to some extent, enhanced profitability and an increase in land utilization on areas of the farm less suitable for crop production. Medics, as a pasture for sheep, are an ideal broad-leaf legume. The livestock carrying capacity of land was derived from a combination of sources. These included research data from Langgewens experimental farm, local agribusiness study group data, and production guide publications. Table 4.6 shows the carrying capacity agreed to be used in this research for the Middle Swartland, validated by the expert group discussions.

Table 4.6: Herd composition and carrying capacity of the Middle Swartland

Ewe's/Ha	2.0
Ewe's/Ram	40
Replacement	25
Lambing %	130
Weaning %	90

4.5.3.5. Product and input prices

Product prices and input prices are listed in data tables in the budget model. Spreadsheet functions use specific data tables for specific calculations. The gross margin for each cropping system is calculated using information from the different data tables.

The data tables consist of various attributes of each item used as an input in the production process. These attributes include; brand name, unit of sale, recommended application rates per hectare for the product, and the unit price. Product prices were taken from the most recent purchases made by Langgewens experimental farm (2014).

Types of fertilizer and application rates are adopted from the Langgewens trial data and local agribusiness information on recommendations. The specific combination of nitrogen (N), phosphorus (P) and potassium (K) are expressed in Table 4.7 with normal quantities applied and relevant prices.

Table 4.7: Seed densities and fertilizer application rates for various crops

Item	2011-2013 Rand/unit	Seeding density and fertiliser rates of various crops kg/ha			
		Wheat	Canola	Lupin	Medic
Seed		95	3.8	80	
Nitrogen at planting	R 11.24	40	40	7.5	0
Nitrogen top dressing	R 11.24	80	60	0	5.5
Phosphorus	R 24.92	14	12.5	14.3	24
Potassium	R 10.17	1	1	0	0

The running costs and purchase price of machinery was incorporated using two separate data sheets. The first is the adapted 'Guide to machinery costs' recently developed and released by local agribusinesses in the Western Cape (Guide to machinery costs, 2014). The following phase which calculated the running cost per ha for each activity uses information from the 'Guide to machinery costs'. It calculates an activity cost for specific practices which is based on a power source (tractor) and implement. Each tractor and implement in the guide is allocated a code. The running cost for an activity is calculated in sheet designed on the coding system. The running cost per hectare of each activity consists of a combination of an engine size (tractor) and an implement. The running cost is then used in the gross margin sheet to calculate non-directly allocatable variable costs for each enterprise. An example of a 'mechanization' data sheet depicting activity cost calculation is provided in Annexure I.

4.5.4. The calculation component

The calculation component comprises of sequences of interrelated calculations. This component forms the structure of the calculation model therefore needs to adhere to two principles. The first is to accurately simulate the processes on the farm being simulated to return a trustworthy outcome regarding the impacts of certain factors, in this case the impact of CA principles on other components of the farm and the whole farm. The second is to structure all the physical/biological factors and interrelationships into the format of standard accounting principles to generate financial results that are universally comparable. The calculation component thus incorporates various input components to determine the results presented in the output component. For instance the gross margin calculation of individual crops will use data sheets from the input component to calculate the, per hectare gross margin. The gross margins are used in the calculation of the net annual flow after fixed cost and net annual flow after capital expenditure. This annual net return is used to calculate the IRR and NPV for the various production systems.

4.5.4.1. Farm inventory

The inventory is a register of the anticipated capital requirement of the whole farm to operate sustainably. The capital requirement is essentially the sum of all the farm assets and typically include items such as; land (being the biggest contributor), fixed improvements, machinery and equipment, and livestock. Annexure J depicts the typical Middle Swartland inventory. An inventory typically includes physical and financial descriptions of all asset items. The physical information includes; number of items for each category, capacity, age, annual usage, depreciation, and current value.

The expert group advised that a farm size of 800 hectares for the Middle Swartland is typical. The price of farm land in the area was obtained from recent valuations of farm land in the Middle Swartland, and validated by the group. The prices of new agricultural machinery and implements were derived from the 'Guide to machinery costs for Western Cape', developed by local agribusinesses. This guide was used in preference to the national guide to machinery costs as it provided information specific to equipment used in the Western Cape. According to the local producers and agribusiness representatives the reason for the development of their own guide to machinery costs is discrepancies in prices of equipment and lack of consistency.

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The number of machines and implements required for the typical farm was determined by the expert group. According to the guide to machinery costs, the norm for replacing machinery is every 12 years and bases annual machine use at 1000 hours. Producers in the Western Cape use machines for 300 to 350 hours per annum and often replace machinery after 15 years or longer, due to financial constraints (Hoffmann, 2010). This point was reiterated during the group discussions.

Investment in livestock is determined by herd size and composition, which in turn depends on available pasture land and grazing capacity. The group of experts decided on the area of land to be allocated to livestock in the typical farm model, as well as the assumptions on the herd composition. These include ram to ewe ratio, and ewe replacement policy. The relevant values of livestock were obtained from industry experts and validated during the group discussions.

4.5.4.2. Crop gross margin calculations

A separate gross margin (GM) calculation was developed for each individual crop in the farm system. For each crop a GM was calculated according to seasonal variation of good, average, or poor yields as determined by rainfall dispersion. Annexure K shows a typical layout of a gross margin calculation for an enterprise under the different tillage practices. The multi-period budget sheet would allocate, according to the frequency of seasonal variation, a corresponding GM for; good, average, or poor yield. This is then multiplied by the area under that crop as determined by land utilisation description. For each individual crop the GM is separately calculated under both no-till (NT) and conventional-till (CT). The result is two multi-period budgets, one for NT and one for CT, used to calculate the IRR and NPV under the three crop rotation systems. The GM is calculated by subtracting the total variable costs of, directly allocatable and non-directly allocatable costs, from the total production value, on a per hectare basis. This part of the whole-farm model is directly connected to the adapted research results described in Paragraph 4.4.

The sequence for the seasonal variations experienced in the Middle Swartland denoted by good, average, and poor yields is completely unpredictable. Selecting a sequence, over the 20 years the budget model is run for, was derived through analysis of historical rainfall patterns obtained from weather stations. This was also validated during the group discussions. It was however agreed that, with the prevalence of good, average, and poor years, any other sequence could be just as likely.

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4.5.4.3. Overhead and fixed costs

Fixed costs are the portion of total costs regarded as fixed in the short-term. These costs cannot be avoided or controlled over the short-term, irrespective of scale or intensity of production. Overhead costs refer to the portion of costs not allocated to an enterprise (Department of Agriculture, 2005).

Values of overhead and fixed costs were derived from personal communications with officers from local agribusinesses and their producer study groups. These values were validated in the expert group discussion. Fixed and overhead costs typically include administration costs, accountant's fee's, banking costs, communication costs, electricity, insurance, licenses, maintenance of fixed improvements and farm vehicles, and permanent labour. These values for each production system are shown in Annexure L under the heading overhead and fixed costs.

4.5.5. The output component

The output component of the model consists of two main financial indicators. The first is the profitability of the whole-farm operation; which is expressed as the internal rate of return on capital investment (IRR) and net present value (NPV). The second is the affordability of the borrowed capital, measured in terms of cash flow.

In Chapter 2, the benefits of CA were described as not being immediate, but rather accumulate over an extended period of time. The crop rotation system also run over extended periods of up to 4 years, and machinery has a life span of 12-15 years. To incorporate these factors, the budget model was run over a 20-year planning period. This still only reflects a random period in the life of the business, and is used to form the basis of comparison.

The model was used to establish the expected profitability of the typical farm based on current typical practices and circumstances. The relative expected financial impact of various factors can then be evaluated. Prices in the model are kept constant. The effect of inflation is incorporated with the use of real interest rates in all cash flow and profitability calculations.

The IRR and NPV calculations are embedded in the multi-period, whole-farm budget. The whole-farm gross margin is derived from the sum of the combined gross margins of all crops in the system. The total gross margin for each enterprise is calculated by the gross margin per hectare multiplied by total hectares allocated to that crop determined by the crop rotation system.

Net annual flow of funds is calculated by subtracting fixed and overhead costs, and capital expenditure from the whole-farm gross margin. The IRR is calculated on the net annual flow over the 20 year period.

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4.5.5.1. Internal rate of return on capital investment (IRR) and Net present value (NPV)

The NPV and IRR are closely related. The NPV is a monetary measure in present value terms of an expected future cash flow. The IRR is a measure of the growth generated by the cash flow, as a percentage return on the initial capital investment. When dealing with projects or options that have different start times, different capital investment, or run for different periods of time, the NPV and IRR measurements provide the ideal basis for comparison and measure of impact on whole-farm profitability. Annexure L shows a multi-period budget model for each of the crop rotation systems indicating the attractiveness of investment with the measure of IRR and NPV.

4.5.5.2. Cash flow budget

The cash flow shows the effect of the ratio of borrowed capital to own capital, and the consequent interest. This measure can be used to gauge the affordability of the investment. The cash flow budget, which includes cash items only, show the impact of interest payments on the farm's bank balance. The prices used in the model are kept constant; therefore it is necessary to convert the nominal interest rate to a real interest rate. This was achieved using the formula:

Real interest rate = {[(1+nominal interest rate) / (1+inflation rate)]-1} %.

The affordability of borrowed capital is indicated by using the break-even year of the operation in the cash flow budget. The impact of the replacement policy of machinery on expected cash flow can also be evaluated in the cash flow budget.

4.6 Conclusions

The two sets of agronomical data used in this research were generated from various trials conducted on Langgewens experimental farm. The first data set used is concerned with soil health under various tillage and rotation systems. The trial data was captured into a farm budget model to generate gross margin per hectare information on trends in factors of production.

Four tillage systems; zero till, no-till, minimum till, and conventional tillage forms part of the experiment. The one practice, zero till, was omitted from the study as the yield results were too erratic to generate trustworthy trends. Under the zero till system the herbicide Trifluralin could not be applied, therefore the wheat was out-competed by ryegrass.

Based on the gross margin analysis the following trends were noted from the Langgewens trials and were valid. The no-till system consistently showed lower non-directly allocatable variable costs because of; less mechanical implements, less field passes and less fuel. The no-till system showed consistently higher average gross margins than the conventional tillage system. These

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trends are pronounced under crop rotation systems such as wheat in rotation with medics (WMWM). The gross margin of wheat in a crop rotation system was consistently higher under no-till than under conventional till. Wheat yields under the wheat medic crop rotation system were higher under no-till than any other tillage practice. And, the gross margin of no-till exceeded other tillage practices in all other systems than wheat mono-cropping during periods of low rainfall.

The second data set is concerned with the production dynamics of crop rotation systems under no-till. The trial data indicated certain trends. Lower non-directly allocatable variable costs and higher average gross margins were realised by the wheat medic crop rotation system. Wheat yields were consistently higher for crop rotation systems compared to the monoculture system. Over a ten year period, 2002-2012, the cumulative variable costs for rotation systems were lower than wheat monoculture. The average gross margins for the rotation systems, especially the wheat medic rotation, were generally higher than that of the wheat monoculture system.

To interpret the trial results of whole-farm level and also include wider, knock-on effects, a process is required that constantly adheres to the systems approach. This process includes three forms of knowledge; meta-science, scientific knowledge, and lay knowledge. Multi-disciplinary group discussions bring together the expert knowledge of various specialists to consider and quantify the impacts of changes to the farm system.

Expert group discussions included producers, agronomists, soil scientists, extension officers, and agricultural economists. The purpose to the group discussion was to generate and validate the data to be used in the development of the model. This included; the typical farm characteristics, input and output relationships and prices, farm inventory, expected yields under the varying crop rotation and tillage systems, and livestock carrying capacity. A whole-farm, multi-period budget model was developed in a spreadsheet programme to simulate the farm system through a sequence of equations. This model simulates the physical/biological farm system and expresses it in standardised accounting format to assess the financial performance of the farm. A typical farm is simulated to serve as basis for comparison to the alternative systems that are described and assessed in the following chapter.

Chapter 5: Farm level financial implications of Conservation Agriculture systems

5.4 Introduction

A description of the research conducted at Langgewens experimental farm on CA was provided in Chapter 4. The financial analysis of the Langgewens trial data provided the basis for the assumptions discussed during the expert group discussions.

The first part of Chapter 5 will describe the components and assumptions specific to the typical Middle Swartland farm model. The assumptions include; farm characteristics, inventory for different tillage and rotation practices, prices of inputs, land, and the structure of the livestock component. The dynamics of the model is explained to understand its capacity to capture the complexity of the whole-farm system. The current financial performance of a typical Middle Swartland farm is established to serve as the basis for comparing differences in profitability for alternative crop rotation and tillage systems.

The second part of Chapter 5 evaluates the financial implications of specific external factors. Three scenarios were simulated, using the model to measure the sensitivity of whole-farm profitability to variations in external factors. The first scenario evaluates the potential impact of rising input prices, specifically chemical, fertiliser, and fuel prices. Secondly, the model is used to measure the sensitivity of variations in output prices, specifically the wheat price, which is traditionally a volatile variable. The third scenario highlights the potential impact of continued devaluation of the Rand to the US dollar exchange rate, resulting in rising costs of machinery and fuel.

The various applications of the model demonstrate its usefulness as a tool to evaluate different farming systems. It can also illustrate the resilience of the systems to variations in external factors.

5.4 Assumptions of the typical Middle Swartland farm

The structure of the calculation model was described in Paragraph 4.5. The expert group agreed on a typical farm size of 800 hectares for the Middle Swartland area. The whole farm is assumed to be owned by the farmer and no additional land rented. The Swartland is a relatively dry area with low incline rolling hills; the percentage of cultivatable land is high. The expert group suggested 95 percent land cultivation rate. The remaining five percent include areas of non-cultivatable riverbeds, roads, wet areas, sandy soils, and areas used for buildings. Table 5.1 shows the validated physical characteristics of the typical Middle Swartland farm.

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Table 5.1: Physical description of typical Middle Swartland farm

Homogeneous Area	**Middle Swartland**
Typical farm size (ha)	800
Land Price R/ha	30,000
% Arable Land	95%
Ha Arable Land	760

The whole-farm budget model is used as a basis for comparison to evaluate the impacts of the different scenarios. For this reason, it was agreed to use equal proportions of land for the different crop rotation systems. In the case of wheat in rotation with canola and lupins, the proportions of each rotation was split 25 percent, of the 760 hectares shown in Table 5.1, of arable land to each crop. For wheat in rotation with medics, 50 percent of arable land was cultivated to wheat. The area under rotation is under medics which serve as a pasture for sheep production. Wheat monoculture comprised a continuous cropping system of wheat on all arable land every year.

5.2.1. Farm inventory

The farm inventory, as described in Chapter 4, comprised of the land, fixed improvements, machinery, and livestock (Annexure J). Land values in the Middle Swartland can differ significantly based on the productive potential of individual farms. Farms with wine grape producing potential are of higher value then farms that are restricted to cereal production. For the purposes of this research it is important that the land value be typical for a cereal production farm. It would therefore be misleading to take an average value of farm land in the Middle Swartland.

The land value of a typical farm was obtained through consultation with estate agents and land evaluators in the area. The expert group considered and agreed to the value of R30 000.00 per hectare (Cilliers, personal communication, 2014) and for a typical farm size of 800 hectares. Land constitutes a large proportion of the total investment required.

The machinery required for the typical farm was based on best practices. The maintenance and replacement, as well as the size and capacity of the machinery depend on farm size and the crop rotation systems in practice. The budget model accommodates the differences in machinery requirements between no-till and conventional tillage practices.

The investment in livestock is determined by herd size and composition which is determined by the land under pasture and the stocking rate. The composition of the herd is derived from assumptions on ram to ewe ratio and the ewe replacement policy. For the purposes of this research the trial data from Langgewens experimental farm was used as a starting point for the

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group discussion. The trial data works on a stocking rate of 1.94 ewes per hectare pasture. The expert group agreed on a stocking rate of 2.0 ewes per hectare pasture to be used for the typical farm model for the Middle Swartland.

The output values for the livestock enterprise were obtained from local agribusiness and the Langgewens trial data. The value of the herd, including rams, ewes, replacement ewes and lambs were obtained from local agribusiness and experts in livestock husbandry.

It is important to note that there are concerns presently raised over whether livestock may potentially negate some of the advantages of CA. The benefits of increased mulch from crop stubble would be diminished as sheep feed on the stubble and the effects of animals trampling the soil may lead to compaction. This could lower soil aggregate stability, leading to reduced soil moisture retention (Derpsch, 2013). Alternatively, if there is sufficient crop stubble on the soil, this would buffer the effects of compaction and increase soil aggregates with more organic matter (Strauss, 2014 and Fisher, 2014).

During the group discussion it was stated that the stocking rate of sheep on one farm was reduced from, an already low rate of 1.25 ewes per hectare medic pasture to 1 ewe per hectare. The reason is the positive effect of the medic rotation on subsequent wheat yields. This effect was greater under lower stocking rates, as soil compaction is lower and retention of medic mulch increases soil health (Bester, personal communication, 2014).

5.2.2. Price and costs

A gross margin analysis for each seasonal variability; good, average, or poor, was compiled for each individual crop (Annexure K).

The gross production value is calculated for each enterprise by multiplying the quantity of output (yield) by the output (commodity) price. The sum of the gross production values of all the enterprises on the farm system result in the whole farm gross production value. Table 5.2 shows the calculation of the three year average prices of output commodities used in the budget model. The price of wheat was derived from the three quality grades, B1, B2, and B3. A typical blend of quality per ton was obtained from local agribusiness and study group data. The proportions of quality per typical ton of wheat are 5 percent B1, 60 percent B2, and 35 percent B3. This results in an average price of R2 792.87 over the three years of 2011 - 2013. Prices for the remaining commodities were taken on a single quality per ton average price from 2011-2013.

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Table 5.2: Commodity prices of units of output (average: 2011-2013)

Product	unit	R/unit AVERAGE	R/unit 2011	R/unit 2012	R/unit 2013	Typical %
Wheat: B1	ton	2959	2303	3200	3374	5%
Wheat: B2	ton	2831	2188	3065	3239	60%
Wheat: B3	ton	2704	2079	2930	3104	35%
Wheat: Average	**ton**	**2793**				
Canola	ton	4292	3850	4550	4475	
Lupin	ton	2722	2200	2800	3166	
Meat (Lamb)	Kg	45.04	48.16	42.21	44.74	
Meat (ewes)	Kg	32.14	30.17	32.10	34.15	
Wool	Kg	74.59	74.84	72.30	76.64	

The input costs contributing to total variable costs remained the same irrespective of the seasonal performance. This excludes silo costs, which are determined by the yield. Table 5.3 shows the percentage contributions of the various input costs for the differing tillage practices.

Table 5.3: Percentage contributions of typical input costs under NT and CT

Variable costs	% for The Middle Swartland	
	NT	CT
Seed	16.85%	13.52%
Fertiliser	37.26%	45.33%
Chemicals	23.52%	18.87%
Fuel	6.05%	6.68%
Maintenance	5.00%	5.52%
Labour	3.35%	3.70%

The input costs were obtained from local agribusiness extension officers and the Langgewens trial data. All the input costs used were derived from a three year average cost; 2011 to 2013, for each individual item. Variable costs include; seed costs, fertilization costs, agrochemical costs, fuel costs, crop insurance, silo costs, and the cost of contractors. Table 5.3 highlights the different proportions attributed to the variable costs for no-till (NT) and conventional-till (CT). The differences are mainly due to reduced fertiliser input in NT and increased mechanical costs in CT. The quantities of the various inputs used in the model were validated during the expert group discussions. Other variable costs include; livestock production costs, marketing costs, silo handling fees, and levies.

5.2.3. Mechanisation

The expert group agreed on the mechanisation requirements. Kilowatt power and implement size requirements, to effectively cultivate the arable land area within a specified time window were estimated. The group of experts expressed the importance of timeliness in the particular practices of planting and harvesting. According to the group a 22 day window for planting and harvesting should be allocated to each activity. Machinery capacity needs to be capable of completing each activity within these time windows.

Planting takes place from the 15th of April to the 15th of May allowing for 27 working days (including Saturdays). This makes a provision for five days lost to breakdowns, rain, and other interruptions. Ideally harvest would take place from 20th of October to the 20th of November. A similar provision of non-working days during harvesting was allocated for variations in wheat moisture content. Wheat must have a moisture content of below 15 percent before harvesting. Harvest period per day is limited by morning and evening dew.

The expert group explained the negative effects on yields of planting outside of this 22 day window. The Middle Swartland has a very definite winter rainfall season, therefore delays in planting can severely reduce possible yields, as crops are unable to reach their full potential within an effective growing season that is shortened. This effect has also been experienced and documented in similar climatic regions of Western Australia and North Africa.

Taking into account the afore mentioned reasoning, the typical farm require a 250kW tractor pulling a 33 tine no-till planter to be able to plant the required hectares within the 22 day time window. Table 5.4 shows the calculations used to determine the planting machinery requirements for the typical farm.

Table 5.4: Calculation for power and implement size requirements for planting

Implement	Power	Power	Work	Work	Field	Hours/	Ha/	Hours	Days to complete
	per tine	**required**	**width**	**Speed**	**Effective**	**Ha**	**Hour**	**/day**	**760 ha**
33 tine no-till planter 9.4m	7kW/tine	231kW	9.4	7	70%	0.217	4.606	8	20.6
									Days to complete
									380 ha
21 tine no-till planter 6.0m	7kW/tine	147kW	6	7	70%	0.34	2.94	8	16.2

The main difference between the farm inventories, for the various farming systems in the model, occurs with the wheat medic rotational system. In the wheat/medic system 50 percent of the arable land is under wheat and the remaining 50 percent under medic pastures. The machinery requirements differ as medics re-establish themselves in the year following wheat. The result is a lower kilowatt requirement and smaller implements can be used. For example an 180kW tractor with a 21 tine no-till planter was used as opposed to a 250kW tractor with a 33 tine no-till planter for the wheat monoculture and wheat canola lupine systems. There were also differences in the implements used according to the tillage practice. Under conventional-till, the inventory comprised of a chisel plough, fields span, and seed drill planters as opposed to only using no-till planters under the no-till practice.

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The expert group highlighted the change in typical conventional tillage practices over the last four decades. The mouldboard plough became practically obsolete, having been replaced with the chisel plough. The practice of broadcasting seed and scarifying the soil to bury it has been replaced with seed drills. This had significant cost implications for the different farming systems and subsequent capital requirements. The differences between the inventories for the various crop rotation systems can be seen in Annexure J.

The cost of a conventional seeding drill was obtained through consultation with local agribusiness with a history in the manufacturing and sales of farm equipment in the Western Cape. There are no commercially manufactured conventional seed drills currently on the market in South Africa. If a farmer requires such a planter it is usually custom built to the specific requirements of the farmer (Van Neikerk, personal communication, 2014).

5.2.4. The dynamics of the model

The model is developed in a spreadsheet programme (Excel) and comprises of sequences of equations that seek to replicate the inter-relatedness of the whole-farm as a system. it was explained in Chapter 3, that the business of farming is best understood within a systems approach. This is because a change in one economic or financial variable will result in a series of causally related events impacting on the final output and profitability of the whole farm.

By using spreadsheet programmes, various formulas can be implemented to mimic the inter-relationships of all the various components of the farm budget model. The first sheets of the budget model contain all the relevant information that shapes the physical and financial extent of the typical farm. These include; characteristics, inventory, crop yields of the typical farm, the cost of machinery, and the prices of inputs. These sheets contain the input data used to calculate the gross margins and whole-farm profitability. All the cells within the enterprise gross margin sheets and whole-farm multi-period cash flow sheets comprise of various formulas that use data from the first sheets to calculate the various profit margins. Any changes in the input data of the first sheets, causes a sequence of changes affecting the net annual flow, which determines the IRR.

For example, an increase in input prices will affect the gross margins of all the cropping enterprises. This will affect the whole-farm gross margin, and the net annual flows. All the enterprises are impacted differently according to tillage practice, either conventional tillage or no-till which affect the net annual flows. The crop rotations are also taken into account, as each system varies on size and type of crop or livestock enterprise. The different seasonal variations of good, average, and poor yields are also taken into consideration. By changing one cell in the model, all of these inter-related components of the system will be altered accordingly to calculate the IRR and NPV under the specific changes.

The budget model is designed in a way that one set of variable data can be manipulated while keeping all other variables static. This increases the usefulness of the model to measure variations in the assumptions. The impact of a change in the assumptions can be isolated and depicted in the absolute and relative change in the IRR and NPV.

5.2.5. Gross margin analysis

The budget model calculates a gross margin for each crop under both no-till and conventional-till practices, as well as a whole-farm gross margin for both practices, across all the crop rotation systems. The gross margin is calculated by subtracting the variable costs of production from the gross production value. Annexure K shows the gross margin analysis for seasonal variations, depicted by good, average, and poor yields for the individual crops both under NT and CT.

Table 5.5 shows the whole-farm gross margin and gross margin per hectare for the different crop rotation systems and under differing tillage practices. The data used for calculating the gross margins presented in Table 5.5 was obtained from the Langgewens crop rotation and Langgewens tillage trials. The trends were discussed in Section 4.4.

Table 5.5: Total gross margin for good, average, and poor seasons for each crop rotation system

Crop Rotation System	Tillage Practice	Gross margin for whole-farm and gross margin per hectare					
		Good year		Average year		Poor year	
		R/farm	R/ha	R/farm	R/ha	R/farm	R/ha
WWWW	NT	4 089 682.85	5 381.16	2 611 622.30	3 436.35	693 556.98	912.57
	CT	3 857 682.61	5 075.90	2 165 879.14	2 849.84	37 041.01	48.74
WCWL	NT	4 705 670.50	6 191.67	3 119 248.90	4 104.27	1 249 319.45	1 643.84
	CT	3 994 159.85	5 255.47	2 193 995.33	2 886.84	245 357.51	322.84
WMWM	NT	4 386 982.56	5 772.35	3 537 951.09	4 655.20	2 370 532.83	3 119.12
	CT	3 803 974.05	5 005.23	2 742 684.72	3 608.80	1 681 395.39	2 212.36
CWWW	NT	5 122 049.67	6 739.54	3 444 471.11	4 532.20	1 330 071.65	1 750.09
	CT	4 269 781.02	5 618.13	2 272 330.60	2 989.91	248 742.11	327.29

5.2.6. Whole-farm financial performance

The budget model measures the profitability of the typical farm over a 20 year period. The financial performance is measured in the internal rate of return on capital investment (IRR) and net present value (NPV) of the future expected cash flow. The IRR and the NPV are calculated for each farming system, which includes the rotational system and tillage practice. The IRR and NPV are calculated in the whole-farm multi-period budget sheet. Annexure L shows a capital budget for the typical farm under the differing rotations and tillage practices.

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Table 5.6 shows the NPV and the IRR for each of the crop rotation systems under the different tillage practices over a 20 year period. The average nominal interest rate was 9.0 percent, the inflation rate 6.1 percent, and the real interest rate 2.73 percent (Statistics South Africa, 2014, and South African Reserve Bank, 2014).

Table 5.6: The net present value (NPV) and internal rate of return on capital investment (IRR) for each typical crop rotation system

Crop Rotation System	Tillage Practice	Internal Rate of Return (IRR)	Net Present Value (NPV)
WWWW	NT	2.24%	R -2 028 333.27
	CT	1.29%	R -5 812 838.41
WCWL	NT	4.06%	R 5 425 665.42
	CT	1.39%	R -5 449 243.16
WMWM	NT	4.69%	R 7 981 843.38
	CT	2.56%	R -712 778.96
CWWW	NT	5.39%	R 10 684 593.17
	CT	1.93%	R -3 241 267.44

When the IRR falls below the real interest rate (2.73%), the NPV moves into a negative value, as the investment over a 20 year period will yield a negative return. Table 5.6 shows that all of the farming systems practicing conventional tillage return an IRR below the real interest rate and a resultant negative NPV. These options are consequently unattractive to investment. In the case of wheat monoculture (WWWW), the farming system under both no-till and conventional tillage practices, renders a negative NPV and an IRR below the real interest rate. Wheat monoculture is therefore unattractive to investment irrespective of tillage practice.

The WCWL system's profitability suffers as lupins do not generate a viable market price and yields are erratic. Despite a positive effect on wheat yields following lupin, the poor gross margin of the lupin enterprise decreases the whole-farm profitability under this crop rotation system. Annexure K shows the gross margin of wheat following lupin, which can be compared to the gross margin of wheat within a monoculture system, shown in Annexure K. The WCWL system was included in this study because it is part of the Langgewens trials.

Wheat in a medic (livestock) rotation (WMWM) is the only system that offers a higher IRR under conventional tillage. The reason is that in the agronomical research there was no conclusive evidence that a pasture system under no-till would increase the output of the livestock enterprise. There is little evidence to support a higher stocking rate of sheep on medic pastures following wheat. Pastures, in a good year, would generate larger quantities of grazing for sheep, it is difficult for the producer to predict the weather in time and buy or sell sheep accordingly. Additional supplementary feeds can be bought in poor years; however there is no research on this to support assumptions on feeding levels. For this reason the output generated from sheep on medic pastures is kept constant irrespective of tillage practice or seasonal variations of good, average, and poor years.

Furthermore, under the mixed crop/livestock rotation system, the producer is unable to take full advantage of a really good year because half of the area available for crop production is under pastures. Therefore, although the WMWM rotation may enjoy the buffer effect in a poor year, the limitations in a good year result in a lower IRR potential for the whole-farm system.

Canola was first introduced into the production systems of the Western Cape as a rotational crop with the benefit of managing weeds, but has in the last 3 to 4 years emerged as a standalone cash crop. Improved cultivars and a rising price per ton, with the addition of lower wheat commodity prices, is responsible for the increase in area planted to canola when compared to wheat, especially in the Middle Swartland (Strauss, 2014). In the long-term wheat producers in the Middle Swartland are projected to progressively incorporate alternative crops such as canola to create a more sustainable crop rotation system (BFAP, 2014). Figure 5.1 shows historical and projected trends from 1995 to 2023 in area cultivated to winter wheat and canola in South Africa, highlighting a decline in winter wheat cultivated and an increase in canola cultivation.

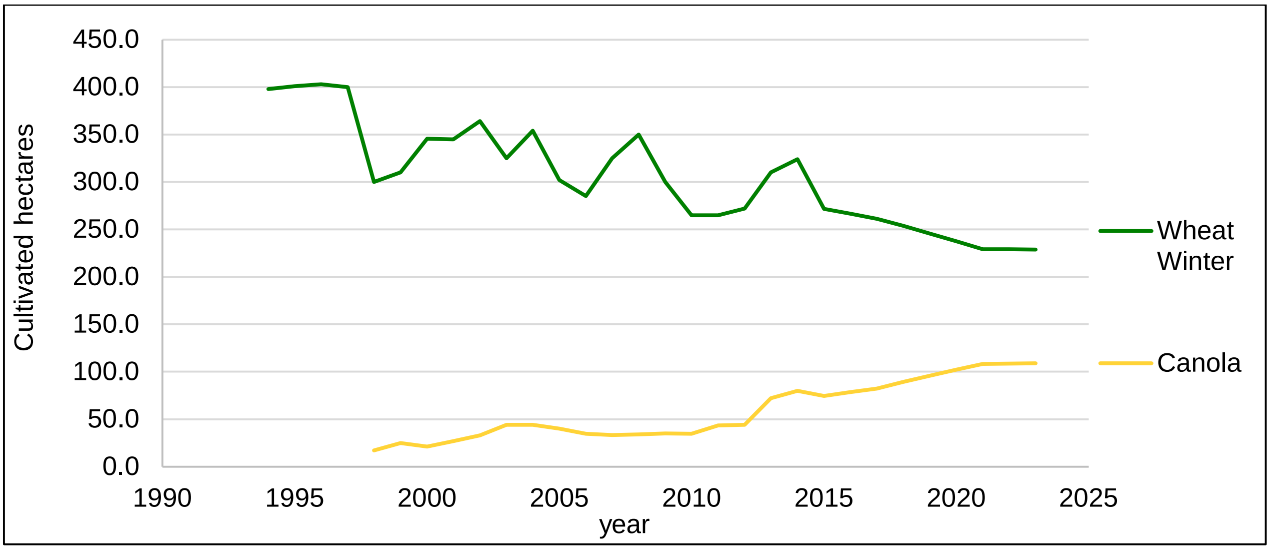

Figure 5.1: Area cultivated under Winter wheat and Canola with projected BFAP baseline trend from 2015 to 2023. Source: BFAP, 2014

The CWWW rotation system records the highest IRR and NPV of the four rotation systems. The reasons for this are; firstly, the producer is able to take full advantage of a good year because all the rotation crops in the system generate a high gross margin. Canola is a profitable cash crop and the benefits of the crop rotation generate high yields for wheat following canola when compared to wheat monoculture. As expressed in Table 4.4, the benefits of wheat following canola are not limited to the first year but also benefit subsequent years of wheat cultivation.

Secondly, the benefits increased yields under no-till further enhance the profitability of the system.

Further to this, the reason the CWWW system records a negative and subsequently a relatively high gap in profitability between no-till and conventional-till is because the system lacks a buffer effect in the poor years, enjoyed by the WMWM system.

5.4 Analysis of financial vulnerability through scenarios

A scenario is a hypothetical description of a possible future. All scenarios share some common features; they begin from an initial state, usually the present, and deal with states, actions and consequences that are causally linked, depicting a final state within a predetermined time frame (Therond et al., 2009). In the case of modelling, Peterson et al. (2003) describes scenarios as "variations in the assumptions used to create models."

Scenarios are widely used in research to assess the impact of 'what if questions'. For instance; 'what will the impact of whole-farm profitability be if the wheat price decreased by 10 percent?' Under normal circumstances, in the event of declining commodity prices, producers are likely to substitute one crop for another. For the purpose of this research a *ceteris paribus* principle is factored into the scenarios. *Ceteris paribus* roughly translates to "holding other things constant". In economic terms it refers to the effect of one economic variable on another, while holding all other variables constant.

A number of scenarios were selected to determine the sensitivity of the various systems to possible changes in the current assumptions. The model can depict the impact of changes in various assumptions on whole-farm profitability. The scenarios included are; increased input prices, declining wheat price, and devaluation in the Rand to the US dollar raising the price of machinery and fuel.

5.3.1. Increasing input cost

The first scenario assessed the profitability impact of an increase in input costs. This was aimed at determining the impact of input price inflation on the typical farm for each of the different systems. Fertiliser, chemicals, and fuel, contribute the largest components of the variable costs. A simulated increase in input costs of 10 percent, 20 percent, and 30 percent was used to evaluate the impact on the IRR. The results of the simulation are shown in Table 5.7. The current situation is depicted in the left four columns under 'Whole-farm model'. The columns to the right under the title 'Rising input cost scenario' show the IRR in the event of a percentage change in input prices. The relative change in the IRR is the percentage change between the current IRR and the new IRR.

Table 5.7: Relative percentage change in IRR as a result of an increase in input costs.

Whole-farm model				Rising input cost scenario					
				10% ↑		20% ↑		30% ↑	
Crop Rotation System	Tillage Practice	Internal Rate of Return (IRR)	Net Present Value (NPV)	Internal Rate of Return (IRR)	Relative change in IRR	Internal Rate of Return (IRR)	Relative change in IRR	Internal Rate of Return (IRR)	Relative change in IRR
WWWW	NT	2.24%	R -2 028 333.27	1.50%	33%	0.76%	66%	0.03%	99%
	CT	1.29%	R -5 812 838.41	0.33%	74%	-0.62%	148%	-1.55%	220%
WCWL	NT	4.06%	R 5 425 665.42	3.45%	15%	2.84%	30%	2.23%	45%
	CT	1.39%	R -5 449 243.16	0.64%	54%	-0.11%	108%	-0.85%	161%
WMWM	NT	4.69%	R 7 981 843.38	4.14%	12%	3.60%	23%	3.05%	35%
	CT	2.56%	R -712 778.96	1.95%	24%	1.26%	51%	0.58%	77%
CWWW	NT	5.39%	R 10 684 593.17	4.71%	13%	4.04%	25%	3.37%	37%
	CT	1.93%	R -3 241 267.44	1.06%	45%	0.21%	89%	-0.64%	133%

Firstly the significance of tillage is highlighted. Table 5.7 shows that, compared to a conventional tillage system, the no-till system is less susceptible to rising input prices. Under conventional tillage an increase in input prices results in double the relative change in the IRR (74 percent) as compared to the relative change in the IRR under no-till (33 percent). Conventional tillage reduces organic matter and carbon levels in the soil making it more input intensive. An estimated 50 percent more nitrogen is required to produce the crop than under no-till practices.

A conservation agriculture system, of combined no-till and crop rotation, shows less than half the relative change in the IRR compared to a conventional system as affected by rising input prices. Table 5.7 shows that the worst performing crop rotation system is wheat, canola, wheat, lupin (WCWL) under no-till in terms of relative change in the IRR. A 10 percent rise in input prices to the system shows a 15 percent relative change in the IRR. A wheat monoculture system (WWWW) under conventional tillage shows a relative change in the IRR of 74 percent. This highlights the buffering effect of increased yields, generated by rotations in the cropping system, to the impact of rising input prices.

5.3.2. Lower wheat price

In Chapter 3, it was expressed that farmers have little control over macro-economic factors. Rising input prices can only be mitigated by optimizing productivity, producing more with less, and expanding production to utilize the advantages of economies of size. Rising input prices may however not be as detrimental to the farming business as declining wheat prices, shown in Table 5.8. Both scenarios are possibilities facing producers in today's world where producers compete internationally.

Table 5.8: Relative percentage change in the IRR as a result of a decline in the wheat price

Whole-farm model				Wheat price decline scenario					
Wheat R2 792.87/ton (3 year average, 2011-2013)				10% ↓	R 2 514	20% ↓	R 2 234	30% ↓	R 1 955
Crop Rotation System	Tillage Practice	Internal Rate of Return (IRR)	Net Present Value (NPV)	Internal Rate of Return (IRR)	Relative change in IRR	Internal Rate of Return (IRR)	Relative change in IRR	Internal Rate of Return (IRR)	Relative change in IRR
WWWW	NT	2.24%	R -2 028 333.27	0.22%	90%	-1.76%	179%	-3.70%	265%
	CT	1.29%	R -5 812 838.41	-0.83%	164%	-2.90%	325%	-4.93%	482%
WCWL	NT	4.06%	R 5 425 665.42	2.69%	34%	1.33%	67%	0.00%	100%
	CT	1.39%	R -5 449 243.16	0.13%	91%	-1.12%	180%	-2.34%	268%
WMWM	NT	4.69%	R 7 981 843.38	3.22%	31%	1.78%	62%	0.37%	92%
	CT	2.56%	R -712 778.96	1.25%	51%	-0.12%	105%	-1.46%	157%
CWWW	NT	5.39%	R 10 684 593.17	3.53%	35%	1.71%	68%	-0.07%	101%
	CT	1.93%	R -3 241 267.44	0.24%	88%	-1.41%	173%	-3.03%	257%

Table 5.8 shows that a 10 percent decline in the wheat price would cause an expected 35 percent relative change in the IRR, for the most profitable farming system (CWWW). This is more than double the relative change in IRR for the same system (CWWW, 13 percent) in the event of a 10 percent rise in input costs. This system (CWWW) is expected to experience a relative change in the IRR of 35 percent, a decrease in the IRR to 3.53 percent in the event of a 10 percent decline in the wheat price. It is expected that a 30 percent rise in input prices could have a similar effect to the systems IRR, decreasing it to 3.37 percent.

