A financial analysis of different livestock management approaches within different crop rotation systems in the Middle Swartland

by

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Declaration

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Abstract

The need for sustainable agricultural production systems is emphasised by the increasing pressure on natural resources. Conservation agriculture (CA) is a holistic approach to sustainable agriculture, encompassing three basic principles: (1) minimal soil disturbance, (2) maximum or permanent levels of soil cover and (3) crop diversification through crop rotation systems. The Swartland grain production area of the Western Cape has seen an increased adoption of CA practices over the last two decades. The reasons for and extent of CA uptake amongst Swartland producers vary significantly.

The Swartland has a typical Mediterranean climate with hot, dry summers and cold, wet winters. Grain production in the Swartland is predominantly based on dry-land production systems, while wheat has traditionally been produced in monoculture systems. As a result of various driving forces, the attractiveness of crop rotation as an alternative to monoculture has increased significantly since the late 1990's. Alternative crops such as canola, lupins, and annual legume pastures have gained popularity in the area and are commonly incorporated into Swartland crop rotation systems.

The addition of annual legume pastures into crop rotation systems with wheat has provided Swartland producers the opportunity to also diversify in terms of farming enterprise by adding a livestock component to their farming operation. The additional incorporation of a livestock component may provide many benefits, including increased diversification, increased financial and income stability and even increased profits.

However, despite the fact that livestock fit perfectly in crop rotation systems, there is concern about the impacts of livestock on soil compaction and cover, posing various threats to the successful implementation of CA. This is mainly due to possible soil compaction caused by livestock trampling and soil cover serving as livestock feed. To achieve successful integration of a livestock component into a mixed farming system without mitigating CA outcomes, therefore, requires livestock approaches based on lower stocking rates or alternative feeding systems. This study aims to assess the financial implications of different approaches that could be followed to achieve successful crop-livestock integration.

Technical data from the Langgewens experimental farm served as basis for developing the livestock approaches and strategies. To capture the interrelatedness of variables and complexity of the farming system, this study is based on a systems approach. To assess the financial performance of the different livestock management approaches on whole-farm level, a typical farm model was developed. A multi-disciplinary expert group discussion was used to obtain valuable information necessary for developing the typical farm model.

The financial performance of the different strategies on whole-farm level was measured in terms of the Internal Rate of Return on Capital (IRR) and the Net Present Value (NPV). Wheat-medic crop rotation systems with additional saltbush pastures proved to be the most profitable. Of the three livestock management approaches modelled, a grazing approach is least profitable. While an intensive speculation approach is the most profitable for integrating livestock on a particular farm, treating medics as a cash crop by selling medic hay to neighbouring producers is a valuable alternative.

Uittreksel

Die behoefte aan volhoubare produksiestelsels in landbou word beklemtoon deur die toenemende druk waaronder natuurlike hulpbronne gebuk gaan. Bewaringslandbou is ‘n holistiese benadering tot volhoubare landbou. Bewaringslandbou word onderlê deur drie kernbeginsels: (1) Minimum grondversteuring, (2) maksimum of permanente grondbedekking en (3) gewasdiversifikasie deur middel van wisselboustelsels. Oor die afgelope twee dekades is bewaringslandboupraktyke toenemend toegepas deur boere in die Swartland graanproduksiearea van die Wes-Kaap. Die redes vir en die omvang van die implementering van bewaringslandbou onder boere in die Swartland verskil noemenswaardig.

Die Swartland het ‘n tipiese Mediterreense klimaat met warm, droë somers en koue, nat winters. Graanproduksie in die Swartland is oorwegend op droëland produksie sisteme gebaseer, terwyl koring tradisioneel in monokultuur verbou is. Verskeie dryfvere het daartoe gelei dat wisselbou as alternatief tot monokultuur al hoe aantrekliker geword het sedert die laat 1990’s. Alternatiewe gewasse soos kanola, lupiene en eenjarige peulgewasse het toenemend gewild geword in die area en word vandag algemeen ingesluit by wisselboustelsels.

Die insluiting van weidingsgewasse in wisselboustelsels het vir Swartlandboere die geleentheid verskaf om ook in terme van bedryfsvertakkings te diversifiseer, deur ‘n veekomponent tot die boerdery toe te voeg. Die toevoeging van ‘n veekomponent hou vele moontlike voordele in, insluitend verhoogde diversifikasie, toenemende finansiële- en inkomste stabiliteit, asook verhoogde winsgewendheid.

Ten spyte daarvan dat vee goed in die wisselboukomponent van bewaringslandbou pas, bestaan daar egter kommer oor die impak wat vee op grondkompaksie- en bedekking kan hê. Die kommer word oorgewend toegeskryf aan moontlike grondkompaksie wat veroorsaak word deur vertrapping, asook die feit dat die deklaag as voer dien. Om suksesvolle integrasie van ‘n veekomponent in ‘n gemengde boerderysisteem te bewerkstellig sonder om inbreuk op die uitkomste van bewaringslandbou te maak, vereis dus veebenaderings wat geskoei is op verlaagde veeladings of alternatiewe voersisteme. Hierdie studie poog om die finansiële implikasies van verskillende benaderings wat gevolg kan word om suksesvolle gewas-vee integrasie te bewerkstellig, te evalueer.

Tegniese data van die Langgewens proefplaas het as basis vir die ontwikkeling van die veebenaderings en integrasie-strategieë gedien. Om die interafhanklikeid van verandelikes en die kompleksiteit van die boerderysisteem vas te vang, is hierdie studie geskoei op ‘n stelselsbenadering. Ten einde die finansiële prestasie van die verskillende veebestuursbenaderings op plaasvlak te evalueer, is daar van ‘n tipiese plaasmodel gebruik gemaak. ‘n Multi-dissiplinêre groepsbespreking is gebruik om belangrike inligting relevant tot die ontwikkeling van die tipiese plaasmodel in te win.

Die finansiële prestasie van die verskillende strategieë op plaasvlak is gemeet in terme van die Interne Opbrenskoers van Kapitaal (IOK) en die Netto Huidige Waarde (NHW). Koring-medic wisselboustelsels met addisionele soutboskampe het die hoogste winsgewendheid getoon. Van die drie veebestuursbenaderings wat gemodelleer is, vaar ‘n weidingsbenadering die swakste in terme van winsgewendheid. Alhoewel ‘n intensiewe spekulasiebenadering die hoogste winsgewendheid toon vir integrasiebenaderings op ‘n gegewe plaas, is die hantering van medics as kontantgewas deur dit as hooi te verkoop ‘n geldige alternatief.

This thesis is dedicated to my dad and our farm, Doornfontein, by whom and where my passion for agriculture was inspired.

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List of Abbreviations

BFAP: Bureau for Food and Agricultural Policy

CA: Conservation Agriculture

FAO: Food and Agriculture Organisation

IRR: Internal Rate of Return on Capital

NPV: Net Present Value of expected cash flows

SSA: Sub-Saharan Africa

USA: United States of America

Crop rotation systems:

WWWW: W = Wheat

WWWC: W = Wheat, C = Canola

WCWL: W = Wheat, C = Canola, L = Lupins

WWLC: W = Wheat, L = Lupins, C = Canola

WMWM: W = Wheat, M = Medics

WMcWMC: W = Wheat, Mc = Medics/clover mix

MWMC: M = Medics, W: Wheat, C = Canola

WMcWMc + S: W = Wheat, Mc = Medics/clover mix, S = Saltbush

Chapter 1: Introduction

1.1 Background

The world population is expected to exceed 9 billion by 2050 and pressure on producers to produce enough food at the lowest cost is increasing. This is evident in the decline in the *per capita* available agricultural land - from 0.43 ha in 1960 to 0.26 ha in 1999. It is also projected that the *per capita* availability of water will significantly decline. Despite these continued and increasing natural resource constraints, global food production has to be increased by as much as 70% by 2050 in order to meet the demands of the projected growing population (Friedrich, Kienzle & Kassam, 2009).

As a result of population growth and continued urbanisation, the available amount of arable farming land to produce enough food is shrinking. Consequently food security becomes increasingly dependent on responsible and sustained production by producers. It is clear that alternative farming methods need to be identified (Hobbs, 2007). Given the expectations from new or alternative production systems, it is clear that the ideal alternative for any production area should have two important properties: (1) The potential to produce sufficient levels of food and (2) sustainability – where the latter encompasses both financial and environmental sustainability (Knott, 2015).

Conservation Agriculture (CA) is an attractive way in which yields and profitability can be sustainably increased (Derpsch, 2001; Dumanski *et al.*, 2006; Hobbs, 2007; Kurothe *et al.*, 2014). CA is a holistic approach to farming and is based on three interconnected and synergistic principals: (1) The retention of crop residues for maximal or permanent soil cover, (2) minimum soil disturbance, and (3) crop diversification through crop rotation systems (Derpsch, 2001). Since the mid 1990's CA adoption rates were high all over the world and across many different production environments (Derpsch *et al.*, 2010). CA is, however, not a generic recipe for sustainable agriculture. The three main principles of CA do provide a point of departure from which the producer can adapt and improve according to his or her farm's unique set of ecological characteristics. An alternative production system based on the holistic CA practice holds potential to be considered as an alternative because it may have the desired properties of the "ideal" alternative. The reason for this lies in the core purpose of the CA practice, which promotes the maintenance or enhancement of the natural resource base, and sustainable management thereof, along with increasing productivity and sustaining the producer's livelihood. This would ultimately result in the alleviation of poverty and food security (Friedrich & Kienzle, 2008; Kurothe *et al.*, 2014).

South Africa's ecological and climatic regions vary significantly – from subtropical, to semi-desert, to Mediterranean. CA has been adopted throughout South Africa, with the Western Cape Province as the largest adopter. The Western Cape has a typical Mediterranean climate. The Swartland area of the Western Cape is one of the main wheat producing areas of the province and in South Africa, while other winter cereals and legumes such as barley, oats, lupins, medics and canola are also commonly produced in crop production systems. The Swartland has traditionally been a region where wheat was regarded the main crop in rain-fed production systems. Although this may still be true in many cases today, adoption rates of CA in the Swartland have been relatively high since the late 1990s.

Due to high profit margins and the region's inherent ability to produce wheat, wheat production was traditionally based on mono-cropping. After the deregulation of agriculture in the 1990s, particularly after the abolishment of marketing boards and protectionist legislation, Swartland producers were not able to produce wheat competitively at world market prices (Hoffmann, 2001). The adoption of crop rotation systems enabled these producers to diversify their crop production and reduce their exposure to risks associated with wheat production in the area. As ryegrass became increasingly herbicide resistant, producers started to adopt no-till because it enabled them to apply pre-emergent herbicides.

After establishing annual legume pastures in crop rotation systems, and still being under pressure to diversify and supplement income in order to survive, producers started to realise the potential of crop rotation systems with annual legume pastures to accommodate livestock. Livestock may however have detrimental impacts on soil quality and health, and therefore on subsequent cash crop profitability. This leads to some extent of contradiction and confusion within the CA literature with regards to whether or not livestock can be integrated into a mixed crop-livestock farming system that is based on CA principles. The degree to which livestock can affect the objectives of CA (either positive or negative) is to a large degree still uncertain and unknown, especially to the producers.

Technical data from the Langgewens experimental farm served as the basis for this study. The data has been collected from trial plots dedicated to CA from 2002 to 2015. The trials consist of eight different crop rotation systems and are based on CA principles: wheat monoculture as control (WWWW), wheat-canola (WWWC), two wheat-lupin-canola systems (WCWL and WWLC), wheat-medic (WMWM), wheat-medic-canola (MWMC), and two wheat-medic/clover (WMcWMc) systems, where one includes a saltbush pasture. The rotation systems without medics do not accommodate any livestock, while sheep are held on the medic pastures in the systems with medics. The same production activities are used on all the rotation systems. The technical data from the trials has been analysed for purposes relevant to plant and soil properties, while the financial implications of the rotations systems along with different livestock management approaches are still unknown.

The interrelatedness between livestock and CA principles and objectives are mostly regarding the possible effects of livestock trampling on soil physical properties on the one hand, and the possible synergistic benefits and gains of integrating livestock and CA on the other. For the purpose of this study, CA is regarded as a given. This study attempted to evaluate CA and livestock within the context of an integrated crop-livestock system, and to establish a point of departure from which livestock and CA can be reconciled in an integrated production system in the Swartland.