Only two systems, Wheat in rotation with canola (CWWW) and the wheat medic rotation (WMWM), are expected to maintain a positive IRR with a 10 percent drop in the wheat price. Further decline in wheat price is expected to render all systems unsustainable as the IRR would fall below the real interest rate and result in a negative NPV. The increased wheat yields in these systems, derived of rotations, enable a buffering effect to cushion the impact of declining wheat prices.

In the WMWM system, only 50 percent of the area is under wheat. More importantly, the wheat yields are more stable and higher than that of the wheat in the monoculture system. The impact of declining wheat prices is consequently expected to be less in contrast to the wheat dependent systems. Table 5.8 shows that the expected effect of a 10 percent decline in wheat price, results in a lower relative change in the IRR for the WMWM system as opposed to the CWWW system. The actual IRR remains lower at 3.22 percent as opposed to 3.53 percent respectively. After a 30 percent decline in wheat price, the WMWM system records an actual IRR of 0.37 percent while the CWWW system falls into a negative IRR at -0.07 percent. This shows that the WMWM system is less susceptible to declining wheat prices.

Table 5.9 shows that in the event of an increase in the wheat price, the scenario would render a greater relative change in the IRR for the monoculture system than the rotational systems as well as a higher relative change in IRR for conventional tillage as opposed to no-till.

Table 5.9: Relative percentage change in the IRR as a result of an increase in the wheat price

Whole-farm model				Wheat price increase scenario					
Wheat R2 792.87/ton (3 year average, 2011-2013)				10% ↑	R 3 072	20% ↑	R 3 351	30% ↑	R 3 631
Crop Rotation System	Tillage Practice	Internal Rate of Return (IRR)	Net Present Value (NPV)	Internal Rate of Return (IRR)	Relative change in IRR	Internal Rate of Return (IRR)	Relative change in IRR	Internal Rate of Return (IRR)	Relative change in IRR
WWWW	NT	2.24%	R -2 028 333.27	4.31%	48%	6.45%	65%	8.66%	74%
	CT	1.29%	R -5 812 838.41	3.47%	63%	5.73%	77%	8.07%	84%
WCWL	NT	4.06%	R 5 425 665.42	5.47%	26%	6.90%	41%	8.36%	51%
	CT	1.39%	R -5 449 243.16	2.68%	48%	3.99%	65%	5.32%	74%
WMWM	NT	4.69%	R 7 694 114.48	6.19%	24%	7.73%	39%	9.30%	50%
	CT	2.56%	R -431 346.44	4.06%	37%	5.51%	54%	6.99%	63%
CWWW	NT	5.39%	R 10 684 593.17	7.30%	26%	9.27%	42%	11.31%	52%
	CT	1.93%	R -3 241 267.44	3.65%	47%	5.43%	65%	7.25%	73%

In this scenario, the buffering effect of the rotations is reversed because the monoculture system utilizes 100 percent of area under wheat, benefiting from the increased wheat price. If this event were to actually occur, producers would likely increase the area of production under wheat.

An increase in the wheat price results in a higher relative change in the IRR for the monoculture system, but the actual IRR resulting from the increased price still remains lower than the rotational systems. Only after a 30 percent increase in wheat price would the IRR of the monoculture system (8.66 percent) surpass one of the rotation systems, the WCWL system (8.36 percent). The benefits of conservation agriculture allow the WMWM and CWWW systems to maintain their competitive edge over the wheat monoculture system even to the extent of a 30 percent rise in wheat price. It is important to note that this price assumption is made for the wheat price over the full 20 year evaluation period. The impact of a longer term price increase in wheat, associated with more plantings, usually causes an inflation effect on input prices, which was not taken into account. The scenario serves only to illustrate the impact of various changes.

5.3.3. Machinery cost as impacted by exchange rate

A third scenario of an increase in machinery base costs and fuel was simulated in the model to depict the possible impact of further devaluation of the Rand to the US dollar. The Bureau for food and agricultural policy (BFAP) expect the Rand to continue to devalue against the US dollar. This trend is projected to 2023 and expressed in Figure 5.2 (BFAP, 2014).

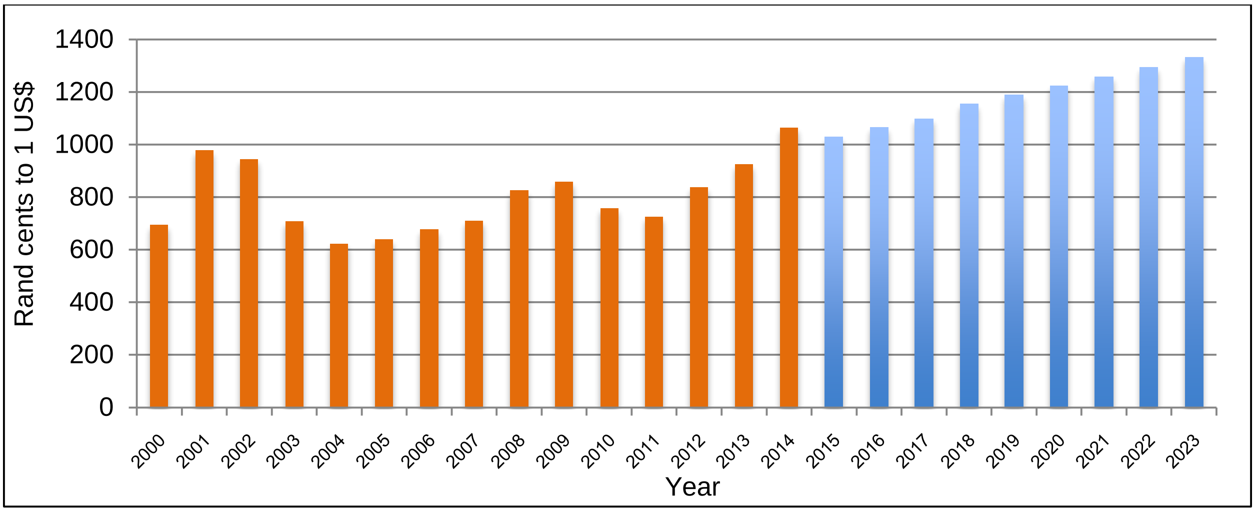

Figure 5.2: Historical Rand to US dollar exchange rate and BFAP projected trend from 2015 to 2023. Source: BFAP, 2014

The group discussions expressed concern over the continued devaluation of the Rand to the US dollar and the potential increase in cost of replacing machinery. The price of planting equipment required for CA is high, therefore the aspect of path dependence can be highlighted. Adopting CA is not a straightforward decision because the financial implications of potentially reduced income during the initial phases of adoption are compounded by the large capital investment required to purchase the necessary machinery. This can have a significant impact on the cash flow of the business and profitability. The rising costs of machinery may deter potential CA adoptees. They would instead continue producing conventionally. This research shows that conventional practices are not viable in the long term, and that CA poses the best option for reducing costs to remain viable.

One of the greatest savings from adopting CA has been the reduction in; kW power requirement, repairs and maintenance on machinery, and fuel (Bignell, personal communication, 2014). Conservation agriculture reduces soil tillage. Therefore, less power is required to establish a crop.

Increases in the price of machinery and fuel of 10 percent, 20 percent, and 30 percent was simulated to evaluate the impact on the profitability.

Table 5.10 shows the actual and relative changes in the IRR in the event of rising fuel and machinery costs. The conventional system, wheat monoculture under conventional tillage, performs the worst. It shows significantly higher relative expected changes to the IRR when compared to the systems under conservation agriculture (WCWL, WMWM, CWWW).

Table 5.10: Relative percentage change in IRR as a result of an increase in base costs of machinery and fuel

Whole-farm model				Rising fuel and machinery cost scenario					
				10% ↑		20% ↑		30% ↑	
Crop Rotation System	Tillage Practice	Internal Rate of Return (IRR)	Net Present Value (NPV)	Internal Rate of Return (IRR)	Relative change in IRR	Internal Rate of Return (IRR)	Relative change in IRR	Internal Rate of Return (IRR)	Relative change in IRR
WWWW	NT	2.24%	R -2 028 333.27	1.84%	18%	1.45%	35%	1.08%	52%
	CT	1.29%	R -5 812 838.41	0.89%	31%	0.50%	61%	0.12%	91%
WCWL	NT	4.06%	R 5 425 665.42	3.64%	10%	3.23%	21%	2.83%	30%
	CT	1.39%	R -5 449 243.16	0.99%	29%	0.61%	56%	0.24%	83%
WMWM	NT	4.69%	R 7 981 843.38	4.38%	7%	4.07%	13%	3.77%	20%
	CT	2.56%	R -712 778.96	2.33%	9%	2.02%	21%	1.72%	33%
CWWW	NT	5.39%	R 10 684 593.17	4.93%	9%	4.49%	17%	4.07%	24%
	CT	1.93%	R -3 241 267.44	1.51%	22%	1.11%	42%	0.72%	63%

The WMWM system operates with a lower total inventory value, as only 50 percent of the area is under cash crops, therefore requiring fewer and smaller capacity machinery. The WMWM system subsequently experiences the lowest relative change in the IRR.

The percentage change after an increase of 10 percent to machinery and fuel costs, between the competing conservation agriculture systems of WMWM, CWWW, and WCWL, is marginal at 7 percent, 9 percent and 10 percent respectively. With the reduced inventory and a minimized impact of rising machinery and fuel costs, the mixed cropping and livestock system (WMWM) is still expected to be less profitable than the CWWW system under no-till.

5.3.4. Climate change implications

There are indications that climate change will affect the Western Cape. Temperatures in the Middle Swartland are expected to rise over an extended period of time. Conservation agriculture, however serves as one example of the ability to adapt and mitigate the effects of variations in climate. There are conflicting schools of thought as to the possible impacts of climate change. Some scientists predict that with an increase in temperatures there will be increased carbon in the soils that will result in increased yields. Others state that the rising temperatures may increase the frequency of droughts and reduce average yields. It is therefore difficult to assume the specific resultant effects of climate change.

What has been established through the literature review and expert discussion group is that the practice of CA does reduce the detrimental effects of low and/or inconsistent rainfall patterns to crop yield. The benefits of increased soil moisture retention and permeability from permanent soil cover and reduced tillage create a more resilient soil structure better able to cope with moisture stress. This has been factored into the model, shown in Annexure I, (Crop yields validated in group discussions) where crop yields in poor years are higher under no-till practices then under conventional tillage. Yields in good years are marginally higher under no-till due to better soil organic matter and structure, however the effects of moisture retention are nullified as rainfall is ideal for yield potential.

Producers practicing CA will therefore be well positioned to sustain the potentially negative effects of climate change and further benefit from the potential positive effects. CA effectively mitigates the effects of climate change, however because of controversial yield effect opinions the actual expected declines were not modelled.

5.4 Conclusions

Various parameters were established and validated for a typical farm in the Middle Swartland. A multi-period budget model was developed to firstly, establish the current profitability of the typical farm, and secondly to evaluate the impacts of variations in the external environment. The dynamics of the model allow it to incorporate the complexity of interrelationships between variables within the whole-farm system. The model was used to determine the current profitability of the typical farm under various crop rotation systems and tillage practices to establish the expected profitability of each farming system.

The models were then used to evaluate the expected impact on profitability of variations in external factors. Three scenarios were selected from issues raised during the group discussions and included; rising input costs, declining wheat price, and rising machinery and fuel costs. The results showed that a decrease in the wheat price is expected to have the most significant impact on profitability. A lesser impact is expected on the profitability of the farming systems with wheat in rotation with canola, lupins, and medics/sheep when compared to the monoculture system. The rotation systems are diversified into various crops, the impact of a decline in a single commodity price would not be as significant as for the monoculture system. The increased yields generated from the crop rotations and no-till also offer a buffering effect in the event of declining wheat prices.

The effect of an increase in input prices has a greater impact on conventional tillage systems that are input intensive. The increased yields in the rotation systems and under no-till serve as a buffer against the effect of inflation on input prices. In the case of increased machinery and fuel costs, the WMWM system was least affected. Only 50 percent of the area cropped was under cash crops, which means less mechanical and fuel requirements.

All the crop rotation systems performed better in terms of profitability than the wheat monoculture system. This is due to the increased yields generated from crop rotations. All the systems under no-till are expected to be more profitable than the systems under conventional. This is caused by the benefits from reduced input costs and mechanical investment. Overall the

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CA system with crop rotation combined with no-till has the highest expected profitability over the 20 year period. These results depict the financial benefits of the three combined pillars of CA; reduced tillage, crop rotations, and continuous soil cover. It is important to note the interrelatedness of the components of the CA system. The benefits are achieved within a holistic approach rather than independent components operating in isolation.

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Chapter 6: Conclusions, Summary and Recommendations

6.1 Conclusions

The natural resources available on the planet are limited. Producers are forced to optimise production through efficient use of the natural resources; land and water, due to expanding populations, globalization, and growing consumer demand for ethical food production. Conservation agriculture is known to be the most holistic approach to sustainable agricultural production. Conservation agriculture encompasses three principles; permanent reduced soil disturbance, permanent organic soil cover, and diversified crop rotations. Conservation agriculture has clear benefits to the environment, but the long term financial implications are not well documented.

Conservation agriculture has amalgamated a number of sustainable production practices that were promoted over the last four decades. Conservation agriculture originated over concerns of environmental degradation. Initially it started as conservation tillage, focused on soil conservation, in the USA and later in Australia, South America, and Asia. The benefits of permanent soil cover and crop rotation were later recognised and with the development of effective herbicides to replace mechanical tillage, the movement towards CA accelerated. The main growth phases and areas were; North America and Australia in the early 1990's, South America, in the late 90's, and Asia and Africa only in the last ten years.

Africa is adopting CA into its unique ecological and cultural agricultural systems. Two factors stand out in Africa regarding CA. Firstly CA is a concept encompassing all aspects of the farm. It is not a recipe, but rather a mind-set of the producer's symbiotic relationship with the farms natural resources. The CA system should be designed and developed specific to the farms ecological resources and limitations. Secondly, the economic and financial sustainability of the producer's livelihood is integral in the system and this requires renewed focus (Knott, Hoffmann & Vink., 2014).

The Middle Swartland area of the Western Cape is predominantly a grain producing area with a Mediterranean climate. It has a harsh farming environment, in terms of climate, soil, and ecology. Production conditions are characterised by shallow shale soils and limited to winter. There are limited alternative sustainable options to increase profitability. Sustainable refers to a continuation of productivity while maintaining the natural resources. Conservation agriculture presents the farmer with a unique opportunity to reduce input costs while enhancing soil health and moisture retention capacity. These benefits are realized in time and can take up to five years before the transition begins to pay off. The initial learning curve associated with the new practice can be expensive as CA planting equipment requires investment in sophisticated

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technology. The Middle Swartland producer would benefit from a financial evaluation of the implications of adopting CA as a practice over the long term.

The farm business operates as a system of interrelated components that generates output, which is measured in farm profitability. Knowledge of the intricate workings within individual components is important for decision making. Broader knowledge of the interrelatedness of individual components and the multi-faceted nature of the farm system is essential to whole-farm profitability. Research on farm level issues that is conducted from the perspective of a specific discipline, despite generating valid information, can lead to compartmentalization of knowledge. It is necessary to evaluate proposed production methods within the whole-farm context to account for the interrelated impacts within the system and to determine implication to the whole system. Expert group discussions are efficient in generating and validating individual, component specific, knowledge from scientific disciplines such as; agronomy, soil science, plant pathology, animal sciences, and agricultural economics. It provides an environment within which specialised knowledge can be shared and carefully considered for meaning and implication on whole-farm production system. Expert group discussions can also bridge the gap between science and producers. Both are forced to jointly verbalise the implications of various perspectives and suggestions on the farm system. This means that the technical and financial aspects of the business can be integrated.

In this research project, the need for sustainable agricultural production based on CA as a progressive approach was highlighted. The study highlights the profitability impact of the innovation of CA on the whole-farm operation, by incorporating the interdependent components of the farm system. A whole-farm model was designed to deal with the interrelated physical-biological and socio-economic factors of the farm system. The model was based on a 'typical farm' in the Middle Swartland area. Crop trial research data from Langgewens experimental farm, and a multi-disciplinary discussion group approach was used to obtain and validate data used in the model. The dynamics of expert group discussion allows for different perspectives to be raised and individual perspectives to be challenged to arrive at a workable solution.

Initially the data from the Langgewens trials was captured in the model to determine the gross production value, variable cost and gross margin for various combinations of crops and tillage production systems. This formed the foundation for the expert group discussions. The first group discussion raised important issues. Firstly, CA is a system with interdependent principles that should not be analysed in isolation. This notion guided the research to a systems approach that accommodates all three principles of CA. Second, trials are designed goal specific and may not render data directly transferable to a whole-farm situation. A follow up round of group discussions was conducted to generate typical farm characteristics and typical yield and input data. An important contribution of the group discussion in this research project was the

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explanation of yield expectations for crops as influenced by both the previous crop and the tillage system.

The model was designed and constructed in a spreadsheet programme (Microsoft Excel). The complexity of the whole-farm system can be captured by using a sequence of mathematical and/or accounting formulas. Each formula corresponds to a set of data and existing results of equations. All the farm characteristics and input data are entered into the information or data set spreadsheets. The information and assumptions spreadsheet determine the parameters on condition for the model. A change in the data on the first page will set off a series of changes in the model consistent with a real life farm situation. The model forms a symbolic simulation of real life possible events.

The whole-farm multi-period model was used to generate a current financial situation for a typical farm in the Middle Swartland from the data that was validated during the group discussion. A 20 year, multi-period, budget model was used to capture the net annual flows of the business and to calculate the IRR and the NPV as measurements of profitability of the farm business. Three year average prices (2011, 2012, and 2013) for all inputs and commodities were used in the model.

The method used in the study, of whole-farm modelling and multi-disciplinary group discussion, seems to have successfully met the requirements of answering the research question. The assumptions within the model, having been validated by various experts, were manipulated to mimic possible variations in external factors and evaluate the impact on farm profitability. The sensitivity of various exogenous factors on farm profitability was measured in the actual and relative change to the IRR for simulated scenarios. Three scenarios were selected consequent to discussions with various experts and factors highlighted during the group discussions. With the aid of expert opinions present at the group discussions the model that was constructed represented a typical Middle Swartland farm that participants could relate to.

The initial farm level financial evaluation of the rotation systems under two tillage practices showed that the monoculture system was least profitable under both tillage practices. No investment option was profitable in terms of IRR under the conventional tillage system. All of the CA systems generated positive NPV's, suggesting positive potential investment options. The most attractive system was the CWWW system under no-till practice, showing an expected IRR of 5.39 percent. Canola production is relatively profitable in itself, but the canola crop has a positive effect on the following three years of wheat production, both in terms of higher expected yield and lower production costs. The expected IRR for no-till systems showed positive results across all the crop rotation systems as compared to conventional tillage. It is important to note that the tillage system itself is accompanied by a whole newly designed production setup. This

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production design includes; yields for good, average, and poor years, mechanisation and investment requirements, input cost adaptations, and changes to cultivation cost.

The expected impact of inflation on input prices, specifically the price of fertiliser, agrochemicals, and fuel was assessed with scenarios. The sensitivity of farm profitability was measured in the actual and relative change to the IRR, in the event of a percentage increase in input prices. Under conventional tillage, an increase in input prices resulted in twice the relative change in the IRR as compared to the relative change in the IRR under no-till. This showed the resilience of a conservation agriculture system.

The second scenario assessed the impact of declining commodity prices for wheat. This had the most significant impact on farm profitability. A 10 percent decline in the wheat price show the same expected impact on IRR of a 30 percent increase in input prices. The CA systems of CWWW and WMWM would be able to remain profitable to a 10 percent decline in the wheat price. Further decline in wheat price would return an IRR below the real interest rate resulting in a negative NPV. The increased yields in the three CA systems serve as a buffering effect to the declining wheat price. The CA systems have reduced reliance on wheat and are therefore less sensitive to fluctuations in the wheat price, however in the event of an increase in the price of wheat, the effect would be reversed and the wheat monoculture system would outperform the CA systems. An increase in wheat price of at least 5 percent is required before the wheat monoculture system can start with a positive NPV.

Thirdly, the impact of a continued devaluation of the Rand to the US dollar, resulting in rising machinery and fuel costs, was simulated in the model. The monoculture system was more sensitive to increased machinery and fuel costs when compared to the CA systems. The mixed cropping and livestock system WMWM, consisting of a reduced total inventory, was unable to outperform the CWWW system under no-till.

The main conclusions from the results of the financial evaluation were:

- The monoculture system is not financially viable. The impact of weed infestations due to herbicide resistant ryegrass is unsustainable. Wheat yields under these circumstances are too low to generate a positive NPV.

- The buffering effect of increased yields derived from diversified crop rotations reduced the farming systems sensitivity to fluctuation in external factors, such as; inflation, a devaluing exchange rate, and to a lesser extent declining wheat commodity prices.

- A diversified farming system can reduce the sensitivity to external factors. A collapse in one commodity price may be buffered by an increase in yield, and the stability of another commodity's price, for example, canola.

- Conventional tillage requires higher fuel and repairs and maintenance costs when compared to no-till. The cost of no-till equipment is higher than conventional seeding equipment, the no-till system generates a higher expected IRR over an extended period of time.

6.2 Summary

The fragility and limitations of the natural resources on our planet was highlighted as the main concern for finding alternative production methods in food production. Global population growth is intensifying pressure on the limited natural resources available for agricultural production. Globalisation and government policies to promote a free market economy create a competitive business environment, exacerbating the effect of price-cost squeeze experienced by farmers. Over 95 percent of population is growth expected to occur in developing nations, sustainable agricultural production will thus be paramount as rapid urbanisation and industrialisation continue to compete for land and water.

Sustainability applies equally to the natural resources and the producers' livelihood. The natural resources should be used in a manner that either sustains or enhances the quality and productive capacity of the resource. This responsibility lies with the producer as the custodian of the natural resources. The importance of the producers' role in sustaining these resources for present and future generations must be appreciated. The viability of the producers best practice production methods should be maintained by the market to ensure sustainable use of natural resources.

The Middle Swartland area of the Western Cape constitutes a relatively dry Mediterranean climate within South Africa. It is predominantly a wheat producing area. Agricultural research carried out in this area is mostly related to grain farming and has been conducted within the boundaries of single scientific disciplines. Research within a single scientific discipline focuses on a problem from a specific perspective. It often disregards impacts that are well understood by other relevant disciplines. In some instances, research on natural sciences may disregard financial implications of the farm system. Financial research may neglect critical technical aspects of the farm system.

This research project focused on an evaluation of farm level profitability of different crop rotation and tillage systems over an extended period of time. There is ample research on the

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physical/biological benefits of crop rotations and tillage. There is however a lack of knowledge of the long term impacts to farm profitability of adopting CA practices.

Sustainable agriculture is concerned with four main aspects; worldwide food security, protecting the environment and natural resource base, sustaining natural resources for present and future generations, and to sustain the economic viability of farm operations and farmer livelihoods. It is important to sustain both the natural resource base and farmer livelihoods for present and future generations to ensure global food security.

Conservation agriculture is an amalgamation of a number of sustainable practices developed over the last century. It encompasses three guiding principles; permanent reduced tillage, permanent organic soil cover, and diversified crop rotations. Conservation agriculture is a system that integrates the three guiding principles to operate concurrently and generate both physical-biological and socio-economic benefits to the farm system.

Despite the benefits of CA, it is not without challenges. The benefits of CA include; improved soil health and structure, improved soil moisture retention, higher soil carbon levels resulting in increased yields, reduced input costs, and reduced $C0_2$ emissions. The main challenges of the practice include; changing the mind-set of the farmer, the initial financial costs of adoption of CA, the required knowledge of CA as a system and adapting it to the unique requirements of the farm.

Historically, the need for soil conservation originated in the USA after catastrophic events of environmental degradation occurred in the Mid-West. Similar events took place in Australia and South America and in conjunction with the development of herbicides and machinery, the practice of no-till and conservation tillage was able to advance. The practice was market driven and enabled the farmer to increase yields and reduce costs with globalisation intensifying the effects of the price-cost squeeze. South America currently has the highest rates of adoption worldwide, surpassing North America in the new millennia. Australia recorded high rates of adoption in the late 1990's. Europe remains unconvinced in CA as a truly sustainable practice due to its reliance on herbicides. Asia and Africa continue to grow slowly as transfer of knowledge and skills to their specific environment is limited and agricultural structures are still developing.

Conservation agriculture was adopted in the Middle Swartland area from the 1990's. Two events guided the adoption process in this area. Firstly, deregulation of markets lead to declining, and often volatile, wheat prices which forced producers to reduce input costs to remain financially viable. Secondly, the prevalence of herbicide resistant ryegrass forced farmers to adopt diversified crop rotations. This is because no-till planting machinery enabled farmers to spray the only effective herbicide, Trifluralin.

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For the purpose of this research project a systems approach that focus on whole-farm was required. The traditional scientific approach to understanding and dealing with complex problems has been a reductionist approach where one component is analysed in isolation. The systems approach, developed over the 20th century, promotes a more holistic approach to problem solving. The farm is acknowledged as a complex and interrelated system of biological, mechanical, and economic components. This notion makes a systems thinking approach ideal for studying farm related issues.

Farming occurs over a large area and output is usually not continuous, but rather seasonal. For this reason, developing a model of the system is a time and cost efficient way of studying farm systems. In terms of the financial evaluation of a farm, a computerised model is ideal to accommodate multiple mathematical and accounting calculations. Whole farm profitability takes into account all the components and interrelationships forming the farm system. The farm can best be studied by simulating the operations over an extended period of time because the issues of tillage and crop rotations are longer term orientated.

The Middle Swartland area forms a relatively homogeneous grain producing area. This research makes use of a typical farm rather than an average farm to avoid the skewing effect of outliers. A typical farm would more closely follow the most common characteristics of farms found in the homogeneous area. It presents a method that accurately relates the impact of certain factors to profitability in a context that other role-players can associate with.

The multi-disciplinary group discussion technique was used to generate and validate typical farm values and characteristics. As trial data is designed around single discipline research and takes place in an intensive manner, the results may sometimes not replicate events on a whole farm level. In farming other perspectives are required to explain certain process or to understand and more accurately foresee their impact on the farm system. Expert group discussions provide the ideal platform to encourage multi-disciplinary knowledge sharing. With the inclusion of producers it can also highlight any technical irregularities in terms of the ease of implementing suggested practices. Experts such as, agronomists, soil scientists, plant pathologists, producers, and agricultural economists are brought together to discuss and share knowledge. Data collected from scientific trials at Langgewens experimental farm served to generate a valid set of data that was used as the basis for the group discussions.

The trial data generated from ongoing trials at Langgewens experimental farm in the Middle Swartland focus on two, mostly agronomical issues. The first looks at the benefits to soil health of both crop rotation and tillage. The second investigates production dynamics of eight crop rotations under no-till practices.

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Langgewens trial data was entered into the budget model to evaluate the profitability of the various systems under current circumstances. Certain trends were established and supported the findings of the literature review in Chapter 2. No-till practices showed a trend of reduced input costs and higher average gross margins when compared to conventional tillage. From a crop rotation perspective the yields of wheat following medics, canola, and lupins were consistently higher than that of wheat in a monoculture system. No-till under a crop rotation system generated higher crop yields than conventional tillage.

The trial data and results were consequently captured into a whole-farm, multi-period budget. A whole-farm budget model comprises of three components. Firstly the input component, which includes; the physical farm description, farming practices and crop rotation systems, yield assumptions, and input and output prices. Changing any of these factors will alter whole-farm profitability through a series of interconnected mathematical and accounting formulas. These equations are part of the calculation component and results in the output component that quantifies results in predetermined profitability criteria.

Applying standard accounting principles, the second component, the calculation component, comprises various calculations that represent the physical/biological and financial interrelations of the farm system. For example, individual enterprise gross margin calculations utilise data from the input component to calculate gross margin per hectare. The gross margins are later used to calculate net annual flows in the output component.

The output component refers to two main measurements. The first profitability measurement of the whole-farm is the internal rate of return on capital investment (IRR). The second measurement is the affordability of capital borrowed, measured in terms of cash flow.

The physical dimensions of the typical Middle Swartland farm model were validated during the expert group discussions. The model is based on standard accounting principle and three year average prices from 2011 to 2013 were used for all input and output prices. The mechanical requirements specific to the typical farm were also presented to and validated by the expert group. The dynamics of the model are designed to capture the complexity of the whole-farm system.

The different crop rotations and tillage systems were evaluated in terms of profitability on gross margin level. Four crop rotation systems and two tillage practices are evaluated in the model. This represents possible opportunities that can be implemented on a typical farm in the Middle Swartland. The crop rotation systems are; wheat monoculture (WWWW), wheat, canola, wheat, lupin rotation (WCWL), wheat, medic, wheat, medic rotation incorporating a sheep component, (WMWM), and a canola, wheat, wheat, wheat rotation (CWWW). The two tillage practices comprise conventional tillage and no-till.

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Three scenarios were simulated with the whole-farm model. The first scenario aims to determine the impact of input price inflation on the various systems. Increments of 10, 20, and 30 percent were used to assess the impact of increased input prices on expected profitability. The simulations highlighted the significance of tillage, because under conventional tillage, an increase in input costs results in twice the relative change in the IRR as compared to no-till. The rotation systems appear less sensitive to the inflated prices showing the buffering effect of increased yields generated by the rotations. It is also a factor of cost saving production practices in terms of fuel and maintenance on machinery.

The second scenario evaluated the implications of lower wheat prices. The simulations showed that all the systems are sensitive to variations in commodity prices. A 10 percent decline in the wheat price resembled the impact of a 30 percent increase in input prices. The CWWW and the WMWM systems could sustain a 10 percent decline in wheat price before becoming unprofitable. Decline in wheat prices of more than 10 percent rendered all the systems unattractive to investment. An increase in the wheat price was simulated to highlight how the systems would benefit from commodity price increases. The wheat monoculture system constituted the highest area under wheat, and consequently it would benefit the most.

The third scenario was designed to determine the impact of continued devaluation of the Rand to the US dollar, which would lead to increased machinery and fuel costs. The WMWM system operates with the lowest capital investment requirement subsequently the expected impact on profitability was less severe when compared to the other systems. The CWWW system, even though operating with a larger farm inventory, performed well under this scenario. It remained the most attractive option even after a 30 percent rise in machinery and fuel costs.

In conclusion the main aim of this research project was to financially quantify the implications of various CA systems in terms of profitability. The methods that were used during this research were successfully used to achieve these goals. The group discussions were particularly valuable in validating the combined impact of CA as a system and not specific components thereof. The most important lesson was that the interrelatedness of the factors and interrelationships of CA as a farming principle necessitates a systems perspective. The group of experts not only quantified expected yields and costs for each system, but also provided substantiated arguments for such suggestions.

The results that were obtained from the crop rotation trials at Langgewens experimental farm served as a basis for the study and the modelling. It was however evident that broader issues need to be simultaneously considered and captured in a whole farm model. It is also necessary to evaluate changes to farm systems over a longer period as many benefits and challenges of adoption of CA are only experienced over time. The model was structured so that it was able to

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assess the implications of different crop rotation and tillage systems on profitability. It was also used to illustrate the impact of various exogenous factors on profitability through scenarios. The results from the simulated scenarios show that the rotation systems under no-till practices are less sensitive to variations in external factors. The buffering effect of increased yields generated associated with crop rotation systems and no-till was apparent and effective for the CA systems. Diversifying the crop rotation systems into viable alternative crops or livestock enterprises effectively reduces the whole-farm exposure to risk. The impact of commodity price variations was higher than variations in input prices. The investment in no-till machinery can be afforded with the increased yield generated over the long-term. This research could contribute towards the implementation and adoption of CA in Africa, at least supporting the dialog on the financial implications of CA in winter cereal production systems. A conference paper was already delivered from this research (First Africa Congress on Conservation Agriculture, 18 – 21 March 2014. Lusaka, Zambia.).

6.3 Recommendations

This research project focused on conservation agriculture as a sustainable agricultural practice in the Middle Swartland, Western Cape. Both scientific and technical expert knowledge was incorporated through the use of multi-disciplinary discussion groups, to construct a whole-farm budget model for a typical Middle Swartland grain producing farm. The model was used to evaluate the profitability of various crop rotation and tillage systems within CA. A more holistic and real to life evaluation could be done by bringing producers, scientists, and extension officers together to discuss issues and available data. A closer longer term working and research relationship between all scientific disciplines and producers is recommended for CA farming in the Western Cape. Conservation agriculture is farm, producer, and resource specific and, to generate knowledge that is applicable to the farm system as a whole is important for new adopters of CA.

The whole-farm budget models proved to be a useful tool to assess the current financial situation on farms. It was also used to identify possible future investment opportunities and areas of research requirements in the industry. The models can be used to assess the financial implications of variations in external factors affecting farm profitability. It is recommended that annual or bi-annual industry assessments be carried out within homogeneous production areas. The results should be presented at various farmers' day meetings to raise awareness and assist with decision making regarding the expected impact of variations in external factors and novel innovations.

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Ongoing and new trials conducted by the Department of Agriculture, Western Cape would benefit from financial analysis of possible crop rotations to determine their viability within cropping systems in homogeneous areas. The models can be used to identify and focus research on topics and issues that contribute towards improving farm-level profitability. Research funders such as the Protein Research Foundation, the Winter Cereal Trust, and Grain SA should use such models to identify and evaluate research opportunities to improve farm level profitability through improved rotation and tillage systems.

A more detailed analysis of mixed cropping and livestock enterprises is recommended. The impact of livestock on soil compaction within a conservation system is worrying. The financial implications of reduced stocking rates or alternative feeding systems need to be researched. During the group discussions, producers and scientists often differed concerning the impact livestock have on soil compaction and residue cover within a CA system. Some producers are reducing stocking rates of sheep implying the benefits from the rotations to the following wheat crop outweighs the financial benefit of higher stocking rates.

Comparative assessment of the Life cycle analysis of the differing sustainable practices including CA is recommended. Europe has expressed concerns over the increased use and dependence on herbicides in a CA system and prefers to promote alternative low external input farming practices. A life cycle assessment would evaluate the demand on energy sources from a life cycle approach of various sustainable agricultural practices.

Finally it is recommended that research be conducted to identify key drivers influencing farmers' adoption of CA. Using multi-disciplinary discussion groups and policy framework analysis, the reasons and process of adoption should be evaluated. The possible need for policy to assist in the transitional phases of adoption for the lagging adoptees should be assessed.

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Annexures

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Annexure A: Maps indicating the homogeneous area of the Middle Swartland in the Western Cape

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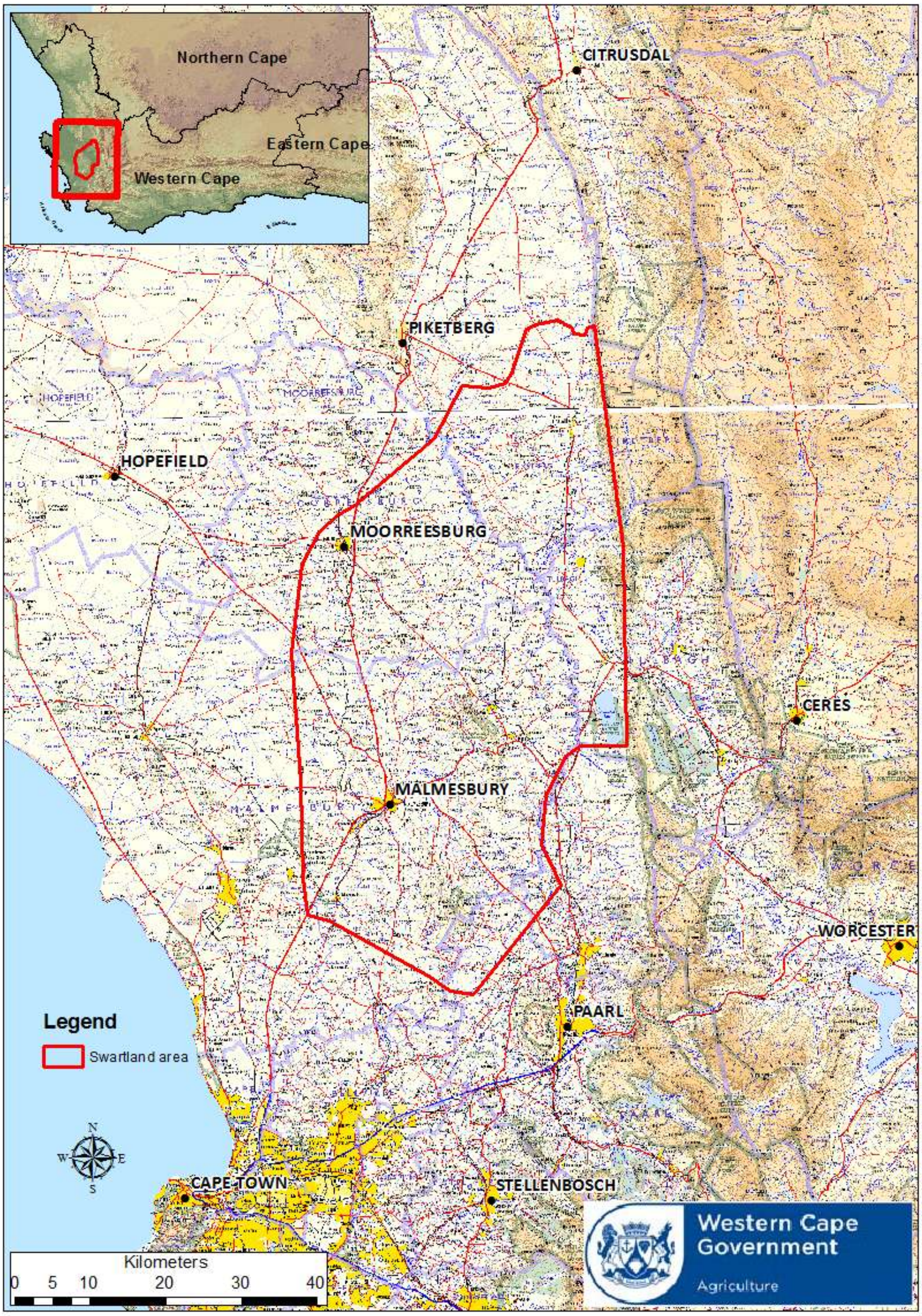
Parameters of the homogeneous Middle Swartland cereal production area in the Western Cape



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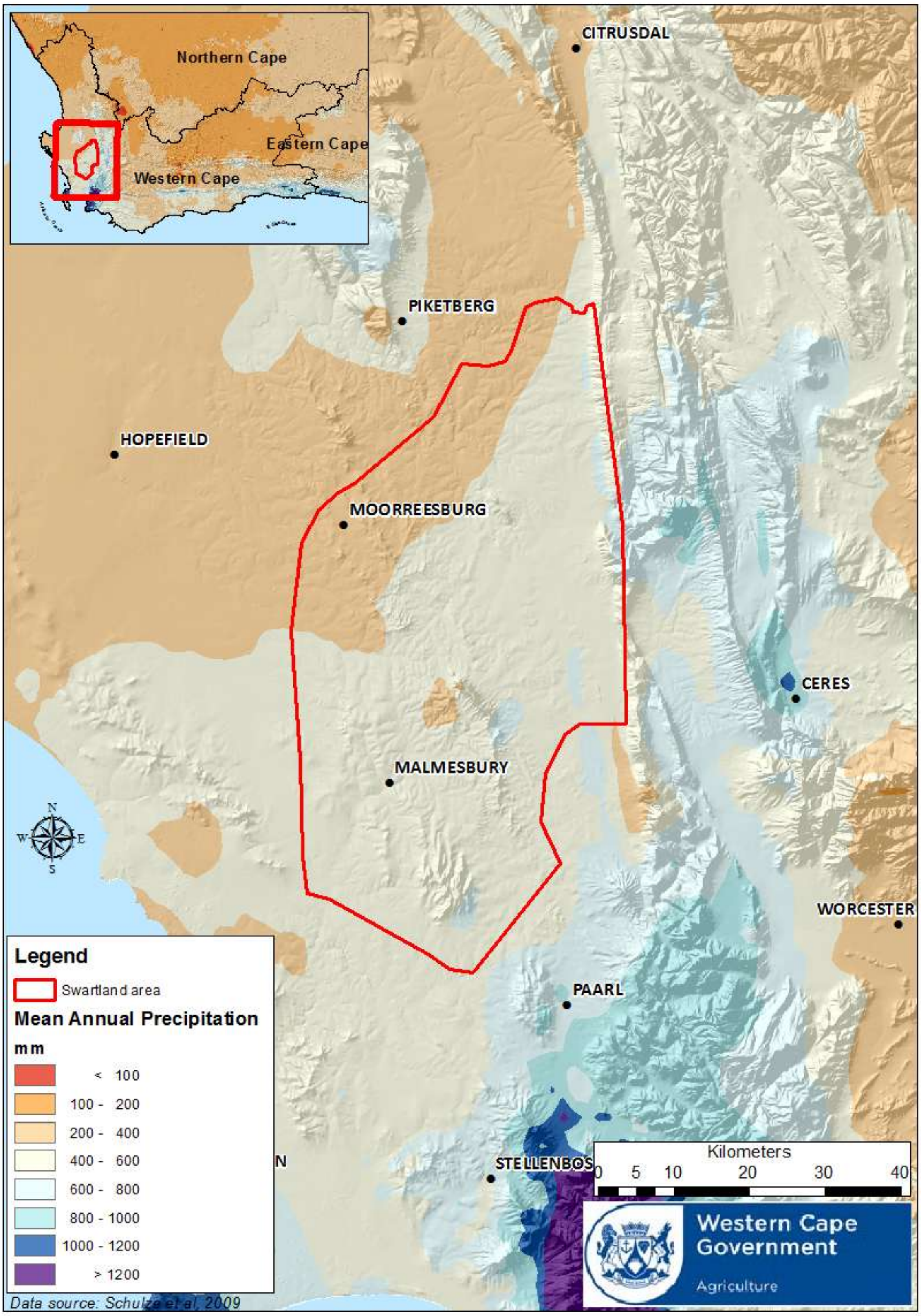
Rainfall Parameters of the homogeneous Middle Swartland cereal production area of the Western Cape



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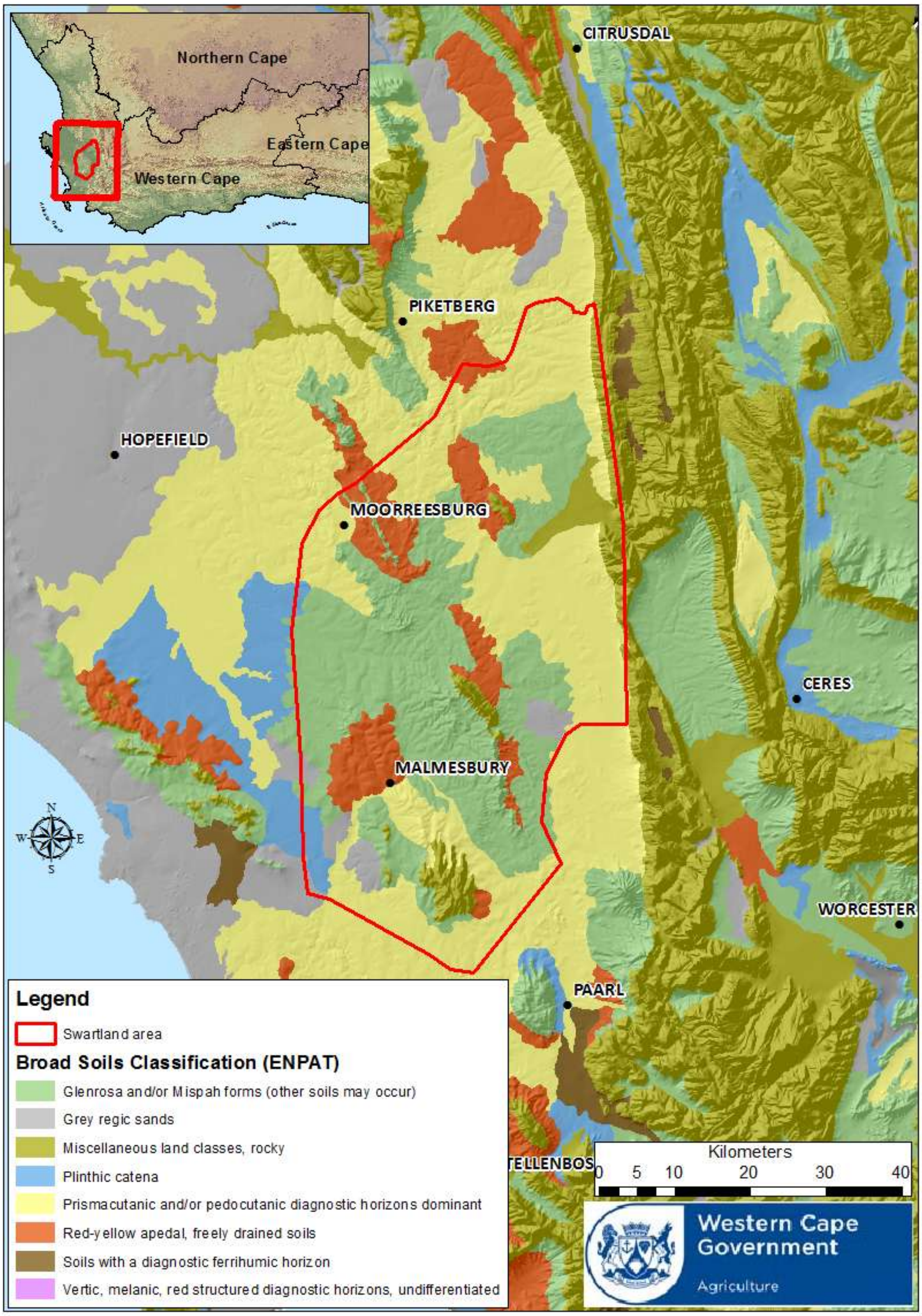
Soil type parameters of the homogeneous Middle Swartland cereal production area of the Western Cape



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Annexure B: Plot plan for soil health trials at Langgewens research farm– altered March 2007

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New plot plan for soil health study at Langgewens – altered March 2007

New plot plan for soil health study at Langgewens - altered in March 2007

1. 2007 is the 1st year or the new trial design ALL crop sequences start with the first letter in the sequence in 2007
2. Plots surrounded by solid lines are the plots allocated to the new tillage treatments (indicated by 4 sub-plots)
3. NOTE: All new tillage trial plots maintain the crop sequence they were allocated in 2002
4. Plots surrounded by hollow lines are to be managed in a CKLK or LKCK rotation and are available for other research projects
5. Rep 1 = plots 1 - 18; rep 2 = plots 19 - 36; rep 3 = plots 37 - 54; rep 4 = plots 55 - 72

N

A

New plot No and crop sequence	Old plot No	New plot No and crop sequence	Old plot No	New plot No and crop sequence	Old plot No	New plot No and crop sequence	Old plot No	New plot No and crop sequence	Old plot No
72 KKKK	56	64 LKCK	65	54 MKMK	49	36 CKLK	24	18 MKMK	13
71 CKLK	69	63 MKMK	67	53 CKLK	46	35 MKMK	31	17 KMKM	3
70 KLKC	61	62 KLKC	70	52 KCKL	50	34 KLKC	25	16 CKLK	6
69 KCKL	68	61 KMKM	57	51 CKLK	37	33 MKMK	22	15 LKCK	17
68 KCKL	59	60 LKCK	71	50 CKLK	45	32 CKLK	33	14 CKLK	11
67 LKCK	72	59 MKMK	58	49 KKKK	36	31 KCKL	23	13 CKLK	15
66 LKCK	64	58 KMKM	66						
65 LKCK	55	57 LKCK	63	48 CKLK	42	30 KMKM	21	12 CKLK	9
		56 CKLK	60	47 CKLK	51	29 LKCK	29	11 CKLK	1
		55 LKCK	62	46 KCKL	41	28 KCKL	32	10 KMKM	12
				45 MKMK	40	27 KKKK	20	9 KCKL	14
				44 CKLK	47	26 LKCK	19	8 CKLK	18
				43 LKCK	53	25 LKCK	35	7 KCKL	5
				42 KMKM	48	24 KLKC	34	6 KLKC	16
				41 LKCK	44	23 O/LKCK	28	5 CKLK	10
				40 KMKM	39	22 LKCK	26	4 LKCK	8
				39 CKLK	54	21 KMKM	30	3 KLKC	7
				38 KLKC	43	20 LKCK	36	2 MKMK	4
				37 KLKC	52	19 LKCK	27	1 KKKK	2

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Annexure C: Langgewens crop systems yield data 2007-2013, condensed on one spread sheet

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Langgewens crop systems yield data 2007-2013, condensed on one spread sheet

Code	Systems Rotation				
1	WWWW	Wheat	Wheat	Wheat	Wheat
2	mWmW	Lupin	Wheat	Canola	Wheat
3	LWCW	Canola	Wheat	Lupin	Wheat
4	CWLW	Medic	Wheat	Medic	Wheat
5	WLWC	Wheat	Lupin	Wheat	Canola
6	WCWL	Wheat	Canola	Wheat	Lupin
7	WmWm	Wheat	Medic		Medic

The last letter refers to the crop harvested

Tillage	
Zero Tillag	ZT
No Tillage	NT
Minimum	MT
Conventic	CT

REP 1

Crop Sequence	Crop Rotation	Previous Crop	Current Crop	2007 ZT	2007 NT	2007 MT	2007 CT	2008 ZT	2008 NT	2008 MT	2008 CT	2009 ZT	2009 NT	2009 MT	2009 CT
1	WWWW	Wheat	Wheat	0	0	0	0	4745	3570	4265	5275	786	2207	2199	1163
2	mWmW	Medic	Wheat	3620	4785	4765	3915	3935	5255	3420	3225	2278	3144	2704	1888
3	LWCW	Canola	Wheat	1715	5033	5433	5428	2685	4665	4810	4855	2084	2991	2585	2763
4	CWLW	Lupin	Wheat	3418	5850	5893	4008	4290	5065	4800	4800	1287	2587	2503	2934
TOTAL WHEAT				8753	15668	16091	13351	15655	18555	17295	18155	6435	10929	9991	8748
5	WLWC	Wheat	Canola	1400	1863	1935	2180	1560	1970	2055	1465	368	105	548	308
6	WCWL	Wheat	Lupin	1350	1000	863	1035	0	0	0	0	0	0	0	0
7	WmWm	Wheat	Medic	0	0	0	0	0	0	0	0	0	0	0	0

Crop Sequence	2010 ZT	2010 NT	2010 MT	2010 CT	2011 ZT	2011 NT	2011 MT	2011 CT	2012 ZT	2012 NT	2012 MT	2012 CT	2013 ZT	2013 NT	2013 MT	2013 CT	Average Yields ZT	Average Yields NT	Average Yields MT	Average Yields CT
1	358	2557	2745	2318	0	0	0	0	1677	3981	4161	4226	1518.9	1561.6	1527.4	1354.3	1 261	2 053	2 228	2 164
2	671	3190	3133	2268	944	3041	1959	2308	4802	6006	5610	4823	4496	2895.6	4334.5	3112.6	2 708	4 237	3 599	3 071
3	574	3058	2947	2452	1243	2805	2272	2611	3689	5339	5225	5361	3703.4	2356.4	3922.8	1446.8	1 998	3 982	3 879	3 912
4	2052	2815	2984	2447	1720	4023	3106	3279	5140	6057	5819	5207	2631.3	1528.2	2928.9	2949.4	2 985	**4 400**	4 184	3 779
TOTAL WHEAT	3655	11620	11809	9485	3907	9869	7337	8198	15308	21383	20815	19617	12349.6	8341.8	12713.6	8863.1	8 952	14 671	13 890	12 926
5	892	947	716	703	1179	1930	1477	1994	1893	2275	2761	2373	1938.3	2115.9	1445	1651.5	1 215	1 515	1 582	1 504
6	1772	1620	736	1577	2357	2639	2482	1744	735	1143	828	745	891.2	840.3	447.1	468.3	1 036	1 067	818	850
7	7000	11100	10700	7000	2400	4544	3536	2024	0	0	0	0	0	0	0	0	1 567	2 607	2 373	1 504

REP 2

Crop Sequence	Crop Rotation	Previous Crop	Current Crop	2007 ZT	2007 NT	2007 MT	2007 CT	2008 ZT	2008 NT	2008 MT	2008 CT	2009 ZT	2009 NT	2009 MT	2009 CT
1	WWWW	Wheat	Wheat	0	0	0	0	3380	5575	4270	4860	1693	3127	2383	2578
2	mWmW	Medic	Wheat	3920	5215	5430	4435	3860	5180	4980	4750	2164	3317	2838	2860
3	LWCW	Canola	Wheat	4620	5450	5323	4863	3440	5700	5440	4900	2436	3352	2819	3013
4	CWLW	Lupin	Wheat	4175	5308	5705	5393	2740	4845	3255	4705	1923	3069	2456	2820
TOTAL WHEAT				12715	15973	16458	14691	13420	21300	17945	19215	8216	12865	10496	11271
5	WLWC	Wheat	Canola	1815	1938	2213	2058	0	0	0	0	358	498	782	660
6	WCWL	Wheat	Lupin	1453	1238	1428	1508	0	0	0	0	0	0	0	0
7	WmWm	Wheat	Medic	0	0	0	0	0	0	0	0	0	0	0	0

Crop Sequence	2010 ZT	2010 NT	2010 MT	2010 CT	2011 ZT	2011 NT	2011 MT	2011 CT	2012 ZT	2012 NT	2012 MT	2012 CT	2013 ZT	2013 NT	2013 MT	2013 CT	Average Yields ZT	Average Yields NT	Average Yields MT	Average Yields CT
1	870	2899	2467	2581	1319	3192	1801	2729	1694	4939	4681	5423	1194.5	1707.8	351.8	1274.1	1 493	3 289	2 600	3 029
2	3056	3622	3535	2651	1956	3783	3069	2181	4062	6325	4552	5690	2343.8	4652	2857	3913.8	3 170	**4 574**	4 067	3 761
3	0	2616	3106	2780	891	2743	2163	2638	1170	3810	4768	5533	3375.1	2389.5	4393.1	1447.4	2 093	3 945	3 937	3 955
4	2020	3284	2820	2072	3616	2644	2616	1967	4929	5171	5439	5161	2282.7	3651.8	3687.4	2916.1	3 234	4 054	3 715	3 686
TOTAL WHEAT	5946	12421	11928	10084	7782	12362	9649	9515	11855	20245	19440	21807	9196.1	12401.1	11289.3	9551.4	9 989	15 861	14 319	14 431
5	853	1041	969	1614	1675	1793	1206	1780	2100	2136	2730	2840	1329.1	1617.8	1487.5	1702.2	1 134	1 234	1 317	1 492
6	2408	1637	2321	1629	2307	2472	2532	2055	754	1047	663	688	521	510.4	250.2	819	1 154	1 066	1 157	980
7	8000	8800	10900	9900	2784	3032	4600	2704	0	0	0	0	0	0	0	0	1 797	1 972	2 583	2 101

REP 3

Crop Sequence	Crop Rotation	Previous Crop	Current Crop	2007 ZT	2007 NT	2007 MT	2007 CT	2008 ZT	2008 NT	2008 MT	2008 CT	2009 ZT	2009 NT	2009 MT	2009 CT
1	WWWW	Wheat	Wheat	0	0	0	0	4280	3060	3410	5350	1605	1544	1959	2080
2	mWmW	Medic	Wheat	4055	5743	5640	4743	5160	5580	5280	4055	2134	2935	2881	3101
3	LWCW	Canola	Wheat	1875	6113	6093	5640	3855	5260	5080	6285	1621	3042	2984	2973
4	CWLW	Lupin	Wheat	3798	4610	5150	4670	4690	5425	2550	4835	1708	3285	3349	2777
TOTAL WHEAT				9728	16466	16883	15053	17985	19325	16320	20525	7068	10806	11173	10931
5	WLWC	Wheat	Canola	1243	1303	1130	1160	0	0	0	0	157	511	440	575
6	WCWL	Wheat	Lupin	1348	1078	1168	1105	0	0	0	0	0	0	0	0
7	WmWm	Wheat	Medic	0	0	0	0	0	0	0	0	0	0	0	0

Crop Sequence	2010 ZT	2010 NT	2010 MT	2010 CT	2011 ZT	2011 NT	2011 MT	2011 CT	2012 ZT	2012 NT	2012 MT	2012 CT	2013 ZT	2013 NT	2013 MT	2013 CT	Average Yields ZT	Average Yields NT	Average Yields MT	Average Yields CT
1	835	2996	2740	2385	1668	2207	1973	2423	929	0	0	5352	1687.5	1621.8	1258.3	1410.9	1 553	1 635	1 680	2 932
2	2524	3555	3262	2467	2139	3769	3723	4207	4350	6165	4984	5552	4099.7	2170.3	3055.3	4335	3 394	**4 625**	4 295	4 021
3	1533	3287	3317	3168	1722	3556	3362	2524	3307	5107	4947	5868	4485.2	3532.9	4667.3	2425.6	2 319	4 394	4 297	4 410
4	3073	3814	2425	3153	1920	3939	3647	3243	3612	5874	5275	5887	0	4933.6	5275	5887	3 134	4 491	3 733	4 094
TOTAL WHEAT	7965	13652	11744	11173	7449	13471	12705	12397	12198	17146	15206	22659	10272.4	12258.6	14255.9	14058.5	10 399	15 144	14 005	15 456
5	747	1289	917	1186	1988	2283	1757	1758	1722	2709	2789	2379	1914.4	1694.3	1762.5	2191.4	976	1 349	1 172	1 176
6	0	0	0	0	1984	2073	1745	2056	721	999	999	753	794.9	739.5	0	222.5	676	692	652	652
7	3300	2100	6200	4300	2008	2008	2736	2344	0	0	0	0	0	0	0	0	885	685	1 489	1 107

REP 4

Crop Sequence	Crop Rotation	Previous Crop	Current Crop	2007 ZT	2007 NT	2007 MT	2007 CT	2008 ZT	2008 NT	2008 MT	2008 CT	2009 ZT	2009 NT	2009 MT	2009 CT
1	WWWW	Wheat	Wheat	0	0	0	0	3320	3835	4080	3895	852	2676	1628	2173
2	mWmW	Medic	Wheat	4760	5663	5425	4560	4650	5065	5295	4875	1758	3039	2190	2693
3	LWCW	Canola	Wheat	4743	5553	5555	4945	5555	4195	5080	6575	1792	2875	2607	2561
4	CWLW	Lupin	Wheat	4770	5980	5965	5033	3305	6050	4555	6095	1819	2539	2853	2877
TOTAL WHEAT				14273	17196	16945	14538	16830	19145	19010	21440	6221	11129	9278	10304
5		Wheat	Canola	1475	1785	1603	1613	852	2676	1628	2173	276	590	312	461
6		Wheat	Lupin	1048	1208	1158	940	0	0	0	0	0	0	0	0
7		Wheat	Medic	0	0	0	0	0	0	0	0	0	0	0	0

Crop Sequence	2010 ZT	2010 NT	2010 MT	2010 CT	2011 ZT	2011 NT	2011 MT	2011 CT	2012 ZT	2012 NT	2012 MT	2012 CT	2013 ZT	2013 NT	2013 MT	2013 CT	Average Yields ZT	Average Yields NT	Average Yields MT	Average Yields CT
1	837	2624	1853	1654	575	2359	1780	2473	149	3919	3602	5140	1528.9	2083.6	0	1347.7	956	2 569	2 157	2 556
2	2800	3145	3734	3284	1642	3550	2724	2812	4271	5543	5436	4912	3566	4562.4	4105.5	2602.5	3 314	4 334	4 134	3 856
3	1955	3324	3135	3260	1304	3200	3320	3458	1719	4845	5553	5468	4249.5	3438.9	4414.1	2002.7	2 845	3 999	4 208	4 378
4	3242	4067	3426	3011	2645	3641	2870	2151	3053	5431	5237	6057	2849.2	2575.5	3564.1	4170.6	3 139	**4 618**	4 151	4 204
TOTAL WHEAT	8834	13160	12148	11209	6166	12750	10694	10894	9192	19738	19828	21577	12193.6	12660.4	12083.7	10123.5	10 253	15 520	14 651	14 994
5	965	1198	1208	1161	1676	1688	1227	1983	2779	3257	2709	3496	0	991.3	1212.4	2606.4	1 337	1 866	1 448	1 815
6	0	0	0	0	0	927	1283	1909	505	1172	396	653	331.1	224.6	770.3	719.9	259	551	473	584
7	2700	4200	3300	2700	3344	1400	4184	1680	0	0	0	0	0	0	0	0	1 007	933	1 247	730

		code	2007 ZT	2007 NT	2007 MT	2007 CT	2008 ZT	2008 NT	2008 MT	2008 CT	2009 ZT	2009 NT	2009 MT	2009 CT
Average Wheat Mon	WWWW	1	0	0	0	0	3931.25	4010	4006.25	4845	1234	2388.5	2042.25	1998.5
Average Wheat after	mWmW	2	4088.75	5351.5	5315	4413.25	4401.25	5270	4743.75	4226.25	2083.5	3108.75	2653.25	2635.5
Average Wheat after	LWCW	3	3238.25	5537.25	5601	5219	3883.75	4955	5102.5	5653.75	1983.25	3065	2748.75	2827.5
Average Wheat after	CWLW	4	4040.25	5437	5678.25	4776	3756.25	5346.25	3790	5108.75	1684.25	2870	2790.25	2852
Average Total Wheat Yield			3789.08	**5441.92**	5531.42	4802.75	5324.17	6527.08	5880.83	**6611.25**	2328.33	**3810.75**	3411.50	3437.83
Average Canola Yielc	WLWC	5	1483.25	1722.25	1720.25	**1752.75**	603	**1161.5**	920.75	909.5	289.75	426	**520.5**	501
Average Lupin Yield	WCWL	6	1299.75	1131	1154.25	1147	0	0	0	0	0	0	0	0
Average Medic Yield	WmWm	7	0	0	0	0	0	0	0	0	0	0	0	0

	2010 ZT	2010 NT	2010 MT	2010 CT	2011 ZT	2011 NT	2011 MT	2011 CT	2012 ZT	2012 NT	2012 MT	2012 CT	2013 ZT	2013 NT	2013 MT	2013 CT
Average Wheat Mon WWWW	725	2769	2451.25	2234.5	890.5	1939.5	1388.5	1906.25	1112.25	3209.75	3111	5035.25	1482.45	1743.7	784.375	1346.75
Average Wheat after mWmW	2262.75	3378	3416	2667.5	1670.25	3535.75	2868.75	2877	4371.25	6009.75	5145.5	5244.25	3626.375	3570.075	3588.075	3490.975
Average Wheat after LWCW	1015.5	3071.25	3126.25	2915	1290	3076	2779.25	2807.75	2471.25	4775.25	5123.25	5557.5	3953.3	2929.425	4349.325	1830.625
Average Wheat after CWLW	2596.75	3495	2913.75	2670.75	2475.25	3561.75	3059.75	2660	4183.5	5633.25	5442.5	5578	1940.8	3172.275	3863.85	3980.775
Average Total Wheat Yield	2200.00	**4237.75**	3969.08	3495.92	2108.67	**4037.67**	3365.42	3417.00	4046.08	6542.67	6274.08	**7138.33**	3667.64	**3805.16**	4195.21	3549.71
Average Canola Yielc WLWC	864.25	1118.75	952.5	**1166**	1629.5	**1923.5**	1416.75	1878.75	2123.5	2594.25	2747.25	**2772**	1295.45	1604.825	1476.85	**2037.875**
Average Lupin Yield WCWL	**1045**	814.25	764.25	801.5	1662	**2027.75**	2010.5	1941	678.75	**1090.25**	721.5	709.75	**634.55**	578.7	366.9	557.425
Average Medic Yield WmWm	5250	6550	**7775**	5975	2634	2746	**3764**	2188	0	0	0	0	0	0	0	0

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Annexure D: Guide to machinery costs and costs related to specific mechanical activities

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Guide to machinery costs and costs related to specific mechanical activities

MECHANIZATION INFORMATION: (All figures are derived from DAFF Guide to Machinery Costs 2013-2014)

TRACTORS: Unless specified, all are 4wheel drive

	Salvage value =	10%	of purchase price
	Depreciation = (Purchase price - salvage value)/life (hrs)		
	Licence & insurance =	2%	of average investment / hours per annum
	Interest =	9%	of average investment / hours per annum
	Repairs & maintenance =	120%	of purchase price/ lifetime (hrs)
Power	**Fuel price =**	13.5	R/litre
Low	**Fuel usage =**	35%	of Tractor power (kW)
	Litres used per kW hour	0.4	
Medium	**Fuel usage =**	45%	of Tractor power (kW)
	Litres used per kW hour	0.35	
High	**Fuel usage =**	60%	of Tractor power (kW)
	Litres used per kW hour	0.30	

LOW POWER DEMAND:

Tractor Power kW	Life (hrs)	Annual Use (hrs)	Purchase Price R	Salvage Value R	Average Investment R	Depre-ciation R/hr	Licence & Insurance R/hr	Interest R/hr	Total fixed costs R/hr	Tot. Fixed cost excluding interest R/hr	Repairs & Maintenance R/hr	Fuel cost R/hr	Tot. var. Costs R/hr	Total Costs R/hr	Tot. costs Excl interest R/hr	Fuel Usage Litre/hr	Cost for set of new tyres:	Life of set of tyres km	Tyre cost per km
68	12000	1000	487996	48799.6	268397.8	36.60	4.70	22.81	64.11	41.30	48.80	128.52	177.32	241.43	218.62	9.52	4000.00	12000.00	0.33
68	12000	1000	487996	48799.6	268397.8	36.60	4.70	22.81	64.11	41.30	48.80	128.52	177.32	241.43	218.62	9.52	4000.00	12000.00	0.33
68	12000	1000	487996	48799.6	268397.8	36.60	4.70	22.81	64.11	41.30	48.80	128.52	177.32	241.43	218.62	9.52	6000.00	12000.00	0.50
68	12000	1000	487996	48799.6	268397.8	36.60	4.70	22.81	64.11	41.30	48.80	128.52	177.32	241.43	218.62	9.52	6000.00	12000.00	0.50
68	12000	1000	487996	48799.6	268397.8	36.60	4.70	22.81	64.11	41.30	48.80	128.52	177.32	241.43	218.62	9.52	6000.00	12000.00	0.50
68	12000	1000	487996	48799.6	268397.8	36.60	4.70	22.81	64.11	41.30	48.80	128.52	177.32	241.43	218.62	9.52	6000.00	12000.00	0.50
68	12000	1000	487996	48799.6	268397.8	36.60	4.70	22.81	64.11	41.30	48.80	128.52	177.32	241.43	218.62	9.52	6000.00	12000.00	0.50
68	12000	1000	487996	48799.6	268397.8	36.60	4.70	22.81	64.11	41.30	48.80	128.52	177.32	241.43	218.62	9.52	6000.00	12000.00	0.50
68	12000	1000	487996	48799.6	268397.8	36.60	4.70	22.81	64.11	41.30	48.80	128.52	177.32	241.43	218.62	9.52	6000.00	12000.00	0.50
68	12000	1000	487996	48799.6	268397.8	36.60	4.70	22.81	64.11	41.30	48.80	128.52	177.32	241.43	218.62	9.52	6000.00	12000.00	0.50
68	12000	1000	487996	48799.6	268397.8	36.60	4.70	22.81	64.11	41.30	48.80	128.52	177.32	241.43	218.62	9.52	6000.00	12000.00	0.50
68	12000	1000	487996	48799.6	268397.8	36.60	4.70	22.81	64.11	41.30	48.80	128.52	177.32	241.43	218.62	9.52	6000.00	12000.00	0.50
68	12000	1000	487996	48799.6	268397.8	36.60	4.70	22.81	64.11	41.30	48.80	128.52	177.32	241.43	218.62	9.52	6000.00	12000.00	0.50
68	12000	1000	487996	48799.6	268397.8	36.60	4.70	22.81	64.11	41.30	48.80	128.52	177.32	241.43	218.62	9.52	6000.00	12000.00	0.50
68	12000	1000	487996	48799.6	268397.8	36.60	4.70	22.81	64.11	41.30	48.80	128.52	177.32	241.43	218.62	9.52	6000.00	12000.00	0.50
68	12000	1000	487996	48799.6	268397.8	36.60	4.70	22.81	64.11	41.30	48.80	128.52	177.32	241.43	218.62	9.52	6000.00	12000.00	0.50
68	12000	1000	487996	48799.6	268397.8	36.60	4.70	22.81	64.11	41.30	48.80	128.52	177.32	241.43	218.62	9.52	6000.00	12000.00	0.50
68	12000	1000	487996	48799.6	268397.8	36.60	4.70	22.81	64.11	41.30	48.80	128.52	177.32	241.43	218.62	9.52	6000.00	12000.00	0.50
68	12000	1000	487996	48799.6	268397.8	36.60	4.70	22.81	64.11	41.30	48.80	128.52	177.32	241.43	218.62	9.52	6000.00	12000.00	0.50
Harvesters:																			
124	12000	1000	1293662	129366.2	711514.1	97.02	12.45	60.48	169.95	109.48	129.37	234.36	363.73	533.68	473.20	17.36			
216	12000	1000	2540455	254045.5	1397250	190.53	24.45	118.77	333.75	214.99	254.05	408.24	662.29	996.04	877.27	30.24			

IMPLEMENTS:

Depreciation cost per hour =	(Purchase price - salvage value)/life period in hours	
Salvage value =	10%	of purchase price
Average investment =	(Purchase price + salvage value)/2	
Interest cost =	10%	of average investment per annum/hours per annum
Repairs and maintenance =	0.012%	culculated as a percentage of purchase price

Code	IMPLEMENT: Description	Life (hrs)	Annual usage (hrs)	Purchase price (R)	Salvage Value (R)	Average investment (R)	Depre-ciation (R/hr)	Interest (R/hr)	Tot. fixed costs (R/hr)	Tot. fixed costs excl interest (R/hr)	Repairs and maint as a % of new price %	Repairs & maint (R/hr)	Tot. var costs (R/hr)	Total costs (R/hr)	Total costs excl interest (R/hr)
101	Spayer 10m, 1000 liter, mounted	2500	250	25675	2567.5	14121.25	9.243	5.6485	14.8915	9.243	30%	3.081	3.081	17.9725	12.324
102	7 row seed drill planter	2500	250	148400	14840	81620	53.424	32.648	86.072	53.424	30%	17.808	17.808	103.88	71.232
103	Spreader, Fertilizer Ddisc 500l	2500	250	28391	2839.1	15615.05	10.22076	6.24602	16.46678	10.22076	30%	3.40692	3.40692	19.8737	13.62768
104	Spreader,Lime Ddisc 3t	2500	250	133564	13356.4	73460.2	48.08304	29.38408	77.46712	48.08304	30%	16.02768	16.02768	93.4948	64.11072
105	Tyres	500	10	0	0	0	0	0	0	0	30%	0	0	0	0
106	5 Disc Plough (not reversible)	2500	250	37550	3755	20652.5	13.518	8.261	21.779	13.518	30%	4.506	4.506	26.285	18.024
107	Rovic Cult 2.0 m - 7 tines (C Shank	2500	250	19478	1947.8	10712.9	7.01208	4.28516	11.29724	7.01208	30%	2.33736	2.33736	13.6346	9.34944
108	3.0m 31 tine cultivator	2500	250	29750	2975	16362.5	10.71	6.545	17.255	10.71	30%	3.57	3.57	20.825	14.28
109	7 row No-Till Planter	2500	250	426786	42678.6	234732.3	153.64296	93.89292	247.5359	153.64296	30%	51.21432	51.21432	298.7502	204.85728
110	Harvester Head 5.2m	2500	250	322816	32281.6	177548.8	116.21376	71.01952	187.2333	116.21376	30%	38.73792	38.73792	225.9712	154.95168
111	Planter 10m no till	2500	250	1250000	125000	687500	450	275	725	450	30%	150	150	875	600
112	Planter 10m no till	2500	250	1250000	125000	687500	450	275	725	450	30%	150	150	875	600
113	Planter 10m no till	2500	250	1250000	125000	687500	450	275	725	450	30%	150	150	875	600
114	Planter 10m no till	2500	250	1250000	125000	687500	450	275	725	450	30%	150	150	875	600
115	Planter 10m no till	2500	250	1250000	125000	687500	450	275	725	450	30%	150	150	875	600

USAGE PER ANNUM:

Power Demand	Code	Activity	Power source	Implement Code	Implement Description	Work width m	Speed km/hour	Efficiency	Ha/hour	Hour/Ha	Fuel Litre/ha	R/ha	Repairs & Maintenance R/ha Power	Repairs & Maintenance R/ha Imple.	Tyre cost:
Medium	1	Spray: herbicide	68	101	Spayer 10m, 1000 liter, mounted	12	5.8	85%	5.916	0.17	1.81	24.44	8.25	0.52	0.490196
Medium	2	Spray: Insecticide	68	101	Spayer 10m, 1000 liter, mounted	12	5.8	85%	5.916	0.17	1.81	24.44	8.25	0.52	0.490196
Medium	3	Spray: Fungicide	68	101	Spayer 10m, 1000 liter, mounted	12	5.8	85%	5.916	0.17	1.81	24.44	8.25	0.52	0.490196
High	4	Plant Star Wheel	68	102	7 row seed drill planter	3.3	5.5	85%	1.543	0.65	7.93	107.11	31.63	11.54	1.782531
High	5	Plant AusPlow	68	109	7 row No-Till Planter	3.3	5.5	85%	1.54275	0.65	7.93	107.11	31.63	33.20	1.782531
Medium	6	Spread: fertilizer	68	103	Spreader, Fertilizer Ddisc 500l	10	9	85%	7.65	0.13	1.40	18.90	6.38	0.45	0.588235
Medium	7	Spread lime	68	104	Spreader,Lime Ddisc 3t	10	9	85%	7.65	0.13	1.40	18.90	6.38	2.10	0.588235
Medium	8	Stubble Spreading	68	105	Tyres	4	10	85%	3.4	0.29	3.15	42.53	14.35	0.00	1.470588
Medium	9	Spray: Trace elements	68	101	Spayer 10m, 1000 liter, mounted	12	5.8	85%	5.916	0.17	1.81	24.44	8.25	0.52	0.490196
Medium	10	Spray: Fung & Insect	68	101	Spayer 10m, 1000 liter, mounted	12	5.8	85%	5.916	0.17	1.81	24.44	8.25	0.52	0.490196
High	11	Harvest	124	110	Harvester Head 5.2m	5	5	83%	2.075	0.48	10.76	145.21	62.35	18.67	1.204819
Medium	12	Spray: Herb & Insect	68	101	Spayer 10m, 1000 liter, mounted	12	5.8	85%	5.916	0.17	1.81	24.44	8.25	0.52	0.490196
Medium	13	Spray: Herb & Trace Elem	68	101	Spayer 10m, 1000 liter, mounted	12	5.8	85%	5.916	0.17	1.81	24.44	8.25	0.52	0.490196
High	14	Spike tooth harrow	68	108	3.0m 31 tine cultivator	3.3	5	85%	1.4025	0.71	8.73	117.82	34.79	2.55	1.782531
High	15	Plough	68	106	5 Disc Plough (not reversible)	2	5	85%	0.85	1.18	14.40	194.40	57.41	5.30	2.941176
Medium	16	Tyre Drag	68	105	Tyres	8	10	85%	6.8	0.15	1.58	21.26	7.18	0.00	0.735294

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Annexure E: Example of one of the Langgewens enterprise gross margin analysis, wheat under WCWL rotation

Gross margin analysis for wheat under WCWL rotation

Activity Code	Month	Item	Description	Unit	R/Unit	Unit/Ha	Repeats	Value	Zero Tillage	No Tillage	Minimum Tillage	Convention Tillage
		Crop: Wheat	Rotation Co	3	LWCW		Year:	2010				
		Location: Langge Swartland Conservation Agriculture Trials										
		Tillage Used	**Yield potential**						Average Yields			
		Zero Tillge	Kg's/Ha					1015.5	1016			
		No Tillage						3071.25		3071		
		Minimum Tillage						3126.25			3126	
		Conventional Tillage						2915				2915
100		Wheat: B1	Price: R/ton					2360				
		Total Production Income (a)							2 396.58	7 248.15	7 377.95	6 879.40
		Directly attributable variable costs: (b)							ZT	NT	MT	CT
		Seed Cost:										
200		Wheat SST 027		kg	5.02	90		451.80	451.80	451.80	451.80	451.80
									-	-	-	-
		Fertilization :										
300		2:1:0 (29)+S Kynoch		kg	3.98	129		513.42	513.42	513.42	513.42	513.42
301		Kysan 27%N + 3%S		kg	3.51	145		508.95	508.95	508.95	508.95	508.95
304		Dolomitiese kalk		kg	0.42	0		-	-	-	-	-
		Weed control :										
407		Paragone (Preeglone)		liter	41.95	2		83.90	83.90	83.90	83.90	83.90
401		Triflurex (Triflorilin)		liter	56.43	1.5		84.65		84.65	84.65	84.65
424		Buctril DS		liter	70.68	1		70.68	70.68	70.68	70.68	70.68
		Fungal control :										
602		Duett		l	163.02	0.8		130.42	130.42	130.42	130.42	130.42
		Insect control :										
500		Mospilan		gram	0.7	50		35.00	35.00	35.00	35.00	35.00
		Contract Work										
802		Transport		ton	47.7	1		47.70	47.70	47.70	47.70	47.70
803		Ariel Spraying		ha	0	0		-	-	-	-	-
804		Lime spreading		ton	107.16	1		107.16	107.16	107.16	107.16	107.16
									-	-	-	-
									-	-	-	-
		Total directly attributable variable costs :						**2033.67**	1 949.03	2 033.67	2 033.67	2 033.67

Not directly attributable variable costs: (c)

Activity Code	Month	Activity	Power sourc	Implemen	Time/km	Implement	Power s	Labour	Implement Repair	Energy	Power Repair	Total Variable Costs	Regular labour co Oper.	Tyre costs:	ZT	NT	MT	CT
			Usage per Year						Cost per Year									
1	May	Spray: herbicide	68	101	1	0.17	0.17	0.20	0.52	24.44	8.25	33.21	10.95	0.49	44.65	44.65	44.65	44.65
14	Apr	Spike tooth harro	68	108	1	0.71	0.71	0.86	2.55	117.82	34.79	155.16	46.20	1.78			203.14	203.14
15	Feb	Plough	68	106	1	1.18	1.18	1.41	5.30	194.40	57.41	257.11	76.24	2.94				336.29
5	Feb	Plant AusPlow	68	109	1	0.65	0.65	0.78	33.20	107.11	31.63	171.94	42.00	1.78		215.72	215.72	215.72
4	May	Plant Star Wheel	68	102	1	0.65	0.65	0.78	11.54	107.11	31.63	150.28	42.00	1.78	194.07			
6	May	Spread: fertilizer	68	103	1	0.13	0.13	0.16	0.45	18.90	6.38	25.72	8.47	0.59	34.78			
6	May	Spread: fertilizer	68	103	1	0.13	0.13	0.16	0.45	18.90	6.38	25.72	8.47	0.59	34.78	34.78	34.78	34.78
10	May	Spray: Fung & Ins	68	101	1	0.17	0.17	0.20	0.52	24.44	8.25	33.21	10.95	0.49	44.65	44.65	44.65	44.65
11	June	Harvest	124	110	1	0.48	0.48	0.58	18.67	145.21	62.35	226.23	31.23	1.20	258.66	258.66	258.66	258.66
Totals:																		
		Total non- directly attributable variable costs :													566.95	553.82	756.96	1 093.25
		Gross Margin : (= a-b - c)													-119.39	4660.66	4587.32	3752.48