1.2 Problem statement and research question

Livestock and cropping systems have been integrated across the globe for many years and for various reasons, even in CA production systems. The relative success of this integration has not been consistent or equal across all the places it has been implemented. This has led to a degree of confusion in the literature about whether or not livestock could be integrated in a CA system. What are the reasons for this difference in the relative success of integrating livestock and a CA based cropping system? What are the key success factors of successfully integrating livestock and CA? Given the CA related concerns of livestock, the integration could be possible through following an intensive management approach where livestock are kept off the land. However, are there sufficient financial benefits from intensifying the livestock component of a farm to such an extent that the possible concerns (and by implication possible synergies) of integrating livestock and CA are avoided rather than managed? The question therefore is: What are the financial benefits of integrating CA and livestock according to different approaches?

There exists a lack of knowledge on the financial costs and benefits of adopting CA and integrating a livestock component over the long-term in the Middle Swartland area. Many producers adopt CA for its ecological and economic value, and have a livestock component for its ability to supplement the farm’s profitability. However, the on-farm knowledge of the links between CA and livestock and the financial impacts thereof are still unknown. What are the main reasons for adopting CA in the area? What are the reasons for establishing a livestock component? What are the reasons for considering integration between livestock and CA? What are the financial implications of adopting CA and an integrated livestock component, and can the farm business afford to invest in expensive means necessary for successful integration?

1.3 Objective of the study

The main objective of this study was to financially assess strategies to integrate livestock into a mixed crop-livestock system within a CA approach on a typical mixed sheep-grain farm in the Middle Swartland.

The specific goals of research in this study were:

- To establish the context of CA in terms of its origins and progression in the Middle Swartland area of the Western Cape, which forms the basis for developing a strategy to integrate livestock and crops within a CA context.
- To financially assess existing trial data of eight crop rotation systems to establish the role of livestock in these systems.
- To identify different approaches to livestock management that could be applied to the relevant crop rotation systems.
- To illustrate the expected whole-farm financial implications of different strategies followed to integrate livestock into a mixed crop-livestock system within a CA context in the Middle Swartland area of the Western Cape.

1.4 Method of the study

In order to establish a point of departure from which different approaches to integrate livestock into a CA based integrated crop-livestock production system can be developed, an overview of the literature will be conducted. In the literature review, the Swartland area itself, as well as the origins and progression of CA in the area will be discussed and put into context. The main focus of the overview will be to determine to what extent livestock and the practice of CA can be integrated. The literature overview will also attempt to identify key areas of concern, possible remedies, and ultimately, to establish possible strategies for the Middle Swartland producer to integrate livestock and CA.

The financial implications of different approaches to integrate livestock into a CA based crop-livestock production system for the typical producer in the Swartland are analysed through a whole-farm financial budgeting model. The model is directly related to the Middle Swartland, because the trial plots of the Langgewens CA trial are situated in this area. The typical farm is developed with the help of current producers and other experts in the industry through consultation and a discussion group session. The farm model can be regarded as typical for the area at the time of the study. It is assumed that the results of the model can act as decision making guidelines in the particular region. Individual farms that differ significantly from what the model represents, may have different results.

As the study of a system necessarily implies that many facets of the same problem should be taken into account simultaneously, the whole-farm implications of integrating livestock and CA were evaluated through the systems approach. The systems approach allowed for the integration of livestock and CA to be dependent on the various forces within the environment it functions in. To account for the complexity of the decision making environment, a multi-disciplinary team of experts in the small grain and livestock industries in the Swartland region was used. This team included experts from disciplines such as agricultural economics, plant science, soil science, animal science, field cropping, pasture management and producers.

1.5 Outline of the study

In Chapter Two the Swartland area of the Western Cape is discussed and an overview of CA as the most holistic approach to sustainable agriculture is given. The relevant definitions within the CA environment, the historical development and progression of CA, as well as the challenges and benefits of CA are discussed. A large part of this chapter focuses on the conceptual challenges and issues of integrating livestock and cropping systems within a CA farming system. Chapter Two also focuses on the complexity of the decision making environment of the producer. A systems thinking approach is presented as a method of evaluating the whole-farm implications of integrating livestock and CA. The concepts of simulation models and multi-disciplinary discussion groups are discussed and outlined.

Chapter Three focuses on the Langgewens trial data. The Langgewens trial is discussed in detail and the data capturing methods are explained. The process of formulating the Langgewens trial data into financial budgets is discussed. Chapter Three also provides a financial analysis of the crop rotation systems implemented in the Langgewens trials and descriptions of the proposed livestock management approaches used in this study. The financial analysis of the Langgewens crop rotation systems and the livestock approaches discussed in Chapter Three form the basis of the strategies modelled in Chapter Four.

Chapter Four focuses on the whole-farm multi-period budget model that was developed for this study. In the first section of Chapter Four the assumptions and parameters of the typical farm are discussed, along with the dynamics of the whole-farm financial model. The components of the calculation model are laid out in this section. In the second section of Chapter Four the results and findings of the whole-farm model are presented and interpreted. The different strategies incorporated into the model are compared financially and their sensitivity to various factors are determined and discussed.

Chapter Five contains a summary of the most important aspects of the study, conclusions and recommendations for possible future studies.

Chapter 2: Literature review and methodology

2.1 Introduction

In Chapter One, the financial assessment of crop-livestock integration strategies within CA based farming systems was identified as the objective of this study. The interrelatedness of livestock and CA principles were discussed briefly and will be addressed in greater detail in this chapter.

This chapter consists of two sections. The first section is a review of existing literature on topics relevant to this study. The Swartland small grain production area is described in detail. The concept of CA is discussed in terms of the relevant definitions, its historical development and progression, as well as the challenges and benefits associated with CA. The interrelatedness of livestock and CA principles are discussed in detail, with particular focus on the conceptual challenges and issues of integrating livestock and cropping components within a CA farming system. This chapter also describes the systems approach as a method of capturing the complexity of the decision making environment. Simulation models and multi-disciplinary group discussions, as the relevant methods identified for answering the research question, are also discussed in this chapter.

2.2 Literature review

2.2.1 The Swartland

The Swartland area of the Western Cape is a winter rainfall area located in the West Coast region of the province. The Swartland has a typical Mediterranean-type climate with hot, dry summers and cold, wet winters. The typical Mediterranean climate is known for its random and unpredictable precipitation distribution and quantity, which can cause uncertainty for dryland producers (Hoffmann, 2001). About 80% of the Swartland's annual precipitation occurs between April and September each year (Halpern & Meadows, 2013). Moorreesburg, which is located in the Middle Swartland and is the nearest town to the Langgewens experimental farm, has a long-term annual precipitation mean of 386mm (Meadows, 2003). The average monthly rainfall and temperatures for Langgewens are illustrated in Figure 2.1. The area indicated in Annexure A marks the Swartland region of the Western Cape.

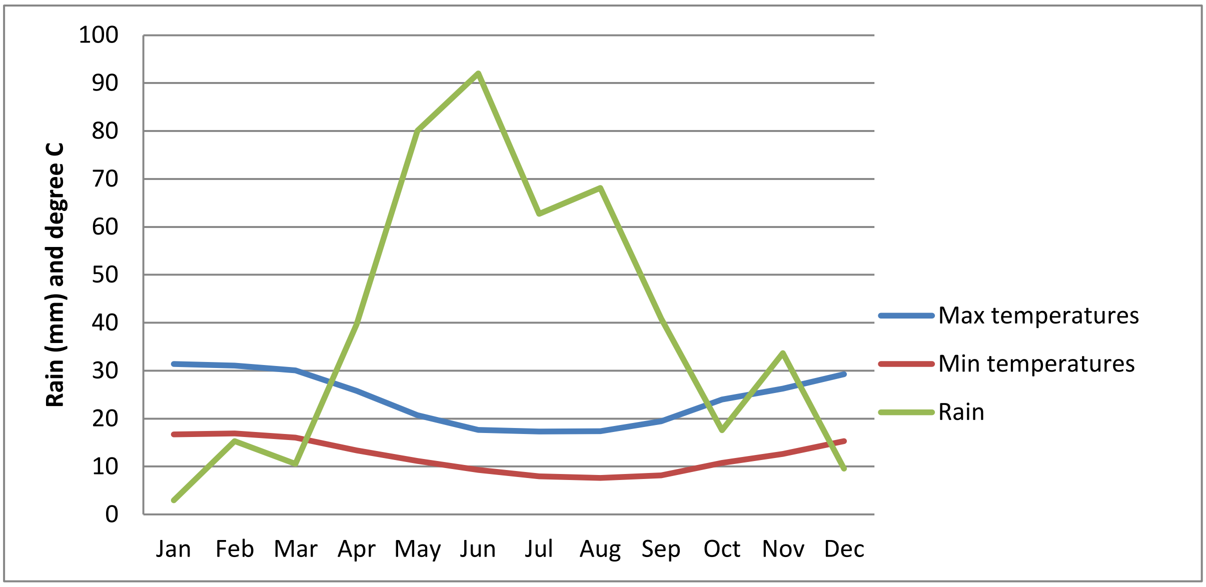

Figure 2.1: Average monthly precipitation and temperatures at Langgewens.
Source: Lombard (2016).

Figure 2.1 illustrates the concentration of rainfall in the winter months for this area. The summer droughts are also characterised by extreme maximum temperatures. This presents a challenge to livestock farming as feed production during summer months is not possible. It thus limits the options available to producers.

The Swartland is characterised by its shallow clay-loamy soils with a clay content of 10-20%. The relatively fertile shale derived soils have an average depth of between 200mm and 400mm. In a large portion of these soils a stone fraction in excess of 30% can be found, while it's not uncommon to find a stone fraction of more than 70% in these soils (Hardy, 2007).

Wheat has been the main crop in rain-fed agricultural production systems in the Swartland for the past century (Strauss, Hardy & Laubscher, 2010). Traditionally wheat was produced in a mono-culture system with an occasional break of bare fallow or oats pasture. The region's inherent potential for wheat production, the increased availability and accessibility of commercial fertilisers, improved chemical weed- and pest-control measures (Strauss, Hardy & Laubscher, 2010), and government policy throughout the isolation era (Halpern & Meadows, 2013) have all contributed to wheat production being based on mono-cropping in the Swartland until the late 1990s. The expansion of grain production into marginal areas were also encouraged by these factors (Hoffmann, 2001).

Despite earlier attempts to encourage producers to produce alternative crops and adopt alternative farming systems, the sustainability of wheat mono-cropping in the Swartland has only started to decrease significantly over the last three decades. The land improvement scheme of the 1970s &

1980s encouraged the establishment of annual legume pastures, but had limited success. The opportunity cost of not producing wheat in that period was still too high, due to the relatively high profit margins of wheat production as a result of relatively high (protected) domestic wheat prices and input subsidies. A number of factors, such as increased input costs, competitive world market prices and uncertain production due to unpredictable rainfall and decreased soil potential, have since the 1990s, significantly reduced the sustainability of wheat mono-cropping in the Swartland - both economically and environmentally (Strauss, Hardy & Laubscher, 2010). After the deregulation of Agriculture in the 1990s, especially the abolishment of trade restrictions in 1994 and protectionist legislation in 1996, wheat production in the Swartland started to decrease significantly, while the production of viticulture and other crops such as barley, canola, oats and triticale became increasingly important (Halpern & Meadows, 2013; Hoffmann & Kleynhans, 2011; Vink, Kleynhans & Street, 1998).

As wheat production in the Swartland became significantly less competitive in the late 1990s producers were subsequently forced to adapt production practices in order to survive. Crop rotation systems as a means of diversification started to gain interest as an alternative to wheat mono-cropping (Hoffmann, 2001). Although these crop rotation systems could include alternative cash crops such as canola or lupins, it is the inclusion of annual legume pastures with sheep that provided the greatest potential to supplement producers' income and improve financial stability. In addition to reduced exposure to risk and other benefits, the inclusion of these alternative cash crops and medic or medic/clover pastures (with sheep) into a cropping system has shown an improved return on capital investment when compared to wheat monoculture (Strauss, Hardy & Laubscher, 2010).