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Annexure F: Summary of costs and gross margins for the Langgewens trials on CA

Summary of costs and margins

Summary Costs and Margins for each crop

Rotation	WWWW				LWCW				CWLW				mWmW				WLWC				WCWL				WmWm			
	ZT	NT	MT	CT	ZT	NT	MT	CT	ZT	NT	MT	CT	ZT	NT	MT	CT	ZT	NT	MT	CT	ZT	NT	MT	CT	ZT	NT	MT	CT
Total Production Income	0	0	0	0	7 440.92	12 723.60	12 870.09	11 992.32	9 283.77	12 493.25	13 047.60	10 974.39	9 395.21	12 296.78	12 212.91	10 140.85	5 191.38	6 027.88	6 020.88	6 134.63	2 242.07	1 950.98	1 991.08	1 978.58	-	-	-	-
Directly Attributable Variable Costs	2 047.15	2 097.60	2 097.60	2 097.60	1 970.53	2 020.98	2 020.98	2 020.98	1 970.53	2 020.98	2 020.98	2 020.98	1 970.53	2 020.98	2 020.98	2 020.98	1 855.49	1 855.49	1 855.49	1 855.49	1 071.46	1 071.46	1 071.46	1 071.46	266.57	266.57	266.57	266.57
Margin above Directly Attributable Variable Cost	-2 047.15	-2 097.60	-2 097.60	-2 097.60	5 470.38	10 702.63	10 849.11	9 971.34	7 313.23	10 472.27	11 026.62	8 953.41	7 424.68	10 275.81	10 191.93	8 119.88	3 335.89	4 172.39	4 165.39	4 279.14	1 170.60	879.51	919.62	907.11	266.57	266.57	266.57	266.57
Not Directly Attributable Costs	501.35	495.56	745.61	828.84	781.99	768.86	1 175.15	1 308.30	781.99	768.86	1 175.15	1 308.30	473.02	467.23	717.28	800.50	702.56	724.21	1 130.50	1 263.64	667.77	689.43	1 095.72	1 228.86	215.04	215.04	215.04	215.04
Gross Margin Above all Attributable Costs	-2 548.51	-2 593.16	-2 843.21	-2 926.43	4 688.39	9 933.76	9 673.96	8 663.05	6 531.24	9 703.41	9 851.47	7 645.11	6 951.66	9 808.58	9 474.66	7 319.37	2 633.33	3 448.18	3 034.89	3 015.49	502.83	190.08	-176.10	-321.75	51.52	51.52	51.52	51.52

2008

Rotation	WWWW				LWCW				CWLW				mWmW				WLWC				WCWL				WmWm			
	ZT	NT	MT	CT	ZT	NT	MT	CT	ZT	NT	MT	CT	ZT	NT	MT	CT	ZT	NT	MT	CT	ZT	NT	MT	CT	ZT	NT	MT	CT
Total Production Income	7948	8107	8100	9795	7 851.93	10 017.72	10 315.93	11 430.41	7 594.16	10 808.73	7 662.39	10 328.56	8 898.18	10 654.57	9 590.63	8 544.38	2 279.34	4 390.47	3 480.44	3 437.91	-	-	-	-	-	-	-	-
Directly Attributable Variable Costs	2 209.63	2 284.87	2 284.87	2 284.87	2 209.63	2 284.87	2 284.87	2 284.87	2 209.63	2 284.87	2 284.87	2 284.87	2 209.63	2 284.87	2 284.87	2 284.87	2 204.42	2 204.42	2 204.42	2 204.42	1 408.36	1 408.36	1 408.36	1 408.36	1 115.64	1 115.64	1 115.64	1 115.64
Margin above Directly Attributable Variable Cost	5 738.34	5 822.31	5 814.73	7 510.46	5 642.30	7 732.85	8 031.06	9 145.54	5 384.53	8 523.86	5 377.52	8 043.69	6 688.55	8 369.70	7 305.76	6 259.51	74.92	2 186.05	1 276.01	1 233.49	-1 408.36	-1 408.36	-1 408.36	-1 408.36	-1 115.64	-1 115.64	-1 115.64	-1 115.64
Not Directly Attributable Costs	561.67	548.07	713.30	983.73	700.91	687.78	890.92	1 227.21	700.91	687.78	890.92	1 227.21	561.67	548.07	713.30	983.73	749.48	771.13	974.28	1 310.57	751.13	772.78	975.93	1 312.22	343.05	343.05	343.05	343.05
Gross Margin Above all Attributable Costs	5 176.67	5 274.24	5 101.42	6 526.73	4 941.40	7 045.07	7 140.14	7 918.33	4 683.62	7 836.08	4 486.60	6 816.48	6 126.89	7 821.63	6 592.45	5 275.78	-674.56	1 414.92	301.74	-77.08	-2 159.49	-2 181.14	-2 384.29	-2 720.58	-1 458.70	-1 458.70	-1 458.70	-1 458.70

2009

Rotation	WWWW				LWCW				CWLW				mWmW				WLWC				WCWL				WmWm			
	ZT	NT	MT	CT	ZT	NT	MT	CT	ZT	NT	MT	CT	ZT	NT	MT	CT	ZT	NT	MT	CT	ZT	NT	MT	CT	ZT	NT	MT	CT
Total Production Income	2181	4222	3610	3532	3 505.32	5 417.26	4 858.31	4 997.49	2 976.84	5 072.61	4 931.66	5 040.80	3 682.50	5 494.59	4 689.51	4 658.14	840.28	1 235.40	1 509.45	1 452.90	-	-	-	-	-	-	-	-
Directly Attributable Variable Costs	2 128.03	2 217.80	2 217.80	2 217.80	2 128.03	2 217.80	2 217.80	2 217.80	2 128.03	2 217.80	2 217.80	2 217.80	2 128.03	2 217.80	2 217.80	2 217.80	2 553.95	2 553.95	2 553.95	2 553.95	1 469.86	1 469.86	1 469.86	1 469.86	1 055.13	1 055.13	1 055.13	1 055.13
Margin above Directly Attributable Variable Cost	53.02	2 003.78	1 391.79	1 314.47	1 377.29	3 199.46	2 640.50	2 779.69	848.82	2 854.81	2 713.85	2 822.99	1 554.48	3 276.79	2 471.71	2 440.34	-1 713.67	-1 318.55	-1 044.50	-1 101.05	-1 469.86	-1 469.86	-1 469.86	-1 469.86	-1 055.13	-1 055.13	-1 055.13	-1 055.13
Not Directly Attributable Costs	503.66	493.19	632.67	865.39	739.61	726.48	929.63	1 265.91	739.61	726.48	929.63	1 265.91	503.66	493.19	632.67	865.39	838.79	860.44	1 063.58	1 399.87	759.35	781.00	984.15	1 320.44	261.97	261.97	261.97	261.97
Gross Margin Above all Attributable Costs	-450.64	1 510.58	759.13	449.08	637.68	2 472.98	1 710.88	1 513.78	109.21	2 128.33	1 784.23	1 557.08	1 050.81	2 783.59	1 839.04	1 574.95	-2 552.46	-2 178.99	-2 108.08	-2 500.92	-2 229.21	-2 250.86	-2 454.01	-2 790.30	-1 317.10	-1 317.10	-1 317.10	-1 317.10

2010

Rotation	WWWW				LWCW				CWLW				mWmW				WLWC				WCWL				WmWm			
	ZT	NT	MT	CT	ZT	NT	MT	CT	ZT	NT	MT	CT	ZT	NT	MT	CT	ZT	NT	MT	CT	ZT	NT	MT	CT	ZT	NT	MT	CT
Total Production Income	1711	6535	5785	5273	2 396.58	7 248.15	7 377.95	6 879.40	6 128.33	8 248.20	6 876.45	6 302.97	5 340.09	7 972.08	8 061.76	6 295.30	2 981.66	3 859.69	3 286.13	4 022.70	2 090.00	1 628.50	1 528.50	1 603.00	-	-	-	-
Directly Attributable Variable Costs	1 949.03	2 033.67	2 033.67	2 033.67	1 949.03	2 033.67	2 033.67	2 033.67	1 949.03	2 033.67	2 033.67	2 033.67	1 949.03	2 033.67	2 033.67	2 033.67	2 016.27	2 086.39	2 086.39	2 086.39	1 688.78	1 688.78	1 688.78	1 688.78	1 019.05	1 019.05	1 019.05	1 019.05
Margin above Directly Attributable Variable Cost	-238.03	4 501.17	3 751.28	3 239.75	447.55	5 214.48	5 344.28	4 845.73	4 179.30	6 214.53	4 842.78	4 269.30	3 391.06	5 938.41	6 028.09	4 261.63	965.39	1 773.29	1 199.73	1 936.31	401.22	-60.28	-160.28	-85.78	-1 019.05	-1 019.05	-1 019.05	-1 019.05
Not Directly Attributable Costs	399.92	386.37	533.95	778.77	566.95	553.82	756.96	1 093.25	566.95	553.82	756.96	1 093.25	399.92	386.37	533.95	778.77	666.12	687.78	890.92	1 227.21	675.99	697.65	900.79	1 237.08	178.61	178.61	178.61	178.61
Gross Margin Above all Attributable Costs	-637.94	4 114.80	3 217.33	2 460.97	-119.39	4 660.66	4 587.32	3 752.48	3 612.36	5 660.71	4 085.82	3 176.05	2 991.15	5 552.04	5 494.14	3 482.85	299.26	1 085.52	308.81	709.10	-274.77	-757.92	-1 061.07	-1 322.86	-1 197.66	-1 197.66	-1 197.66	-1 197.66

2011

Rotation	WWWW				LWCW				CWLW				mWmW				WLWC				WCWL				WmWm			
	ZT	NT	MT	CT	ZT	NT	MT	CT	ZT	NT	MT	CT	ZT	NT	MT	CT	ZT	NT	MT	CT	ZT	NT	MT	CT	ZT	NT	MT	CT
Total Production Income	2051	4467	3198	4390	2 970.87	7 084.03	6 400.61	6 466.25	5 700.50	8 202.71	7 046.60	6 125.98	3 846.59	8 142.83	6 606.73	6 625.73	6 273.58	7 405.48	5 454.49	7 233.19	3 656.40	4 461.05	4 423.10	4 270.20	-	-	-	-
Directly Attributable Variable Costs	3 135.08	3 215.45	3 215.45	3 215.45	3 135.08	3 215.45	3 215.45	3 215.45	3 135.08	3 215.45	3 215.45	3 215.45	3 135.08	3 215.45	3 215.45	3 215.45	3 012.24	3 012.24	3 012.24	3 012.24	1 497.08	1 497.08	1 497.08	1 497.08	715.94	715.94	715.94	715.94
Margin above Directly Attributable Variable Cost	-1 084.26	1 251.21	-17.74	1 174.64	-164.21	3 868.57	3 185.16	3 250.79	2 565.42	4 987.26	3 831.15	2 910.53	711.50	4 927.38	3 391.28	3 410.28	3 261.34	4 393.24	2 442.25	4 220.95	2 159.32	2 963.97	2 926.02	2 773.12	-715.94	-715.94	-715.94	-715.94
Not Directly Attributable Costs	591.55	574.73	740.25	1 014.36	745.56	732.43	935.57	1 271.86	745.56	732.43	935.57	1 271.86	591.55	574.73	740.25	1 014.36	710.78	732.43	935.57	1 271.86	675.99	697.65	900.79	1 237.08	168.74	168.74	168.74	168.74
Gross Margin Above all Attributable Costs	-1 675.82	676.48	-757.99	160.28	-909.77	3 136.14	2 249.58	1 978.93	1 819.86	4 254.83	2 895.58	1 638.66	119.95	4 352.65	2 651.03	2 395.91	2 550.56	3 660.81	1 506.67	2 949.08	1 483.33	2 266.32	2 025.23	1 536.04	-884.68	-884.68	-884.68	-884.68

2012

Rotation	WWWW				LWCW				CWLW				mWmW				WLWC				WCWL				WmWm			
	ZT	NT	MT	CT	ZT	NT	MT	CT	ZT	NT	MT	CT	ZT	NT	MT	CT	ZT	NT	MT	CT	ZT	NT	MT	CT	ZT	NT	MT	CT
Total Production Income	3559	10271	9955	16113	7 908.00	15 280.80	16 394.40	17 784.00	13 387.20	18 026.40	17 416.00	17 849.60	13 988.00	19 231.20	16 465.60	16 781.60	9 661.93	11 803.84	12 499.99	12 612.60	1 900.50	3 052.70	2 020.20	1 987.30	-	-	-	-
Directly Attributable Variable Costs	2 955.17	3 061.63	3 061.63	3 061.63	2 955.17	3 061.63	3 061.63	3 061.63	2 955.17	3 061.63	3 061.63	3 061.63	2 955.17	3 061.63	3 061.63	3 061.63	3 468.45	3 468.45	3 468.45	3 468.45	1 683.91	1 683.91	1 683.91	1 683.91	1 265.38	1 265.38	1 265.38	1 265.38
Margin above Directly Attributable Variable Cost	604.03	7 209.57	6 893.57	13 051.17	4 952.83	12 219.17	13 332.77	14 722.37	10 432.03	14 964.77	14 354.37	14 787.97	11 032.83	16 169.57	13 403.97	13 719.97	6 193.48	8 335.39	9 031.54	9 144.15	216.59	1 368.79	336.29	303.39	-1 265.38	-1 265.38	-1 265.38	-1 265.38
Not Directly Attributable Costs	632.66	613.97	791.10	1 084.36	745.56	732.43	935.57	1 271.86	745.56	732.43	935.57	1 271.86	632.66	613.97	791.10	1 084.36	666.12	687.78	890.92	1 227.21	631.34	652.99	856.14	1 192.43	178.61	178.61	178.61	178.61
Gross Margin Above all Attributable Costs	-28.63	6 595.60	6 102.48	11 966.81	4 207.27	11 486.74	12 397.20	13 450.51	9 686.47	14 232.34	13 418.80	13 516.11	10 400.17	15 555.60	12 612.88	12 635.61	5 527.35	7 647.61	8 140.62	7 916.94	-414.75	715.80	-519.85	-889.04	-1 443.99	-1 443.99	-1 443.99	-1 443.99

2013

Rotation	WWWW				LWCW				CWLW				mWmW				WLWC				WCWL				WmWm			
	ZT	NT	MT	CT	ZT	NT	MT	CT	ZT	NT	MT	CT	ZT	NT	MT	CT	ZT	NT	MT	CT	ZT	NT	MT	CT	ZT	NT	MT	CT
Total Production Income	5002	5883	2646	4544	13 338.43	9 883.88	14 674.62	6 176.53	6 548.26	10 703.26	13 036.63	13 431.13	12 235.39	12 045.43	12 106.17	11 778.55	5 797.14	7 181.59	6 608.90	9 119.49	2 008.81	1 832.00	1 161.50	1 764.65	-	-	-	-
Directly Attributable Variable Costs	2 842.41	2 949.72	2 949.72	2 949.72	2 842.41	2 949.72	2 949.72	2 949.72	2 842.41	2 949.72	2 949.72	2 949.72	2 842.41	2 949.72	2 949.72	2 949.72	4 012.83	4 020.33	4 020.33	4 020.33	1 996.62	1 996.62	1 996.62	1 996.62	1 614.01	1 614.01	1 614.01	1 614.01
Margin above Directly Attributable Variable Cost	2 159.37	2 933.52	-303.24	1 594.21	10 496.02	6 934.16	11 724.90	3 226.81	3 705.85	7 753.53	10 086.91	10 481.41	9 392.98	9 095.71	9 156.44	8 828.83	1 784.31	3 161.26	2 588.57	5 099.16	12.19	-164.62	-835.12	-231.97	5.02	5.02	5.02	5.02
Not Directly Attributable Costs	784.26	771.13	974.28	1 310.57	784.26	771.13	974.28	1 310.57	784.26	771.13	974.28	1 310.57	784.26	771.13	974.28	1 310.57	838.79	860.44	1 063.58	1 399.87	670.04	691.70	894.84	1 231.13	133.96	133.96	133.96	133.96
Gross Margin Above all Attributable Costs	1 375.11	2 162.39	-1 277.52	283.65	9 711.76	6 163.02	10 750.62	1 916.24	2 921.58	6 982.40	9 112.63	9 170.85	8 608.71	8 324.58	8 182.17	7 518.26	945.52	2 300.82	1 524.99	3 699.29	-657.86	-856.32	-1 729.96	-1 463.10	-128.94	-128.94	-128.94	-128.94

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Annexure G: Attendance register and minutes for the various multi-disciplinary expert group discussions

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Minutes of Expert Group Discussion held at Langgewens on the 16th April 2014

Present:	Dr J Labuschagne	JL
	Dr W Hoffmann	WH
	Cobus Bester	CB
	Koos Blanckenberg	KB
	Sakkie Rust	SR
	Frehan Bester	FB
	Carel van Neikerk	CvN
	Louis Coetzee	LC
	Heinrich van Zyl	HvZ
	Samie Loubser	SL
	Johann Boonzaaier	JB
	Stuart Knott	SK

Language Used: ***afrk***
eng

Meeting started at 09:15am

Dr Willem Hoffmann *(eng)* – opened meeting with introductions

Dr Labuschagne *(eng)* – Presentation

SR:- *(eng/afrk)* commented on soil biology, there was a lack of info on soil biological benefits from tillage. The trial data did not seem to resolve any issues on soil improvements. There is any opportunity to study soil samples over the years to see the improvements and benefits of tillage. And to look at the organic structure and the carbon content over the long term.

FB:- *(afrk)* There is a difference in the carbon content in the soil of the Ruens and the Swartland which has to be taken into consideration when being compared. A change in tillage practice and rotation would lead to reduced inputs of chemicals and fertilisers. One wants to achieve a stable operating system and then turbocharge specific components within the system to improve the system as a whole.

WH:- *(afrk)* Expressed a disconnection between the disciplines of agric economics and soil science, and agronomy, and hence the need for multi-disciplinary discussion groups.

KB:- *(afrk)* explained that nitrogen does not have any impact on the microbial biology. Overtime, nitrogen can be reduced as soil structure and microbial activity is increased. (later agreed by CB and KB)

Stuart Knott *(eng)* – Presentation

Discussion Started at 10:15 after tea and coffee

SR:- *(afrk)* In the Swartland, when compared to the Ruens/Overberg, farmers are less likely to operate continuous cropping systems, they are more inclined to incorporate sheep at there is a lack of summer rainfall and soils are shallow and poor.

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(eng) The compaction of the soil by sheep and late rains leads to an increased demand on horse power from the suppliers advised 6hp per tine to around 10hp per tine. There is therefore a need to distinguish between a continuous cropping system and mixed livestock/cropping system in the Swartland.

Crops have shown an increase in yield with deeper ripper depths due to higher capacity to capture moisture from rainfall. The disturbance from the ripper tine creates a deep water harvesting area, farmers have experienced an increase in yields from 4100kg to 5010kg with ripper depths of 15cm to 30cm respectively.

Due to compaction of soil from livestock and dry non cultivatable summer months, the Swartland soils may have a greater need to be ripped at planting.

JL:- (afrk) responded saying the Langgewens trials work at a planting depth of 150mm to 200mm from a tine planter.

WH:- ***(eng)*** Expressed that CA farmers are not recipe farmers, rather they are thinkers who analyse and generate alternatives to problems.

CB:- ***(afrk)*** Following his father who farmed monoculture wheat for 25years applying 120 units of Nitrogen up until 1994. Cobus has since introduced medics to the system and in 2013 he applied 20 units of Nitrogen and yielded 4,4ton/ha.

Expressed the importance of no-till machinery applicable to CA, disc planters plant at a shallow depth when compared to tine planters that plant at depths of 20-30cm. the benefit of this is seen in the drought months (September) when the wheat is starved of water and must rely on water harvested and stored in the soil. The tine implement provides more water harvested.

Planting distance between rows of 300mm.

He mentioned an article in the landbou weekblad in Dec 2013, situated in Natal. The important balance of the nitrogen and the other microbial organisms in the soil structure, implying that increased nitrogen will not have a negative impact on the micro-organisms in the soil. (Koos Blanckenberg agreed this point)

Guide to machinery costs, this costs system wouldn't be recommended for the Swartland as it works on a life cycle of a machine of 10 years. The soils are harder than the Ruens, so the implements life is not as long (Louis expressed they farm in rocks in the Swartland).

Cobus developed a replacement schedule for machinery which was in line with the study groups findings researched by Kaap Agri and SSK, and Overberg Agri. Louis said the study groups could be made available for this research if need be.

SR:- ***(afrk)*** has seen some planters planting on half capacity as the soil is too hard. This would apply 10kw per tine required to pull where there should be 6kw per tine.

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FB:- *(afrk)* For a whole farm model approach, a trial has to be done over a longer period, =/- 10years. This would provide sufficient data to compile a whole farm model in the Swartland.

Compare different farming systems with each other to identify the comparative advantages of the systems (on different levels).

KB:- *(afrk)* spoke of the compaction effects of livestock. To plough these lands larger HP was needed to prepare these lands. He farms with on part of the farm dedicated to continuous cropping system and the rest to livestock and pastures. He again expressed the importance of livestock compaction and the benefits to the soil of no livestock and less compaction and the resulting benefits of micro-organisms and less HP required to plant. If you incorporate livestock the cropping system has to be done at an increased working depth.

There is need to compare a mixed system (medics and sheep and crops) with a cropping system (cash crops) with livestock separate.

LC:- *(afrk)* a few years back planters used a single skaar, then progressed to a tine, and now most recently to a disc.

SR:- *(afrk)* advised we compromise, and focus on the section of the typical farm with high soil fertility (eg. 60%), to develop a best fit CA model for this section of the farm and allow the farmer to manage the remaining section (40%) as best he can. To incorporate various tillage and rotation systems on the 60% continuous cropping, and to leave the rest to pastures and livestock.

Highlighted the impact and importance of the devaluation of the Rand and how this would affect the replacement schedule of machinery and how second hand implements have a place (CB, agreed to these impacts).

CvN:- *(eng)* spoke of the strong market for second hand planters from the northern regions where a good second hand 10 yr machine could fetch up to R50,000. He said the salvage value would be approx. 30% value of a new machine.

Maintenance costs ranged from R12/ha for a Tyne machine in prepared soils, it would be higher for no-till operations and further higher for disc planters, due to bearings. Bearing would generally be replaced every 2 years, where discs would be replaced every 6 years.

He referred to Koos le Roux in Pretoria who he knew and said may be able to help with the value in the guide to machinery costs for implements as he previously worked on the valuations in the guide.

LC:- *(afrk)* added that the coops had experienced similar difficulties with prices and the guide to machinery costs, and so had developed their own guide which was released this year and is a work in progress. The guide is specifically directed to the machinery and implements used in the Western Cape.

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KB:- *(afrk)* Advised to use the study group as a point of departure.

WH:- *(eng)* said that it would be a good time to adjourn the meeting as there seemed little more to discuss. It would be best to analyse the study group data from Louis Coetzee and the coops, to assess a typical farm, and see whether there is a trend and where it is headed with reference to adoption of CA.

It was again highlighted the importance of the devaluation of the Rand and its impact on the maintenance costs and replacement value. This would certainly effect decisions on replacement.

SR:- *(eng)* expressed that the 2 most important machines on the farm are the spraying and seeding machines. Better to use bigger machines requiring larger hp incorporating all the activities in one machine, and move towards precision farming like in the USA.

KB:- *(eng)* farmers don't just shift to CA, rather they grow into the system slowly over time.

12:30 - Meeting was adjourned, Dr Hoffmann expressed thanks to all participants. Tea and coffee followed.

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Minutes of Expert Group Discussion

Date: Wednesday 28 May 2014

Time 9:00am

Place: White room, Faculty of AgEcons, Victoria Street, Stellenbosch University

Present:

- Prof Agenbag – Agronomy, Stellenbosch University
- Dr. Strauss – Dept of Agriculture, Plant sciences, Elsenberg
- Dr. Labuschagne– Dept of Agriculture, Plant sciences, Elsenberg
- Pete Lombard– Dept of Agriculture, Plant sciences, Elsenberg
- Dr. Hoffmann – AgriEcon's, Stellenbosch University
- Louis Coetzee – agricultural economist, Kaap Agri
- Stuart Knott– AgriEcon's, Stellenbosch University

Meeting began at 9:20

Dr. Hoffmann outlined previous discussion group in Langgewens and reason for the follow up discussion.

Initial discussion with reference to data available to which region should be researched and best fits the data available. It was agreed that the area described would be the 'Middle Swartland' best demarcated in Dr. Hoffmann's 2010 PhD thesis map as shown in Appendix A[1]. the only amendment would be to reduce the western border line of the Middle Swartland to exclude the sandy soils and near it to the N7. This amended map is shown in Appendix A[2].

Stuart Knott presented slides of crop yield data collected from Dr. Strauss, Dr. Labuschagne, and Prof Agenbag. The results were discussed between the participants and the results in Appendix B were agreed as the yields to be used in the research.

Inventory of a Typical Swartland Farm was presented by Stuart Knott, the participants discussed possible inventory components and all agreed to the listed inventories in Appendix C, D, and E.

It was agreed that the model should follow the principles of Conservation Agriculture (CA) and individual farmers would be able to adopt the model to their specific conditions.

The participants agreed that the root system of canola and lupine have a positive beneficial effect on the following wheat crop as they improve soil structure, and promote better root development in the wheat crop following. Moisture retention of the soil is increased through retained organic matter on the surface in the form of stubble from the previous crop. The benefits of soil moisture retention are not only to aid planting times but throughout the season to assist in dry spells leading to higher yields and lower risk of yield loss due to water stress to the plant.

In the initial years of adopting CA nitrogen is tied up in the organic matter in the soil resulting in no additional nitrogen being made available to the plant and in some cases a reduction in yield due to applied nitrogen being used to aid decomposition of previous years stubble. However in the long term, there is increased nitrogen available to the plant through the organic matter as the soil structure is transformed and stabilises, this results in increased yields and reduced application of nitrogen.

The beneficial increase in nitrogen availability through nitrogen fixing legumes in the rotation is apparent immediately and wheat yields increase following medics and lupines.

The main benefit of rotations is the ability to alternate herbicides and target rye grass weeds in the broad leaf crops stage of the rotation. This results in a reduced seed bank when planting wheat in the following year. Wheat monoculture is plagued by rye grass weeds, reducing yields and the effective lifespan of herbicides such as Trifluralin.

It was established that the model would look at the CA as an established system receiving the benefits of the practice and a scenario would be adopted to evaluate the effects of adopting CA and the cash flow of the initial years of learning curve and switch from Ct to CA.

It was agreed that there would be a gradual improvement in the yields from the time of switch over from CT to CA. this gradual improvement would be relative to the start at wheat monoculture yields to 10 years later achieving the yields of the rotational system as specified in Appendix B.

Also agreed was the need to deep rip the lands on the first year in adopting CA, this ripping would be undertaken by a contractor as it is a once off practice to break any existing plough pan.

The expert group agreed on a typical Swartland farm of 800ha, this was seen through personal experience of consulting, dealing with and research on farms in the Swartland Area. Including an extensive research conducted by Prof Agenbag where he recalled the typical farm size in the Swartland was calculated at 780ha.

Thanks were expressed to all participants.

The meeting was adjourned at 12:45.

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Annexure H: Crop yields under differing crop rotations and tillage practices validated through the expert group discussions

Expert validated yields under differing crop rotations and tillage practices

WHEAT YIELDS	Dr Strauss		Dr Labuschagne		Prof Agenbag		Hoffmann, 2010		Average		THESIS	
SYSTEM	WWWW	WWWW	WWWW	WWWW	WWWW	WWWW	WWWW	WWWW	WWWW	WWWW	PROPOSAL	
TILLAGE	NT	CT	NT	CT	NT	CT	NT	CT	NT	CT	NT	CT
POOR YEAR	970		1 940	1 906			1800		1 570		1 600	1 600
AVERAGE YEAR	2 681		2 975	3 471	3 105	3 724	2400		2 790	3 597	2 500	2 600
GOOD YEAR	3 636		4 010	5 035			3000		3 549		3 200	3 400

WHEAT YIELDS	Dr Strauss		Dr Labuschagne		Prof Agenbag		Hoffmann, 2010		Average		THESIS	
SYSTEM	LWCW	LWCW	LWCW	LWCW	LWCW	LWCW	LWCW	LWCW	LWCW	LWCW	PROPOSAL	
TILLAGE	NT	CT	NT	CT	NT	CT	NT	CT	NT	CT	NT	CT
POOR YEAR	2 269		3 065	2 828			2196		2 510		2 350	2 100
AVERAGE YEAR	3 682		4 301	4 193			2928		3 637		3 400	3 100
GOOD YEAR	4 791		5 537	5 558			3660		5 164		4 100	4 000

WHEAT YIELDS	Dr Strauss		Dr Labuschagne		Prof Agenbag		Hoffmann, 2010		Average		THESIS	
SYSTEM	CWLW	CWLW	CWLW	CWLW	CWLW	CWLW	CWLW	CWLW	CWLW	CWLW	PROPOSAL	
TILLAGE	NT	CT	NT	CT	NT	CT	NT	CT	NT	CT	NT	CT
POOR YEAR	2 296		2 870	2 852			2250		2 472		2 350	2 100
AVERAGE YEAR	3 932		4 252	4 215	3 516	3 038	3000		3 675	3 627	3 400	3 100
GOOD YEAR	4 899		5 633	5 578			3840		4 791		4 100	4 000

WHEAT YIELDS	Dr Strauss		Dr Labuschagne		Prof Agenbag		Hoffmann, 2010		Average		THESIS	
SYSTEM	mWmW	mWmW	mWmW	mWmW	mWmW	mWmW	mWmW	mWmW	mWmW	mWmW	PROPOSAL	
TILLAGE	NT	CT	NT	CT	NT	CT	NT	CT	NT	CT	NT	CT
POOR YEAR	2 291		3 109	2 636			2304		2 568		2 500	2 200
AVERAGE YEAR	3 745		4 560	3 940			3072		3 792		3 600	3 200
GOOD YEAR	5 147		6 010	5 244			3840		4 999		4 400	4 200

CANOLA YIELDS	Dr Strauss		Dr Labuschagne		Prof Agenbag		Hoffmann, 2010		Average		THESIS	
SYSTEM	Canola	Canola	Canola	canola	canola	canola	canola	canola	canola	canola	PROPOSAL	
TILLAGE	NT	CT	NT	CT	NT	CT	NT	CT	NT	CT	NT	CT
POOR YEAR	438		426	501			800		555		800	600
AVERAGE YEAR	1 301		1 510	1 637			1400		1 404		1 400	1 300
GOOD YEAR	2 034		2 594	2 772			1800		2 143		2 000	1 900

LUPINE YIELDS	Dr Strauss		Dr Labuschagne		Prof Agenbag		Hoffmann, 2010		Average		THESIS	
SYSTEM	lupine	lupine	lupine	lupine	lupine	lupine	lupine	lupine	lupine	lupine	PROPOSAL	
TILLAGE	NT	CT	NT	CT	NT	CT	NT	CT	NT	CT	NT	CT
POOR YEAR	639		579	557					609		800	600
AVERAGE YEAR	1 092		1 303	1 249					1 198		1 300	1 200
GOOD YEAR	1 818		2 028	1 941					1 923		2 000	1 900

CANOLA AFTER MEDIC	
NT	CT
1 300	1 100
1 900	1 800
2 500	2 400

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Annexure I: Machinery and Implement costs and workings used in the typical Middle Swartland farm model

MECHANISATION INFORMATION: (All figures are derived from DAFF Guide to Machinery Costs 2007)

TRACTORS: Unless specified, all are 4wheel drive

Salvage value = 10% of purchase price

Depreciation = (Purchase price - salvage value)/life (hrs)

Licence & insurance = 2% of average investment / hours per annum

Interest = 9% of average investment / hours per annum

Repairs & maintenance = 120% of purchase price/ lifetime (hrs)

Fuel price = 11 R/litre

Low **Fuel usage =** 35% of Tractor power (kW)

Litres used per kW hour 0.4

Medium **Fuel usage =** 45% of Tractor power (kW)

Litres used per kW hour 0.35

High **Fuel usage =** 60% of Tractor power (kW)

Litres used per kW hour 0.30

LOW POWER DEMAND:

Tractor Power	Life	Annual Use	Purchase Price	Salvage Value	Average Investment	Depre-ciation	Licence & Insurance	Interest	Total fixed costs	Tot. Fixed cost excluding interest	Repairs & Maintenance	Fuel cost	Tot. var. Costs	Total Costs	Tot. costs Excl interest	Fuel Usage Litre /hr	Cost for set of new tyres:	Life of set of tyres	Tyre cost per km
kW	(hrs)	(hrs)	R	R	R	R/hr	R/hr	R/hr	R/hr	R/hr	R/hr	R/hr	R/hr	R/hr	R/hr			km	
250	12000	1000	2861500	286150	1573825	214.61	27.54	133.78	375.93	242.15	286.15	385.00	671.15	1047.08	913.30	35	4000	12000	0.33
180	12000	1000	2000500	200050	1100275	150.04	19.25	93.52	262.82	169.29	200.05	277.20	477.25	740.07	646.54	25	4000	12000	0.33
80	12000	1000	621000	62100	341550	46.58	5.98	29.03	81.58	52.55	62.10	123.20	185.30	266.88	237.85	11	6000	12000	0.50
50	12000	1000	301000	30100	165550	22.58	2.90	14.07	39.54	25.47	30.10	77.00	107.10	146.64	132.57	7	6000	12000	0.50
50	12000	1000	301000	30100	165550	22.58	2.90	14.07	39.54	25.47	30.10	77.00	107.10	146.64	132.57	7	6000	12000	0.50
50	12000	1000	301000	30100	165550	22.58	2.90	14.07	39.54	25.47	30.10	77.00	107.10	146.64	132.57	7	6000	12000	0.50
50	12000	1000	301000	30100	165550	22.58	2.90	14.07	39.54	25.47	30.10	77.00	107.10	146.64	132.57	7	6000	12000	0.50
50	12000	1000	301000	30100	165550	22.58	2.90	14.07	39.54	25.47	30.10	77.00	107.10	146.64	132.57	7	6000	12000	0.50
50	12000	1000	301000	30100	165550	22.58	2.90	14.07	39.54	25.47	30.10	77.00	107.10	146.64	132.57	7	6000	12000	0.50
50	12000	1000	301000	30100	165550	22.58	2.90	14.07	39.54	25.47	30.10	77.00	107.10	146.64	132.57	7	6000	12000	0.50
50	12000	1000	301000	30100	165550	22.58	2.90	14.07	39.54	25.47	30.10	77.00	107.10	146.64	132.57	7	6000	12000	0.50
50	12000	1000	301000	30100	165550	22.58	2.90	14.07	39.54	25.47	30.10	77.00	107.10	146.64	132.57	7	6000	12000	0.50
50	12000	1000	301000	30100	165550	22.58	2.90	14.07	39.54	25.47	30.10	77.00	107.10	146.64	132.57	7	6000	12000	0.50
50	12000	1000	301000	30100	165550	22.58	2.90	14.07	39.54	25.47	30.10	77.00	107.10	146.64	132.57	7	6000	12000	0.50
50	12000	1000	301000	30100	165550	22.58	2.90	14.07	39.54	25.47	30.10	77.00	107.10	146.64	132.57	7	6000	12000	0.50
50	12000	1000	301000	30100	165550	22.58	2.90	14.07	39.54	25.47	30.10	77.00	107.10	146.64	132.57	7	6000	12000	0.50
50	12000	1000	301000	30100	165550	22.58	2.90	14.07	39.54	25.47	30.10	77.00	107.10	146.64	132.57	7	6000	12000	0.50
50	12000	1000	301000	30100	165550	22.58	2.90	14.07	39.54	25.47	30.10	77.00	107.10	146.64	132.57	7	6000	12000	0.50
50	12000	1000	301000	30100	165550	22.58	2.90	14.07	39.54	25.47	30.10	77.00	107.10	146.64	132.57	7	6000	12000	0.50
Harvesters:																			
210	12000	1000	3060000	306000	1683000	229.50	29.45	143.06	402.01	258.95	306.00	323.40	629.40	1031.41	888.35	29			
210	12000	1000	3060000	306000	1683000	229.50	29.45	143.06	402.01	258.95	306.00	323.40	629.40	1031.41	888.35	29			

IMPLEMENTS:

Depreciation cost per hour = (Purchase price - salvage value)/life period in hours

Salvage value = 10% of purchase price

Average investment = (Purchase price + salvage value)/2

Interest cost = 10% of average investment per annum/hours per annum

Repairs and maintenance = 0.012% culculated as a percentage of purchase price

Code	IMPLEMENT: Description	Life (hrs)	Annual usage (hrs)	Purchase price (R)	Salvage Value (R)	Average investment (R)	Depre-ciation (R/hr)	Interest (R/hr)	Tot. fixed costs (R/hr)	Tot. fixed costs excl interest (R/hr)	Repairs and maint as a % of new price %	Repairs & maint (R/hr)	Tot. var costs (R/hr)	Total costs (R/hr)	Total costs excl interest (R/hr)
101	Spayer 18m, 2000 liter, mounted	2500	250	216500	21 650	119 075	77.94	47.63	125.57	77.94	0.30	25.98	25.98	151.55	103.92
102	Fert Spreader, Ddisc 1500l, 10-36m	2500	250	105750	10 575	58 163	38.07	23.27	61.34	38.07	0.30	12.69	12.69	74.03	50.76
103	Spreader,Lime Ddisc 3t	2500	250	85270	8 527	46 899	30.70	18.76	49.46	30.70	0.30	10.23	10.23	59.69	40.93
104	Chisel Plough, 15tine, 4.5m, 3point	2500	250	146750	14 675	80 713	52.83	32.29	85.12	52.83	0.30	17.61	17.61	102.73	70.44
105	Chisel Plough, 23tine, 6.9m, 3point	2500	250	324500	32 450	178 475	116.82	71.39	188.21	116.82	0.30	38.94	38.94	227.15	155.76
106	Fieldspan, 41tine, 6.1m, trailed, 'S'tine	2500	250	137250	13 725	75 488	49.41	30.20	79.61	49.41	0.30	16.47	16.47	96.08	65.88
107	Fieldspan, 61tine, 9.3m, trailed, 'S'tine	2500	250	170500	17 050	93 775	61.38	37.51	98.89	61.38	0.30	20.46	20.46	119.35	81.84
108	Single seed drill Planter CT	2500	250	350000	35 000	192 500	126.00	77.00	203.00	126.00	0.30	42.00	42.00	245.00	168.00
109	Double seed drill Planter CT	2500	250	700000	70 000	385 000	252.00	154.00	406.00	252.00	0.30	84.00	84.00	490.00	336.00
110	21 tine No-till planter, 6m	2500	250	804500	80 450	442 475	289.62	176.99	466.61	289.62	0.30	96.54	96.54	563.15	386.16
111	33 tine No-till planter, 9.4m	2500	250	1324250	132 425	728 338	476.73	291.34	768.07	476.73	0.30	158.91	158.91	926.98	635.64
112	Planter 10m no till	2500	250	1250000	125 000	687 500	450.00	275.00	725.00	450.00	0.30	150.00	150.00	875.00	600.00
113	Planter 10m no till	2500	250	1250000	125 000	687 500	450.00	275.00	725.00	450.00	0.30	150.00	150.00	875.00	600.00
114	Planter 10m no till	2500	250	1250000	125 000	687 500	450.00	275.00	725.00	450.00	0.30	150.00	150.00	875.00	600.00
115	Planter 10m no till	2500	250	1250000	125 000	687 500	450.00	275.00	725.00	450.00	0.30	150.00	150.00	875.00	600.00

USAGE PER ANNUM:

Power Demand	Code	Activity	Power source	Implement Code	Implement Description	Work width m	Speed km/hour	Efficiency	Ha/hour	Hour/Ha	Fuel Litre/ha	R/ha	Repairs & Maintenance R/ha Power	Repairs & Maintenance R/ha Imple.	Tyre cost:
Medium	1	Spray: herbicide	80	101	Spayer 18m, 2000 liter, mounted	18	12	85%	18.36	0.05	0.43	4.72	1.64	1.42	0.33
Medium	2	Spray: Insecticide	80	101	Spayer 18m, 2000 liter, mounted	18	12	85%	18.36	0.05	0.43	4.72	1.64	1.42	0.33
Medium	3	Spray: Fungicide	80	101	Spayer 18m, 2000 liter, mounted	18	12	85%	18.36	0.05	0.43	4.72	1.64	1.42	0.33
High	4	Plant Conventional Till	180	108	Single seed drill Planter CT	4	6	85%	2.040	0.49	4.41	48.53	14.75	20.59	1.47
High	5	Plant Conventional Till	250	109	Double seed drill Planter CT	8	6	85%	4.08	0.25	2.21	24.26	7.38	20.59	0.74
High	6	Plant No-till	180	110	21 tine No-till planter, 6m	6	6	85%	3.06	0.33	2.94	32.35	9.84	31.55	0.98
High	7	Plant No-till	250	111	33 tine No-till planter, 9.4m	9.4	6	85%	4.794	0.21	1.88	20.65	6.28	33.15	0.63
Medium	8	Spray: Herb & Trace Elem	80	101	Spayer 18m, 2000 liter, mounted	18	12	85%	18.36	0.05	0.43	4.72	1.64	1.42	0.33
Medium	9	Spray: Trace elements	80	101	Spayer 18m, 2000 liter, mounted	18	12	85%	18.36	0.05	0.43	4.72	1.64	1.42	0.33
Medium	10	Spray: Fung & Insect	80	101	Spayer 18m, 2000 liter, mounted	18	12	85%	18.36	0.05	0.43	4.72	1.64	1.42	0.33
High	11	Harvest	210	0	#N/A	5	6	83%	2.49	0.40	15.18	166.99	122.89	0.00	1.20
Medium	12	Spray: Herb & Insect	80	101	Spayer 18m, 2000 liter, mounted	18	12	85%	18.36	0.05	0.43	4.72	1.64	1.42	0.33
Medium	13	Fieldspan seedbed prep	180	106	Fieldspan, 41tine, 6.1m, trailed, 'S'tine	6.1	6	85%	3.111	0.32	2.53	27.84	9.68	5.29	0.96

Medium	14	Fieldspan seedbed prep	250	107	Fieldspan, 61tine, 9.3m, trailed, 'S'tine	9.3	6	85%	4.743	0.21	1.66	18.26	6.35	4.31	0.63
High	15	Chisel Plough	180	104	Chisel Plough, 15tine, 4.5m, 3point	4.5	5	85%	1.9125	0.52	4.71	51.76	15.74	9.21	1.31
High	16	Chisel Plough	250	105	Chisel Plough, 23tine, 6.9m, 3point	6.9	5	85%	2.9325	0.34	3.07	33.76	10.26	13.28	0.85
Medium	17	Spread Fertiliser	80	102	Fert Spreader, Ddisc 1500l, 10-36m	18	12	85%	18.36	0.05	0.43	4.72	1.64	0.69	0.33
Medium	18	Spread Lime	80	102	Fert Spreader, Ddisc 1500l, 10-36m	18	12	85%	18.36	0.05	0.43	4.72	1.64	0.69	0.33

BAKKIES EN VRAGMOTORS

kode	MODEL OF Vehicle	Purchase price (excluding VAT)	Aannames: Life	Annual Use	H&O	Fuel consumption		Type	Fixed costs: Value	Insurance & Licence	Interest	Total	Variable costs: Fuel	R & M	Other	Total	Total current cost: Dry	Total
		Rand	Km	Km	%	L/100km	Km/Liter	D / P	R/Km	R/Km	R/Km	**R/Km**	R/Km	R/Km	R/Km	**R/Km**	R/Km	**R/Km**
94	10.0 ton vragmotor	824 500	300 000	15 000	60	30.00	3.33	Diesel	2.47	2.27	2.72	**7.46**	3.93	1.65	2.04	**7.62**	11.15	**15.08**
95	2500 CC 4x2 Enkel	225 000	160 000	20 000	50	10.50	9.52	Diesel	1.27	0.46	0.56	**2.29**	1.38	0.70	0.42	**2.49**	3.41	**4.78**
96	2800 CC 4x2 Enkel	250 000	160 000	20 000	50	11.76	8.50	Diesel	1.41	0.52	0.62	**2.54**	1.54	0.78	0.44	**2.77**	3.77	**5.31**

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Annexure J: Farm inventory under different crop rotation systems and tillage practices

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Middle Swartland typical farm inventory - CWWW, no-till

Item	Amount (ha)	R/unit	Value
Land & Fixed improvements (a)	800	30 000	**24 000 000**

Mechanization:					
Item	**Price/new R**	**Current Age (years)**	**Expected Lifetime**	**Depreciation R**	**Value R**
Combine Harvester 210kW	3 060 000	5	15	1 275 000	1 785 000
Tractor 250kW	2 861 500	4	15	953 833	1 907 667
Tractor 80kW	621 000	8	12	414 000	207 000
Tractor 80kW	621 000	8	12	414 000	207 000
Tractor 50kW	301 000	10	12	250 833	50 167
Boom Sprayer 18m, 2000L	216 500	3	12	54 125	162 375
Boom Sprayer 18m, 2000L	216 500	9	12	162 375	54 125
Fertiliser Spreader 1500L, 10-36m	105 750	4	12	35 250	70 500
Fertiliser Spreader 1500L, 10-36m	105 750	9	12	79 313	26 438
No-till Planter, 33 tine, 9.4m	1 324 250	6	12	662 125	662 125
6ton 4wl, trailer	92 000	6	12	46 000	46 000
Grain cart 8ton	210 000	3	12	52 500	157 500
Road scraper, 2.4m, 3point	18 000	3	12	4 500	13 500
Wheat grain massebakke, 10ton	50 000	4	12	16 667	33 333
Front loader	94 000	5	12	39 167	54 833
Lorry, 10ton, SD	824 500	4	12	274 833	549 667
LDV 1	225 000	2	24	37 500	187 500
LDV 2	250 000	5	12	104 167	145 833
Movable and tools:					140 000
Total mechanization equipment (b)					**6 460 563**

Livestock:	Number	R/ssu	Value
Rams	-	3 500	-
Ewes	-	1 600	-
Replacement ewes	-	1 000	-
Lambs	-	200	-
Total sheep: (c)			**-**

Total assets: (a + b + c + d)	**30 460 563**

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Middle Swartland typical farm inventory - CWWW, conventional-tillage

Item	Amount (ha)	R/unit	Value
Land & Fixed improvements (a)	800	30 000	**24 000 000**

Mechanization:					
Item	**Price/new R**	**Current Age (years)**	**Expected Lifetime**	**Depreciation R**	**Value R**
Combine Harvester 210kW	3 060 000	5	15	1 275 000	1 785 000
Tractor 250kW	2 861 500	4	15	953 833	1 907 667
Tractor 80kW	621 000	8	12	414 000	207 000
Tractor 80kW	621 000	8	12	414 000	207 000
Tractor 50kW	301 000	10	12	250 833	50 167
Boom Sprayer 18m, 2000L	216 500	3	12	54 125	162 375
Boom Sprayer 18m, 2000L	216 500	9	12	162 375	54 125
Fertiliser Spreader 1500L, 10-36m	105 750	4	12	35 250	70 500
Fertiliser Spreader 1500L, 10-36m	105 750	9	12	79 313	26 438
Double seed drill, CT planter	700 000	6	12	350 000	350 000
Chisel Plough, 23tine, 6.9m	324 500	8	12	216 333	108 167
Fieldspan, 61tine, 9.3m	170 500	6	12	85 250	85 250
6ton 4wl, trailer	92 000	6	12	46 000	46 000
Grain cart 8ton	210 000	3	12	52 500	157 500
Road scraper, 2.4m, 3point	18 000	3	12	4 500	13 500
Wheat grain massebakke, 10ton	50 000	4	12	16 667	33 333
Front loader	94 000	5	12	39 167	54 833
Lorry, 10ton, SD	824 500	4	12	274 833	549 667
LDV 1	225 000	2	24	37 500	187 500
LDV 2	250 000	5	12	104 167	145 833
Movable and tools:					140 000
Total mechanization equipment (b)					**6 341 854**

Livestock:	**Number**	**R/ssu**	**Value**
Rams	-	3 500	-
Ewes	-	1 600	-
Replacement ewes	-	1 000	-
Lambs	-	200	-
Total sheep: (c)			**-**

Total assets: (a + b + c + d)	**30 341 854**

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Middle Swartland typical farm inventory - WWWW, no-till

Item	Amount (ha)	R/unit	Value
Land & Fixed improvements (a)	800	30 000	**24 000 000**

Mechanization:					
Item	**Price/new R**	**Current Age (years)**	**Expected Lifetime**	**Depreciation R**	**Value R**
Combine Harvester 210kW	3 060 000	5	15	1 275 000	1 785 000
Tractor 250kW	2 861 500	4	15	953 833	1 907 667
Tractor 80kW	621 000	8	12	414 000	207 000
Tractor 80kW	621 000	8	12	414 000	207 000
Tractor 50kW	301 000	10	12	250 833	50 167
Boom Sprayer 18m, 2000L	216 500	3	12	54 125	162 375
Boom Sprayer 18m, 2000L	216 500	9	12	162 375	54 125
Fertiliser Spreader 1500L, 10-36m	105 750	4	12	35 250	70 500
Fertiliser Spreader 1500L, 10-36m	105 750	9	12	79 313	26 438
No-till Planter, 33 tine, 9.4m	1 324 250	6	12	662 125	662 125
6ton 4wl, trailer	92 000	6	12	46 000	46 000
Grain cart 8ton	210 000	3	12	52 500	157 500
Road scraper, 2.4m, 3point	18 000	3	12	4 500	13 500
Wheat grain massebakke, 10ton	50 000	4	12	16 667	33 333
Front loader	94 000	5	12	39 167	54 833
Lorry, 10ton, SD	824 500	4	12	274 833	549 667
LDV 1	225 000	2	24	37 500	187 500
LDV 2	250 000	5	12	104 167	145 833
Movable and tools:					140 000
Total mechanization equipment (b)					**6 460 563**

Livestock:	**Number**	**R/ssu**	**Value**
Rams	-	3 500	-
Ewes	-	1 600	-
Replacement ewes	-	1 000	-
Lambs	-	200	-
Total sheep: (c)			**-**

Total assets: (a + b + c + d)	**30 460 563**

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Middle Swartland typical farm inventory - WWWW, conventional-tillage

Item	Amount (ha)	R/unit	Value
Land & Fixed improvements (a)	800	30 000	**24 000 000**

Mechanization:					
Item	**Price/new R**	**Current Age (years)**	**Expected Lifetime**	**Depreciation R**	**Value R**
Combine Harvester 210kW	3 060 000	5	15	1 275 000	1 785 000
Tractor 250kW	2 861 500	4	15	953 833	1 907 667
Tractor 80kW	621 000	8	12	414 000	207 000
Tractor 80kW	621 000	8	12	414 000	207 000
Tractor 50kW	301 000	10	12	250 833	50 167
Boom Sprayer 18m, 2000L	216 500	3	12	54 125	162 375
Boom Sprayer 18m, 2000L	216 500	9	12	162 375	54 125
Fertiliser Spreader 1500L, 10-36m	105 750	4	12	35 250	70 500
Fertiliser Spreader 1500L, 10-36m	105 750	9	12	79 313	26 438
Double seed drill, CT planter	700 000	6	12	350 000	350 000
Chisel Plough, 23tine, 6.9m	324 500	8	12	216 333	108 167
Fieldspan, 61tine, 9.3m	170 500	6	12	85 250	85 250
6ton 4wl, trailer	92 000	6	12	46 000	46 000
Grain cart 8ton	210 000	3	12	52 500	157 500
Road scraper, 2.4m, 3point	18 000	3	12	4 500	13 500
Wheat grain massebakke, 10ton	50 000	4	12	16 667	33 333
Front loader	94 000	5	12	39 167	54 833
Lorry, 10ton, SD	824 500	4	12	274 833	549 667
LDV 1	225 000	2	24	37 500	187 500
LDV 2	250 000	5	12	104 167	145 833
Movable and tools:					140 000
Total mechanization equipment (b)					**6 341 854**

Livestock:	**Number**	**R/ssu**	**Value**
Rams	-	3 500	-
Ewes	-	1 600	-
Replacement ewes	-	1 000	-
Lambs	-	200	-
Total sheep: (c)			**-**

Total assets: (a + b + c + d)	**30 341 854**

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Middle Swartland typical farm inventory - WCWL, no-till

Item	Amount (ha)	R/unit	Value
Land & Fixed improvements (a)	800	30 000	**24 000 000**

Mechanization:					
Item	**Price/new R**	**Current Age (years)**	**Expected Lifetime**	**Depreciation R**	**Value R**
Combine Harvester 210kW	3 060 000	5	15	1 275 000	1 785 000
Tractor 250kW	2 861 500	4	15	953 833	1 907 667
Tractor 80kW	621 000	8	12	414 000	207 000
Tractor 80kW	621 000	8	12	414 000	207 000
Tractor 50kW	301 000	10	12	250 833	50 167
Boom Sprayer 18m, 2000L	216 500	3	12	54 125	162 375
Boom Sprayer 18m, 2000L	216 500	9	12	162 375	54 125
Fertiliser Spreader 1500L, 10-36m	105 750	4	12	35 250	70 500
Fertiliser Spreader 1500L, 10-36m	105 750	9	12	79 313	26 438
No-till Planter, 33 tine, 9.4m	1 324 250	6	12	662 125	662 125
6ton 4wl, trailer	92 000	6	12	46 000	46 000
Grain cart 8ton	210 000	3	12	52 500	157 500
Road scraper, 2.4m, 3point	18 000	3	12	4 500	13 500
Wheat grain massebakke, 10ton	50 000	4	12	16 667	33 333
Front loader	94 000	5	12	39 167	54 833
Lorry, 10ton, SD	824 500	4	12	274 833	549 667
LDV 1	225 000	2	24	37 500	187 500
LDV 2	250 000	5	12	104 167	145 833
Movable and tools:					140 000
Total mechanization equipment (b)					**6 460 563**

Livestock:	Number	R/ssu	Value
Rams	-	3 500	-
Ewes	-	1 600	-
Replacement ewes	-	1 000	-
Lambs	-	200	-
Total sheep: (c)			**-**

Total assets: (a + b + c + d)	**30 460 563**

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Middle Swartland typical farm inventory - WCWL, conventional-tillage

Item	Amount (ha)	R/unit	Value
Land & Fixed improvements (a)	800	30 000	**24 000 000**

Mechanization:					
Item	**Price/new R**	**Current Age (years)**	**Expected Lifetime**	**Depreciation R**	**Value R**
Combine Harvester 210kW	3 060 000	5	15	1 275 000	1 785 000
Tractor 250kW	2 861 500	4	15	953 833	1 907 667
Tractor 80kW	621 000	8	12	414 000	207 000
Tractor 80kW	621 000	8	12	414 000	207 000
Tractor 50kW	301 000	10	12	250 833	50 167
Boom Sprayer 18m, 2000L	216 500	3	12	54 125	162 375
Boom Sprayer 18m, 2000L	216 500	9	12	162 375	54 125
Fertiliser Spreader 1500L, 10-36m	105 750	4	12	35 250	70 500
Fertiliser Spreader 1500L, 10-36m	105 750	9	12	79 313	26 438
Double seed drill, CT planter	700 000	6	12	350 000	350 000
Chisel Plough, 23tine, 6.9m	324 500	8	12	216 333	108 167
Fieldspan, 61tine, 9.3m	170 500	6	12	85 250	85 250
6ton 4wl, trailer	92 000	6	12	46 000	46 000
Grain cart 8ton	210 000	3	12	52 500	157 500
Road scraper, 2.4m, 3point	18 000	3	12	4 500	13 500
Wheat grain massebakke, 10ton	50 000	4	12	16 667	33 333
Front loader	94 000	5	12	39 167	54 833
Lorry, 10ton, SD	824 500	4	12	274 833	549 667
LDV 1	225 000	2	24	37 500	187 500
LDV 2	250 000	5	12	104 167	145 833
Movable and tools:					140 000
Total mechanization equipment (b)					**6 341 854**

Livestock:	**Number**	**R/ssu**	**Value**
Rams	-	3 500	-
Ewes	-	1 600	-
Replacement ewes	-	1 000	-
Lambs	-	200	-
Total sheep: (c)			**-**

Total assets: (a + b + c + d)	**30 341 854**

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Middle Swartland typical farm inventory - WMWM, no-till

Item	Amount (ha)	R/unit	Value
Land & Fixed improvements (a)	800	30 000	**24 000 000**

Mechanization:					
Item	**Price/new R**	**Current Age (years)**	**Expected Lifetime**	**Depreciation R**	**Value R**
Combine Harvester 210kW	3 060 000	5	15	1 275 000	1 785 000
Tractor 180kW	2 000 500	9	12	1 500 375	500 125
Tractor 80kW	621 000	8	12	414 000	207 000
Tractor 50kW	301 000	10	12	250 833	50 167
Boom Sprayer 18m, 2000L	216 500	7	12	126 292	90 208
Fertiliser Spreader 1500L, 10-36m	105 750	7	12	61 644	44 063
No-till Planter, 21 tine, 6m	804 500	6	12	402 250	402 250
6ton 4wl, trailer	92 000	6	12	46 000	46 000
Grain cart 8ton	210 000	3	12	52 500	157 500
Road scraper, 2.4m, 3point	18 000	3	12	4 500	13 500
Wheat grain massebakke, 10ton	50 000	4	12	16 667	33 333
Front loader	94 000	5	12	39 167	54 833
Lorry, 10ton, SD	824 500	4	12	274 833	549 667
LDV 1	225 000	2	24	37 500	187 500
LDV 2	250 000	5	12	104 167	145 833
Movable and tools:					140 000
Total mechanization equipment (b)					**4 406 979**

Livestock:	**Number**	**R/ssu**	**Value**
Rams	19	3 500	66 500
Ewes	760	1 600	1 216 000
Replacement ewes	190	1 000	190 000
Lambs	798	200	-
Total sheep: (c)			**1 472 500**

Total assets: (a + b + c + d)	**29 879 479**

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Middle Swartland typical farm inventory - WMWM, conventional-tillage

Item	Amount (ha)	R/unit	Value
Land & Fixed improvements (a)	800	30 000	**24 000 000**

Mechanization:					
Item	**Price/new R**	**Current Age (years)**	**Expected Lifetime**	**Depreciation R**	**Value R**
Combine Harvester 210kW	3 060 000	5	15	1 275 000	1 785 000
Tractor 180kW	2 000 500	9	12	1 500 375	500 125
Tractor 80kW	621 000	8	12	414 000	207 000
Tractor 50kW	301 000	10	12	250 833	50 167
Boom Sprayer 18m, 2000L	216 500	7	12	126 292	90 208
Fertiliser Spreader 1500L, 10-36m	105 750	7	12	61 644	44 063
Single seed drill, CT planter	350 000	6	12	175 000	175 000
Chisel Plough, 15tine, 4.5m	146 750	8	12	97 833	48 917
Fieldspan, 41tine, 6.1m	137 250	6	12	68 625	68 625
6ton 4wl, trailer	92 000	6	12	46 000	46 000
Grain cart 8ton	210 000	3	12	52 500	157 500
Road scraper, 2.4m, 3point	18 000	3	12	4 500	13 500
Wheat grain massebakke, 10ton	50 000	4	12	16 667	33 333
Front loader	94 000	5	12	39 167	54 833
Lorry, 10ton, SD	824 500	4	12	274 833	549 667
LDV 1	225 000	2	24	37 500	187 500
LDV 2	250 000	5	12	104 167	145 833
Movable and tools:					140 000
Total mechanization equipment (b)					**4 297 271**

Livestock:	Number	R/ssu	Value
Rams	19	3 500	66 500
Ewes	760	1 600	1 216 000
Replacement ewes	190	1 000	190 000
Lambs	798	200	-
Total sheep: (c)			**1 472 500**

Total assets: (a + b + c + d)	**29 769 771**

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Annexure K: Example of a gross margin calculation for two of the crop rotation systems WWWW and WCWL showing different costs between tillage practices

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GROSS MARGIN CALCULATION FOR WHEAT IN ROTATION SYSTEM WWWW IN GOOD, AVERAGE, AND POOR YEARS

		NT	CT			NT	CT			NT	CT	
1	Good	3 200	3 400	2	Average	2 500	2 600	3	Poor	1 600	1 600	Kg/Ha

Activity Code	Year	Crop: Wheat	Rotation Code:	WWWW	Good Year				No Tillage	Conventional Tillage
	1	Location:	Langgewens,							
		No Tillage	Kg's/Ha				3 200.00		3200	
		Conventional Tillage	Kg's/Ha				3 400.00			3400
103		Wheat: Average	Price: R/ton				2 792.87			
		Total Production Income (a)					-		8 937.17	9 495.75

Activity Code	Month	Item Description	Unit	R/Unit	Unit/Ha NT	Unit/Ha CT	Value NT	Value CT	NT	CT
		Directly attributable variable costs: (b)								
		Seed Cost:								
200		Wheat SST 027	kg	6.21	95.00	95.00	590.27	590.27	590.27	590.27
		Fertilization :							-	-
315		N	kg	11.24	60.00	120.00	674.20	1 348.40	674.20	1 348.40
316		P	kg	24.92	14.00	14.00	348.93	348.93	348.93	348.93
317		K	kg	10.17	1.00	1.00	10.17	10.17	10.17	10.17
318		S	kg	8.95	9.00	9.00	80.52	80.52	80.52	80.52
304		Dolomitiese kalk	kg	0.38	500.00	500.00	191.29	191.29	191.29	191.29
		Weed control :							-	-
407		Paragone (Preeglone)	liter	36.64	1.50	1.50	54.95	54.95	54.95	54.95
401		Triflurex (Triflorilin)	liter	65.36	1.50	1.50	98.05	98.05	98.05	98.05
430		Aurora	kg	3 211	0.02	0.02	64.21	64.21	64.21	64.21
422		Logran	kg	2 280	0.02	0.02	45.60	45.60	45.60	45.60
424		Buctril DS	liter	88.04	0.50	0.50	44.02	44.02	44.02	44.02
428		Trend	liter	88.92	0.08	0.08	6.67	6.67	6.67	6.67
429		Pallas	liter	928.87	0.44	0.44	408.70	408.70	408.70	408.70
400		Glifosaat 360 (Glyphosate)	liter	33.90	3.00	3.00	101.69	101.69	101.69	101.69
		Fungal control :							-	-
602		Duett	liter	186.96	0.80	0.80	149.57	149.57	149.57	149.57
601		Bumper	liter	109.44	0.50	0.50	54.72	54.72	54.72	54.72
		Insect control :							-	-
502		Dimethoate	liter	46.46	0.50	0.50	23.23	23.23	23.23	23.23
501		Cyperfos 500EC	liter	64.38	0.80	0.80	51.50	51.50	51.50	51.50
		Contract Work							-	-
802		Transport	ton	53.48	1.00	1.00	53.48	53.48	53.48	53.48
804		Lime spreading	ton	111.34	-	-	-	-	-	-
		Total directly attributable variable costs :							3 051.76	3 725.96

Not directly attributable variable costs: (c)

Activity Code	Month	Activity	Power source	Implement	Time/km	Usage per Implement	Year Power	Labour	Cost per Repair	Year Implement Energy	Power Repair	Total Variable Costs	Regular Labour Oper.	Tyre:	NT	CT
18	Feb	Spread Lime	80	102	1.00	0.05	0.05	0.07	0.69	4.72	1.64	7.05	4.64	0.33	12.02	12.02
1	Feb	Spray: herbicide	80	101	1.00	0.05	0.05	0.07	1.42	4.72	1.64	7.77	4.64	0.33	12.74	12.74
14	Feb	Fieldspan seedbed prep	250	107	1.00	0.21	0.21	0.25	4.31	18.26	6.35	28.92	17.96	0.63		47.52
14	May	Fieldspan seedbed prep	250	107	1.00	0.21	0.21	0.25	4.31	18.26	6.35	28.92	17.96	0.63		47.52
16	May	Chisel Plough	250	105	1.00	0.34	0.34	0.41	13.28	33.76	10.26	57.30	29.05	0.85		87.21
1	May	Spray: herbicide	80	101	1.00	0.05	0.05	0.07	1.42	4.72	1.64	7.77	4.64	0.33	12.74	12.74
5	May	Plant Conventional Till	250	109	1.00	0.25	0.25	0.29	20.59	24.26	7.38	52.23	20.88	0.74		73.85
7	May	Plant No-till	250	111	1.00	0.21	0.21	0.25	33.15	20.65	6.28	60.08	17.77	0.63	78.48	
17	June	Spread Fertiliser	80	102	1.00	0.05	0.05	0.07	0.69	4.72	1.64	7.05	4.64	0.33		12.02
1	Jun	Spray: herbicide	80	101	1.00	0.05	0.05	0.07	1.42	4.72	1.64	7.77	4.64	0.33	12.74	12.74
17	Jun	Spread Fertiliser	80	102	1.00	0.05	0.05	0.07	0.69	4.72	1.64	7.05	4.64	0.33	12.02	12.02
10	Aug	Spray: Fung & Insect	80	101	1.00	0.05	0.05	0.07	1.42	4.72	1.64	7.77	4.64	0.33	12.74	12.74
10	Sep	Spray: Fung & Insect	80	101	1.00	0.05	0.05	0.07	1.42	4.72	1.64	7.77	4.64	0.33	12.74	12.74
1	Sep	Spray: herbicide	80	101	1.00	0.05	0.05	0.07	1.42	4.72	1.64	7.77	4.64	0.33	12.74	12.74
11	Oct	Harvest	210	0	1.00	0.40	0.40	0.48	-	166.99	122.89	289.88	34.22	1.20	325.30	325.30
		Total non- directly attributable variable costs :													504.25	693.88
		Gross Margin : (= a-b - c)													5381.16	5075.90

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Average Year

Activity Code	Year	Crop: Wheat	Rotation Code:	WWWW						No Tillage	Conventional Tillage
	2	Location:	Langgewens,								
		Tillage Used	**Yield potential**								
		No Tillage	Kg's/Ha					2 500.00		2500	
		Conventional Tillage	Kg's/Ha					2 600.00			2600
103		Wheat: Average	Price: R/ton					2 792.87			
		Total Production Income (a)						-		6 982.17	7 261.45

Activity Code	Month	Item	Description	Unit	R/Unit	Unit/Ha NT	Unit/Ha CT	Value NT	Value CT	NT	CT
		Directly attributable variable costs: (b)									
		Seed Cost:									
200		Wheat SST 027		kg	6.21	95.00	95.00	590.27	590.27	590.27	590.27
		Fertilization :								-	-
315		N		kg	11.24	60.00	120.00	674.20	1 348.40	674.20	1 348.40
316		P		kg	24.92	14.00	14.00	348.93	348.93	348.93	348.93
317		K		kg	10.17	1.00	1.00	10.17	10.17	10.17	10.17
318		S		kg	8.95	9.00	9.00	80.52	80.52	80.52	80.52
304		Dolomitiese kalk		kg	0.38	500.00	500.00	191.29	191.29	191.29	191.29
		Weed control :								-	-
407		Paragone (Preeglone)		liter	36.64	1.50	1.50	54.95	54.95	54.95	54.95
401		Triflurex (Triflorilin)		liter	65.36	1.50	1.50	98.05	98.05	98.05	98.05
430		Aurora		kg	3 211	0.02	0.02	64.21	64.21	64.21	64.21
422		Logran		kg	2 280	0.02	0.02	45.60	45.60	45.60	45.60
424		Buctril DS		liter	88.04	0.50	0.50	44.02	44.02	44.02	44.02
428		Trend		liter	88.92	0.08	0.08	6.67	6.67	6.67	6.67
429		Pallas		liter	928.87	0.44	0.44	408.70	408.70	408.70	408.70
400		Glifosaat 360 (Glyphosate)		liter	33.90	3.00	3.00	101.69	101.69	101.69	101.69
		Fungal control :								-	-
602		Duett		liter	186.96	0.80	0.80	149.57	149.57	149.57	149.57
601		Bumper		liter	109.44	0.50	0.50	54.72	54.72	54.72	54.72
		Insect control :								-	-
502		Dimethoate		liter	46.46	0.50	0.50	23.23	23.23	23.23	23.23
501		Cyperfos 500EC		liter	64.38	0.80	0.80	51.50	51.50	51.50	51.50
		Contract Work								-	-
802		Transport		ton	53.48	1.00	1.00	53.48	53.48	53.48	53.48
803		Ariel Spraying		ha	-	-	-	-	-	-	-
804		Lime spreading		ton	111.34	-	-	-	-	-	-
		Total directly attributable variable costs :								3 051.76	3 725.96

Not directly attributable variable costs: (c)

Activity Code	Month	Activity	Power source	Implement	Time/km	Usage per Implement	Year Power	Labour	Cost per Repair	Year Implement Energy	Power Repair	Total Variable Costs	Regular Labour Oper.	Tyre:	NT	CT
18	Feb	Spread Lime	80	102	1.00	0.05	0.05	0.07	0.69	4.72	1.64	7.05	4.64	0.33	12.02	12.02
1	Feb	Spray: herbicide	80	101	1.00	0.05	0.05	0.07	1.42	4.72	1.64	7.77	4.64	0.33	12.74	12.74
14	Feb	Fieldspan seedbed prep	250	107	1.00	0.21	0.21	0.25	4.31	18.26	6.35	28.92	17.96	0.63		47.52
14	May	Fieldspan seedbed prep	250	107	1.00	0.21	0.21	0.25	4.31	18.26	6.35	28.92	17.96	0.63		47.52
16	May	Chisel Plough	250	105	1.00	0.34	0.34	0.41	13.28	33.76	10.26	57.30	29.05	0.85		87.21
1	May	Spray: herbicide	80	101	1.00	0.05	0.05	0.07	1.42	4.72	1.64	7.77	4.64	0.33	12.74	12.74
5	May	Plant Conventional Till	250	109	1.00	0.25	0.25	0.29	20.59	24.26	7.38	52.23	20.88	0.74		73.85
7	May	Plant No-till	250	111	1.00	0.21	0.21	0.25	33.15	20.65	6.28	60.08	17.77	0.63	78.48	
17	June	Spread Fertiliser	80	102	1.00	0.05	0.05	0.07	0.69	4.72	1.64	7.05	4.64	0.33		12.02
1	Jun	Spray: herbicide	80	101	1.00	0.05	0.05	0.07	1.42	4.72	1.64	7.77	4.64	0.33	12.74	12.74
17	Jun	Spread Fertiliser	80	102	1.00	0.05	0.05	0.07	0.69	4.72	1.64	7.05	4.64	0.33	12.02	12.02
10	Aug	Spray: Fung & Insect	80	101	1.00	0.05	0.05	0.07	1.42	4.72	1.64	7.77	4.64	0.33	12.74	12.74
10	Sep	Spray: Fung & Insect	80	101	1.00	0.05	0.05	0.07	1.42	4.72	1.64	7.77	4.64	0.33	12.74	12.74
1	Sep	Spray: herbicide	80	101	1.00	0.05	0.05	0.07	1.42	4.72	1.64	7.77	4.64	0.33	12.74	12.74
11	Oct	Harvest	210	0	1.00	0.40	0.40	0.48	-	166.99	122.89	289.88	34.22	1.20	325.30	325.30
		Total non- directly attributable variable costs :													504.25	693.88
		Gross Margin : (= a-b - c)													3426.15	2841.60

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Activity Code	Year	Crop: Wheat	Rotation Code:	WWWW	Poor year		No Tillage	Conventional Tillage
	3	Location:	Langgewens,					
		Tillage Used	**Yield potential**					
		No Tillage	Kg's/Ha			1 600.00	1600	
		Conventional Tillage	Kg's/Ha			1 600.00		1600
103		Wheat: Average	Price: R/ton			2 792.87		
		Total Production Income (a)				-	4 468.59	4 468.59

Activity Code	Month	Item	Description	Unit	R/Unit	Unit/Ha NT	Unit/Ha CT	Value NT	Value CT	NT	CT
		Directly attributable variable costs: (b)									
		Seed Cost:									
200		Wheat SST 027		kg	6.21	95.00	95.00	590.27	590.27	590.27	590.27
		Fertilization :								-	-
315		N		kg	11.24	60.00	120.00	674.20	1 348.40	674.20	1 348.40
316		P		kg	24.92	14.00	14.00	348.93	348.93	348.93	348.93
317		K		kg	10.17	1.00	1.00	10.17	10.17	10.17	10.17
318		S		kg	8.95	9.00	9.00	80.52	80.52	80.52	80.52
304		Dolomitiese kalk		kg	0.38	500.00	500.00	191.29	191.29	191.29	191.29
		Weed control :								-	-
407		Paragone (Preeglone)		liter	36.64	1.50	1.50	54.95	54.95	54.95	54.95
401		Triflurex (Triflorilin)		liter	65.36	1.50	1.50	98.05	98.05	98.05	98.05
430		Aurora		kg	3 211	0.02	0.02	64.21	64.21	64.21	64.21
422		Logran		kg	2 280	0.02	0.02	45.60	45.60	45.60	45.60
424		Buctril DS		liter	88.04	0.50	0.50	44.02	44.02	44.02	44.02
428		Trend		liter	88.92	0.08	0.08	6.67	6.67	6.67	6.67
429		Pallas		liter	928.87	0.44	0.44	408.70	408.70	408.70	408.70
400		Glifosaat 360 (Glyphosate)		liter	33.90	3.00	3.00	101.69	101.69	101.69	101.69
		Fungal control :								-	-
602		Duett		liter	186.96	0.80	0.80	149.57	149.57	149.57	149.57
601		Bumper		liter	109.44	0.50	0.50	54.72	54.72	54.72	54.72
		Insect control :								-	-
502		Dimethoate		liter	46.46	0.50	0.50	23.23	23.23	23.23	23.23
501		Cyperfos 500EC		liter	64.38	0.80	0.80	51.50	51.50	51.50	51.50
		Contract Work								-	-
802		Transport		ton	53.48	1.00	1.00	53.48	53.48	53.48	53.48
803		Ariel Spraying		ha	-	-	-	-	-	-	-
804		Lime spreading		ton	111.34	-	-	-	-	-	-
		Total directly attributable variable costs :								3 051.76	3 725.96

Not directly attributable variable costs: (c)

Activity Code	Month	Activity	Power source	Implement	Time/km	Usage per Implement	Year Power	Labour	Cost per Repair	Year Implement Energy	Power Repair	Total Variable Costs	Regular Labour Oper.	Tyre:	NT	CT
18	Feb	Spread Lime	80	102	1.00	0.05	0.05	0.07	0.69	4.72	1.64	7.05	4.64	0.33	12.02	12.02
1	Feb	Spray: herbicide	80	101	1.00	0.05	0.05	0.07	1.42	4.72	1.64	7.77	4.64	0.33	12.74	12.74
14	Feb	Fieldspan seedbed prep	250	107	1.00	0.21	0.21	0.25	4.31	18.26	6.35	28.92	17.96	0.63		47.52
14	May	Fieldspan seedbed prep	250	107	1.00	0.21	0.21	0.25	4.31	18.26	6.35	28.92	17.96	0.63		47.52
16	May	Chisel Plough	250	105	1.00	0.34	0.34	0.41	13.28	33.76	10.26	57.30	29.05	0.85		87.21
1	May	Spray: herbicide	80	101	1.00	0.05	0.05	0.07	1.42	4.72	1.64	7.77	4.64	0.33	12.74	12.74
5	May	Plant Conventional Till	250	109	1.00	0.25	0.25	0.29	20.59	24.26	7.38	52.23	20.88	0.74		73.85
7	May	Plant No-till	250	111	1.00	0.21	0.21	0.25	33.15	20.65	6.28	60.08	17.77	0.63	78.48	
17	June	Spread Fertiliser	80	102	1.00	0.05	0.05	0.07	0.69	4.72	1.64	7.05	4.64	0.33		12.02
1	Jun	Spray: herbicide	80	101	1.00	0.05	0.05	0.07	1.42	4.72	1.64	7.77	4.64	0.33	12.74	12.74
17	Jun	Spread Fertiliser	80	102	1.00	0.05	0.05	0.07	0.69	4.72	1.64	7.05	4.64	0.33	12.02	12.02
10	Aug	Spray: Fung & Insect	80	101	1.00	0.05	0.05	0.07	1.42	4.72	1.64	7.77	4.64	0.33	12.74	12.74
10	Sep	Spray: Fung & Insect	80	101	1.00	0.05	0.05	0.07	1.42	4.72	1.64	7.77	4.64	0.33	12.74	12.74
1	Sep	Spray: herbicide	80	101	1.00	0.05	0.05	0.07	1.42	4.72	1.64	7.77	4.64	0.33	12.74	12.74
11	Oct	Harvest	210	0	1.00	0.40	0.40	0.48	-	166.99	122.89	289.88	34.22	1.20	325.30	325.30
		Total non- directly attributable variable costs :													504.25	693.88
		Gross Margin : (= a-b - c)													912.57	48.74

GROSS MARGIN CALCULATION FOR LUPIN IN ROTATION SYSTEM WCWL IN GOOD, AVERAGE, AND POOR YEARS			NT	CT			NT	CT			NT	CT	
	1	Good	2 000	1 900	2	Average	1 300	1 200	3	Poor	800	600	Kg/Ha

Activity Code	Year	Crop: LUPIN	Rotation Code:	WCWL						No Tillage	Conventional Tillage
	1	Location:	Langgewens,		**Good year**						
		Tillage Used	**Yield potential**								
		No Tillage	Kg's/Ha					2 000.00		2000	
		Conventional Tillage	Kg's/Ha					1 900.00			1900
106		Lupin	Price: R/ton					2 721.91			
		Total Production Income (a)						-		5 443.81	5 171.62