Another important catalyst of the producers' motivation for considering alternatives to wheat mono-cropping is the relatively high risk of land degradation. The typical Mediterranean climate, together with the relatively shallow sandy loam and/or loamy clay soils, may lead to Swartland landscapes being potentially susceptible to land degradation and soil erosion under low levels of organic matter and intensive cultivation (Halpern & Meadows, 2013; Meadows, 2003).

Through crop rotations, minimum soil disturbance and soil cover, the adoption of CA practices provided producers with the opportunity to minimise their exposure to financial risk, as well as limit the risk of land degradation due to continuous tillage practices associated with wheat mono-cropping. The opportunity to add a livestock component to the farming operation for even more diversification (and thus lower risk), possible increased income and possible increased profitability is created by the inclusion of annual legume pastures into a crop rotation system.

Although there are many benefits of integrating the livestock and CA, there is also concern about the potential impacts livestock may have on CA practices and its objectives. It is therefore not clear how livestock and CA can be reconciled with one another in the Middle Swartland. The concept of CA, the rationale behind integrated mixed crop-livestock systems and the links between CA and livestock integration are discussed in the next section.

2.2.2 Conservation agriculture: the concepts

Inappropriate tillage practice (where excessive tillage led to exposure of soil to wind) resulted in the famous Dust Bowl in the US Great Plains in the 1930s. The Dust Bowl created new consciousness about the negative impacts man could have on soil management and how ploughing and deep excessive tillage lead to unsustainable soil management and soil degradation by severe erosion. CA has its origin in the two main responses to the Dust Bowl: (1) conservation tillage and (2) no-till. Conservation tillage and no-till can be defined as follows:

- Conservation tillage:

  Conservation tillage can be seen as the umbrella term commonly given to direct drilling, minimum tillage and/or ridge tillage and is concerned with maintaining soil cover, increase water infiltration and reduce erosion (Knott, 2015). Alternatively, conservation tillage can be referred to as tillage practice that requires reduced tillage compared to conventional mouldboard ploughing (Reicosky, 2015).

- No-till:

  No-till refers to the sowing of seeds into the soil that has not been previously tilled in any way to form a seedbed (Knott, 2015).

There exists confusion surrounding the different tillage practices that are used in academic research on CA, and therefore there are some inconsistencies in results. Some tillage practices such as minimum tillage, reduced tillage and mulch tillage may in some instances fall under the conservation tillage definition, and may therefore be sometimes used in CA experiments (Knott, 2015).

CA can be formally described as an “approach to maintaining agro-ecosystems for improved and sustained productivity, increased profits and food security while preserving and enhancing the resource base and the environment” (Friedrich, Derpsch & Kassam, 2012).

CA is a holistic approach that is based on three interactive principles, namely: (1) crop rotation, (2) maximal or permanent soil cover and (3) minimum soil disturbance. When adopted successfully the interaction between these three principles can lead to many benefits for the producer as well as the environment.

2.2.2.1 Benefits of conservation agriculture

The benefits of CA are *numerous*. What originated from a response to poor soil management and severe soil erosion, has developed into a scientific and sophisticated practice. Today improved soil fertility, reduced soil erosion and compaction are only a small portion of the aims and benefits of CA (Erenstein *et al.*, 2012).

One of the most important indicators of sustainability is increased soil organic matter. Increased organic matter in the soil as a result of cover crops in crop rotation and retention of crop residues, improves the aggregate stability of the soil under no-till (Raiesi & Riahi, 2014). In the presence of mulch, combined with no-till, increased density in earthworm and other beneficial organisms' populations were also observed. Mulch protects the soil surface from direct solar radiation and provides greater resistance or protection against air flow, resulting in reduced water or moisture losses due to evaporation from the soil surface (Thierfelder *et al.*, 2014). Mulch and reduced soil disturbance increase biotic diversity in the soil, which produces higher levels of soil organic carbon than when soils are tilled (Du *et al.*, 2015).

Another direct consequence of CA, that improves the soil moisture content, is increased infiltration rates. An increase in infiltration rates is a direct result of a reduction in soil surface disturbance due to no-till. This leads to further continuity of macro-pores and higher biological activity (Thierfelder *et al.*, 2014). The benefits of having higher soil moisture levels are obvious as it translates into greater drought resistance and even early planting. Increased infiltration rates also bring about another important beneficial consequence: reduced water runoff, which ultimately translates into less erosion and environmental degradation (Mason *et al.*, 2015; Willekens *et al.*, 2014).

A major and important benefit of CA – which makes CA especially popular among producers - is the fact that it is physically cheaper in terms of time and money (Hobbs, 2007). After the initial capital investment has been made, for example, to buy a new no-till planter, it saves a lot of time and money as no other soil preparation is needed before planting.

More efficient weed control under CA has been reported (Hobbs, 2007). Although weeds can be a problem in some situations of CA, especially in the transition period from conventional agriculture to CA, crop rotations and cover crops (especially in the form of annual legume pastures) make it relatively easy to control weeds with efficient herbicide application. By planting annual legumes in the pasture phase of a particular piece of land, the producer is able to spray the weeds and pests with alternative chemicals because the legumes are genetically different from the usual cash crop. In the case when a livestock enterprise is present, grazing during the pasture phase contributes to weed control.

Plant residues seem to have a significant impact on soil crusting as the mulch avoids the direct impact of raindrops on the bare soil surface. The importance of interaction between the three basic principles of CA is emphasised by the fact that sufficient soil cover provides the best remedy for soil crusting and compaction under no-till.

The extent to which CA objectives are reached and translated into benefits for the producers varies among different settings and environments. Different climatic conditions, soil types and the degree to which the principles of CA are successfully applied may all influence the extent to which benefits are realised. The benefits from practicing CA in the Swartland, seems to be significant. Trials that have been conducted at the Langgewens experimental farm have shown that crop rotation systems combined with no-till and maximum levels of soil cover increase the average wheat yields (Figure 2.2), as well as gross margins per hectare (Figure 2.3). Table 2.1 shows a breakdown of the eight rotation systems included in the Langgewens trials for each year in the four-year cycle.

Table 2.1: Breakdown of crop rotation systems at Langgewens

System	Year 1	Year 2	Year 3	Year 4
A	Wheat	Wheat	Wheat	Wheat
B	Wheat	Wheat	Wheat	Canola
C	Wheat	Canola	Wheat	Lupin
D	Wheat	Wheat	Lupin	Canola
E	Wheat	Medic	Wheat	Medic
F	Wheat	Medic/Clover	Wheat	Medic/Clover
G	Medic	Wheat	Medic	Canola
H	Wheat	Medic/Clover with Saltbush	Wheat	Medic/Clover with Saltbush

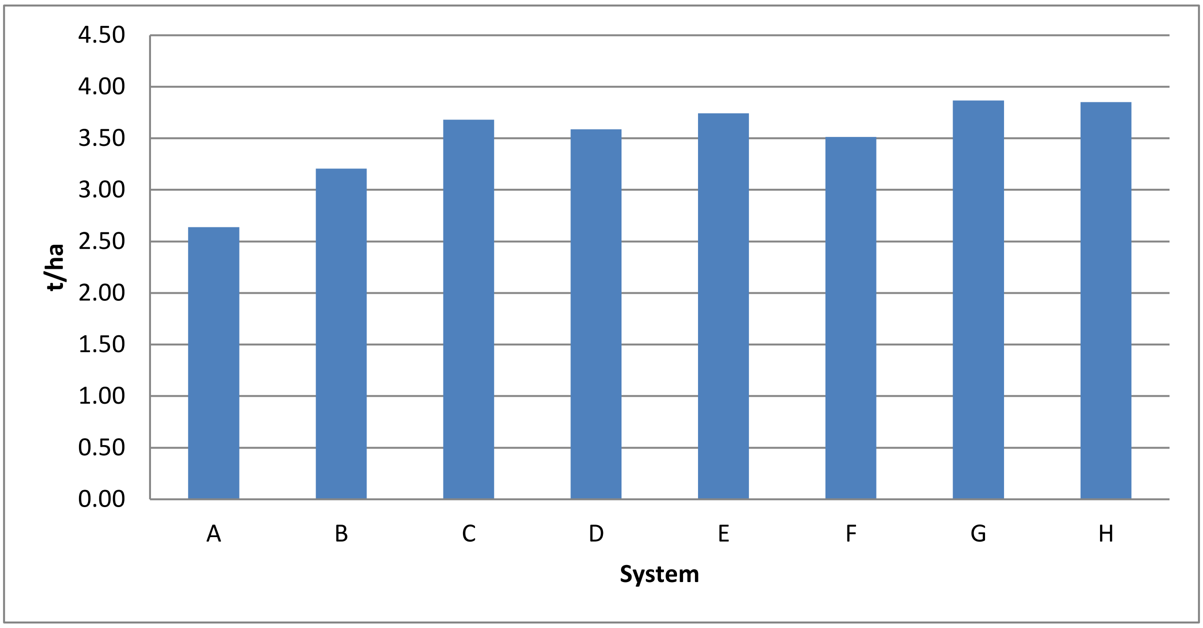

Figure 2.2: Average wheat yield of different crop rotation systems from 2002 to 2015. Source: Strauss (2014).

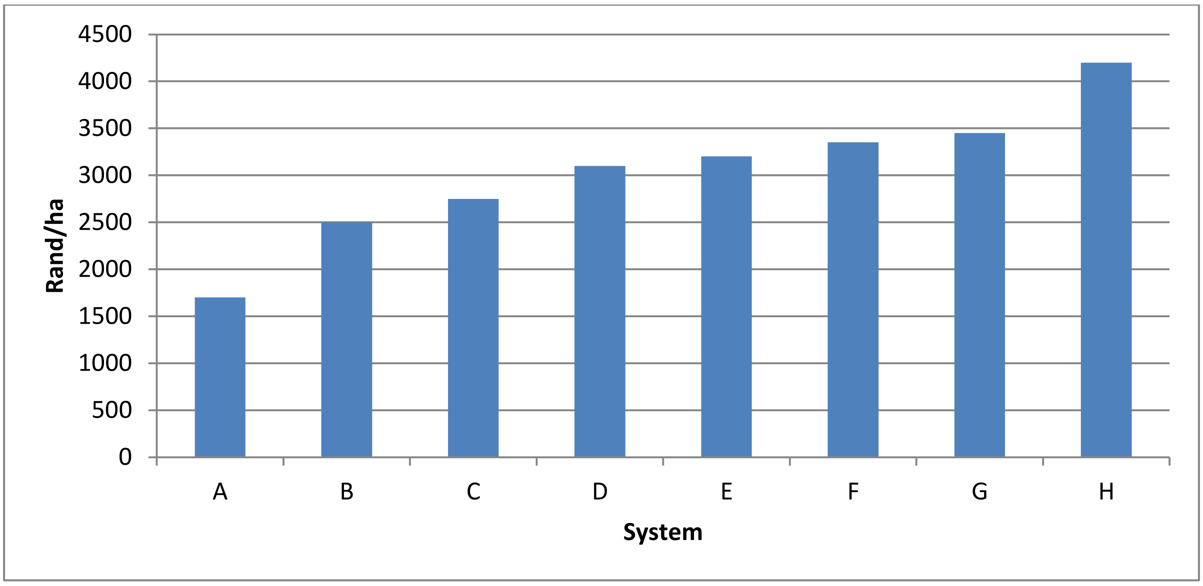

Figure 2.3: Mean annual gross margin (R/ha) for all rotation systems in the trial (2002-2015) Source: Strauss, Hardy & Laubscher (2010).

The benefits of CA can be considered without regard as to which principal of CA it specifically relates as the principals all interact. If the three basic principles of CA are implemented successfully, one may argue that CA advocates the philosophy of "feed the soil rather than fertilise the crop". This philosophy seems to be substantiated in the CA literature (Derpsch, 2001; Hobbs, 2007).

2.2.2.2 Conservation agriculture today

As stated earlier, CA has its origin in the two main responses to the famous American Dust Bowl of the 1930s. In the 1940s new developments to seeding machinery allowed for no-till and the theoretical concepts of CA were shaped. However, it was only 20 years later (in the 1960s) that no-till started to enter the United States of America (USA) as a farming practice and Brazil followed in the 1970s. From this early stage of no-till, Brazil has played a significant role in the development of CA as this was where producers and scientists transformed the no-till technology into the farming system that is today known as CA (Friedrich, Derpsch & Kassam, 2012).

The adoption of CA crop production systems has spread around the world exponentially since the 1990s and today there are only a few countries around the world where CA is not practiced at all. Friedrich, Derpsch & Kassam (2012) argue that CA became the fastest growing production system in recent years. Today CA is practised in many parts of the world under many different conditions: from dry (with rainfall less than 250 mm per year) to wet (3000 mm per year), from sea level to countries with a 3000 m altitude, on many soil types and on many different scales (Friedrich, Derpsch & Kassam, 2012).

The USA, Argentina, Brazil, Australia and Canada are the countries with the most hectares under CA (Friedrich, Derpsch & Kassam, 2012). What is further notable is that the area under CA in South America (Argentina, Brazil, Paraguay and Uruguay) makes for around 70% of total cultivated area in these countries. The significance of South America in terms of CA is further emphasised by the fact that 45% of the global area under CA is in South America.

South Africa is currently the largest adopter of CA in Sub-Saharan Africa (SSA) with 368 000 ha in total. Zambia (200 000 ha) and Mozambique (152 000 ha) are second and third respectively (Friedrich, Derpsch & Kassam, 2012). Ghana is currently the African country with the highest number of small-scale CA producers (400 000). Zambia has the second most CA small-scale producers (100 000) and Malawi the third with 5407 small-scale producers practicing CA (FAO, 2009).

In the Swartland, the adoption of CA has not been a holistic event as one should expect from a holistic approach to agricultural production. Different aspects of CA were individually implemented by some producers, and the rest followed subsequently. The need for crop diversification, instead of mono-cropping, led to the initial implementation of crop rotation systems, while no-till was adopted as a result of two events: Firstly, domestic wheat prices declining to world market levels in the 1990s, and secondly, the ability to spray pre-emergent herbicides as ryegrass became increasingly herbicide-resistant (Knott, 2015). The control of soil erosion may also have played a role in adopting no-till, as it remains one of the main driving forces for no-till adoption around the world (Derpsch, 2001). As a result of the shallow soils that characterise the Swartland, improving soil fertility is considered the main motivation for adopting CA in the Swartland, rather than conserving soil moisture as in other parts of the Western Cape (Knott, 2015).

In a recent study on the uptake of CA technology among Western Cape wheat producers, 49% indicated that they have implemented all three basic principles of CA, while 29% indicated that they have implemented no-till. Separate adoption of soil cover and crop rotation were both indicated to be 1.96% (Modiselle, Verschoor & Strauss, 2015). Figure 2.4 shows the CA categories as they have been adopted by these producers.

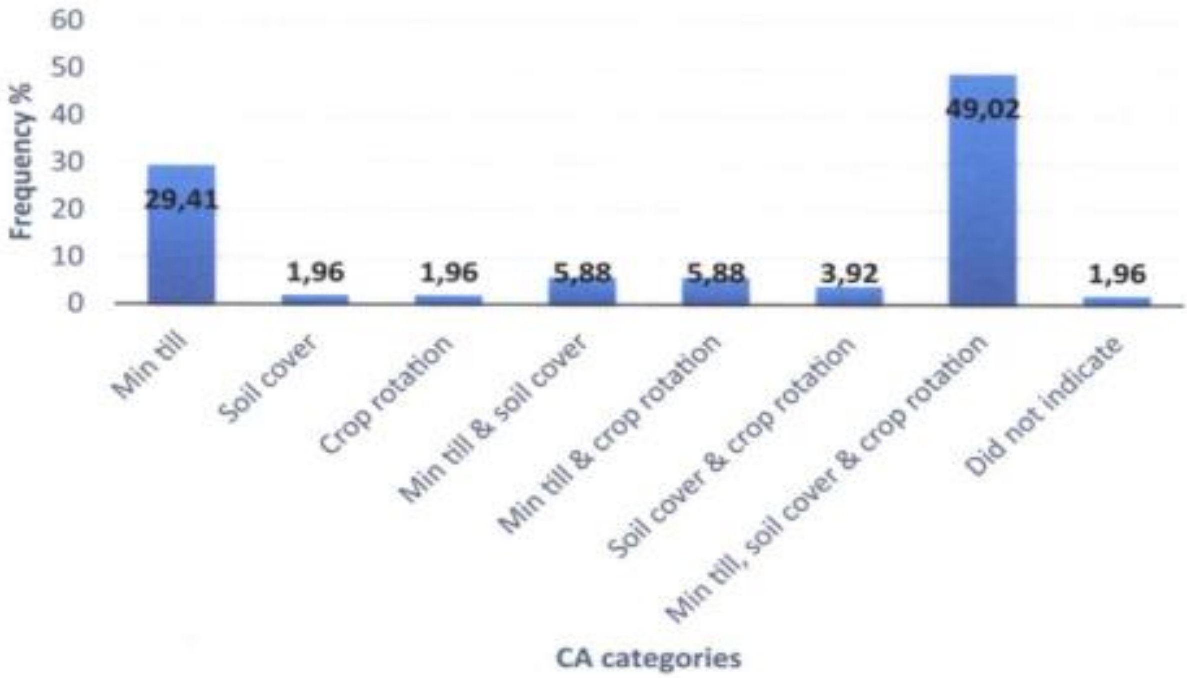

Figure 2.4: CA categories adopted in the Western Cape.
Source: Modiselle, Verschoor & Strauss (2015).

2.2.2.3 Constraints to the widespread adoption of conservation agriculture

CA is not a generic "one-size-fits-all" approach to agriculture. Although exciting and significant developments on the technological side of the CA spectrum were made over the last 35-40 years, there still are many other constraints to the widespread adoption of CA around the world.

CA goes against what most producers think and believe. A mental change is required of producers, technicians and researchers away from soil degrading tillage operations towards sustainable production systems. Producers' perceptions that soil has to be tilled in order to plant something poses a constraint to CA adoption.

Site-specific knowledge is one of the main limitations to the spread of no-till systems. As weeds may become a problem in a situation where a producer moves from conventional tillage to CA, the producer has to be up-to-date with the latest and most effective herbicides and application technology to control the weeds. Weed situations may differ from farm to farm, or even from one piece of land or one crop to another, therefore the process of converting to CA is very knowledge-intensive. The need for continuous interaction between producers, support groups and stakeholders is key in the process of CA adoption (Modiselle, Verschoor & Strauss, 2015). This poses some difficulty for the adoption of CA as traditional agriculturalists or other experts are not necessarily CA experts.

One of the most limiting constraints to the adoption of CA, is the retention of crop residues. This is especially appropriate in rural communities where livestock play an integral role in the community. It can also be the case when a producer that wants to adopt CA has an existing livestock component to his farming operation, or in a region where significant livestock numbers are farmed and there exists a market for the crop residues. This particular constraint and its implications are the main focus of this study and will be discussed in greater detail in the next section.

Soil types can be considered an important constraint to the adoption of CA, especially in terms of its impact on no-till adoption. For example, when soils are acid or contain toxic aluminium, lime application as remedy can be a problem under no-till as the lime can't be incorporated into the soil. However, this may only be a problem in the early stages of CA adoption when infiltration rates are still relatively low. Lime application in the year before entering CA is therefore suggested, as it would be the last opportunity to incorporate it (Derpsch, 2001). Increased infiltration rates have been shown to allow unincorporated lime to move into deeper soil layers (Derpsch, 2001). Therefore, this problem should become less significant within a CA farming system as time goes by.

2.2.3 The need for crop-livestock integration

The integration of crops and livestock should be regarded as a means by which other synergistic objectives can be achieved, rather than being an objective in its own right. The degree to which crop and livestock is integrated on a particular farm is a result of decisions that encompass both strategic and tactical considerations, and may be influenced by biophysical as well as socio-economic objectives and constraints (Bell & Moore, 2012).

Producers are generally considered risk-averse, which makes risk mitigation one of the key incentives for integrating livestock into their cropping system (Bell & Moore, 2012). In the case of larger farms, and typical in the Swartland, substantial variability in land capability occurs. Exploiting the spatial variability by implementing the enterprise (or sequence enterprises) that maximises profit can be considered another important and relevant incentive for crop-livestock integration.

In addition to the reduction in risk exposure and possible income stabilisation, CA producers may want to have a livestock component in their operations to complement the CA production system and the benefits thereof. The flow of nutrients is modified and accelerated by animals that, through grazing, can be seen as catalysers. Of the plant nutrients that are ingested as plant biomass by grazing animals, 70%-95% is returned to the soil as manure and urine (Martins *et al.*, 2014). Increased root exudation, which affects the rhizosphere community and increases plant nitrogen availability, can be the result of defoliation through grazing (Mills & Adl, 2011). Other studies have also shown that both nitrogen (Ilmarinen *et al.*, 2005) and carbon (Hokka *et al.*, 2004) allocation to roots, as well as nematode community dynamics (Mikola *et al.*, 2001) seem to be affected by the grazing intensity. If the livestock are managed in a proper manner that prevents compaction due to trampling and over-grazing, the livestock and CA principles combined may lead to a significant decrease in input costs such as fertiliser, lime and herbicides (FAO, 2009).

The establishment of annual legume pastures plays an integral role in achieving these kinds of biological objectives of crop-livestock integration. Soil organic matter has been shown to be increased by medics and clovers, while these crops can also provide between 40kg to 100 kg nitrogen per ha, of which up to 40% may be available to the subsequent crop (Strauss, Hardy & Laubscher, 2010). The nitrogen that is supplied by the legumes is also more effectively retrieved by wheat compared to surface applied nitrogen fertiliser under certain conditions (Strauss, Hardy & Laubscher, 2010; Wiltshire & Du Preez, 1993). Another important effort and cost saving benefit of the inclusion of annual legume pastures is effective weed control. Grass weeds can relatively easily be eliminated during the pasture phase through removal or applying relatively cheap chemicals to which resistance has not yet been built. This would limit or prevent the addition of grass or weed seeds to the seed bank, and therefore limit the potential for grass or weed contamination and competition, reducing costs, and increasing yields of the subsequent grain crop (Strauss, Hardy & Laubscher, 2010). A further implication of the introduction of an annual legume pasture is the decrease in mechanical soil disturbance, while increases in soil carbon content have also been reported (Strauss, Hardy & Laubscher, 2010).

Livestock-induced compaction in mixed crop-livestock farming systems has gained much research attention (see for example Bell *et al.*, 2011; Mills & Adl, 2011; Southorn & Cattle, 2004; Thornton & Herrero, 2001; Tom *et al.*, 2006), however not always from a CA perspective. Soil disturbance due to livestock trampling in a functioning CA farming system is an important issue when one wants to consider introducing annual legume pastures with sheep into a CA-based farming system, and will be discussed in greater detail in Paragraph 2.2.4.3.

There are many direct links between annual legume pastures and the production of cereal grains in the same, as well as the subsequent year. Annual legume pastures can provide beneficial possibilities with regards to subsequent cash crop production, including lower financial risk by obtaining higher or similar gross margins with lower input costs (Strauss, Hardy & Laubscher, 2010).

However, some of these benefits, such as increases in nitrogen and carbon levels in the soil may not be immediately evident, and may therefore, from a financial perspective only be significantly beneficial in the medium to long-term. By utilising the ability of the annual legume pastures and increased levels of crop residue due to CA practices to accommodate livestock, CA producers may want to integrate a livestock component into their farming operation. The livestock component would be the key to gain short to medium term economic benefits from establishing annual legume pastures as cover crops, while also providing the opportunity for increasing income, reducing risk and increasing profitability. However, the integration of livestock into a CA farming system poses some issues regarding possible soil disturbance and compaction due to trampling, and also the grazing of crop residues and cover crops that are supposed to serve as soil cover or mulch.

2.2.4 Conservation agriculture principles and livestock's impacts on each

The three principles of CA interact with one another and there are direct links between each of them and livestock in an integrated mixed crop-livestock system within a CA farming context. The three main principles of CA are discussed below in terms of their relation to CA as well as to livestock.