Activity Code	Month	Item	Description	Unit	R/Unit	Unit/Ha NT	Unit/Ha CT	Value NT	Value CT	NT	CT
		Directly attributable variable costs: (b)									
		Seed Cost:									
213		Lupin Mandellup		kg	6.54	80.00	80.00	522.93	522.93	522.93	522.93
		Fertilization :								-	-
319		Lupine N		kg	11.24	7.50	7.50	84.28	84.28	84.28	84.28
320		Lupine P		kg	24.92	14.30	14.30	356.40	356.40	356.40	356.40
311		Gypsum		kg	0.71	250.00	250.00	178.12	178.12	178.12	178.12
		Weed control :								-	-
407		Paragone (Preeglone)		liter	36.64	1.50	1.50	54.95	54.95	54.95	54.95
430		Aurora		kg	3 211	0.02	0.02	64.21	64.21	64.21	64.21
408		Simazol (Simazine)		kg	43.32	1.00	1.00	43.32	43.32	43.32	43.32
405		Aramo		liter	238.20	1.00	1.00	238.20	238.20	238.20	238.20
406		Dash		liter	55.79	1.00	1.00	55.79	55.79	55.79	55.79
400		Glifosaat 360 (Glyphosate)		liter	33.90	3.00	3.00	101.69	101.69	101.69	101.69
		Fungal control :								-	-
603		Topaz		liter	584.59	0.30	0.30	175.38	175.38	175.38	175.38
		Insect control :								-	-
										-	-
		Contract Work								-	-
802		Transport		ton	53.48	1.00	1.00	53.48	53.48	53.48	53.48
803		Ariel Spraying		ha	-	-	-	-	-	-	-
804		Lime spreading		ton	111.34	-	-	-	-	-	-
				Total directly attributable variable costs :						1 928.75	1 928.75
				Not directly attributable variable costs: (c)							

Activity Code	Month	Activity	Power source	Implement	Time/km	Usage per Implement	Year Power	Labour	Cost per Repair	Year Implement Energy	Power Repair	Total Variable Costs	Regular Labour Oper.	Tyre	NT	CT
18	Feb	Spread Lime	80	102	1.00	0.05	0.05	0.07	0.69	4.72	1.64	7.05	4.64	0.33	12.02	12.02
1	Feb	Spray: herbicide	80	101	1.00	0.05	0.05	0.07	1.42	4.72	1.64	7.77	4.64	0.33	12.74	12.74
16	Mar	Chisel Plough	250	105	1.00	0.34	0.34	0.41	13.28	33.76	10.26	57.30	29.05	0.85		87.21
14	May	Fieldspan seedbed prep	250	107	1.00	0.21	0.21	0.25	4.31	18.26	6.35	28.92	17.96	0.63		47.52
1	May	Spray: herbicide	80	101	1.00	0.05	0.05	0.07	1.42	4.72	1.64	7.77	4.64	0.33	12.74	12.74
5	May	Plant Conventional Till	250	109	1.00	0.25	0.25	0.29	20.59	24.26	7.38	52.23	20.88	0.74		73.85
7	May	Plant No-till	250	111	1.00	0.21	0.21	0.25	33.15	20.65	6.28	60.08	17.77	0.63	78.48	
17	May	Spread Fertiliser	80	102	1.00	0.05	0.05	0.07	0.69	4.72	1.64	7.05	4.64	0.33	12.02	12.02
1	Jun	Spray: herbicide	80	101	1.00	0.05	0.05	0.07	1.42	4.72	1.64	7.77	4.64	0.33	12.74	12.74
1	Sep	Spray: herbicide	80	101	1.00	0.05	0.05	0.07	1.42	4.72	1.64	7.77	4.64	0.33	12.74	12.74
11	Oct	Harvest	210	0	1.00	0.40	0.40	0.48	-	166.99	122.89	289.88	34.22	1.20	325.30	325.30
		Total non- directly attributable variable costs :													**478.77**	**608.87**
		Gross Margin : (= a-b - c)													**3036.29**	**2634.00**

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Activity Code	Year	Crop: LUPINE	Rotation Code:	WCWL	Average Year					No Tillage	Conventional Tillage
	2	Location: Langgewens,									
		Tillage Used	**Yield potential**								
		No Tillage	Kg's/Ha					1 300.00		1300	
		Conventional Tillage	Kg's/Ha					1 200.00			1200
106		Lupin	Price: R/ton					2 721.91			
		Total Production Income (a)						-		3 538.48	3 266.29

Activity Code	Month	Item	Description	Unit	R/Unit	Unit/Ha NT	Unit/Ha CT	Value NT	Value CT	NT	CT
		Directly attributable variable costs: (b)									
		Seed Cost:									
213		Lupin Mandellup		kg	6.54	80.00	80.00	522.93	522.93	522.93	522.93
		Fertilization :								-	-
319		Lupine N		kg	11.24	7.50	7.50	84.28	84.28	84.28	84.28
320		Lupine P		kg	24.92	14.30	14.30	356.40	356.40	356.40	356.40
311		Gypsum		kg	0.71	250.00	250.00	178.12	178.12	178.12	178.12
		Weed control :								-	-
407		Paragone (Preeglone)		liter	36.64	1.50	1.50	54.95	54.95	54.95	54.95
430		Aurora		kg	3 211	0.02	0.02	64.21	64.21	64.21	64.21
408		Simazol (Simazine)		kg	43.32	1.00	1.00	43.32	43.32	43.32	43.32
405		Aramo		liter	238.20	1.00	1.00	238.20	238.20	238.20	238.20
406		Dash		liter	55.79	1.00	1.00	55.79	55.79	55.79	55.79
400		Glifosaat 360 (Glyphosate)		liter	33.90	3.00	3.00	101.69	101.69	101.69	101.69
		Fungal control :								-	-
603		Topaz		liter	584.59	0.30	0.30	175.38	175.38	175.38	175.38
		Insect control :								-	-
										-	-
		Contract Work								-	-
802		Transport		ton	53.48	1.00	1.00	53.48	53.48	53.48	53.48
803		Ariel Spraying		ha	-	-	-	-	-	-	-
804		Lime spreading		ton	111.34	-	-	-	-	-	-
			Total directly attributable variable costs :							1 928.75	1 928.75

Activity Code	Month	Activity	Power source	Implement	Time/km	Usage per Implement	Year Power	Labour	Cost per Repair	Year Implement Energy	Power Repair	Total Variable Costs	Regular Labour Oper.	Tyre:	NT	CT
		Not directly attributable variable costs: (c)														
18	Feb	Spread Lime	80	102	1.00	0.05	0.05	0.07	0.69	4.72	1.64	7.05	4.64	0.33	12.02	12.02
1	Feb	Spray: herbicide	80	101	1.00	0.05	0.05	0.07	1.42	4.72	1.64	7.77	4.64	0.33	12.74	12.74
16	Mar	Chisel Plough	250	105	1.00	0.34	0.34	0.41	13.28	33.76	10.26	57.30	29.05	0.85		87.21
14	May	Fieldspan seedbed prep	250	107	1.00	0.21	0.21	0.25	4.31	18.26	6.35	28.92	17.96	0.63		47.52
1	May	Spray: herbicide	80	101	1.00	0.05	0.05	0.07	1.42	4.72	1.64	7.77	4.64	0.33	12.74	12.74
5	May	Plant Conventional Till	250	109	1.00	0.25	0.25	0.29	20.59	24.26	7.38	52.23	20.88	0.74		73.85
7	May	Plant No-till	250	111	1.00	0.21	0.21	0.25	33.15	20.65	6.28	60.08	17.77	0.63	78.48	
17	May	Spread Fertiliser	80	102	1.00	0.05	0.05	0.07	0.69	4.72	1.64	7.05	4.64	0.33	12.02	12.02
1	Jun	Spray: herbicide	80	101	1.00	0.05	0.05	0.07	1.42	4.72	1.64	7.77	4.64	0.33	12.74	12.74
1	Sep	Spray: herbicide	80	101	1.00	0.05	0.05	0.07	1.42	4.72	1.64	7.77	4.64	0.33	12.74	12.74
11	Oct	Harvest	210	0	1.00	0.40	0.40	0.48	-	166.99	122.89	289.88	34.22	1.20	325.30	325.30
		Total non- directly attributable variable costs :													478.77	608.87
		Gross Margin : (= a-b - c)													1130.96	728.67

Activity Code	Year	Crop: LUPINE	Rotation Code:	WCWL	Poor Year	No Tillage	Conventional Tillage
	3	Location: Langgewens,					
		Tillage Used	**Yield potential**				
		No Tillage	Kg's/Ha		800.00	800	
		Conventional Tillage	Kg's/Ha		600.00		600
106		Lupin	Price: R/ton		2 721.91		
		Total Production Income (a)			-	2 177.53	1 633.14

Activity Code	Month	Item	Description	Unit	R/Unit	Unit/Ha NT	Unit/Ha CT	Value NT	Value CT	NT	CT
		Directly attributable variable costs: (b)									
		Seed Cost:									
213		Lupin Mandellup		kg	6.54	80.00	80.00	522.93	522.93	522.93	522.93
		Fertilization :								-	-
319		Lupine N		kg	11.24	7.50	7.50	84.28	84.28	84.28	84.28
320		Lupine P		kg	24.92	14.30	14.30	356.40	356.40	356.40	356.40
311		Gypsum		kg	0.71	250.00	250.00	178.12	178.12	178.12	178.12
		Weed control :								-	-
407		Paragone (Preeglone)		liter	36.64	1.50	1.50	54.95	54.95	54.95	54.95
430		Aurora		kg	3 211	0.02	0.02	64.21	64.21	64.21	64.21
408		Simazol (Simazine)		kg	43.32	1.00	1.00	43.32	43.32	43.32	43.32
405		Aramo		liter	238.20	1.00	1.00	238.20	238.20	238.20	238.20
406		Dash		liter	55.79	1.00	1.00	55.79	55.79	55.79	55.79
400		Glifosaat 360 (Glyphosate)		liter	33.90	3.00	3.00	101.69	101.69	101.69	101.69
		Fungal control :								-	-
603		Topaz		liter	584.59	0.30	0.30	175.38	175.38	175.38	175.38
		Insect control :								-	-
										-	-
		Contract Work								-	-
802		Transport		ton	53.48	1.00	1.00	53.48	53.48	53.48	53.48
803		Ariel Spraying		ha	-	-	-	-	-	-	-
804		Lime spreading		ton	111.34	-	-	-	-	-	-
			Total directly attributable variable costs :							1 928.75	1 928.75
			Not directly attributable variable costs: (c)								

Activity Code	Month	Activity	Power source	Implement	Time/km	Usage per Implement	Year Power	Labour	Cost per Repair	Year Implement Energy	Power Repair	Total Variable Costs	Regular Labour Oper.	Tyre	NT	CT
18	Feb	Spread Lime	80	102	1.00	0.05	0.05	0.07	0.69	4.72	1.64	7.05	4.64	0.33	12.02	12.02
1	Feb	Spray: herbicide	80	101	1.00	0.05	0.05	0.07	1.42	4.72	1.64	7.77	4.64	0.33	12.74	12.74
16	Mar	Chisel Plough	250	105	1.00	0.34	0.34	0.41	13.28	33.76	10.26	57.30	29.05	0.85		87.21
14	May	Fieldspan seedbed prep	250	107	1.00	0.21	0.21	0.25	4.31	18.26	6.35	28.92	17.96	0.63		47.52
1	May	Spray: herbicide	80	101	1.00	0.05	0.05	0.07	1.42	4.72	1.64	7.77	4.64	0.33	12.74	12.74
5	May	Plant Conventional Till	250	109	1.00	0.25	0.25	0.29	20.59	24.26	7.38	52.23	20.88	0.74		73.85
7	May	Plant No-till	250	111	1.00	0.21	0.21	0.25	33.15	20.65	6.28	60.08	17.77	0.63	78.48	
17	May	Spread Fertiliser	80	102	1.00	0.05	0.05	0.07	0.69	4.72	1.64	7.05	4.64	0.33	12.02	12.02
1	Jun	Spray: herbicide	80	101	1.00	0.05	0.05	0.07	1.42	4.72	1.64	7.77	4.64	0.33	12.74	12.74
1	Sep	Spray: herbicide	80	101	1.00	0.05	0.05	0.07	1.42	4.72	1.64	7.77	4.64	0.33	12.74	12.74
11	Oct	Harvest	210	0	1.00	0.40	0.40	0.48	-	166.99	122.89	289.88	34.22	1.20	325.30	325.30
		Total non- directly attributable variable costs :													478.77	608.87
		Gross Margin : (= a-b - c)													-229.99	-904.48

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Annexure L: Whole-farm multu-period budgets for the different crop rotation systems under different tillage practices

Whole-farm multi-period budget - Middle Swartland, CWWW, no-till

Year in calculation period:		1	2	3	4	5	6	7	8	9	10
Wheat: Year classification* (good, average, poor)		2	1	3	2	1	2	2	1	2	3
Canola & Lupin: Year classification* (good, average, poor)		2	2	3	2	1	2	2	1	2	3
Crop	Hectare										
Wheat after wheat	-	-	-	-	-	-	-	-	-	-	-
Wheat after canola	190	1 203 410	1 574 862	646 233	1 203 410	1 574 862	1 203 410	1 203 410	1 574 862	1 203 410	646 233
WCWW	190	911 556	1 335 010	367 114	911 556	1 335 010	911 556	911 556	1 335 010	911 556	367 114
CWWW	190	831 959	1 233 126	316 172	831 959	1 233 126	831 959	831 959	1 233 126	831 959	316 172
Wheat after lupine	-	-	-	-	-	-	-	-	-	-	-
Wheat after Medics	-	-	-	-	-	-	-	-	-	-	-
Canola	190	489 802	489 802	552	489 802	979 052	489 802	489 802	979 052	489 802	552
Lupins	-	-	-	-	-	-	-	-	-	-	-
Medics	-	-	-	-	-	-	-	-	-	-	-
Capital sales		-	-	25 083	26 854	103 500	-	118 021	28 667	81 688	37 042
Gross margin: total farming:	**760**	**3 436 727**	**4 632 800**	**1 355 155**	**3 463 581**	**5 225 550**	**3 436 727**	**3 554 747**	**5 150 716**	**3 518 414**	**1 367 113**
Overhead and fixed costs:											
Regular work:		426 000	426 000	426 000	426 000	426 000	426 000	426 000	426 000	426 000	426 000
Water fees:		33 000	33 000	33 000	33 000	33 000	33 000	33 000	33 000	33 000	33 000
Municipal taxes:		24 000	24 000	24 000	24 000	24 000	24 000	24 000	24 000	24 000	24 000
Insurance (overall):		453 803	453 803	453 803	453 803	453 803	453 803	453 803	453 803	453 803	453 803
Licenses:		8 280	8 280	8 280	8 280	8 280	8 280	8 280	8 280	8 280	8 280
Bank charges:		17 000	17 000	17 000	17 000	17 000	17 000	17 000	17 000	17 000	17 000
Phone		32 000	32 000	32 000	32 000	32 000	32 000	32 000	32 000	32 000	32 000
Administration		12 000	12 000	12 000	12 000	12 000	12 000	12 000	12 000	12 000	12 000
Auditors & Consultation fees		16 000	16 000	16 000	16 000	16 000	16 000	16 000	16 000	16 000	16 000
Provision: camps		30 000	30 000	30 000	30 000	30 000	30 000	30 000	30 000	30 000	30 000
Supply: water distribution		28 000	28 000	28 000	28 000	28 000	28 000	28 000	28 000	28 000	28 000
Employee wages		300 000	300 000	300 000	300 000	300 000	300 000	300 000	300 000	300 000	300 000
Miscellaneous costs (4%)		55 203	55 203	55 203	55 203	55 203	55 203	55 203	55 203	55 203	55 203
Total overhead and fixed costs:		**1 435 287**	**1 435 287**	**1 435 287**	**1 435 287**	**1 435 287**	**1 435 287**	**1 435 287**	**1 435 287**	**1 435 287**	**1 435 287**
Margin above overhead and fixed costs:		**2 001 440**	**3 197 513**	**- 80 132**	**2 028 294**	**3 790 263**	**2 001 440**	**2 119 461**	**3 715 430**	**2 083 127**	**- 68 173**
Capital:											
Long-term capital:											
Land & fixed improvements		24 000 000	-	-	-	-	-	-	-	-	-
Intermediary Capital:	age										
Harvester 210kW	5	1 785 000	-	-	-	-	-	-	-	-	-
Tractor 250kW	4	1 907 667	-	-	-	-	-	-	-	-	-
Tractor 80kW	8	207 000	-	-	-	621 000	-	-	-	-	-
Tractor 80kW	8	207 000	-	-	-	621 000	-	-	-	-	-
Tractor 50kW	10	50 167	-	301 000	-	-	-	-	-	-	-
Sprayer 18m, 2000L	3	162 375	-	-	-	-	-	-	-	-	216 500
Sprayer 18m, 2000L	9	54 125	-	-	216 500	-	-	-	-	-	-
Fertiliser Spreader 1500L, 10-36m, 3point	4	70 500	-	-	-	-	-	-	-	105 750	-
Fertiliser Spreader 1500L, 10-36m, 3point	9	26 438	-	-	105 750	-	-	-	-	-	-
No-till Planter, 33 tine, 9.4m	6	662 125	-	-	-	-	-	1 324 250	-	-	-
6ton 4wl, trailer	6	46 000	-	-	-	-	-	92 000	-	-	-
Grain cart 8ton	3	157 500	-	-	-	-	-	-	-	-	210 000
Road scraper, 2.4m, 3point	3	13 500	-	-	-	-	-	-	-	-	18 000
Wheat grain massebakke, 10ton	4	33 333	-	-	-	-	-	-	-	50 000	-
Front loader	5	54 833	-	-	-	-	-	-	94 000	-	-

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Lorry, 10ton, SD	4	549 667	-	-	-	-	-	-	-	824 500	-
LDV 1	2	187 500	-	-	-	-	-	-	-	-	-
LDV 2	5	145 833	-	-	-	-	-	-	250 000	-	-
Tools and Equipment		140 000									
Total intermediary capital:		6 460 563	-	301 000	322 250	1 242 000	-	1 416 250	344 000	980 250	444 500
Livestock:		-									
Total capital:		30 460 563	-	301 000	322 250	1 242 000	-	1 416 250	344 000	980 250	444 500
Net annual flows:		**- 28 459 123**	**3 197 513**	**- 381 132**	**1 706 044**	**2 548 263**	**2 001 440**	**703 211**	**3 371 430**	**1 102 877**	**- 512 673**
IRR	**5.39%**										
NPV	**10 684 593**										

*Type of year indicated by code: good year=1, average year=2, poor year=3.

Cash Flow:										
Opening	-	1 429 239	4 049 944	3 342 513	4 487 348	7 318 662	8 127 140	8 665 331	10 814 385	11 298 975
Inflow	3 436 727	4 632 800	1 355 155	3 463 581	5 225 550	3 436 727	3 554 747	5 150 716	3 518 414	1 367 113
Outflow	2 019 510	2 046 159	2 090 701	2 356 490	2 455 794	2 696 608	3 089 442	3 092 625	3 128 862	3 144 455
Flow before interest	1 417 217	4 015 879	3 314 398	4 449 604	7 257 104	8 058 781	8 592 445	10 723 423	11 203 937	9 521 633
Interest	12 022	34 065	28 115	37 744	61 559	68 359	72 886	90 962	95 038	80 768
Closing balance	1 429 239	4 049 944	3 342 513	4 487 348	7 318 662	8 127 140	8 665 331	10 814 385	11 298 975	9 602 401

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Whole-farm multi-period budget - Middle Swartland, CWWW, no-till

Year in calculation period:	11	12	13	14	15	16	17	18	19	20	
Wheat: Year classification* (good, average, poor)	1	2	2	2	1	2	2	2	2	2	
Canola & Lupin: Year classification* (good, average, poor)	1	2	2	2	1	2	2	2	2	2	
Crop											
Wheat after wheat	-	-	-	-	-	-	-	-	-	-	
Wheat after canola	1 574 862	1 203 410	1 203 410	1 203 410	1 574 862	1 203 410	1 203 410	1 203 410	1 203 410	1 203 410	
WCWW	1 335 010	911 556	911 556	911 556	1 335 010	911 556	911 556	911 556	911 556	911 556	
CWWW	1 233 126	831 959	831 959	831 959	1 233 126	831 959	831 959	831 959	831 959	831 959	
Wheat after lupine	-	-	-	-	-	-	-	-	-	-	
Wheat after Medics	-	-	-	-	-	-	-	-	-	-	
Canola	979 052	489 802	489 802	489 802	979 052	489 802	489 802	489 802	489 802	489 802	
Lupins	-	-	-	-	-	-	-	-	-	-	
Medics	-	-	-	-	-	-	-	-	-	-	
Capital sales	255 000	238 458	-	-	25 083	26 854	103 500	-	118 021	28 667	
Gross margin: total farming:	**5 377 050**	**3 675 185**	**3 436 727**	**3 436 727**	**5 147 133**	**3 463 581**	**3 540 227**	**3 436 727**	**3 554 747**	**3 465 393**	
Overhead and fixed costs:											
Regular work:	426 000	426 000	426 000	426 000	426 000	426 000	426 000	426 000	426 000	426 000	
Water fees:	33 000	33 000	33 000	33 000	33 000	33 000	33 000	33 000	33 000	33 000	
Municipal taxes:	24 000	24 000	24 000	24 000	24 000	24 000	24 000	24 000	24 000	24 000	
Insurance (overall):	453 803	453 803	453 803	453 803	453 803	453 803	453 803	453 803	453 803	453 803	
Licenses:	8 280	8 280	8 280	8 280	8 280	8 280	8 280	8 280	8 280	8 280	
Bank charges:	17 000	17 000	17 000	17 000	17 000	17 000	17 000	17 000	17 000	17 000	
Phone	32 000	32 000	32 000	32 000	32 000	32 000	32 000	32 000	32 000	32 000	
Administration	12 000	12 000	12 000	12 000	12 000	12 000	12 000	12 000	12 000	12 000	
Auditors & Consultation fees	16 000	16 000	16 000	16 000	16 000	16 000	16 000	16 000	16 000	16 000	
Provision: camps	30 000	30 000	30 000	30 000	30 000	30 000	30 000	30 000	30 000	30 000	
Supply: water distribution	28 000	28 000	28 000	28 000	28 000	28 000	28 000	28 000	28 000	28 000	
Employee wages	300 000	300 000	300 000	300 000	300 000	300 000	300 000	300 000	300 000	300 000	
Miscellaneous costs (4%)	55 203	55 203	55 203	55 203	55 203	55 203	55 203	55 203	55 203	55 203	
Total overhead and fixed costs:	**1 435 287**	**1 435 287**	**1 435 287**	**1 435 287**	**1 435 287**	**1 435 287**	**1 435 287**	**1 435 287**	**1 435 287**	**1 435 287**	
Margin above overhead and fixed costs:	**3 941 763**	**2 239 898**	**2 001 440**	**2 001 440**	**3 711 846**	**2 028 294**	**2 104 940**	**2 001 440**	**2 119 461**	**2 030 106**	
Capital:											Resale value:
Long-term capital:											
Land & fixed improvements	-	-	-	-	-	-	-	-	-	-	24 000 000
Intermediary Capital:											
Harvester 210kW	3 060 000	-	-	-	-	-	-	-	-	-	1 224 000
Tractor 250kW	-	2 861 500	-	-	-	-	-	-	-	-	1 335 367
Tractor 80kW	-	-	-	-	-	-	621 000	-	-	-	465 750
Tractor 80kW	-	-	-	-	-	-	621 000	-	-	-	465 750

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Tractor 50kW	-	-	-	-	301 000	-	-	-	-	-	175 583
Sprayer 18m, 2000L	-	-	-	-	-	-	-	-	-	-	36 083
Sprayer 18m, 2000L	-	-	-	-	-	216 500	-	-	-	-	144 333
Fertiliser Spreader 1500L, 10-36m, 3point	-	-	-	-	-	-	-	-	-	-	8 813
Fertiliser Spreader 1500L, 10-36m, 3point	-	-	-	-	-	105 750	-	-	-	-	70 500
No-till Planter, 33 tine, 9.4m	-	-	-	-	-	-	-	-	1 324 250	-	641 667
6ton 4wl, trailer	-	-	-	-	-	-	-	-	92 000	-	84 333
Grain cart 8ton	-	-	-	-	-	-	-	-	-	-	35 000
Road scraper, 2.4m, 3point	-	-	-	-	-	-	-	-	-	-	3 000
Wheat grain massebakke, 10ton	-	-	-	-	-	-	-	-	-	-	4 167
Front loader	-	-	-	-	-	-	-	-	-	94 000	-
Lorry, 10ton, SD	-	-	-	-	-	-	-	-	-	-	68 708
LDV 1	-	-	-	-	-	-	-	-	-	-	253 125
LDV 2	-	-	-	-	-	-	-	-	-	250 000	-
Tools and Equipment											
Total intermediary capital:	3 060 000	2 861 500	-	-	301 000	322 250	1 242 000	-	1 416 250	344 000	5 016 179
Livestock:											-
Total capital:	3 060 000	2 861 500	-	-	301 000	322 250	1 242 000	-	1 416 250	344 000	29 016 179
Net annual flows:	**881 763**	**- 621 602**	**2 001 440**	**2 001 440**	**3 410 846**	**1 706 044**	**862 940**	**2 001 440**	**703 211**	**30 702 286**	

IRR

NPV

*Type of year indicated by code: good year=1, average year=2, poor year=3.

Cash Flow:

Opening	9 602 401	12 358 250	13 576 174	14 118 666	14 943 474	17 571 144	18 348 156	19 376 952	20 781 125	21 920 065
Inflow	5 377 050	3 675 185	3 436 727	3 436 727	5 147 133	3 463 581	3 540 227	3 436 727	3 554 747	3 465 393
Outflow	2 725 148	2 571 453	3 012 989	2 737 612	2 667 257	2 840 899	2 674 415	2 207 348	2 600 182	2 603 364
Flow before interest	12 254 302	13 461 982	13 999 911	14 817 781	17 423 350	18 193 826	19 213 968	20 606 331	21 735 691	22 782 094
Interest	103 948	114 192	118 755	125 693	147 795	154 330	162 984	174 795	184 374	193 251
Closing balance	12 358 250	13 576 174	14 118 666	14 943 474	17 571 144	18 348 156	19 376 952	20 781 125	21 920 065	22 975 345

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Whole-farm multi-period budget - Middle Swartland, CWWW, conventional tillage

Year in calculation period:		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Wheat: Year classification* (good, average, poor)		2	1	3	2	1	2	2	1	2	3
Canola & Lupin: Year classification* (good, average, poor)		2	2	3	2	1	2	2	1	2	3
Crop	Hectare										
Wheat after wheat	-	-	-	-	-	-	-	-	-	-	-
Wheat after canola	190	880 088	1 357 668	349 443	880 088	1 357 668	880 088	880 088	1 357 668	880 088	349 443
WCWW	190	588 233	1 117 817	96 856	588 233	1 117 817	588 233	588 233	1 117 817	588 233	96 856
CWWW	190	508 637	1 015 933	84 121	508 637	1 015 933	508 637	508 637	1 015 933	508 637	84 121
Wheat after lupine	-	-	-	-	-	-	-	-	-	-	-
Wheat after Medics	-	-	-	-	-	-	-	-	-	-	-
Canola	190	289 113	289 113	- 281 678	289 113	778 363	289 113	289 113	778 363	289 113	- 281 678
Lupins	-	-	-	-	-	-	-	-	-	-	-
Medics	-	-	-	-	-	-	-	-	-	-	-
Capital sales		-	-	25 083	26 854	130 542	-	80 208	-	8 813	35 542
Gross margin: total farming:	**760**	**2 266 071**	**3 780 531**	**273 825**	**2 292 925**	**4 400 323**	**2 266 071**	**2 346 279**	**4 269 781**	**2 274 884**	**284 284**
Overhead and fixed costs:											
Regular work:		426 000	426 000	426 000	426 000	426 000	426 000	426 000	426 000	426 000	426 000
Water fees:		33 000	33 000	33 000	33 000	33 000	33 000	33 000	33 000	33 000	33 000
Municipal taxes:		24 000	24 000	24 000	24 000	24 000	24 000	24 000	24 000	24 000	24 000
Insurance (overall):		452 023	452 023	452 023	452 023	452 023	452 023	452 023	452 023	452 023	452 023
Licenses:		8 280	8 280	8 280	8 280	8 280	8 280	8 280	8 280	8 280	8 280
Bank charges:		17 000	17 000	17 000	17 000	17 000	17 000	17 000	17 000	17 000	17 000
Phone		32 000	32 000	32 000	32 000	32 000	32 000	32 000	32 000	32 000	32 000
Administration		12 000	12 000	12 000	12 000	12 000	12 000	12 000	12 000	12 000	12 000
Auditors & Consultation fees		16 000	16 000	16 000	16 000	16 000	16 000	16 000	16 000	16 000	16 000
Provision: camps		30 000	30 000	30 000	30 000	30 000	30 000	30 000	30 000	30 000	30 000
Supply: water distribution		28 000	28 000	28 000	28 000	28 000	28 000	28 000	28 000	28 000	28 000
Employee wages		300 000	300 000	300 000	300 000	300 000	300 000	300 000	300 000	300 000	300 000
Miscellaneous costs (4%)		55 132	55 132	55 132	55 132	55 132	55 132	55 132	55 132	55 132	55 132
Total overhead and fixed costs:		**1 433 435**	**1 433 435**	**1 433 435**	**1 433 435**	**1 433 435**	**1 433 435**	**1 433 435**	**1 433 435**	**1 433 435**	**1 433 435**
Margin above overhead and fixed costs:		**832 636**	**2 347 096**	**- 1 159 609**	**859 490**	**2 966 888**	**832 636**	**912 845**	**2 836 346**	**841 449**	**- 1 149 151**
Capital:											
Long-term capital:											
Land & fixed improvements		24 000 000	-	-	-	-	-	-	-	-	-
Intermediary Capital:	age										
Harvester 210kW	5	1 785 000	-	-	-	-	-	-	-	-	-
Tractor 250kW	4	1 907 667	-	-	-	-	-	-	-	-	-
Tractor 80kW	8	207 000	-	-	-	621 000	-	-	-	-	-
Tractor 80kW	8	207 000	-	-	-	621 000	-	-	-	-	-
Tractor 50kW	10	50 167	-	301 000	-	-	-	-	-	-	-
Sprayer 18m, 2000L	3	162 375	-	-	-	-	-	-	-	-	216 500
Sprayer 18m, 2000L	9	54 125	-	-	216 500	-	-	-	-	-	-
Fertiliser Spreader 1500L, 10-36m, 3point	4	70 500	-	-	-	-	-	-	-	105 750	-
Fertiliser Spreader 1500L, 10-36m, 3point	9	26 438	-	-	105 750	-	-	-	-	-	-
Double seed drill, CT planter	6	350 000	-	-	-	-	-	700 000	-	-	-
Chisel Plough, 23tine, 6.9m	8	108 167	-	-	-	324 500	-	-	-	-	-

Fieldspan, 61tine, 9.3m	6	85 250	-	-	-	-	-	170 500	-	-	-
6ton 4wl, trailer	6	46 000	-	-	-	-	-	92 000	-	-	-
Grain cart 8ton	3	157 500	-	-	-	-	-	-	-	-	210 000
Road scraper, 2.4m, 3point	3	13 500	-	-	-	-	-	-	-	-	18 000
Wheat grain massebakke, 10ton	4	33 333	-	-	-	-	-	-	-	50 000	-
Front loader	5	54 833	-	-	-	-	-	-	94 000	-	-
Lorry, 10ton, SD	4	549 667	-	-	-	-	-	-	-	824 500	-
LDV 1	2	187 500	-	-	-	-	-	-	-	-	-
LDV 2	5	145 833	-	-	-	-	-	-	250 000	-	-
Tools and Equipment		140 000									
Total intermediary capital:		5 230 688	-	301 000	322 250	1 566 500	-	962 500	-	105 750	426 500
Livestock:		-									
Total capital:		29 230 688	-	301 000	322 250	1 566 500	-	962 500	-	105 750	426 500
Net annual flows:		**-28 398 051**	**2 347 096**	**- 1 460 609**	**537 240**	**1 400 388**	**832 636**	**- 49 655**	**2 836 346**	**735 699**	**- 1 575 651**

IRR **1.93%**

NPV **- 3 241 267**

*Type of year indicated by code: good year=1, average year=2, poor year=3.

Cash Flow:

Opening	-	250 521	2 003 597	190 173	129 550	2 093 540	1 678 977	945 620	2 142 650	1 301 471
Inflow	2 266 071	3 780 531	273 825	2 292 925	4 400 323	2 266 071	2 346 279	4 269 781	2 274 884	284 284
Outflow	2 017 658	2 044 307	2 088 849	2 354 638	2 453 942	2 694 756	3 087 590	3 090 773	3 127 010	3 142 604
Flow before interest	248 413	1 986 745	188 573	128 460	2 075 931	1 664 855	937 666	2 124 628	1 290 524	- 1 556 849
Interest	2 107	16 853	1 600	1 090	17 609	14 122	7 954	18 022	10 947	- 42 553
Closing balance	250 521	2 003 597	190 173	129 550	2 093 540	1 678 977	945 620	2 142 650	1 301 471	- 1 599 402

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Whole-farm multi-period budget - Middle Swartland, CWWW, conventional tillage

Year in calculation period:	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	
Wheat: Year classification* (good, average, poor)	1	2	2	2	1	2	2	2	2	2	
Canola & Lupin: Year classification* (good, average, poor)	1	2	2	2	1	2	2	2	2	2	
Crop											
Wheat after wheat	-	-	-	-	-	-	-	-	-	-	
Wheat after canola	1 357 668	880 088	880 088	880 088	1 357 668	880 088	880 088	880 088	880 088	880 088	
WCWW	1 117 817	588 233	588 233	588 233	1 117 817	588 233	588 233	588 233	588 233	588 233	
CWWW	1 015 933	508 637	508 637	508 637	1 015 933	508 637	508 637	508 637	508 637	508 637	
Wheat after lupine	-	-	-	-	-	-	-	-	-	-	
Wheat after Medics	-	-	-	-	-	-	-	-	-	-	
Canola	778 363	289 113	289 113	289 113	778 363	289 113	289 113	289 113	289 113	289 113	
Lupins	-	-	-	-	-	-	-	-	-	-	
Medics	-	-	-	-	-	-	-	-	-	-	
Capital sales	255 000	238 458	-	-	25 083	26 854	130 542	-	80 208	-	
Gross margin: total farming:	**4 524 781**	**2 504 529**	**2 266 071**	**2 266 071**	**4 294 864**	**2 292 925**	**2 396 613**	**2 266 071**	**2 346 279**	**2 266 071**	
Overhead and fixed costs:											
Regular work:	426 000	426 000	426 000	426 000	426 000	426 000	426 000	426 000	426 000	426 000	
Water fees:	33 000	33 000	33 000	33 000	33 000	33 000	33 000	33 000	33 000	33 000	
Municipal taxes:	24 000	24 000	24 000	24 000	24 000	24 000	24 000	24 000	24 000	24 000	
Insurance (overall):	452 023	452 023	452 023	452 023	452 023	452 023	452 023	452 023	452 023	452 023	
Licenses:	8 280	8 280	8 280	8 280	8 280	8 280	8 280	8 280	8 280	8 280	
Bank charges:	17 000	17 000	17 000	17 000	17 000	17 000	17 000	17 000	17 000	17 000	
Phone	32 000	32 000	32 000	32 000	32 000	32 000	32 000	32 000	32 000	32 000	
Administration	12 000	12 000	12 000	12 000	12 000	12 000	12 000	12 000	12 000	12 000	
Auditors & Consultation fees	16 000	16 000	16 000	16 000	16 000	16 000	16 000	16 000	16 000	16 000	
Provision: camps	30 000	30 000	30 000	30 000	30 000	30 000	30 000	30 000	30 000	30 000	
Supply: water distribution	28 000	28 000	28 000	28 000	28 000	28 000	28 000	28 000	28 000	28 000	
Employee wages	300 000	300 000	300 000	300 000	300 000	300 000	300 000	300 000	300 000	300 000	
Miscellaneous costs (4%)	55 132	55 132	55 132	55 132	55 132	55 132	55 132	55 132	55 132	55 132	
Total overhead and fixed costs:	**1 433 435**	**1 433 435**	**1 433 435**	**1 433 435**	**1 433 435**	**1 433 435**	**1 433 435**	**1 433 435**	**1 433 435**	**1 433 435**	
Margin above overhead and fixed costs:	**3 091 346**	**1 071 095**	**832 636**	**832 636**	**2 861 429**	**859 490**	**963 178**	**832 636**	**912 845**	**832 636**	
Capital:											Resale:
Long-term capital:											
Land & fixed improvements	-	-	-	-	-	-	-	-	-	-	24 000 000
Intermediary Capital:											
Harvester 210kW	3 060 000	-	-	-	-	-	-	-	-	-	1 224 000
Tractor 250kW	-	2 861 500	-	-	-	-	-	-	-	-	1 335 367
Tractor 80kW	-	-	-	-	-	-	621 000	-	-	-	465 750
Tractor 80kW	-	-	-	-	-	-	621 000	-	-	-	465 750
Tractor 50kW	-	-	-	-	301 000	-	-	-	-	-	175 583
Sprayer 18m, 2000L	-	-	-	-	-	-	-	-	-	-	36 083
Sprayer 18m, 2000L	-	-	-	-	-	216 500	-	-	-	-	144 333
Fertiliser Spreader 1500L, 10-36m, 3point	-	-	-	-	-	-	-	-	-	-	8 813
Fertiliser Spreader 1500L, 10-36m, 3point	-	-	-	-	-	105 750	-	-	-	-	70 500
Double seed drill, CT planter	-	-	-	-	-	-	-	-	700 000	-	641 667
Chisel Plough, 23tine, 6.9m	-	-	-	-	-	-	324 500	-	-	-	243 375

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Fieldspan, 61tine, 9.3m	-	-	-	-	-	-	-	-	170 500	-	156 292
6ton 4wl, trailer	-	-	-	-	-	-	-	-	92 000	-	84 333
Grain cart 8ton	-	-	-	-	-	-	-	-	-	-	35 000
Road scraper, 2.4m, 3point	-	-	-	-	-	-	-	-	-	-	3 000
Wheat grain massebakke, 10ton	-	-	-	-	-	-	-	-	-	-	4 167
Front loader	-	-	-	-	-	-	-	-	-	94 000	-
Lorry, 10ton, SD	-	-	-	-	-	-	-	-	-	-	68 708
LDV 1	-	-	-	-	-	-	-	-	-	-	253 125
LDV 2	-	-	-	-	-	-	-	-	-	250 000	-
Tools and Equipment											
Total intermediary capital:	3 060 000	2 861 500	-	-	301 000	322 250	1 566 500	-	962 500	-	5 086 846
Livestock:											-
Total capital:	3 060 000	2 861 500	-	-	301 000	322 250	1 566 500	-	962 500	-	29 086 846
Net annual flows:	**31 346**	**- 1 790 405**	**832 636**	**832 636**	**2 560 429**	**537 240**	**- 603 322**	**832 636**	**- 49 655**	**29 919 482**	
IRR											
NPV											
*Type of year indicated by code: good year=1, average year=2, poor year=3.											
Cash Flow:											
Opening	- 1 599 402	203 797	139 902	- 621 705	- 1 121 225	512 545	- 34 495	- 318 930	- 265 416	- 531 611	
Inflow	4 524 781	2 504 529	2 266 071	2 266 071	4 294 864	2 292 925	2 396 613	2 266 071	2 346 279	2 266 071	
Outflow	2 723 296	2 569 602	3 011 137	2 735 760	2 665 405	2 839 047	2 672 563	2 205 496	2 598 330	2 601 512	
Flow before interest	202 083	138 725	- 605 165	- 1 091 395	508 234	- 33 577	- 310 445	- 258 355	- 517 467	- 867 052	
Interest	1 714	1 177	- 16 541	- 29 831	4 311	- 918	- 8 485	- 7 062	- 14 144	- 23 699	
Closing balance	203 797	139 902	- 621 705	- 1 121 225	512 545	- 34 495	- 318 930	- 265 416	- 531 611	- 890 751	

Whole-farm multi-period budget - Middle Swartland, WWWW, No-till

Year in calculation period:		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Wheat: Year classification (good, average, poor)		2	1	3	2	1	2	2	1	2	3
Canola & Lupin: Year classification (good, average, poor)		2	2	3	2	1	2	2	1	2	3
Crop	Hectare										
Wheat after wheat	760	2 603 878	4 089 683	693 557	2 603 878	4 089 683	2 603 878	2 603 878	4 089 683	2 603 878	693 557
Wheat after canola	-	-	-	-	-	-	-	-	-	-	-
Wheat after lupine	-	-	-	-	-	-	-	-	-	-	-
Wheat after Medics	-	-	-	-	-	-	-	-	-	-	-
Canola	-	-	-	-	-	-	-	-	-	-	-
Lupins	-	-	-	-	-	-	-	-	-	-	-
Medics	-	-	-	-	-	-	-	-	-	-	-
Capital sales		-	-	25 083	26 854	103 500	-	118 021	28 667	81 688	37 042
Gross margin: total farming:	**760**	**2 603 878**	**4 089 683**	**718 640**	**2 630 732**	**4 193 183**	**2 603 878**	**2 721 899**	**4 118 350**	**2 685 565**	**730 599**
Overhead and fixed costs:											
Regular work:		426 000	426 000	426 000	426 000	426 000	426 000	426 000	426 000	426 000	426 000
Water fees:		33 000	33 000	33 000	33 000	33 000	33 000	33 000	33 000	33 000	33 000
Municipal taxes:		24 000	24 000	24 000	24 000	24 000	24 000	24 000	24 000	24 000	24 000
Insurance (overall):		453 803	453 803	453 803	453 803	453 803	453 803	453 803	453 803	453 803	453 803
Licenses:		8 280	8 280	8 280	8 280	8 280	8 280	8 280	8 280	8 280	8 280
Bank charges:		17 000	17 000	17 000	17 000	17 000	17 000	17 000	17 000	17 000	17 000
Phone		32 000	32 000	32 000	32 000	32 000	32 000	32 000	32 000	32 000	32 000
Administration		12 000	12 000	12 000	12 000	12 000	12 000	12 000	12 000	12 000	12 000
Auditors & Consultation fees		16 000	16 000	16 000	16 000	16 000	16 000	16 000	16 000	16 000	16 000
Provision: camps		30 000	30 000	30 000	30 000	30 000	30 000	30 000	30 000	30 000	30 000
Supply: water distribution		28 000	28 000	28 000	28 000	28 000	28 000	28 000	28 000	28 000	28 000
Employee wages		300 000	300 000	300 000	300 000	300 000	300 000	300 000	300 000	300 000	300 000
Miscellaneous costs (4%)		55 203	55 203	55 203	55 203	55 203	55 203	55 203	55 203	55 203	55 203
Total overhead and fixed costs:		**1 435 287**	**1 435 287**	**1 435 287**	**1 435 287**	**1 435 287**	**1 435 287**	**1 435 287**	**1 435 287**	**1 435 287**	**1 435 287**
Margin above overhead and fixed costs:		**1 168 591**	**2 654 396**	**-716 646**	**1 195 445**	**2 757 896**	**1 168 591**	**1 286 612**	**2 683 063**	**1 250 279**	**-704 688**
Capital:											
Long-term capital:											
Land & fixed improvements		24 000 000	-	-	-	-	-	-	-	-	-
Intermediary Capital:	age										
Harvester 210kW	5	1 785 000	-	-	-	-	-	-	-	-	-
Tractor 250kW	4	1 907 667	-	-	-	-	-	-	-	-	-
Tractor 80kW	8	207 000	-	-	-	621 000	-	-	-	-	-
Tractor 80kW	8	207 000	-	-	-	621 000	-	-	-	-	-
Tractor 50kW	10	50 167	-	301 000	-	-	-	-	-	-	-
Sprayer 18m, 2000L	3	162 375	-	-	-	-	-	-	-	-	216 500
Sprayer 18m, 2000L	9	54 125	-	-	216 500	-	-	-	-	-	-
Fertiliser Spreader 1500L, 10-36m, 3point	4	70 500	-	-	-	-	-	-	-	105 750	-
Fertiliser Spreader 1500L, 10-36m, 3point	9	26 438	-	-	105 750	-	-	-	-	-	-

No-till Planter, 33 tine, 9.4m	6	662 125	-	-	-	-	-	1 324 250	-	-	-
6ton 4wl, trailer	6	46 000	-	-	-	-	-	92 000	-	-	-
Grain cart 8ton	3	157 500	-	-	-	-	-	-	-	-	210 000
Road scraper, 2.4m, 3point	3	13 500	-	-	-	-	-	-	-	-	18 000
Wheat grain massebakke, 10ton	4	33 333	-	-	-	-	-	-	-	50 000	-
Front loader	5	54 833	-	-	-	-	-	-	94 000	-	-
Lorry, 10ton, SD	4	549 667	-	-	-	-	-	-	-	824 500	-
LDV 1	2	187 500	-	-	-	-	-	-	-	-	-
LDV 2	5	145 833	-	-	-	-	-	-	250 000	-	-
Tools and Equipment		140 000									
Total intermediary capital:		6 460 563	-	301 000	322 250	1 242 000	-	1 416 250	344 000	980 250	444 500
Livestock:		-									
Total capital:		30 460 563	-	301 000	322 250	1 242 000	-	1 416 250	344 000	980 250	444 500
Net annual flows:		**-29 291 971**	**2 654 396**	**-1 017 646**	**873 195**	**1 515 896**	**1 168 591**	**-129 638**	**2 339 063**	**270 029**	**-1 149 188**

IRR **2.24%**

NPV **-2 028 333**

*Type of year indicated by code: good year=1, average year=2, poor year=3.