2.2.4.1 Crop rotations

Crop rotation systems allow the producer to achieve crop diversification in his farming operation. Crop diversification through crop rotation systems can be in the form of introducing cover crops, or even a new cash crop. The former would enable the producer to increase the levels of soil cover on his farm and reap the benefits thereof. The latter may decrease his exposure to risks associated with the production of a particular cash crop. Crop residues from cash crops as well as cover crops have potential to be fed to, or grazed by livestock (Hoffmann, 2001). Therefore, one of the most important attributes of crop rotation systems is that it may enable the producer to add a livestock component to his farming operation. This creates an opportunity for the producer to enhance nutrient cycling, to realise short to medium term income from cover crops or legume pastures and to provide some extent of income stability.

Crop rotations therefore provide a great alternative to monoculture, which have been shown to be less profitable and more risky compared to wheat monoculture in the Swartland (Hoffmann, 2001; Modiselle, Verschoor & Strauss, 2015).

2.2.4.2 Soil cover

Sufficient levels of soil cover can be obtained in two ways: First, the planting of cover crops during a pasture phase in a crop rotation system, and second, the retention of crop residues after the cash crop harvest. Although the lowest level of soil cover for a particular setting that is regarded as sufficient for CA purposes may be quite difficult to establish, and may vary significantly, a soil surface cover of 30% at plant emergence is usually regarded as sufficient (Hobbs, 2007).

Sufficient levels of soil cover hold many possible benefits for the producer and the environment (Hartwig & Ammon, 2002), including:

- A reduction in water run-off (and ultimately a reduction is soil erosion);
- Increased levels of organic matter in the soil;
- Improved soil structure;
- Fixing of atmospheric nitrogen (in the case of many legume cover crops);
- More effective weed control;
- Greater soil productivity.

It is important to understand that these benefits are optimized when attempts to increase the levels of soil cover are made in conjunction with crop rotations and minimum soil disturbance.

In general, crop residues are considered agricultural by-products (Erenstein, 2002). However, for a CA producer crop residues are likely to become a valuable way to increase soil organic matter and cover without, or in addition to, incorporating cover crops into his rotation system. Organic matter and soil cover play an important role in dealing with compaction. Therefore soil degradation caused by grazing livestock, organic matter and soil cover levels are directly impacted by livestock as they would be feeding off the soil cover. Reaching sufficient levels of soil cover in a mixed crop-livestock farming system may therefore be difficult. The opportunity cost of not using crop residues and cover crops as livestock feed, increases significantly in the presence of livestock. The higher opportunity cost of soil cover in mixed crop-livestock systems poses possible trade-offs and difficulties with regards to livestock grazing and/or feeding within the CA environment.

There are three main factors that determine the intensity of these trade-offs (Turmel *et al.*, 2015). The first is the benefits vs. the opportunity costs of residue retention. The second is the intensity of the production system, and the third is the existence or absence of alternative functions livestock are playing in addition to the production of animal products.

In mixed crop-livestock systems, the benefits vs. the cost of the residue retention depend on the value of the crop residue as soil amendment vs. its value as feed. The value of crop residue as soil amendment depends on several agro-ecological and socioeconomic factors (Giller *et al.*, 2011). Although the value of crop residue as feed depends mainly on wool and meat markets, as well as prices of substitute feed, the value of crop residues as feed is also influenced by other functions of livestock, besides its production function. These can include the cycling of nutrients through manure, inflation-proof saving and insurance.

In order to develop a strategy to successfully integrate livestock and CA, one should look at possibilities to address the high opportunity cost of residue retention for CA purposes. Although CA practices would increase soil organic matter and soil cover, having livestock grazing on pastures planted with cover crops or on cash crop residues would result in residue extraction. Complete residue extraction would mean soil cover levels that are insufficient for CA purposes. Therefore partial residue extraction would be the only possibility to successfully permit livestock feeding, while at the same time retaining sufficient levels of crop residue for soil cover. This leads to the problem of establishing sufficient levels of soil cover. One indicating threshold that is generally accepted, is that at least 30% of the soil surface should be covered by organic residue by the time of plant emergence (Erenstein, 2002). Livestock within a CA system may thus only be allowed to consume crop residue up and until a level that would be sufficient to cover 30% of the soil – with residue weathering taken into account. Residue weathering encompasses both natural decomposition, as well as residue removal by natural elements (Erenstein, 2002).

Considering the above, it becomes clear that the integration of a livestock component into a CA system may bring about higher opportunity costs, and therefore important trade-offs. Developing a strategy around partial residue extraction for livestock may provide a possibility of successfully dealing with the high opportunity cost of leaving crop residues on the field.

2.2.4.3 Minimum soil disturbance

Soil disturbance in crop and/or livestock production systems can be caused by two important factors: (1) Tillage and (2) livestock trampling. The latter may lead to some extent of disturbance of biological activity in the soil, but its greatest cause of disturbance seems to be its effect on soil physical properties. There exists a direct link between the possible negative impacts of livestock trampling on soil physical properties – which is most commonly a cause for soil compaction - and tillage as an obvious remedy for this livestock-induced compaction. Soil compaction can be described as a process where the volume of a given mass of soil changes due to an applied load (Kuncoro *et al.*, 2014).

This study focusses on the integration of livestock within a CA farming system, hence tillage is not regarded a remedy for soil compaction. The extent to which livestock trampling may lead to significant soil compaction should be reviewed. If livestock-induced compaction is insignificant and does not affect the yields of subsequent cash crops, or if it's possible to manage the livestock in order to prevent significant compaction, there would be no need to consider tillage. This would prove it possible for the producer to practice no-till and integrate livestock. In this case there would be no concern regarding the minimum soil disturbance principle of CA in a mixed crop-livestock production system.

As mentioned, tillage and livestock trampling are the two main causes of soil disturbance in a mixed crop-livestock system. In order to clarify whether or not it is possible to successfully practice the minimum soil disturbance principle in such a system, each are discussed below in greater detail.

Tillage and soil disturbance are inseparable from each other: Tillage is by definition disturbing the soil (Botha, 2013). For ages producers have believed that soil has to be tilled in order to plant and produce crops. However, with the introduction of concepts such as no-till and conservation tillage, the contrast has also been proved to be true. It is however important to note that many factors – of which soil type is probably the most important – influence the issue of whether or not tillage is the most appropriate technology to be used in a particular setting (Derpsch, 2001).

Tillage practices are commonly adopted throughout the world for many reasons (Hobbs, 2007), including:

- To incorporate previous crop residues, weeds, or soil amendments;
- To prepare a seedbed;
- To control several soil- and residue-borne diseases and pests;
- To provide relief from compaction (although in some cases only temporarily); and
- Tillage is aesthetically pleasing in terms of look and smell.

However, despite the many benefits of tillage, there are also a few problems associated with tillage, which have to be bared by the producers or the environment. The problems associated with tillage include (Hobbs, 2007):

- Costliness in terms of fuel, wear and tear on equipment, cost of operator;
- Soil organic matter is oxidized when exposed to air, resulting in a reduction of organic matter content in the soil (when no additional organic matter is returned to the soil);
- Disruption of pores that were left by roots and microbial activity;
- Bare soil surfaces are prone to breakdown of soil aggregates;
- Clogging of soil pores;
- Reduced infiltration rates and increased water run-off (which may lead to soil erosion); and
- Possible surface crusting, which forms a barrier to plant emergence.

All of the above mentioned problems often form part of the counter argument in favour of no-till, especially when combined with crop rotation and sufficient levels of soil cover (Derpsch, 2001). Tillage is not the only cause of soil disturbance. In mixed crop-livestock farming systems, soil disturbance can also occur in the form of soil compaction and altered soil physical properties caused by livestock trampling.

When the opportunity to integrate CA and livestock into a mixed crop-livestock system exists, the possible impacts of livestock on CA practices and its objectives should be carefully considered. If one is to develop a strategy to integrate livestock and CA in a mixed crop-livestock system, the issue of compaction due to livestock trampling should be considered and evaluated in order to determine whether or not it’s possible to integrate CA and livestock without creating problems of soil disturbance.

Minimum soil disturbance is one of the fundamental principles of CA, and as a result no-till and other traffic-controlled cropping systems have been widely adopted around the world in order to gain the benefits from reduced machinery compaction. Small livestock, such as sheep, have a similar static pressure to the nominal tyre and track contact of unloaded tractors and vehicles, and as a result questions about the potential impact of grazing livestock on soil physical properties and subsequent crop growth were raised (Bell *et al.*, 2011). The compaction effect of livestock is generally shallower than for vehicles. It is still important to consider the changes in soil physical properties due to livestock grazing as these changes may contribute to the intensity of trade-offs between the benefits of keeping livestock and the possible decreases in yields (and therefore profits) of the subsequent cash crop.

The key factors determining the impacts livestock have on soil compaction are the effects of different stocking rates, grazing patterns and rest periods on the populations of soil organisms, and soil physical properties. In a study where three different grazing practices - (1) a conventional set stocking (SS), (2) a high intensity-short duration (HI-SD), and (3) an un-grazed control were compared in terms of the populations of soil organisms, earthworm numbers were found to be unaffected by grazing regimes (Tom *et al.*, 2006).

The three most important soil physical properties that may be altered by grazing livestock and have an impact on the growth of the subsequent cash crop are: (1) increased soil strength and bulk density, (2) reduced soil macro-porosity, and (3) reduced soil hydraulic conductivity and infiltration rates (Bell *et al.*, 2011).

Although it has been shown that the surface soil bulk density and soil strength of untilled soils are consistently increased by grazing livestock (even with various stocking rates, livestock species, soil moisture levels and soil types), livestock grazing does not seem to affect these properties at deeper layers (Bell *et al.*, 2011, Hunt *et al.*, 2016). The deeper layers of the soil seem to be affected in terms of soil strength and bulk density by livestock trampling only after recent tillage (Bell *et al.*, 2011). Therefore, as no-till is inherently part of sound CA practices, the only concern regarding soil bulk density and soil strength as influenced by livestock trampling, is the soil surface.

Soil porosity, particularly macro-porosity is a sensitive indicator of soil physical condition, as it is important for soil aeration and water movement into and through the soil (Bell *et al.*, 2011; Bilotta, Brazier & Haygarth, 2007). Soil macro-porosity can be significantly influenced by livestock grazing. It has been shown that soil macro-porosity is typically reduced between 10% and 40% in wet conditions with high stocking rates (Bell *et al.*, 2011). However, these reductions are only of concern in the surface layer of the soil, as they significantly decrease with depth (Bell *et al.*, 2011; Hunt *et al.*, 2016).

Trampling by livestock has been shown to decrease infiltration rates of bare soil, with stocking intensity having an impact on the intensity of the reduction (Bell *et al.*, 2011; Bilotta, Brazier & Haygarth, 2007). However, despite the possible reduction in infiltration rates, livestock grazing has not really been proven to affect the accumulation of soil water. The reduction in infiltration rates could, to some extent, also be limited by retaining sufficient levels of ground cover (Bell *et al.*, 2011), which should not be a problem under CA.

Researchers and scientists have very sophisticated tools to measure soil compaction. This makes it easy for them to demonstrate that soils are more compact under certain conditions than other. Producers seem to be evaluating the degree of soil compaction in terms of crop response and yields (Derpsch, 2001). Therefore, when a producer makes a controversial change to his farming operation that could lead to possible soil compaction, soil compaction would not be an issue if his yields were to remain the same or increase (Derpsch, 2001). This argument could even be further extended when the relevant change to the producer's operation involves short-term economic returns. The addition of a livestock component may provide the opportunity to realize short term economic returns. If soil compaction due to the livestock grazing during the pasture phase were to lead to decreases in yields of the subsequent cash crop, compaction may not even in the case of decreasing yields be an issue for the producer, as long as the benefit gained from the addition of livestock is great enough to offset the decrease in crop profit margins that resulted because of the livestock compaction.

Subsequent crop growth and yields however do not seem to be influenced by the structural degradation of the soil due to livestock grazing (Hunt *et al.*, 2016). The persistence thereof is too small in either magnitude or in depth (Bell *et al.*, 2011). Therefore the increase in surface soil bulk density and soil strength caused by livestock trampling should not have any significant effect on the growth of the subsequent crop. This means the addition of a livestock component may indeed provide net benefits to the producer because of the insignificant risk of physical degradation of the soil due to livestock trampling.