Cash Flow:

Opening	-	589 325	2 655 182	1 294 006	1 581 551	3 347 093	3 281 968	2 939 146	3 998 503	3 585 363
Inflow	2 603 878	4 089 683	718 640	2 630 732	4 193 183	2 603 878	2 721 899	4 118 350	2 685 565	730 599
Outflow	2 019 510	2 046 159	2 090 701	2 356 490	2 455 794	2 696 608	3 089 442	3 092 625	3 128 862	3 144 455
Flow before interest	584 368	2 632 849	1 283 122	1 568 248	3 318 940	3 254 362	2 914 424	3 964 871	3 555 206	1 171 507
Interest	4 957	22 333	10 884	13 303	28 153	27 605	24 722	33 632	30 157	9 937
Closing balance	589 325	2 655 182	1 294 006	1 581 551	3 347 093	3 281 968	2 939 146	3 998 503	3 585 363	1 181 444

Whole-farm multi-period budget - Middle Swartland, WWWW, No-till

Year	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	
Wheat: Year classification (good, moderate, poor)	1	2	2	2	1	2	2	2	2	2	
Canola & Lupin: Year classification (good, moderate, poor)	1	2	2	2	1	2	2	2	2	2	
Crop											
Wheat after wheat	4 089 683	2 603 878	2 603 878	2 603 878	4 089 683	2 603 878	2 603 878	2 603 878	2 603 878	2 603 878	
Wheat after canola	-	-	-	-	-	-	-	-	-	-	
Wheat after lupine	-	-	-	-	-	-	-	-	-	-	
Wheat after Medics	-	-	-	-	-	-	-	-	-	-	
Canola	-	-	-	-	-	-	-	-	-	-	
Lupins	-	-	-	-	-	-	-	-	-	-	
Medics	-	-	-	-	-	-	-	-	-	-	
Capital sales	255 000	238 458	-	-	25 083	26 854	103 500	-	118 021	28 667	
Gross margin: total farming	**4 344 683**	**2 842 336**	**2 603 878**	**2 603 878**	**4 114 766**	**2 630 732**	**2 707 378**	**2 603 878**	**2 721 899**	**2 632 544**	2 845 119
Overall annual costs											
Regular work:	426 000	426 000	426 000	426 000	426 000	426 000	426 000	426 000	426 000	426 000	
Water fees:	33 000	33 000	33 000	33 000	33 000	33 000	33 000	33 000	33 000	33 000	
Municipal taxes:	24 000	24 000	24 000	24 000	24 000	24 000	24 000	24 000	24 000	24 000	
Insurance (overall):	453 803	453 803	453 803	453 803	453 803	453 803	453 803	453 803	453 803	453 803	
Licenses:	8 280	8 280	8 280	8 280	8 280	8 280	8 280	8 280	8 280	8 280	
Bank charges:	17 000	17 000	17 000	17 000	17 000	17 000	17 000	17 000	17 000	17 000	
Phone	32 000	32 000	32 000	32 000	32 000	32 000	32 000	32 000	32 000	32 000	
Administration	12 000	12 000	12 000	12 000	12 000	12 000	12 000	12 000	12 000	12 000	
Auditors & Consultation fees	16 000	16 000	16 000	16 000	16 000	16 000	16 000	16 000	16 000	16 000	
Provision: camps	30 000	30 000	30 000	30 000	30 000	30 000	30 000	30 000	30 000	30 000	
Supply: water distribution	28 000	28 000	28 000	28 000	28 000	28 000	28 000	28 000	28 000	28 000	
Employee wages	300 000	300 000	300 000	300 000	300 000	300 000	300 000	300 000	300 000	300 000	
Miscellaneous costs (4%)	55 203	55 203	55 203	55 203	55 203	55 203	55 203	55 203	55 203	55 203	
Total overhead and fixed costs:	**1 435 287**	**1 435 287**	**1 435 287**	**1 435 287**	**1 435 287**	**1 435 287**	**1 435 287**	**1 435 287**	**1 435 287**	**1 435 287**	
Margin above overhead and fixed costs:	**2 909 396**	**1 407 049**	**1 168 591**	**1 168 591**	**2 679 479**	**1 195 445**	**1 272 091**	**1 168 591**	**1 286 612**	**1 197 258**	
Capital:											Resale:
Long-term:											
Land & fixed improvements	-	-	-	-	-	-	-	-	-	-	24 000 000
Intermediary Capital:											
Harvester 210kW	3 060 000	-	-	-	-	-	-	-	-	-	1 224 000

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Tractor 250kW	-	2 861 500	-	-	-	-	-	-	-	-	1 335 367
Tractor 80kW	-	-	-	-	-	-	621 000	-	-	-	465 750
Tractor 80kW	-	-	-	-	-	-	621 000	-	-	-	465 750
Tractor 50kW	-	-	-	-	301 000	-	-	-	-	-	175 583
Sprayer 18m, 2000L	-	-	-	-	-	-	-	-	-	-	36 083
Sprayer 18m, 2000L	-	-	-	-	-	216 500	-	-	-	-	144 333
Fertiliser Spreader 1500L, 10-36m, 3point	-	-	-	-	-	-	-	-	-	-	8 813
Fertiliser Spreader 1500L, 10-36m, 3point	-	-	-	-	-	105 750	-	-	-	-	70 500
No-till Planter, 33 tine, 9.4m	-	-	-	-	-	-	-	-	1 324 250	-	641 667
6ton 4wl, trailer	-	-	-	-	-	-	-	-	92 000	-	84 333
Grain cart 8ton	-	-	-	-	-	-	-	-	-	-	35 000
Road scraper, 2.4m, 3point	-	-	-	-	-	-	-	-	-	-	3 000
Wheat grain massebakke, 10ton	-	-	-	-	-	-	-	-	-	-	4 167
Front loader	-	-	-	-	-	-	-	-	-	94 000	-
Lorry, 10ton, SD	-	-	-	-	-	-	-	-	-	-	68 708
1	-	-	-	-	-	-	-	-	-	-	253 125
2	-	-	-	-	-	-	-	-	-	250 000	-
Tools and Equipment											
Total intermediary capital:	3 060 000	2 861 500	-	-	301 000	322 250	1 242 000	-	1 416 250	344 000	5 016 179
Livestock:											-
Total capital:	3 060 000	2 861 500	-	-	301 000	322 250	1 242 000	-	1 416 250	344 000	29 016 179
Net annual flows:	**-150 604**	**-1 454 451**	**1 168 591**	**1 168 591**	**2 378 479**	**873 195**	**30 091**	**1 168 591**	**-129 638**	**29 869 437**	

IRR

NPV

*Type of year indicated by code: good year=1, average year=2, poor year=3.

Cash Flow:										
Opening	1 181 444	2 824 738	3 121 880	2 735 780	2 624 117	4 106 164	3 929 045	3 995 616	4 429 403	4 589 725
Inflow	4 344 683	2 842 336	2 603 878	2 603 878	4 114 766	2 630 732	2 707 378	2 603 878	2 721 899	2 632 544
Outflow	2 725 148	2 571 453	3 012 989	2 737 612	2 667 257	2 840 899	2 674 415	2 207 348	2 600 182	2 603 364
Flow before interest	2 800 979	3 095 621	2 712 768	2 602 045	4 071 626	3 895 997	3 962 008	4 392 146	4 551 120	4 618 905
Interest	23 759	26 259	23 011	22 072	34 538	33 048	33 608	37 257	38 605	39 180
Closing balance	2 824 738	3 121 880	2 735 780	2 624 117	4 106 164	3 929 045	3 995 616	4 429 403	4 589 725	4 658 085

Whole-farm multi-period budget - Middle Swartland, WWWW, conventional tillage

Year in calculation period:		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Wheat: Year classification (good, average, poor)		2	1	3	2	1	2	2	1	2	3
Canola & Lupin: Year classification (good, average, poor)		2	2	3	2	1	2	2	1	2	3
Crop	Hectare										
Wheat after wheat	760	2 159 620	3 857 683	37 041	2 159 620	3 857 683	2 159 620	2 159 620	3 857 683	2 159 620	37 041
Wheat after canola	-	-	-	-	-	-	-	-	-	-	-
Wheat after lupine	-	-	-	-	-	-	-	-	-	-	-
Wheat after Medics	-	-	-	-	-	-	-	-	-	-	-
Canola	-	-	-	-	-	-	-	-	-	-	-
Lupins	-	-	-	-	-	-	-	-	-	-	-
Medics	-	-	-	-	-	-	-	-	-	-	-
Capital sales		-	-	25 083	26 854	130 542	-	80 208	-	8 813	35 542
Gross margin: total farming:	**760**	**2 159 620**	**3 857 683**	**62 124**	**2 186 474**	**3 988 224**	**2 159 620**	**2 239 828**	**3 857 683**	**2 168 432**	**72 583**
Overhead and fixed costs:											
Regular work:		426 000	426 000	426 000	426 000	426 000	426 000	426 000	426 000	426 000	426 000
Water fees:		33 000	33 000	33 000	33 000	33 000	33 000	33 000	33 000	33 000	33 000
Municipal taxes:		24 000	24 000	24 000	24 000	24 000	24 000	24 000	24 000	24 000	24 000
Insurance (overall):		452 023	452 023	452 023	452 023	452 023	452 023	452 023	452 023	452 023	452 023
Licenses:		8 280	8 280	8 280	8 280	8 280	8 280	8 280	8 280	8 280	8 280
Bank charges:		17 000	17 000	17 000	17 000	17 000	17 000	17 000	17 000	17 000	17 000
Phone		32 000	32 000	32 000	32 000	32 000	32 000	32 000	32 000	32 000	32 000
Administration		12 000	12 000	12 000	12 000	12 000	12 000	12 000	12 000	12 000	12 000
Auditors & Consultation fees		16 000	16 000	16 000	16 000	16 000	16 000	16 000	16 000	16 000	16 000
Provision: camps		30 000	30 000	30 000	30 000	30 000	30 000	30 000	30 000	30 000	30 000
Supply: water distribution		28 000	28 000	28 000	28 000	28 000	28 000	28 000	28 000	28 000	28 000
Employee wages		300 000	300 000	300 000	300 000	300 000	300 000	300 000	300 000	300 000	300 000
Miscellaneous costs (4%)		55 132	55 132	55 132	55 132	55 132	55 132	55 132	55 132	55 132	55 132
Total overhead and fixed costs:		**1 433 435**	**1 433 435**	**1 433 435**	**1 433 435**	**1 433 435**	**1 433 435**	**1 433 435**	**1 433 435**	**1 433 435**	**1 433 435**
Margin above overhead and fixed costs:		**726 185**	**2 424 248**	**- 1 371 311**	**753 039**	**2 554 789**	**726 185**	**806 393**	**2 424 248**	**734 997**	**- 1 360 852**
Capital:											
Long-term capital:											
Land & fixed improvements		24 000 000	-	-	-	-	-	-	-	-	-
Intermediary Capital:	age										
Harvester 210kW	5	1 785 000	-	-	-	-	-	-	-	-	-
Tractor 250kW	4	1 907 667	-	-	-	-	-	-	-	-	-
Tractor 80kW	8	207 000	-	-	-	621 000	-	-	-	-	-
Tractor 80kW	8	207 000	-	-	-	621 000	-	-	-	-	-
Tractor 50kW	10	50 167	-	301 000	-	-	-	-	-	-	-
Sprayer 18m, 2000L	3	162 375	-	-	-	-	-	-	-	-	216 500

Sprayer 18m, 2000L	9	54 125	-	-	216 500	-	-	-	-	-	-
Fertiliser Spreader 1500L, 10-36m, 3point	4	70 500	-	-	-	-	-	-	-	105 750	-
Fertiliser Spreader 1500L, 10-36m, 3point	9	26 438	-	-	105 750	-	-	-	-	-	-
Double seed drill, CT planter	6	350 000	-	-	-	-	-	700 000	-	-	-
Chisel Plough, 23tine, 6.9m	8	108 167	-	-	-	324 500	-	-	-	-	-
Fieldspan, 61tine, 9.3m	6	85 250	-	-	-	-	-	170 500	-	-	-
6ton 4wl, trailer	6	46 000	-	-	-	-	-	92 000	-	-	-
Grain cart 8ton	3	157 500	-	-	-	-	-	-	-	-	210 000
Road scraper, 2.4m, 3point	3	13 500	-	-	-	-	-	-	-	-	18 000
Wheat grain massebakke, 10ton	4	33 333	-	-	-	-	-	-	-	50 000	-
Front loader	5	54 833	-	-	-	-	-	-	94 000	-	-
Lorry, 10ton, SD	4	549 667	-	-	-	-	-	-	-	824 500	-
LDV 1	2	187 500	-	-	-	-	-	-	-	-	-
LDV 2	5	145 833	-	-	-	-	-	-	250 000	-	-
Tools and Equipment		140 000									
Total intermediate capital:		5 230 688	-	301 000	322 250	1 566 500	-	962 500	-	105 750	426 500
Livestock:		-									
Total capital:		29 230 688	-	301 000	322 250	1 566 500	-	962 500	-	105 750	426 500
Net annual flows:		**- 28 504 503**	**2 424 248**	**- 1 672 311**	**430 789**	**988 289**	**726 185**	**- 156 107**	**2 424 248**	**629 247**	**- 1 787 352**

IRR 1.29%

NPV - 5 812 838

*Type of year indicated by code: good year=1, average year=2, poor year=3.

Cash Flow:

Opening	-	143 166	1 973 138	- 55 051	- 229 317	1 316 035	787 522	- 61 886	711 004	- 254 341
Inflow	2 159 620	3 857 683	62 124	2 186 474	3 988 224	2 159 620	2 239 828	3 857 683	2 168 432	72 583
Outflow	2 017 658	2 044 307	2 088 849	2 354 638	2 453 942	2 694 756	3 087 590	3 090 773	3 127 010	3 142 604
Flow before interest	141 962	1 956 542	- 53 587	- 223 215	1 304 966	780 898	- 60 240	705 023	- 247 574	- 3 324 362
Interest	1 204	16 596	- 1 465	- 6 101	11 069	6 624	- 1 647	5 980	- 6 767	- 90 864
Closing balance	143 166	1 973 138	- 55 051	- 229 317	1 316 035	787 522	- 61 886	711 004	- 254 341	- 3 415 226

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Whole-farm multi-period budget - Middle Swartland, WWWW, conventional tillage

Year in calculation period:	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	
Wheat: Year classification (good, average, poor)	1	2	2	2	1	2	2	2	2	2	
Canola & Lupin: Year classification (good, average, poor)	1	2	2	2	1	2	2	2	2	2	
Crop											
Wheat after wheat	3 857 683	2 159 620	2 159 620	2 159 620	3 857 683	2 159 620	2 159 620	2 159 620	2 159 620	2 159 620	
Wheat after canola	-	-	-	-	-	-	-	-	-	-	
Wheat after lupine	-	-	-	-	-	-	-	-	-	-	
Wheat after Medics	-	-	-	-	-	-	-	-	-	-	
Canola	-	-	-	-	-	-	-	-	-	-	
Lupins	-	-	-	-	-	-	-	-	-	-	
Medics	-	-	-	-	-	-	-	-	-	-	
Capital sales	255 000	238 458	-	-	25 083	26 854	130 542	-	80 208	-	
Gross margin: total farming:	**4 112 683**	**2 398 078**	**2 159 620**	**2 159 620**	**3 882 766**	**2 186 474**	**2 290 161**	**2 159 620**	**2 239 828**	**2 159 620**	**2 425 037**
Overhead and fixed costs:											
Regular work:	426 000	426 000	426 000	426 000	426 000	426 000	426 000	426 000	426 000	426 000	
Water fees:	33 000	33 000	33 000	33 000	33 000	33 000	33 000	33 000	33 000	33 000	
Municipal taxes:	24 000	24 000	24 000	24 000	24 000	24 000	24 000	24 000	24 000	24 000	
Insurance (overall):	452 023	452 023	452 023	452 023	452 023	452 023	452 023	452 023	452 023	452 023	
Licenses:	8 280	8 280	8 280	8 280	8 280	8 280	8 280	8 280	8 280	8 280	
Bank charges:	17 000	17 000	17 000	17 000	17 000	17 000	17 000	17 000	17 000	17 000	
Phone	32 000	32 000	32 000	32 000	32 000	32 000	32 000	32 000	32 000	32 000	
Administration	12 000	12 000	12 000	12 000	12 000	12 000	12 000	12 000	12 000	12 000	
Auditors & Consultation fees	16 000	16 000	16 000	16 000	16 000	16 000	16 000	16 000	16 000	16 000	
Provision: camps	30 000	30 000	30 000	30 000	30 000	30 000	30 000	30 000	30 000	30 000	
Supply: water distribution	28 000	28 000	28 000	28 000	28 000	28 000	28 000	28 000	28 000	28 000	
Employee wages	300 000	300 000	300 000	300 000	300 000	300 000	300 000	300 000	300 000	300 000	
Miscellaneous costs (4%)	55 132	55 132	55 132	55 132	55 132	55 132	55 132	55 132	55 132	55 132	
Total overhead and fixed costs:	**1 433 435**	**1 433 435**	**1 433 435**	**1 433 435**	**1 433 435**	**1 433 435**	**1 433 435**	**1 433 435**	**1 433 435**	**1 433 435**	
Margin above overhead and fixed costs:	**2 679 248**	**964 643**	**726 185**	**726 185**	**2 449 331**	**753 039**	**856 726**	**726 185**	**806 393**	**726 185**	
Capital:											**Resale:**
Long-term capital:											
Land & fixed improvements	-	-	-	-	-	-	-	-	-	-	24 000 000
Intermediary Capital:											
Harvester 210kW	3 060 000	-	-	-	-	-	-	-	-	-	1 224 000
Tractor 250kW	-	2 861 500	-	-	-	-	-	-	-	-	1 335 367
Tractor 80kW	-	-	-	-	-	-	621 000	-	-	-	465 750
Tractor 80kW	-	-	-	-	-	-	621 000	-	-	-	465 750
Tractor 50kW	-	-	-	-	301 000	-	-	-	-	-	175 583
Sprayer 18m, 2000L	-	-	-	-	-	-	-	-	-	-	36 083

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Sprayer 18m, 2000L	-	-	-	-	-	216 500	-	-	-	-	144 333
Fertiliser Spreader 1500L, 10-36m, 3point	-	-	-	-	-	-	-	-	-	-	8 813
Fertiliser Spreader 1500L, 10-36m, 3point	-	-	-	-	-	105 750	-	-	-	-	70 500
Double seed drill, CT planter	-	-	-	-	-	-	-	-	700 000	-	641 667
Chisel Plough, 23tine, 6.9m	-	-	-	-	-	-	324 500	-	-	-	243 375
Fieldspan, 61tine, 9.3m	-	-	-	-	-	-	-	-	170 500	-	156 292
6ton 4wl, trailer	-	-	-	-	-	-	-	-	92 000	-	84 333
Grain cart 8ton	-	-	-	-	-	-	-	-	-	-	35 000
Road scraper, 2.4m, 3point	-	-	-	-	-	-	-	-	-	-	3 000
Wheat grain massebakke, 10ton	-	-	-	-	-	-	-	-	-	-	4 167
Front loader	-	-	-	-	-	-	-	-	-	94 000	-
Lorry, 10ton, SD	-	-	-	-	-	-	-	-	-	-	68 708
LDV 1	-	-	-	-	-	-	-	-	-	-	253 125
LDV 2	-	-	-	-	-	-	-	-	-	250 000	-
Tools and Equipment											
Total intermediate capital:	3 060 000	2 861 500	-	-	301 000	322 250	1 566 500	-	962 500	-	5 086 846
Livestock:											-
Total capital:	3 060 000	2 861 500	-	-	301 000	322 250	1 566 500	-	962 500	-	29 086 846
Net annual flows:	**- 380 752**	**- 1 896 857**	**726 185**	**726 185**	**2 148 331**	**430 789**	**- 709 774**	**726 185**	**- 156 107**	**29 813 031**	

IRR

NPV

*Type of year indicated by code: good year=1, average year=2, poor year=3.

Cash Flow:										
Opening	- 3 415 226	- 2 081 211	- 2 314 308	- 3 252 356	- 3 933 140	- 2 790 009	- 3 536 677	- 4 026 198	- 4 183 375	- 4 666 019
Inflow	4 112 683	2 398 078	2 159 620	2 159 620	3 882 766	2 186 474	2 290 161	2 159 620	2 239 828	2 159 620
Outflow	2 723 296	2 569 602	3 011 137	2 735 760	2 665 405	2 839 047	2 672 563	2 205 496	2 598 330	2 601 512
Flow before interest	- 2 025 839	- 2 252 735	- 3 165 826	- 3 828 497	- 2 715 779	- 3 442 582	- 3 919 079	- 4 072 074	- 4 541 877	- 5 107 912
Interest	- 55 372	- 61 573	- 86 531	- 104 643	- 74 230	- 94 095	- 107 119	- 111 301	- 124 142	- 139 613
Closing balance	- 2 081 211	- 2 314 308	- 3 252 356	- 3 933 140	- 2 790 009	- 3 536 677	- 4 026 198	- 4 183 375	- 4 666 019	- 5 247 525

Whole-farm multi-period budget - Middle Swartland, WCWL, no-till

Year in calculation period:		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Wheat: Year classification* (good, average, poor)		2	1	3	2	1	2	2	1	2	3
Canola & Lupin: Year classification* (good, average, poor)		2	2	3	2	1	2	2	1	2	3
Crop	Hectare										
Wheat after wheat	-	-	-	-	-	-	-	-	-	-	-
Wheat after canola	190	1 203 410	1 574 862	646 233	1 203 410	1 574 862	1 203 410	1 203 410	1 574 862	1 203 410	646 233
Wheat after lupine	190	1 203 410	1 574 862	646 233	1 203 410	1 574 862	1 203 410	1 203 410	1 574 862	1 203 410	646 233
Wheat after Medics	-	-	-	-	-	-	-	-	-	-	-
Canola	190	489 802	489 802	552	489 802	979 052	489 802	489 802	979 052	489 802	552
Lupins	190	214 882	214 882	- 43 699	214 882	576 896	214 882	214 882	576 896	214 882	- 43 699
Medics	-	-	-	-	-	-	-	-	-	-	-
Capital sales		-	-	25 083	26 854	103 500	-	118 021	28 667	81 688	37 042
Gross margin: total farming:	**760**	**3 111 504**	**3 854 407**	**1 274 403**	**3 138 359**	**4 809 171**	**3 111 504**	**3 229 525**	**4 734 337**	**3 193 192**	**1 286 361**
Overhead and fixed costs:											
Regular work:		426 000	426 000	426 000	426 000	426 000	426 000	426 000	426 000	426 000	426 000
Water fees:		33 000	33 000	33 000	33 000	33 000	33 000	33 000	33 000	33 000	33 000
Municipal taxes:		24 000	24 000	24 000	24 000	24 000	24 000	24 000	24 000	24 000	24 000
Insurance (overall):		453 803	453 803	453 803	453 803	453 803	453 803	453 803	453 803	453 803	453 803
Licenses:		8 280	8 280	8 280	8 280	8 280	8 280	8 280	8 280	8 280	8 280
Bank charges:		17 000	17 000	17 000	17 000	17 000	17 000	17 000	17 000	17 000	17 000
Phone		32 000	32 000	32 000	32 000	32 000	32 000	32 000	32 000	32 000	32 000
Administration		12 000	12 000	12 000	12 000	12 000	12 000	12 000	12 000	12 000	12 000
Auditors & Consultation fees		16 000	16 000	16 000	16 000	16 000	16 000	16 000	16 000	16 000	16 000
Provision: camps		30 000	30 000	30 000	30 000	30 000	30 000	30 000	30 000	30 000	30 000
Supply: water distribution		28 000	28 000	28 000	28 000	28 000	28 000	28 000	28 000	28 000	28 000
Employee wages		300 000	300 000	300 000	300 000	300 000	300 000	300 000	300 000	300 000	300 000
Miscellaneous costs (4%)		55 203	55 203	55 203	55 203	55 203	55 203	55 203	55 203	55 203	55 203
Total overhead and fixed costs:		**1 435 287**	**1 435 287**	**1 435 287**	**1 435 287**	**1 435 287**	**1 435 287**	**1 435 287**	**1 435 287**	**1 435 287**	**1 435 287**
Margin above overhead and fixed costs:		1 676 218	2 419 120	- 160 884	1 703 072	3 373 884	1 676 218	1 794 238	3 299 050	1 757 905	- 148 926
Capital:											
Long-term capital:											
Land & fixed improvements		24 000 000	-	-	-	-	-	-	-	-	-
Intermediary Capital:	age										
Harvester 210kW	5	1 785 000	-	-	-	-	-	-	-	-	-
Tractor 250kW	4	1 907 667	-	-	-	-	-	-	-	-	-
Tractor 80kW	8	207 000	-	-	-	621 000	-	-	-	-	-
Tractor 80kW	8	207 000	-	-	-	621 000	-	-	-	-	-
Tractor 50kW	10	50 167	-	301 000	-	-	-	-	-	-	-
Sprayer 18m, 2000L	3	162 375	-	-	-	-	-	-	-	-	216 500

Sprayer 18m, 2000L	9	54 125	-	-	216 500	-	-	-	-	-	-
Fertiliser Spreader 1500L, 10-36m, 3point	4	70 500	-	-	-	-	-	-	-	105 750	-
Fertiliser Spreader 1500L, 10-36m, 3point	9	26 438	-	-	105 750	-	-	-	-	-	-
No-till Planter, 33 tine, 9.4m	6	662 125	-	-	-	-	-	1 324 250	-	-	-
6ton 4wl, trailer	6	46 000	-	-	-	-	-	92 000	-	-	-
Grain cart 8ton	3	157 500	-	-	-	-	-	-	-	-	210 000
Road scraper, 2.4m, 3point	3	13 500	-	-	-	-	-	-	-	-	18 000
Wheat grain massebakke, 10ton	4	33 333	-	-	-	-	-	-	-	50 000	-
Front loader	5	54 833	-	-	-	-	-	-	94 000	-	-
Lorry, 10ton, SD	4	549 667	-	-	-	-	-	-	-	824 500	-
LDV 1	2	187 500	-	-	-	-	-	-	-	-	-
LDV 2	5	145 833	-	-	-	-	-	-	250 000	-	-
Tools and Equipment		140 000									
Total intermediate capital:		6 460 563	-	301 000	322 250	1 242 000	-	1 416 250	344 000	980 250	444 500
Livestock:		-									
Total capital:		30 460 563	-	301 000	322 250	1 242 000	-	1 416 250	344 000	980 250	444 500
Net annual flows:		**- 28 784 345**	**2 419 120**	**- 461 884**	**1 380 822**	**2 131 884**	**1 676 218**	**377 988**	**2 955 050**	**777 655**	**- 593 426**

IRR	**4.06%**
NPV	**5 425 665**

*Type of year indicated by code: good year=1, average year=2, poor year=3.

Cash Flow:

Opening	-	1 101 258	2 934 186	2 135 853	2 942 471	5 340 770	5 804 489	5 994 997	7 701 489	7 831 693
Inflow	3 111 504	3 854 407	1 274 403	3 138 359	4 809 171	3 111 504	3 229 525	4 734 337	3 193 192	1 286 361
Outflow	2 019 510	2 046 159	2 090 701	2 356 490	2 455 794	2 696 608	3 089 442	3 092 625	3 128 862	3 144 455
Flow before interest	1 091 995	2 909 506	2 117 887	2 917 721	5 295 848	5 755 666	5 944 572	7 636 710	7 765 818	5 973 598
Interest	9 263	24 680	17 965	24 750	44 922	48 823	50 425	64 779	65 874	50 671
Closing balance	1 101 258	2 934 186	2 135 853	2 942 471	5 340 770	5 804 489	5 994 997	7 701 489	7 831 693	6 024 270

Whole-farm multi-period budget - Middle Swartland, WCWL, no-till

Year in calculation period:	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	
Wheat: Year classification* (good, average, poor)	1	2	2	2	1	2	2	2	2	2	
Canola & Lupin: Year classification* (good, average, poor)	1	2	2	2	1	2	2	2	2	2	
Crop											
Wheat after wheat	-	-	-	-	-	-	-	-	-	-	
Wheat after canola	1 574 862	1 203 410	1 203 410	1 203 410	1 574 862	1 203 410	1 203 410	1 203 410	1 203 410	1 203 410	
Wheat after lupine	1 574 862	1 203 410	1 203 410	1 203 410	1 574 862	1 203 410	1 203 410	1 203 410	1 203 410	1 203 410	
Wheat after Medics	-	-	-	-	-	-	-	-	-	-	
Canola	979 052	489 802	489 802	489 802	979 052	489 802	489 802	489 802	489 802	489 802	
Lupins	576 896	214 882	214 882	214 882	576 896	214 882	214 882	214 882	214 882	214 882	
Medics	-	-	-	-	-	-	-	-	-	-	
Capital sales	255 000	238 458	-	-	25 083	26 854	103 500	-	118 021	28 667	
Gross margin: total farming:	**4 960 671**	**3 349 963**	**3 111 504**	**3 111 504**	**4 730 754**	**3 138 359**	**3 215 004**	**3 111 504**	**3 229 525**	**3 140 171**	
Overhead and fixed costs:											
Regular work:	426 000	426 000	426 000	426 000	426 000	426 000	426 000	426 000	426 000	426 000	
Water fees:	33 000	33 000	33 000	33 000	33 000	33 000	33 000	33 000	33 000	33 000	
Municipal taxes:	24 000	24 000	24 000	24 000	24 000	24 000	24 000	24 000	24 000	24 000	
Insurance (overall):	453 803	453 803	453 803	453 803	453 803	453 803	453 803	453 803	453 803	453 803	
Licenses:	8 280	8 280	8 280	8 280	8 280	8 280	8 280	8 280	8 280	8 280	
Bank charges:	17 000	17 000	17 000	17 000	17 000	17 000	17 000	17 000	17 000	17 000	
Phone	32 000	32 000	32 000	32 000	32 000	32 000	32 000	32 000	32 000	32 000	
Administration	12 000	12 000	12 000	12 000	12 000	12 000	12 000	12 000	12 000	12 000	
Auditors & Consultation fees	16 000	16 000	16 000	16 000	16 000	16 000	16 000	16 000	16 000	16 000	
Provision: camps	30 000	30 000	30 000	30 000	30 000	30 000	30 000	30 000	30 000	30 000	
Supply: water distribution	28 000	28 000	28 000	28 000	28 000	28 000	28 000	28 000	28 000	28 000	
Employee wages	300 000	300 000	300 000	300 000	300 000	300 000	300 000	300 000	300 000	300 000	
Miscellaneous costs (4%)	55 203	55 203	55 203	55 203	55 203	55 203	55 203	55 203	55 203	55 203	
Total overhead and fixed costs:	**1 435 287**	**1 435 287**	**1 435 287**	**1 435 287**	**1 435 287**	**1 435 287**	**1 435 287**	**1 435 287**	**1 435 287**	**1 435 287**	
Margin above overhead and fixed costs:	3 525 384	1 914 676	1 676 218	1 676 218	3 295 467	1 703 072	1 779 718	1 676 218	1 794 238	1 704 884	
Capital:											Resale value:
Long-term capital:											
Land & fixed improvements	-	-	-	-	-	-	-	-	-	-	24 000 000
Intermediary Capital:											
Harvester 210kW	3 060 000	-	-	-	-	-	-	-	-	-	1 224 000
Tractor 250kW	-	2 861 500	-	-	-	-	-	-	-	-	1 335 367
Tractor 80kW	-	-	-	-	-	-	621 000	-	-	-	465 750
Tractor 80kW	-	-	-	-	-	-	621 000	-	-	-	465 750
Tractor 50kW	-	-	-	-	301 000	-	-	-	-	-	175 583
Sprayer 18m, 2000L	-	-	-	-	-	-	-	-	-	-	36 083

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Sprayer 18m, 2000L	-	-	-	-	-	216 500	-	-	-	-	144 333
Fertiliser Spreader 1500L, 10-36m, 3point	-	-	-	-	-	-	-	-	-	-	8 813
Fertiliser Spreader 1500L, 10-36m, 3point	-	-	-	-	-	105 750	-	-	-	-	70 500
No-till Planter, 33 tine, 9.4m	-	-	-	-	-	-	-	-	1 324 250	-	641 667
6ton 4wl, trailer	-	-	-	-	-	-	-	-	92 000	-	84 333
Grain cart 8ton	-	-	-	-	-	-	-	-	-	-	35 000
Road scraper, 2.4m, 3point	-	-	-	-	-	-	-	-	-	-	3 000
Wheat grain massebakke, 10ton	-	-	-	-	-	-	-	-	-	-	4 167
Front loader	-	-	-	-	-	-	-	-	-	94 000	-
Lorry, 10ton, SD	-	-	-	-	-	-	-	-	-	-	68 708
LDV 1	-	-	-	-	-	-	-	-	-	-	253 125
LDV 2	-	-	-	-	-	-	-	-	-	250 000	-
Tools and Equipment											
Total intermediate capital:	3 060 000	2 861 500	-	-	301 000	322 250	1 242 000	-	1 416 250	344 000	5 016 179
Livestock:											-
Total capital:	3 060 000	2 861 500	-	-	301 000	322 250	1 242 000	-	1 416 250	344 000	29 016 179
Net annual flows:	**465 384**	**- 946 824**	**1 676 218**	**1 676 218**	**2 994 467**	**1 380 822**	**537 718**	**1 676 218**	**377 988**	**30 377 063**	

IRR

NPV

*Type of year indicated by code: good year=1, average year=2, poor year=3.

Cash Flow:										
Opening	6 024 270	8 329 856	9 185 628	9 362 896	9 819 381	11 983 676	12 385 311	13 035 545	14 057 946	14 811 875
Inflow	4 960 671	3 349 963	3 111 504	3 111 504	4 730 754	3 138 359	3 215 004	3 111 504	3 229 525	3 140 171
Outflow	2 725 148	2 571 453	3 012 989	2 737 612	2 667 257	2 840 899	2 674 415	2 207 348	2 600 182	2 603 364
Flow before interest	8 259 792	9 108 366	9 284 143	9 736 789	11 882 878	12 281 135	12 925 900	13 939 702	14 687 289	15 348 682
Interest	70 064	77 262	78 753	82 593	100 797	104 176	109 645	118 244	124 586	130 196
Closing balance	8 329 856	9 185 628	9 362 896	9 819 381	11 983 676	12 385 311	13 035 545	14 057 946	14 811 875	15 478 878

Whole-farm multi-period budget - Middle Swartland, WCWL, conventional tillage

Year in calculation period:		1	2	3	4	5	6	7	8	9	10
Wheat: Year classification* (good, average, poor)		2	1	3	2	1	2	2	1	2	3
Canola & Lupin: Year classification* (good, average, poor)		2	2	3	2	1	2	2	1	2	3
Crop	Hectare										
Wheat after wheat	-	-	-	-	-	-	-	-	-	-	-
Wheat after canola	190	880 088	1 357 668	349 443	880 088	1 357 668	880 088	880 088	1 357 668	880 088	349 443
Wheat after lupine	190	880 088	1 357 668	349 443	880 088	1 357 668	880 088	880 088	1 357 668	880 088	349 443
Wheat after Medics	-	-	-	-	-	-	-	-	-	-	-
Canola	190	289 113	289 113	- 281 678	289 113	778 363	289 113	289 113	778 363	289 113	- 281 678
Lupins	190	138 447	138 447	- 171 851	138 447	500 460	138 447	138 447	500 460	138 447	- 171 851
Medics	-	-	-	-	-	-	-	-	-	-	-
Capital sales		-	-	25 083	26 854	130 542	-	80 208	-	8 813	35 542
Gross margin: total farming:	**760**	**2 187 736**	**3 142 896**	**270 441**	**2 214 590**	**4 124 702**	**2 187 736**	**2 267 944**	**3 994 160**	**2 196 548**	**280 899**
Overhead and fixed costs:											
Regular work:		426 000	426 000	426 000	426 000	426 000	426 000	426 000	426 000	426 000	426 000
Water fees:		33 000	33 000	33 000	33 000	33 000	33 000	33 000	33 000	33 000	33 000
Municipal taxes:		24 000	24 000	24 000	24 000	24 000	24 000	24 000	24 000	24 000	24 000
Insurance (overall):		452 023	452 023	452 023	452 023	452 023	452 023	452 023	452 023	452 023	452 023
Licenses:		8 280	8 280	8 280	8 280	8 280	8 280	8 280	8 280	8 280	8 280
Bank charges:		17 000	17 000	17 000	17 000	17 000	17 000	17 000	17 000	17 000	17 000
Phone		32 000	32 000	32 000	32 000	32 000	32 000	32 000	32 000	32 000	32 000
Administration		12 000	12 000	12 000	12 000	12 000	12 000	12 000	12 000	12 000	12 000
Auditors & Consultation fees		16 000	16 000	16 000	16 000	16 000	16 000	16 000	16 000	16 000	16 000
Provision: camps		30 000	30 000	30 000	30 000	30 000	30 000	30 000	30 000	30 000	30 000
Supply: water distribution		28 000	28 000	28 000	28 000	28 000	28 000	28 000	28 000	28 000	28 000
Employee wages		300 000	300 000	300 000	300 000	300 000	300 000	300 000	300 000	300 000	300 000
Miscellaneous costs (4%)		55 132	55 132	55 132	55 132	55 132	55 132	55 132	55 132	55 132	55 132
Total overhead and fixed costs:		**1 433 435**	**1 433 435**	**1 433 435**	**1 433 435**	**1 433 435**	**1 433 435**	**1 433 435**	**1 433 435**	**1 433 435**	**1 433 435**
Margin above overhead and fixed costs:		754 301	1 709 461	- 1 162 994	781 155	2 691 267	754 301	834 509	2 560 725	763 113	- 1 152 536
Capital:											
Long-term capital:											
Land & fixed improvements		24 000 000	-	-	-	-	-	-	-	-	-
Intermediary Capital:	age										
Harvester 210kW	5	1 785 000	-	-	-	-	-	-	-	-	-
Tractor 250kW	4	1 907 667	-	-	-	-	-	-	-	-	-
Tractor 80kW	8	207 000	-	-	-	621 000	-	-	-	-	-
Tractor 80kW	8	207 000	-	-	-	621 000	-	-	-	-	-
Tractor 50kW	10	50 167	-	301 000	-	-	-	-	-	-	-
Sprayer 18m, 2000L	3	162 375	-	-	-	-	-	-	-	-	216 500

Sprayer 18m, 2000L	9	54 125	-	-	216 500	-	-	-	-	-	-
Fertiliser Spreader 1500L, 10-36m, 3point	4	70 500	-	-	-	-	-	-	-	105 750	-
Fertiliser Spreader 1500L, 10-36m, 3point	9	26 438	-	-	105 750	-	-	-	-	-	-
Double seed drill, CT planter	6	350 000	-	-	-	-	-	700 000	-	-	-
Chisel Plough, 23tine, 6.9m	8	108 167	-	-	-	324 500	-	-	-	-	-
Fieldspan, 61tine, 9.3m	6	85 250	-	-	-	-	-	170 500	-	-	-
6ton 4wl, trailer	6	46 000	-	-	-	-	-	92 000	-	-	-
Grain cart 8ton	3	157 500	-	-	-	-	-	-	-	-	210 000
Road scraper, 2.4m, 3point	3	13 500	-	-	-	-	-	-	-	-	18 000
Wheat grain massebakke, 10ton	4	33 333	-	-	-	-	-	-	-	50 000	-
Front loader	5	54 833	-	-	-	-	-	-	94 000	-	-
Lorry, 10ton, SD	4	549 667	-	-	-	-	-	-	-	824 500	-
LDV 1	2	187 500	-	-	-	-	-	-	-	-	-
LDV 2	5	145 833	-	-	-	-	-	-	250 000	-	-
Tools and Equipment		140 000									
Total intermediate capital:		5 230 688	-	301 000	322 250	1 566 500	-	962 500	-	105 750	426 500
Livestock:		-									
Total capital:		29 230 688	-	301 000	322 250	1 566 500	-	962 500	-	105 750	426 500
Net annual flows:		**- 28 476 387**	**1 709 461**	**- 1 463 994**	**458 905**	**1 124 767**	**754 301**	**- 127 991**	**2 560 725**	**657 363**	**- 1 579 036**

IRR **1.39%**

NPV **- 5 449 243**

*Type of year indicated by code: good year=1, average year=2, poor year=3.

Cash Flow:

Opening	-	171 521	1 280 884	- 552 217	- 711 186	967 713	464 600	- 364 750	543 206	- 397 841
Inflow	2 187 736	3 142 896	270 441	2 214 590	4 124 702	2 187 736	2 267 944	3 994 160	2 196 548	280 899
Outflow	2 017 658	2 044 307	2 088 849	2 354 638	2 453 942	2 694 756	3 087 590	3 090 773	3 127 010	3 142 604
Flow before interest	170 078	1 270 110	- 537 525	- 692 264	959 573	460 693	- 355 046	538 637	- 387 256	- 3 259 545
Interest	1 443	10 774	- 14 692	- 18 921	8 140	3 908	- 9 704	4 569	- 10 585	- 89 092
Closing balance	171 521	1 280 884	- 552 217	- 711 186	967 713	464 600	- 364 750	543 206	- 397 841	- 3 348 637

Whole-farm multi-period budget - Middle Swartland, WCWL, conventional tillage

Year in calculation period:	11	12	13	14	15	16	17	18	19	20	
Wheat: Year classification* (good, average, poor)	1	2	2	2	1	2	2	2	2	2	
Canola & Lupin: Year classification* (good, average, poor)	1	2	2	2	1	2	2	2	2	2	
Crop											
Wheat after wheat	-	-	-	-	-	-	-	-	-	-	
Wheat after canola	1 357 668	880 088	880 088	880 088	1 357 668	880 088	880 088	880 088	880 088	880 088	
Wheat after lupine	1 357 668	880 088	880 088	880 088	1 357 668	880 088	880 088	880 088	880 088	880 088	
Wheat after Medics	-	-	-	-	-	-	-	-	-	-	
Canola	778 363	289 113	289 113	289 113	778 363	289 113	289 113	289 113	289 113	289 113	
Lupins	500 460	138 447	138 447	138 447	500 460	138 447	138 447	138 447	138 447	138 447	
Medics	-	-	-	-	-	-	-	-	-	-	
Capital sales	255 000	238 458	-	-	25 083	26 854	130 542	-	80 208	-	
Gross margin: total farming:	**4 249 160**	**2 426 194**	**2 187 736**	**2 187 736**	**4 019 243**	**2 214 590**	**2 318 278**	**2 187 736**	**2 267 944**	**2 187 736**	
Overhead and fixed costs:											
Regular work:	426 000	426 000	426 000	426 000	426 000	426 000	426 000	426 000	426 000	426 000	
Water fees:	33 000	33 000	33 000	33 000	33 000	33 000	33 000	33 000	33 000	33 000	
Municipal taxes:	24 000	24 000	24 000	24 000	24 000	24 000	24 000	24 000	24 000	24 000	
Insurance (overall):	452 023	452 023	452 023	452 023	452 023	452 023	452 023	452 023	452 023	452 023	
Licenses:	8 280	8 280	8 280	8 280	8 280	8 280	8 280	8 280	8 280	8 280	
Bank charges:	17 000	17 000	17 000	17 000	17 000	17 000	17 000	17 000	17 000	17 000	
Phone	32 000	32 000	32 000	32 000	32 000	32 000	32 000	32 000	32 000	32 000	
Administration	12 000	12 000	12 000	12 000	12 000	12 000	12 000	12 000	12 000	12 000	
Auditors & Consultation fees	16 000	16 000	16 000	16 000	16 000	16 000	16 000	16 000	16 000	16 000	
Provision: camps	30 000	30 000	30 000	30 000	30 000	30 000	30 000	30 000	30 000	30 000	
Supply: water distribution	28 000	28 000	28 000	28 000	28 000	28 000	28 000	28 000	28 000	28 000	
Employee wages	300 000	300 000	300 000	300 000	300 000	300 000	300 000	300 000	300 000	300 000	
Miscellaneous costs (4%)	55 132	55 132	55 132	55 132	55 132	55 132	55 132	55 132	55 132	55 132	
Total overhead and fixed costs:	**1 433 435**	**1 433 435**	**1 433 435**	**1 433 435**	**1 433 435**	**1 433 435**	**1 433 435**	**1 433 435**	**1 433 435**	**1 433 435**	
Margin above overhead and fixed costs:	2 815 725	992 759	754 301	754 301	2 585 808	781 155	884 843	754 301	834 509	754 301	
Capital:											Resale value:
Long-term capital:											
Land & fixed improvements	-	-	-	-	-	-	-	-	-	-	24 000 000
Intermediary Capital:											
Harvester 210kW	3 060 000	-	-	-	-	-	-	-	-	-	1 224 000
Tractor 250kW	-	2 861 500	-	-	-	-	-	-	-	-	1 335 367
Tractor 80kW	-	-	-	-	-	-	621 000	-	-	-	465 750
Tractor 80kW	-	-	-	-	-	-	621 000	-	-	-	465 750
Tractor 50kW	-	-	-	-	301 000	-	-	-	-	-	175 583
Sprayer 18m, 2000L	-	-	-	-	-	-	-	-	-	-	36 083

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Sprayer 18m, 2000L	-	-	-	-	-	216 500	-	-	-	-	144 333
Fertiliser Spreader 1500L, 10-36m, 3point	-	-	-	-	-	-	-	-	-	-	8 813
Fertiliser Spreader 1500L, 10-36m, 3point	-	-	-	-	-	105 750	-	-	-	-	70 500
Double seed drill, CT planter	-	-	-	-	-	-	-	-	700 000	-	641 667
Chisel Plough, 23tine, 6.9m	-	-	-	-	-	-	324 500	-	-	-	243 375
Fieldspan, 61tine, 9.3m	-	-	-	-	-	-	-	-	170 500	-	156 292
6ton 4wl, trailer	-	-	-	-	-	-	-	-	92 000	-	84 333
Grain cart 8ton	-	-	-	-	-	-	-	-	-	-	35 000
Road scraper, 2.4m, 3point	-	-	-	-	-	-	-	-	-	-	3 000
Wheat grain massebakke, 10ton	-	-	-	-	-	-	-	-	-	-	4 167
Front loader	-	-	-	-	-	-	-	-	-	94 000	-
Lorry, 10ton, SD	-	-	-	-	-	-	-	-	-	-	68 708
LDV 1	-	-	-	-	-	-	-	-	-	-	253 125
LDV 2	-	-	-	-	-	-	-	-	-	250 000	-
Tools and Equipment											
Total intermediate capital:	3 060 000	2 861 500	-	-	301 000	322 250	1 566 500	-	962 500	-	5 086 846
Livestock:											-
Total capital:	3 060 000	2 861 500	-	-	301 000	322 250	1 566 500	-	962 500	-	29 086 846
Net annual flows:	**- 244 275**	**- 1 868 741**	**754 301**	**754 301**	**2 284 808**	**458 905**	**- 681 657**	**754 301**	**- 127 991**	**29 841 147**	

IRR

NPV

*Type of year indicated by code: good year=1, average year=2, poor year=3.

Cash Flow:

Opening	- 3 348 637	- 1 872 595	- 2 071 105	- 2 973 621	- 3 617 902	- 2 325 947	- 3 031 046	- 3 477 862	- 3 591 167	- 4 028 739
Inflow	4 249 160	2 426 194	2 187 736	2 187 736	4 019 243	2 214 590	2 318 278	2 187 736	2 267 944	2 187 736
Outflow	2 723 296	2 569 602	3 011 137	2 735 760	2 665 405	2 839 047	2 672 563	2 205 496	2 598 330	2 601 512
Flow before interest	- 1 822 774	- 2 016 002	- 2 894 506	- 3 521 646	- 2 264 064	- 2 950 404	- 3 385 332	- 3 495 622	- 3 921 553	- 4 442 516
Interest	- 49 821	- 55 103	- 79 115	- 96 256	- 61 883	- 80 643	- 92 530	- 95 545	- 107 187	- 121 426
Closing balance	- 1 872 595	- 2 071 105	- 2 973 621	- 3 617 902	- 2 325 947	- 3 031 046	- 3 477 862	- 3 591 167	- 4 028 739	- 4 563 942

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Whole-farm multi-period budget - Middle Swartland, WMWM, no-till

Year in calculation period:		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Wheat: Year classification (good, average, poor)		2	1	3	2	1	2	2	1	2	3
Canola & Lupin: Year classification (good, average, poor)		2	2	3	2	1	2	2	1	2	3
Crop	Hectare										
Wheat after wheat	-	-	-	-	-	-	-	-	-	-	-
Wheat after canola	-	-	-	-	-	-	-	-	-	-	-
Wheat after lupine	-	-	-	-	-	-	-	-	-	-	-
Wheat after Medics	380	2 609 925	3 458 957	1 442 507	2 609 925	3 458 957	2 609 925	2 609 925	3 458 957	2 609 925	1 442 507
Canola	-	-	-	-	-	-	-	-	-	-	-
Lupins	-	-	-	-	-	-	-	-	-	-	-
Medics	380	614 401	614 401	614 401	614 401	614 401	614 401	614 401	614 401	614 401	614 401
Capital sales		-	-	25 083	166 708	51 750	26 854	74 708	28 667	72 875	19 000
Gross margin: total farming:	**380**	**3 224 326**	**4 073 358**	**2 081 991**	**3 391 035**	**4 125 108**	**3 251 180**	**3 299 035**	**4 102 024**	**3 297 201**	**2 075 908**
Overhead and fixed costs:											
Regular work:											
Water fees:		426 000	426 000	426 000	426 000	426 000	426 000	426 000	426 000	426 000	426 000
Municipal taxes:		33 000	33 000	33 000	33 000	33 000	33 000	33 000	33 000	33 000	33 000
Insurance (overall):		24 000	24 000	24 000	24 000	24 000	24 000	24 000	24 000	24 000	24 000
licenses:		450 817	450 817	450 817	450 817	450 817	450 817	450 817	450 817	450 817	450 817
Bank charges:		8 280	8 280	8 280	8 280	8 280	8 280	8 280	8 280	8 280	8 280
phone		17 000	17 000	17 000	17 000	17 000	17 000	17 000	17 000	17 000	17 000
Administration		32 000	32 000	32 000	32 000	32 000	32 000	32 000	32 000	32 000	32 000
Auditors & Consultation fees		12 000	12 000	12 000	12 000	12 000	12 000	12 000	12 000	12 000	12 000
Provision: camps		16 000	16 000	16 000	16 000	16 000	16 000	16 000	16 000	16 000	16 000
Supply: water distribution		30 000	30 000	30 000	30 000	30 000	30 000	30 000	30 000	30 000	30 000
Employee wages		28 000	28 000	28 000	28 000	28 000	28 000	28 000	28 000	28 000	28 000
Miscellaneous costs (4%)		300 000	300 000	300 000	300 000	300 000	300 000	300 000	300 000	300 000	300 000
Total overhead and fixed costs:		**55 084**	**55 084**	**55 084**	**55 084**	**55 084**	**55 084**	**55 084**	**55 084**	**55 084**	**55 084**
Margin above overhead and fixed costs:		**1 792 145**	**2 641 177**	**649 810**	**1 958 854**	**2 692 927**	**1 818 999**	**1 866 854**	**2 669 843**	**1 865 020**	**643 727**
Capital:											
long-term capital:											
Land & fixed improvements		24 000 000	-	-	-	-	-	-	-	-	-
Intermediary Capital:	age										
Harvester 210kW	5	1 785 000	-	-	-	-	-	-	-	-	-
Tractor 180kW	9	500 125	-	-	2 000 500	-	-	-	-	-	-
Tractor 80kW	8	207 000	-	-	-	621 000	-	-	-	-	-
Tractor 50kW	10	50 167	-	301 000	-	-	-	-	-	-	-

Sprayer 18m, 2000L	7	90 208	-	-	-	-	216 500	-	-	-	-
Fertiliser Spreader 1500L, 10-36m, 3point	7	44 063	-	-	-	-	105 750	-	-	-	-
No-till Planter, 21 tine, 6m	6	402 250	-	-	-	-	-	804 500	-	-	-
6ton 4wl, trailer	6	46 000	-	-	-	-	-	92 000	-	-	-
Grain cart 8ton	3	157 500	-	-	-	-	-	-	-	-	210 000
Road scraper, 2.4m, 3point	3	13 500	-	-	-	-	-	-	-	-	18 000
Wheat grain massebakke, 10ton	4	33 333	-	-	-	-	-	-	-	50 000	-
Front loader	5	54 833	-	-	-	-	-	-	94 000	-	-
Lorry, 10ton, SD	4	549 667	-	-	-	-	-	-	-	824 500	-
LDV 1	2	187 500	-	-	-	-	-	-	-	-	-
LDV 2	5	145 833	-	-	-	-	-	-	250 000	-	-
Tools and Equipment		140 000									
Total intermediate capital:		4 406 979	-	301 000	2 000 500	621 000	322 250	896 500	344 000	874 500	228 000
livestock:		1 472 500									
Total capital:		29 879 479	-	301 000	2 000 500	621 000	322 250	896 500	344 000	874 500	228 000
Net annual flows:		**- 28 087 334**	**2 641 177**	**348 810**	**- 41 646**	**2 071 927**	**1 496 749**	**970 354**	**2 325 843**	**990 520**	**415 727**

IRR **4.69%**

NPV **7 981 843**

*Type of year indicated by code: good year=1, average year=2, poor year=3.

Cash Flow:

opening	-	1 218 169	3 276 029	3 298 166	4 372 596	6 096 292	6 710 413	6 981 837	8 062 155	8 303 442
inflow	3 224 326	4 073 358	2 081 991	3 391 035	4 125 108	3 251 180	3 299 035	4 102 024	3 297 201	2 075 908
outflow	2 016 404	2 043 053	2 087 595	2 353 384	2 452 688	2 693 503	3 086 336	3 089 519	3 125 756	3 141 350
Flow before interest	1 207 922	3 248 473	3 270 425	4 335 817	6 045 015	6 653 970	6 923 111	7 994 342	8 233 600	7 238 000
interest	10 246	27 555	27 742	36 779	51 277	56 443	58 726	67 813	69 842	61 397
Closing balance	1 218 169	3 276 029	3 298 166	4 372 596	6 096 292	6 710 413	6 981 837	8 062 155	8 303 442	7 299 397

Whole-farm multi-period budget - Middle Swartland, WMWM, no-till

Year in calculation period:	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	
Wheat: Year classification (good, average, poor)	1	2	2	2	1	2	2	2	2	2	
Canola & Lupin: Year classification (good, average, poor)	1	2	2	2	1	2	2	2	2	2	
Crop											
Wheat after wheat	-	-	-	-	-	-	-	-	-	-	
Wheat after canola	-	-	-	-	-	-	-	-	-	-	
Wheat after lupine	-	-	-	-	-	-	-	-	-	-	
Wheat after Medics	3 458 957	2 609 925	2 609 925	2 609 925	3 458 957	2 609 925	2 609 925	2 609 925	2 609 925	2 609 925	
Canola	-	-	-	-	-	-	-	-	-	-	
Lupins	-	-	-	-	-	-	-	-	-	-	
Medics	614 401	614 401	614 401	614 401	614 401	614 401	614 401	614 401	614 401	614 401	
Capital sales	255 000	-	-	-	25 083	166 708	51 750	26 854	74 708	28 667	
Gross margin: total farming:	**4 328 358**	**3 224 326**	**3 224 326**	**3 224 326**	**4 098 441**	**3 391 035**	**3 276 076**	**3 251 180**	**3 299 035**	**3 252 993**	**3 374 563**
Overhead and fixed costs:											
Regular work:											
Water fees:	426 000	426 000	426 000	426 000	426 000	426 000	426 000	426 000	426 000	426 000	
Municipal taxes:	33 000	33 000	33 000	33 000	33 000	33 000	33 000	33 000	33 000	33 000	
Insurance (overall):	24 000	24 000	24 000	24 000	24 000	24 000	24 000	24 000	24 000	24 000	
licenses:	450 817	450 817	450 817	450 817	450 817	450 817	450 817	450 817	450 817	450 817	
Bank charges:	8 280	8 280	8 280	8 280	8 280	8 280	8 280	8 280	8 280	8 280	
phone	17 000	17 000	17 000	17 000	17 000	17 000	17 000	17 000	17 000	17 000	
Administration	32 000	32 000	32 000	32 000	32 000	32 000	32 000	32 000	32 000	32 000	
Auditors & Consultation fees	12 000	12 000	12 000	12 000	12 000	12 000	12 000	12 000	12 000	12 000	
Provision: camps	16 000	16 000	16 000	16 000	16 000	16 000	16 000	16 000	16 000	16 000	
Supply: water distribution	30 000	30 000	30 000	30 000	30 000	30 000	30 000	30 000	30 000	30 000	
Ondernemenrs wage	28 000	28 000	28 000	28 000	28 000	28 000	28 000	28 000	28 000	28 000	
Miscellaneous costs (4%)	300 000	300 000	300 000	300 000	300 000	300 000	300 000	300 000	300 000	300 000	
Total overhead and fixed costs:	**55 084**	**55 084**	**55 084**	**55 084**	**55 084**	**55 084**	**55 084**	**55 084**	**55 084**	**55 084**	
Margin above overhead and fixed costs:	**2 896 177**	**1 792 145**	**1 792 145**	**1 792 145**	**2 666 260**	**1 958 854**	**1 843 895**	**1 818 999**	**1 866 854**	**1 820 812**	
Capital:											**Resale:**
long-term capital:											
Land & fixed improvements	-	-	-	-	-	-	-	-	-	-	24 000 000
Intermediary Capital:											
Harvester 210kW	3 060 000	-	-	-	-	-	-	-	-	-	1 224 000
Tractor 180kW	-	-	-	-	-	2 000 500	-	-	-	-	1 333 667
Tractor 80kW	-	-	-	-	-	-	621 000	-	-	-	465 750
Tractor 50kW	-	-	-	-	301 000	-	-	-	-	-	175 583

Sprayer 18m, 2000L	-	-	-	-	-	-	-	216 500	-	-	180 417
Fertiliser Spreader 1500L, 10-36m, 3point	-	-	-	-	-	-	-	105 750	-	-	88 125
No-till Planter, 21 tine, 6m	-	-	-	-	-	-	-	-	804 500	-	320 833
6ton 4wl, trailer	-	-	-	-	-	-	-	-	92 000	-	84 333
Grain cart 8ton	-	-	-	-	-	-	-	-	-	-	35 000
Road scraper, 2.4m, 3point	-	-	-	-	-	-	-	-	-	-	3 000
Wheat grain massebakke, 10ton	-	-	-	-	-	-	-	-	-	-	4 167
Front loader	-	-	-	-	-	-	-	-	-	94 000	-
Lorry, 10ton, SD	-	-	-	-	-	-	-	-	-	-	68 708
LDV 1	-	-	-	-	-	-	-	-	-	-	253 125
LDV 2	-	-	-	-	-	-	-	-	-	250 000	-
Tools and Equipment											
Total intermediate capital:	3 060 000	-	-	-	301 000	2 000 500	621 000	322 250	896 500	344 000	4 236 708
livestock:											1 472 500
Total capital:	3 060 000	-	-	-	301 000	2 000 500	621 000	322 250	896 500	344 000	29 709 208
Net annual flows:	**- 163 823**	**1 792 145**	**1 792 145**	**1 792 145**	**2 365 260**	**- 41 646**	**1 222 895**	**1 496 749**	**970 354**	**31 186 020**	

IRR

NPV

*Type of year indicated by code: good year=1, average year=2, poor year=3.

Cash Flow:

opening	7 299 397	8 981 256	9 718 983	10 017 686	10 596 637	12 132 980	12 793 833	13 512 254	14 682 692	15 515 152
inflow	4 328 358	3 224 326	3 224 326	3 224 326	4 098 441	3 391 035	3 276 076	3 251 180	3 299 035	3 252 993
outflow	2 722 042	2 568 348	3 009 883	2 734 507	2 664 151	2 837 793	2 671 309	2 204 242	2 597 076	2 600 259
Flow before interest	8 905 712	9 637 234	9 933 426	10 507 506	12 030 927	12 686 221	13 398 600	14 559 193	15 384 650	16 167 886
interest	75 543	81 748	84 261	89 131	102 053	107 612	113 654	123 499	130 501	137 145
Closing balance	8 981 256	9 718 983	10 017 686	10 596 637	12 132 980	12 793 833	13 512 254	14 682 692	15 515 152	16 305 031

Whole-farm multi-period budget - Middle Swartland, WMWM, conventional tillage

Year in calculation period:		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Wheat: Year classification (good, average, poor)		2	1	3	2	1	2	2	1	2	3
Canola & Lupin: Year classification (good, average, poor)		2	2	3	2	1	2	2	1	2	3
Crop	Hectare										
Wheat after wheat	-	-	-	-	-	-	-	-	-	-	-
Wheat after canola	-	-	-	-	-	-	-	-	-	-	-
Wheat after lupine	-	-	-	-	-	-	-	-	-	-	-
Wheat after Medics	380	1 814 659	2 875 948	753 370	1 814 659	2 875 948	1 814 659	1 814 659	2 875 948	1 814 659	753 370
Canola	-	-	-	-	-	-	-	-	-	-	-
Lupins	-	-	-	-	-	-	-	-	-	-	-
Medics	380	614 401	614 401	614 401	614 401	614 401	614 401	614 401	614 401	614 401	614 401
Capital sales		-	-	25 083	166 708	63 979	26 854	48 271	-	-	17 500
Gross margin: total farming:	**380**	**2 429 060**	**3 490 349**	**1 392 854**	**2 595 768**	**3 554 328**	**2 455 914**	**2 477 331**	**3 490 349**	**2 429 060**	**1 385 271**
Overhead and fixed costs:											
Regular work:		426 000	426 000	426 000	426 000	426 000	426 000	426 000	426 000	426 000	426 000
Water fees:		33 000	33 000	33 000	33 000	33 000	33 000	33 000	33 000	33 000	33 000
Municipal taxes:		24 000	24 000	24 000	24 000	24 000	24 000	24 000	24 000	24 000	24 000
Insurance (overall):		452 580	452 580	452 580	452 580	452 580	452 580	452 580	452 580	452 580	452 580
Licenses:		8 280	8 280	8 280	8 280	8 280	8 280	8 280	8 280	8 280	8 280
Bank charges:		17 000	17 000	17 000	17 000	17 000	17 000	17 000	17 000	17 000	17 000
Phone		32 000	32 000	32 000	32 000	32 000	32 000	32 000	32 000	32 000	32 000
Administration		12 000	12 000	12 000	12 000	12 000	12 000	12 000	12 000	12 000	12 000
Auditors & Consultation fees		16 000	16 000	16 000	16 000	16 000	16 000	16 000	16 000	16 000	16 000
Provision: camps		30 000	30 000	30 000	30 000	30 000	30 000	30 000	30 000	30 000	30 000
Supply: water distribution		28 000	28 000	28 000	28 000	28 000	28 000	28 000	28 000	28 000	28 000
Employee wages		300 000	300 000	300 000	300 000	300 000	300 000	300 000	300 000	300 000	300 000
Miscellaneous costs (4%)		55 154	55 154	55 154	55 154	55 154	55 154	55 154	55 154	55 154	55 154
Total overhead and fixed costs:		**1 434 015**	**1 434 015**	**1 434 015**	**1 434 015**	**1 434 015**	**1 434 015**	**1 434 015**	**1 434 015**	**1 434 015**	**1 434 015**
Margin above overhead and fixed costs:		**995 045**	**2 056 335**	**- 41 161**	**1 161 754**	**2 120 314**	**1 021 899**	**1 043 316**	**2 056 335**	**995 045**	**- 48 744**
Capital:											
Long-term capital:											
Land & fixed improvements		24 000 000	-	-	-	-	-	-	-	-	-
Intermediary Capital:	age										
Harvester 210kW	5	1 785 000	-	-	-	-	-	-	-	-	-
Tractor 180kW	9	500 125	-	-	2 000 500	-	-	-	-	-	-
Tractor 80kW	8	207 000	-	-	-	621 000	-	-	-	-	-
Tractor 50kW	10	50 167	-	301 000	-	-	-	-	-	-	-
Sprayer 18m, 2000L	7	90 208	-	-	-	-	216 500	-	-	-	-
Fertiliser Spreader 1500L, 10-36m, 3point	7	44 063	-	-	-	-	105 750	-	-	-	-

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Single seed drill, CT planter	6	175 000	-	-	-	-	-	350 000	-	-	-
Chisel Plough, 15tine, 4.5m	8	48 917	-	-	-	146 750	-	-	-	-	-
Fieldspan, 41tine, 6.1m	6	68 625	-	-	-	-	-	137 250	-	-	-
6ton 4wl, trailer	6	46 000	-	-	-	-	-	92 000	-	-	-
Grain cart 8ton	3	157 500	-	-	-	-	-	-	-	-	210 000
Road scraper, 2.4m, 3point	3	13 500	-	-	-	-	-	-	-	-	18 000
Wheat grain massebakke, 10ton	4	33 333	-	-	-	-	-	-	-	50 000	-
Front loader	5	54 833	-	-	-	-	-	-	94 000	-	-
Lorry, 10ton, SD	4	549 667	-	-	-	-	-	-	-	824 500	-
LDV 1	2	187 500	-	-	-	-	-	-	-	-	-
LDV 2	5	145 833	-	-	-	-	-	-	250 000	-	-
Tools and Equipment		140 000									
Total intermediate capital:		3 186 104	-	301 000	2 000 500	767 750	322 250	579 250	-	-	210 000
Livestock:		1 472 500									
Total capital:		28 658 604	-	301 000	2 000 500	767 750	322 250	579 250	-	-	210 000
Net annual flows:		**- 27 663 559**	**2 056 335**	**- 342 161**	**- 838 746**	**1 352 564**	**699 649**	**464 066**	**2 056 335**	**995 045**	**- 258 744**

IRR **2.56%**

NPV **- 712 779**

*Type of year indicated by code: good year=1, average year=2, poor year=3.

Cash Flow:

Opening	-	414 307	1 875 545	1 188 971	1 441 647	2 563 012	2 343 300	1 747 156	2 164 358	1 478 262
Inflow	2 429 060	3 490 349	1 392 854	2 595 768	3 554 328	2 455 914	2 477 331	3 490 349	2 429 060	1 385 271
Outflow	2 018 237	2 044 887	2 089 429	2 355 218	2 454 522	2 695 336	3 088 170	3 091 353	3 127 590	3 143 183
Flow before interest	410 822	1 859 770	1 178 970	1 429 521	2 541 454	2 323 590	1 732 460	2 146 153	1 465 828	- 279 651
Interest	3 485	15 776	10 001	12 126	21 558	19 710	14 696	18 205	12 434	- 7 644
Closing balance	414 307	1 875 545	1 188 971	1 441 647	2 563 012	2 343 300	1 747 156	2 164 358	1 478 262	- 287 295

Whole-farm multi-period budget - Middle Swartland, WMWM, conventional tillage

Year in calculation period:	11	12	13	14	15	16	17	18	19	20	
Wheat: Year classification (good, average, poor)	1	2	2	2	1	2	2	2	2	2	
Canola & Lupin: Year classification (good, average, poor)	1	2	2	2	1	2	2	2	2	2	
Crop											
Wheat after wheat	-	-	-	-	-	-	-	-	-	-	
Wheat after canola	-	-	-	-	-	-	-	-	-	-	
Wheat after lupine	-	-	-	-	-	-	-	-	-	-	
Wheat after Medics	2 875 948	1 814 659	1 814 659	1 814 659	2 875 948	1 814 659	1 814 659	1 814 659	1 814 659	1 814 659	
Canola	-	-	-	-	-	-	-	-	-	-	
Lupins	-	-	-	-	-	-	-	-	-	-	
Medics	614 401	614 401	614 401	614 401	614 401	614 401	614 401	614 401	614 401	614 401	
Capital sales	255 000	-	-	-	25 083	166 708	63 979	26 854	48 271	-	
Gross margin: total farming:	**3 745 349**	**2 429 060**	**2 429 060**	**2 429 060**	**3 515 433**	**2 595 768**	**2 493 039**	**2 455 914**	**2 477 331**	**2 429 060**	**2 634 968**
Overhead and fixed costs:											
Regular work:	426 000	426 000	426 000	426 000	426 000	426 000	426 000	426 000	426 000	426 000	
Water fees:	33 000	33 000	33 000	33 000	33 000	33 000	33 000	33 000	33 000	33 000	
Municipal taxes:	24 000	24 000	24 000	24 000	24 000	24 000	24 000	24 000	24 000	24 000	
Insurance (overall):	452 580	452 580	452 580	452 580	452 580	452 580	452 580	452 580	452 580	452 580	
Licenses:	8 280	8 280	8 280	8 280	8 280	8 280	8 280	8 280	8 280	8 280	
Bank charges:	17 000	17 000	17 000	17 000	17 000	17 000	17 000	17 000	17 000	17 000	
Phone	32 000	32 000	32 000	32 000	32 000	32 000	32 000	32 000	32 000	32 000	
Administration	12 000	12 000	12 000	12 000	12 000	12 000	12 000	12 000	12 000	12 000	
Auditors & Consultation fees	16 000	16 000	16 000	16 000	16 000	16 000	16 000	16 000	16 000	16 000	
Provision: camps	30 000	30 000	30 000	30 000	30 000	30 000	30 000	30 000	30 000	30 000	
Supply: water distribution	28 000	28 000	28 000	28 000	28 000	28 000	28 000	28 000	28 000	28 000	
Employee wages	300 000	300 000	300 000	300 000	300 000	300 000	300 000	300 000	300 000	300 000	
Miscellaneous costs (4%)	55 154	55 154	55 154	55 154	55 154	55 154	55 154	55 154	55 154	55 154	
Total overhead and fixed costs:	**1 434 015**	**1 434 015**	**1 434 015**	**1 434 015**	**1 434 015**	**1 434 015**	**1 434 015**	**1 434 015**	**1 434 015**	**1 434 015**	
Margin above overhead and fixed costs:	**2 311 335**	**995 045**	**995 045**	**995 045**	**2 081 418**	**1 161 754**	**1 059 024**	**1 021 899**	**1 043 316**	**995 045**	
Capital:											Resale:
Long-term capital:											
Land & fixed improvements	-	-	-	-	-	-	-	-	-	-	24 000 000
Intermediary Capital:											
Harvester 210kW	3 060 000	-	-	-	-	-	-	-	-	-	1 224 000
Tractor 180kW	-	-	-	-	-	2 000 500	-	-	-	-	1 333 667
Tractor 80kW	-	-	-	-	-	-	621 000	-	-	-	465 750
Tractor 50kW	-	-	-	-	301 000	-	-	-	-	-	175 583
Sprayer 18m, 2000L	-	-	-	-	-	-	-	216 500	-	-	180 417
Fertiliser Spreader 1500L, 10-36m, 3point	-	-	-	-	-	-	-	105 750	-	-	88 125

Single seed drill, CT planter	-	-	-	-	-	-	-	-	350 000	-	320 833
Chisel Plough, 15tine, 4.5m	-	-	-	-	-	-	146 750	-	-	-	110 063
Fieldspan, 41tine, 6.1m	-	-	-	-	-	-	-	-	137 250	-	125 813
6ton 4wl, trailer	-	-	-	-	-	-	-	-	92 000	-	84 333
Grain cart 8ton	-	-	-	-	-	-	-	-	-	-	35 000
Road scraper, 2.4m, 3point	-	-	-	-	-	-	-	-	-	-	3 000
Wheat grain massebakke, 10ton	-	-	-	-	-	-	-	-	-	-	4 167
Front loader	-	-	-	-	-	-	-	-	-	94 000	-
Lorry, 10ton, SD	-	-	-	-	-	-	-	-	-	-	68 708
LDV 1	-	-	-	-	-	-	-	-	-	-	253 125
LDV 2	-	-	-	-	-	-	-	-	-	250 000	-
Tools and Equipment											
Total intermediate capital:	3 060 000	-	-	-	301 000	2 000 500	767 750	322 250	579 250	-	4 143 583
Livestock:											1 472 500
Total capital:	3 060 000	-	-	-	301 000	2 000 500	767 750	322 250	579 250	-	29 616 083
Net annual flows:	**- 748 665**	**995 045**	**995 045**	**995 045**	**1 780 418**	**- 838 746**	**291 274**	**699 649**	**464 066**	**30 611 129**	

IRR

NPV

*Type of year indicated by code: good year=1, average year=2, poor year=3.

Cash Flow:										
Opening	- 287 295	740 406	604 368	21 895	- 293 185	560 981	319 812	140 894	394 046	274 778
Inflow	3 745 349	2 429 060	2 429 060	2 429 060	3 515 433	2 595 768	2 493 039	2 455 914	2 477 331	2 429 060
Outflow	2 723 876	2 570 181	3 011 717	2 736 340	2 665 985	2 839 627	2 673 143	2 206 076	2 598 910	2 602 092
Flow before interest	734 178	599 285	21 711	- 285 385	556 262	317 122	139 709	390 732	272 467	101 746
Interest	6 228	5 083	184	- 7 800	4 719	2 690	1 185	3 314	2 311	863
Closing balance	740 406	604 368	21 895	- 293 185	560 981	319 812	140 894	394 046	274 778	102 609