Although there is evidence that the presence of livestock can affect soil quality, the same can't be said of the relative impacts of different grazing tactics. It has been shown that livestock effects are cumulative over time and that stocking rates seem to have no impact on soil physical properties in the long run (Southorn & Cattle, 2004).

The risk of soil compaction increases as soil water content increases. This might be the reason why the impact of trampling on soil physical properties was observed to be greater when the livestock were grazing during periods of high surface soil moisture (Bilotta, Brazier & Haygarth, 2007). Damage to soil physical properties, or structural damage, could be minimised by removing the livestock during (or after) rain for brief periods (Proffitt, Bendotti & McGarry, 1995). This could typically be done by implementing a grazing strategy that requires more intense management than continuous grazing, or by keeping the livestock in a dedicated pasture that will never be planted or in a shed.

Controlled grazing systems, where the livestock are removed for brief periods from a certain pasture, have proved to be more likely to improve soil resistance to compaction due to livestock trampling than continuous grazing (Proffitt, Bendotti & McGarry, 1995). These periods in which the livestock are kept off the particular pasture (i.e. rest or withholding periods), would be determined by the recovery capability of the soil and climatic conditions (Drewry, 2006). The rest periods should not be long-lasting, as compaction due to livestock trampling is shallow (Bell *et al.*, 2011). The natural recovery period will also depend on the wetting-drying cycles and the level of biological activity. Therefore, natural recovery tends to be slower in areas with less frequent wetting-drying cycles and lower levels of biological activity (Bell *et al.*, 2011).

Soil organic matter seems to be an important and useful mechanism to limit soil degradation. Soils with higher levels of organic matter and surface residues tend to have a greater capacity to bind soil particles and maintain the stability of aggregates (Greenwood & McKenzie, 2001, Soane, 1990). Soil compaction caused by livestock trampling would be a greater risk for a conventional mixed crop-livestock farming system where high levels of organic matter is not pursued, or in CA systems where the livestock are allowed to graze off too much of the soil cover - which leads to insufficient levels of organic matter and crop residue on the surface. Plant roots can also help to limit soil compaction, as the roots reinforce the soil by producing macro-pores in the soil and assist stabilisation of the soil structure (Greenwood & McKenzie, 2001). Cover crops in pastures are planted in autumn in the Swartland. The roots, organic matter and soil cover in the pastures would suggest greater resistance to compaction due to trampling during the wet winter months than an unplanted soil.

It is clear that soils with higher organic matter and that are better structured, are less affected by livestock grazing than soils with low organic matter, which are poorer in aggregation or conventionally tilled. As a result the possibility to successfully integrate livestock and CA becomes greater. The successful integration of livestock and CA with compaction not being an issue seems to be directly related to the successful implementation of CA principles. The retention of sufficient levels of soil cover and organic matter, together with crop rotation and rotational grazing systems, and no-till planting seem to be the answer to ensure that the possible compaction by livestock trampling is insignificant enough to not conflict the CA principle of minimal soil disturbance.

Livestock may cause problems for CA when the CA principles are not sufficiently implemented and practised. Sufficient and sustained implementation of CA practices is important to establish strong inter-linkages between the CA principles. This makes the integration of a livestock component possible. Thus, the better CA is practised, the greater the opportunity to integrate livestock.

CA proved to increase yields and decrease input costs, therefore increasing gross margins for wheat in the Swartland. Through implementing a livestock component and successfully integrating it into a CA farming system, the producer's exposure to risk may be further reduced, while his income and profitability are likely to increase. Livestock may also contribute positively to CA objectives and have the possibility to lead to synergies when correctly combined with CA.

Just as there are many benefits to the integration of livestock and CA, there are many possible concerns and trade-offs. The greatest trade-offs may be in the decision to use crop residues for soil cover or for other activities such as feeding livestock, and possible soil compaction due to livestock trampling. The former may be the most significant because the opportunity cost of leaving crop residues for soil cover instead of using it to feed livestock may be too high for a producer to practise all three principles of CA successfully and sufficiently, while the latter seems to be fully manageable (either through controlled grazing or feedlots).

Given the large capital investment and the infrastructural changes required by an intensive livestock management approach where the livestock are kept off the land (i.e. in feedlots) in order to prevent compaction, it may seem equally attractive to explore the possibility of a grazing system that could be followed in a CA context. The grazing system should be accommodated by the crop rotation system and encompass two things in order to optimise the benefits and objectives of an integrated CA crop-livestock system: (1) Sufficient rest periods of pastures and (2) only limited extraction of soil cover.

When considering the above, there is enough substance to the argument that livestock can be accommodated within a CA system. The success of integrating livestock and CA in terms of the possible benefits gained from each would be dependent on successfully establishing a suitable livestock management approach, and therefore, also on the managerial ability of the producer.

2.3 Method

The previous section of Chapter Two gave an overview of the relevant literature used to establish a point of departure for developing a strategy to integrate livestock and CA farming systems. The possible synergistic benefits as well as the boundaries of crop and livestock integration within a CA system have been laid out.

The purpose of this study is to financially analyse three different livestock management approaches applied to different crop rotation systems on whole-farm level for the typical Middle Swartland farm. These strategies are made up from various smaller components that are all linked and work synergistically to the success of the system as a whole. This section will focus on the relevant methods used to gather and quantify the data necessary to analyse and compare the livestock management approaches and rotation systems on whole-farm level.

2.3.1 Systems thinking

In the strategies to be analysed in this study, there is a relatively high degree of complexity. This complexity is brought about by the many different variables and components that are all linked in such a way that even small alterations or changes in one, are likely to impact the outcome of another, or of the entire holistic system.

Traditional evaluations of production systems such as these of importance for this study were largely through reductionist approaches. A reductionist approach is insufficient for the purpose of comparing holistic systems with each other. In reductionist studies a component in isolation is the objective of the study. Reductionist studies neglect to capture the links between components. Knock-on implications that components can have on each other and on the outcome of the whole system are ignored (Knott, 2015).

The main reason that the evaluation of sustainable agricultural systems requires a systems approach is because whole-farm systems have properties, qualities and characteristics that are not present in their constituent components (Ikerd, 1993). Agricultural production systems are concerned with turning various forms of inputs and other components of the entire system into more valuable products. Production is a physical process. Value creation is, however, not only achieved by altering the form of things through physical production, but also by affecting the time, place and individual possession dimensions of things. This is achieved through a rearrangement process of the physical form of things. The mere total of all these inputs and constituent components added together does not represent the end result of the entire system. The arrangement of these constituent components is rather what leads to a result of an entire system (Ikerd, 1993). The process of rearranging resources, inputs and constituent parts of a system, is referred to as the process of synergism.

For example, when the constituent components and inputs of a particular crop rotation system have been rearranged, the system represents a particular temporal sequence of farming practices within a given spatial context. When the particular sequence of crops is followed, benefits like increased yields, reduced soil erosion, nitrogen fixation from the air and soil protection from heavy rains may occur. However, if the same crops were being continuously produced in a separate field, it may lead to lower profits, higher environmental risks and lower production than in the case of producing the same crops in a particular rotation or sequence. The added benefits of the rotational cropping are therefore due to the temporal arrangement (Ikerd, 1993).

For the purpose of this study the complexity and the interrelatedness of the different components of the agricultural systems of interest, are important. These components include, among others, the ecological region, the links between crops and livestock, fertilisation, mechanical processes, marketing systems, product prices and input costs (Knott, 2015). To enhance informed decision making, the whole system has to be evaluated. A systems-thinking approach allows for this and would thus be necessary to make clear and credible comparisons between the production systems of interest for this study.

Producers face many short-term tactical, as well as medium to long-term strategic challenges. Producers experience these challenges across different disciplines, knowledge bases and value systems, and therefore require inputs and involvement from many different stakeholders and role-players to address these challenges. One way of getting the various role-players like researchers, scientists, other producers, businesses, etc. involved, is through the use of multi-disciplinary group discussions.

2.3.2 Multi-disciplinary group discussions as research method

A key contribution of the systems approach is that it presents an opportunity to integrate information that may already exist but have become fragmented because of specialisation. Multi-disciplinary expert group discussions - as a technique of the systems approach - are particularly useful in this regard.

Group discussions, where experts from various disciplines in a particular industry are present, can be a useful tool in the research process. For the purposes of this study, a multi-disciplinary group discussion was used to validate assumptions and parameters of the typical farm budget model that was constructed for this study. The validation process through a multi-disciplinary group discussion had three main objectives: First, to get experts from various fields and disciplines in the relevant industries together, in order to present and validate the original data and stimulate conversation. Second was to gain valuable inputs from the experts in the discussion in order to establish consensual assumptions and parameters. Third, was to have all the experts agreeing on the final assumptions and parameters of the model after the necessary changes could be made.

The original data that was captured in the budget model and presented to the expert members of the group discussion was obtained from the Langgewens trial data and consultation with industry experts.

2.3.2.1 The panel of experts

The process of compiling a panel of experts for the group discussion was based on selected criteria. A panel from various disciplines relevant to have sufficient contributions and outcomes was identified and invited. In order to identify the relevant disciplines in the industry that are required for the group discussion, it was important to consider the main objective of the study. As the objective of this study was to financially analyse different CA based integrated crop-livestock farming systems, it became clear that not only experts from the grain industry were required. Experts from the livestock industry also had a valuable part to play in the research process. Furthermore, the value of a multi-disciplinary group discussion was specifically embedded in the presence of experts with alternative opinions.

The main objective of this study necessitated that producers and researchers from the particular region had to be present. Technical experts were also required for the group discussions because of their knowledge on the latest technological innovations and the costs thereof. It was important to include experts who were up to date with the latest knowledge on the particular topic. The scientists contributed to the understanding of input-output relationships on the whole-farm, as well as the interrelatedness of crop and livestock systems. Producers in the region were used to provide input and guidance in order to maintain a good balance between proposals on assumptions and parameters, and the practical feasibility thereof. They contributed to the physical description and mechanisation needs of the typical farm. The agricultural economists provided valuable knowledge on factors that influence farm profitability and the transformation of physical-biological data into financial data. Agricultural economists especially contributed to the discussion in terms of trade-offs between capital investments in livestock and machinery.

The following people were present at the expert group discussion:

Mr. Sameuel Laubscher – Manager of Langgewens research farm.

Dr. Johann Strauss – Plant scientist at the Department of Agriculture: Western Cape and coordinator of the long-term crop rotation trial at Langgewens.

Prof. Schalk Cloete – Animal scientist at the Department of Agriculture: Western Cape.

Dr. Buks Olivier – Scientific manager of the Directorate Animal Sciences at the Department of Agriculture: Western Cape.

Mr. S.G. Basson – Producer.

Mr. Abrie Richter – Producer.

Mr. Wynand Heunis – Agricultural economist at Overberg Agri in Moorreesburg.

Mr. Rens Smit – M.Sc. Agronomy student at Stellenbosch University

Mr. Johann Boonzaaier – Agricultural economist at BFAP.

Mrs. Annelene Swanepoel: Scientific manager of the Directorate Plant Sciences at the Department of Agriculture: Western Cape.

Dr. Willem Hoffmann – Agricultural economist at the Stellenbosch University.

2.3.2.2 The group discussion

The group discussion took place on the 15th of June 2016 at Langgewens. The session included a visit to the trial sites. The background information of the study and the topics for discussion were outlined in an information sheet that was sent out with the invitations to all participants three weeks prior to the discussion. The information included parameters and data used in the construction of the whole-farm budgeting model. These parameters were suggested by role-players from the industry and based on trial data. This provided the participants with enough information and time to prepare for the discussion.

During the group discussion a brief introduction on the topics to be addressed during the workshop was presented. All participants had the opportunity to discuss the presented information, to provide critical inputs and to make suggestions. The suggestions that were made were then open for discussion until consensus has been reached on each topic. The main topics discussed at the workshop were the physical and financial extent of the typical farm. The proposed approaches to livestock management that could be followed to incorporate a livestock component into a CA based mixed farming system were discussed in detail. Lastly the different input variables needed for determining whole-farm profitability required attention. With regards to the physical and financial extent of the typical farm, specific aspects that required attention included the farm size, the typical portions of arable and fallout land, the infrastructure and mechanisation requirements to sustainably operate the typical farm, as well as the land price.

The different approaches to livestock management received much more detailed attention. The initial strategies were identified through consultation with role-players from the industry. The proposed strategies were discussed in depth and important parameters and variables regarding the grazing strategy were determined. These included the stocking rate, herd composition and certain product prices and costs of the typical Middle Swartland farm with the maximisation of CA benefits as underlying basis. Concern about the intensive approach was expressed. The experts agreed that a herd-approach would not be practically feasible in an intensive feedlot context. It was suggested that the intensive approach should rather be a lamb speculation strategy. Consensus on the relevant variables and parameters regarding such an approach was reached. Further suggestions and concerns about the trade-offs between livestock and CA practices led to the development of a third strategy. In this strategy medic pastures are financially successful without the presence of livestock in the same farming system. This approach would mean that medics are sold to neighbouring farms and, therefore, treated as a cash crop in the crop-pasture systems.

Other topics that received attention during the workshop were the frequency of seasonal variability in rainfall and the impacts thereof on crop yields, as well as the prices and costs of certain products. The seasonal variability was categorised in terms of good, average and poor years. The prevalence of good, average and poor years for wheat, canola and medics was suggested and accepted by the experts.

The expert group contributed significantly to the process of validating strategies and data obtained from the Langgewens trial as typical to the area. However, further consultation with some of the experts present at the workshop, as well as other experts in the industry was necessary to obtain and validate outstanding information. This included many of the practical arrangements, prices and costs regarding the intensive speculation approach.

2.3.3 Whole-farm, multi-period budgeting as a financial simulation tool

2.3.3.1 The typical farm model

Farms or farming units differ all over the world between countries and even between different regions within countries. As this study focusses on how certain production systems within a specific area compare, the use of a typical farm model is well suited for this study. The multi-period attribute of a whole-farm budget model is particularly important because the implications of different systems are usually seen over the longer term, especially where crop rotation and livestock are concerned.

A model can be defined as “a simplified representation of the real world, based on an ordered set of assumptions and observations” (Knott, 2015). When using the typical farm model, the results and findings that come out of the model can be regarded as typical to the area of interest. Given this, it’s practicality and the fact that models are relatively easily understandable to producers, make typical farm models ideal research tools (Knott, 2015).

The typical farm model has three key components. The first is where all the model data inputs are built into the model. These include inflow variables (like farm-gate prices, and crop and livestock yields), outflow variables (variable costs, overhead costs, intermediate capital, land and fixed improvements) and all operational assumptions. The second is the calculations part where gross margin analysis of the each system, and overhead cost and asset replacement calculations are done. The final component of the typical farm model is the information outputs. In this component a multi-period budget, total inflow and total outflow, total gross margin of the farm business, net annual flow, internal rate of return (IRR), net present value (NPV) and the cash flow are calculated and shown (Mugido, Kleynhans & Hoffmann, 2012). The three components of a typical whole-farm, multi-period budget model are graphically expressed in Figure 2.5. Constructing such a model in a spreadsheet programme integrates the physical-biological farming system with standard accounting principles.

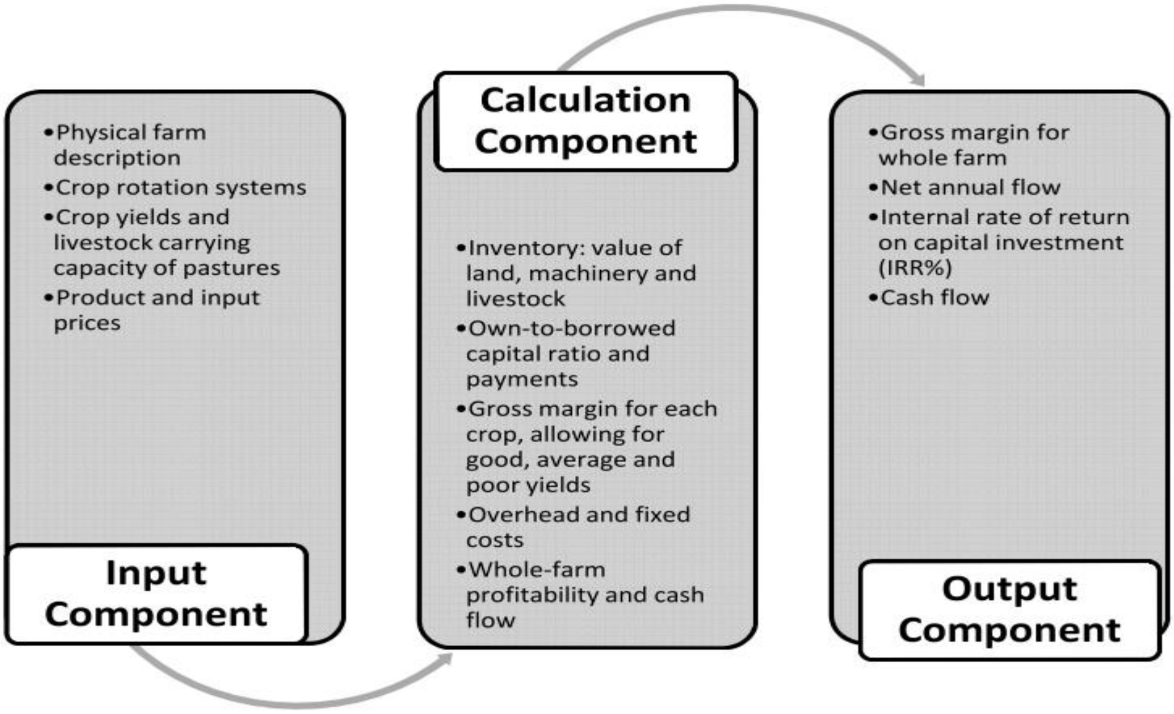

Figure 2.5: Graphic representation of components of a whole-farm, multi-period budget model. Source: Hoffmann & Kleynhans (2011).

The research process when developing a typical farm model has three distinct phases (Hoffmann & Kleynhans, 2011): Model construction, model validation and model utilisation. The scientific knowledge base for this study was formed by the research data of trials conducted at Langgewens and expert knowledge, while the utilisation of the model was based on lay knowledge.

2.3.3.2 Type of model and model requirements

Deterministic and stochastic models are the two basic types of models. The appropriate one to use for particular research depends on the type of system that has to be modelled and what the main objective of the modelling or simulation exercise is. When a systematic approach is being followed, a deterministic model is best suited as probabilities of model variables and random variables are not dealt with in deterministic models. For this study, a deterministic model is best suited as none of the input values are unknown and risk will be dealt with through scenarios.

The main objective of a model also determines the approach that should be used (i.e. positive or normative). While a normative approach is concerned with "what ought to be", a positive approach deals with "what is", "what was" and/or "what will be". In a positive approach a specific outcome is predicted by the use of both historical and current values. A deterministic model describes the system as it is. A positive approach is better suited as it doesn't explore "how" the system should be.

Simulation can be defined as a process where, by means of a model, relationships between objects and persons in the real world are attempted to be reproduced or mimicked (Knott, 2015). For the purpose of this study, an important consideration when building a financial simulation model for the typical farm is the determination of the correct criteria to compare different crop rotation systems and different integrated crop-livestock systems with each other. There are many different criteria that could be used for this purpose, of which the first is margin analysis. Through margin analysis, the different crop rotation systems' and livestock integration strategies' profitability above specified cost could be directly compared with one another.

It is further important that the model is developed in a way that it accommodates and encompasses as much available and relevant information as possible, while at the same time not being overly complicated and clumsy (Hoffmann, 2001). Product prices and yields can have significant impacts on the financial implications of different production systems; therefore, it is important that the model allows for a sensitivity analysis that shows the implications on profitability of changes in these variables. All overhead costs that are applicable for the whole farm have to be taken into account by the model, especially since these costs are likely to differ substantially between production systems and strategies. The ultimate aim of the inclusion of all overhead costs is to determine the return on investments. The return on investments is another useful criterion to compare the different systems and strategies with one another as it represents the extent to which the capital structure of each system and strategy impact whole-farm profitability.

2.4 Conclusion

CA principles have been continuously adopted by producers in the Middle Swartland since the late 1990s for various reasons, including greater success in ryegrass control, increased profitability and reduced input costs. An integrated livestock component can contribute positively to the financial performance of the farming system. Sheep are accommodated on the farm when crop-pasture rotation systems are followed. Stocking rates of grazing sheep may impact soil physical properties in the soil surface, leading to some degree of soil compaction. Adequate pasture rest periods are key to limit the soil surface compaction to such an extent where it is regarded as insignificant. The effect of stocking rate and rest periods are captured in the financial analysis of the Langgewens crop rotation systems in Chapter Three.

In conjunction to the livestock management factors taken into consideration for successful integration, the success of integrating a livestock component into a CA based system also draws on the extent to which CA principles are implemented on the farm. Sufficient soil organic matter content and soil cover levels would counter the detrimental impacts livestock could induce on CA goals.

The different crop-livestock integration strategies may differ in terms of infrastructure requirements, inputs, mechanisation requirements and other variables. Mere margin analysis would not accommodate all the variables required by the different approaches, therefore, the need for whole-farm financial analysis has been expressed in this chapter. Changes in certain input variables will impact the performance of the whole-farm system; hence the study was based on a systems approach.

An expert group discussion provided the opportunity for creative thinking among experts from many different disciplines relevant to the study. An expert group discussion had been used for validating input data as typical to the Middle Swartland. Industry experts also played an important role in establishing the livestock approaches and provided valuable input regarding the practical implications of each.

Chapter 3: Financial analysis of the Langgewens crop rotation trials

3.1 Introduction

The issues regarding livestock and CA have been addressed in Chapter Two. It was established that CA principles have been adopted increasingly in the Middle Swartland over the last 20 years with sheep being traditionally incorporated through a set-stocking grazing approach. It was shown that rest periods and the successful implementation of CA practices are important to prevent livestock induced soil compaction. However, successful implementation of some CA practices, such as maximal levels of soil cover and no soil disturbance, can be difficult to achieve in the presence of an integrated livestock component.

Different livestock approaches could be followed to practise crop-pasture rotation systems profitably. The Langgewens crop rotation trial provides encompassing data on crop rotation systems with a livestock approach for the Middle Swartland. Through financial analysis of the Langgewens crop rotation trial, the effect of stocking rate and pasture rest periods could be captured, addressing the issues surrounding livestock and CA. This provided the basis for the development of the livestock approaches and strategies incorporated into the whole-farm budget.

This chapter consists of a thorough outline and discussion of the Langgewens crop rotation trial. The methods used to capture sheep data from the trial are also discussed. The process of formulating trial data to financial budgets is explained – this includes per-hectare financial analysis of the crop rotation systems in the trial. Lastly, the different approaches to livestock management are explained.

3.2 Langgewens crop rotation trials

3.2.1 Background

Langgewens is situated 18 km north of Malmesbury on the N7. This is in the heart of the Middle Swartland small grain production area of the Western Cape. The Middle Swartland region is a winter rainfall area with a typical Mediterranean climate. Typical to a Mediterranean climate, the summers are hot and dry, while the winters are cold and wet. The annual precipitation of the Middle Swartland area is on average 396 mm (Knott, 2015). Langgewens has an average annual precipitation of 386 mm, of which 80% occurs during the autumn, winter and spring months (refer to Figure 2.1 for illustration) (Meadows, 2003). Planting times for the area, for most of the crops, are from the end of April, after the first rain has fallen, until the end of May each year. Crops are generally harvested between mid-October to the end of November (Botha, 2013). The shallow (250 mm – 300 mm) soils of Langgewens are typical to the Middle Swartland area. The soil is a sandy loam soil with a gravel and stone content of 44.61% in the A-horizon (Maali & Agenbag, 2003). The soils in the Middle Swartland range from average to high potential soil for small grain production (Hoffmann, 2001). The success of dryland small grain production on the Middle Swartland can be considered uncertain. This is due to the unpredictability of and fluctuations in both the quantity and spatial distribution of rain in the area – typical to a Mediterranean climate. Due to the shallow soils and the lack of moisture-retention ability of the soils, consistent rains through the season are of more importance than total rainfall.

3.2.2 Management of the trial

The nature of the Langgewens crop rotation trial allows for experts across many disciplines to be involved, including plant and soil sciences, pest and weed management, as well as economics. Experts from all the various disciplines and the industry were used to establish guidelines for the trial.

Management of the Langgewens experimental farm is conducted by the Swartland Crop Rotation Technical Committee. The committee was established to ensure that the crops used in the trials are optimally managed in a way that is as close to a practical farm situation as possible. The committee consists of Departmental research and advisory personnel, as well as specialist advisers from local agribusinesses including Kaap Agri and Overberg Agri, Stellenbosch University, Agricultural Research Council's Small Grain Institute (ARC-SGI) and the Association of Veterinary and Crop Associations of South Africa (AVCASA). The committee is responsible for the managerial decision making of the trial. These decisions include important decisions such as production methods and practices, plant density, fertilisation rates, as well as spraying programmes for weed and pest control. The committee also has to ensure that the best production practices are followed on the trial.

Apart from the particular crop rotation trial of interest for this study, Langgewens has also been a catalyst for research in other fields including plant pathology, cultivar studies, soil nitrogen studies and no-till experiments.

3.2.3 Description of the trial

Crop rotation trials have been conducted at Langgewens since 1996. The main objective of these trials was to evaluate the various, most-suitable, cash crop and cash crop – pasture rotation systems in the Swartland in terms of short and long-term yields, pest management, weeds management, disease suppression, soil production potential, sheep production, as well as economically sustainable soil use. The technical data captured for the trial purposes on Langgewens include yields, product and input prices, quantities of inputs used per hectare, as well as other technical information regarding the animal production that forms part of the trials.

The trial data that have been selected for use for this study were taken from the long-term crop rotation trial conducted at the Langgewens experimental farm. The trial has been titled "An investigation into the production dynamics of eight crop rotations systems, including wheat, canola, lupins and pasture species in the Swartland, Western Cape" and was conducted by Dr Strauss of the Western Cape Department of Agriculture. All eight the crop rotation systems were in a four year cycle. A wheat monoculture system was used as control. Refer to Table 2.1 for a description of the eight different crop rotation systems.

The 50 hectares of trial area were divided into 38 camps with 0.5 and 2 hectares as the smallest and largest respectively. The trial had been laid out across all these camps to ensure that all the crops were represented within a particular system in any given year.

As livestock formed a key part of this study, the relevant sheep data from the trial is important. Livestock were accommodated in all crop-pasture systems. Each year of the trial had ten medic camps across all the crop-pasture systems (E-H). The medics produced in these camps were grazed by sheep. As the crop-pasture systems may have different grazing requirements and potential, sheep were divided among all the medic camps according to these requirements.

All eight systems were subjected to no-till planting practices. A maximum soil disturbance of 20% (between 100 mm and 150 mm) in the planting row was achieved through this practice.

3.3 The alternative crops in the rotation systems

Wheat has traditionally been the main crop in this particular production area but has lost its competitiveness as well as economic and environmental sustainability in the Middle Swartland as a monoculture. Producers' needs to diversify have put pressure on researchers to identify and test alternative crops in terms of their role within crop rotation systems (as a means of diversification) as well as their environmental sustainability. The crops that were included as alternatives at the inception of the trial are briefly discussed below.

3.3.1 Medics and clovers

With regards to the climate conditions in the Swartland, grazing crops such as clover and medics are well adapted in the area. These two crops also present benefits for the producer as they contribute to the organic matter content of the soil. These legumes also fix significant levels of nitrogen from the air. It has been shown that medics and clover can fix between 40 kg to 100 kg of nitrogen in the soil per hectare per year, with as much as 40% of the fixed nitrogen available in the soil for the subsequent crop. The relative success of medics and clover in controlling grass weeds has also contributed to the popularity among Swartland producers. Ultimately the production of medics and clover is likely to reduce input costs, as well as increase yields of subsequent cash crops (Hoffmann, 2001; Knott, 2015).

Medic and clover mixtures are also considered a catalyst for livestock production as they make for excellent feed. Stocking rates of sheep on medic or medic-clover pastures differ across the Swartland, especially since producers leave different levels of soil cover after grazing. Although stocking rates of up to four breeding ewes per hectare pasture may have been followed in the trial and on some farms, the stocking rate is likely to be lower under CA practices. The feed quality of medics and clovers is the main reason that livestock can be accommodated in the crop-pasture systems included in the Langgewens trial.

3.3.2 Dryland cash crops

At the initiation stage of the trial, lupins were considered an attractive alternative cash crop for the Swartland and were therefore included in the trial for various reasons: First were the key functions that lupins were able to provide within a CA system. These included the ability of lupins to fix nitrogen from the air and lower soil density. While the former is likely to reduce subsequent nitrogen requirements, and thus achieve lower input costs for the subsequent crop, the latter would improve the soil structure which may lead to increases in yields of the subsequent crop. The second reason lupins were considered an ideal alternative cash crop was due to the fact that they are well-adapted to the area's conditions. Due to possible diseases, a minimum gap of two years between lupin production on a specific field is suggested (Hoffmann, 2001; Knott, 2015).

3.3.3 Oil seeds

Canola has been included in the trial as the only oilseed crop. Other crops such as sunflowers and linseed have also been considered, but canola proved to be more favourable and well-adapted in the Swartland. Canola has many possible benefits, on both bio-physical and output sides. The taproot system of canola is likely to improve soil structure as it aerates the soil and increases water infiltration rates. Canola is also a good option for breaking disease cycles of legume and grass crops. These are all factors that make canola an attractive crop within a rotation system (Hoffmann, 2001; Knott, 2015). Canola is generally considered to have favourable yields in the area. Canola oil is highly edible and of good quality, while canola is also rich in protein, making the oilcake very high in demand in the livestock feed industry (Hoffmann, 2001).

3.4 Description of crop rotation systems

The main reason for this study was to assess how livestock can be integrated into a CA based crop-livestock production system. The basis for this lies in financial comparisons of the Langgewens crop rotation systems. It was shown that crop rotation systems in the Swartland yielded higher returns on capital, net present values and higher gross margins when compared to monoculture wheat production in the long-term (Hoffmann, 2001). As explained in the previous section, of the eight crop rotation systems tested at the Langgewens trial, four accommodated and depended on livestock in terms of profitability. A clear understanding of the importance of a livestock component in crop rotation systems in the Swartland is necessary. Consequently, the crop rotation systems of the Langgewens trial are described below followed by a brief financial comparison between the systems.

All seven crop rotation systems were replicated twice in the trial. The wheat monoculture control had four repetitions. The available space and size of the trial plots limited the trial to two repetitions. Due to the four year cycle of the rotation systems, each system had more than one sequence of crops. Consequently, all crops within a particular system and sequence were represented in the field in any given year. Systems B, C, D and G all had four sequences each. Systems E, F and H had two sequences each. Refer to Annexure B for an illustration of the crop rotation systems, sequences and repetitions. Annual records of all inputs and outputs for each camp were kept. The data relevant for this study was available from 2002 to 2015, which allowed for accurate calculations of input costs and outputs.

3.4.1 Cash crop systems

System A was in fact not a rotation system, but a wheat monoculture system used as comparative control. Thus, System B was considered the first cash crop rotation system in the trial. Wheat and canola were the crops produced in System B. Wheat was produced for three consecutive years, followed by one year canola. The canola year broke the wheat cycle, and allowed for possible improvements in weed and disease management.

System C consisted of wheat, lupins and canola. The sequence of the three crops in this system had been set in a way that there was a change between broadleaf and narrow leaf crops on any given piece of land in the system. The four year cycle had a sequence of wheat, canola, wheat, lupins. More efficient weed control was enhanced by the alternation between cereal and broadleaf crops on a year to year basis. The lupins contributed to increased levels of nitrogen available in the soil for the subsequent year’s wheat.

System D and System C were the same in terms of crops, as wheat, canola and lupins were also the crops produced in System D. The difference between the two systems was the sequence in which the crops were produced. In System D wheat was produced for two years consecutively, followed by one year lupins and one year canola.

3.4.2 Crop-pasture systems

The last four rotation systems in the trial were all cash crop/pasture systems. The first of these systems was System E, where wheat and medics were alternated on an annual basis. The medics in this system were a great contributor to increased levels of soil nitrogen available for the subsequent year's wheat crop. Weed and disease control also improved as a result of the medics pasture phase.

Systems E and F did not differ significantly and the same sequence was followed by both systems. The difference between the two was that in System F, the medics were supplemented by clover. During the pasture phase of this system, a medic-clover mix was used. The clover is well suited to make better use of wet areas.

System G was another adaptation of System E where one of the wheat cycles of System E was replaced by canola. Canola was included because of its possible cash flow benefits as well as the positive effects it can have on the structure of the soil.

Systems H and F were exactly the same, except the additional use of "Oldman saltbush". The additional saltbush pasture made it possible for the sheep to be kept out of the medics pasture for a longer period at the start of the raining season. This allowed for the medics to be better established by the time the livestock were put in the pasture for grazing.

3.5 Sheep system and data capturing

The methodology applied when capturing sheep income and expenditure data in the Langgewens long-term crop rotation trial was important for the purpose of this study because the original trial data had to be converted to typical commercial data. There were two approaches that were used over the course of the trial, with important differences between the two. The first approach had been used for all sheep in the trial in the period from 2002 to 2008. The approach currently followed had been used since 2009.

For purposes of this study, the two sheep data capturing approaches are explained below to give a sound understanding of how the original data had been obtained.

3.5.1 Sheep income and expenditure data capturing methodology from 2002 – 2008

Firstly, it is important to note that sheep were only accommodated in the crop-pasture systems (Systems E-H). In any given year, for each of these systems, there were two hectares of pasture available – with an additional 0.25 hectares of fallout land planted to saltbush available for all animals in System H.

The second important factor to take note of is that each system represents a farm that was divided in two – 50% cash crops and 50% pastures. The average farm listed in the MKB Bureau Service (relevant to the geographical area of this study) comprised 81% arable land and 19% fallout land. The 50% cash crop and 50% pasture calculation is therefore only applicable to the arable land. This means the additional area required in System H for the saltbush pastures should, in any event, be available on the average farm - for example: As System H requires 2 hectares for cash crops, 2 hectares of pastures and 0.25ha of fall-out land in any given moment, the fall-out land needed in the system is 6% of the total farm size, i.e. less than the available 19%.

To obtain animal production data from the pastures, a stocking rate of 4 SA Meat Merino (SAMM) breeding ewes per hectare pasture was applied in Systems E, F and G. In System H, a stocking rate of 4.5 breeding ewes per hectare pasture was applied. However, since the design of the trial did not accommodate replacement ewes and rams required to maintain the breeding ewe flock, the number of breeding ewes per hectare in each system had to be adjusted to allow for the required number of followers. These adjusted stocking rates would then simulate the total stocking rate of sheep in terms of large stock units (LSU) per hectare pasture on the farm.

For this adjustment in stocking rates from breeding ewes per hectare pasture to total LSU per hectare pasture, the following information is of importance: A lambing percentage of 150% and a weaning percentage of 100% were assumed for all systems. A replacement strategy for breeding ewes of 25% per year was applied, while 75% of the weaned ewe lambs was marketed. It was further assumed that three rams were required per 100 breeding ewes.

The adjustment was therefore done with the above–mentioned information as a basis and using a hypothetical herd that comprised 100 breeding ewes, a 25% follower flock and three rams. Through the use of the Meissner Tables for dual purpose sheep, the following LSU-values could be assigned to the sheep in the trial (Meissner *et al.*, 1983):

- A ram = 0.25 LSU
- A lactating ewe = 0.25 LSU
- A non-lactating ewe (replacement ewe) = 0.17 LSU

Thus, the adjusted stocking rate was calculated as follows:

For the total hypothetical herd:

- 3 Rams: (3 x 0.25) = 0.75 LSU
- 100 Lactating ewes: (100 x 0.25) = 25 LSU

- 25 Replacement ewes: (25 x 0.17) = 4.25 LSU
- Total herd size for 100 breeding ewes was thus: 25 LSU + 0.75 LSU + 4.25 LSU = 30 LSU

In order to do the necessary calculation for each system, the percentages that breeding ewes and follower flock comprise of the total herd were used.

Therefore:

- % Breeding ewes: (25 LSU/30 LSU) x 100 = 83%
- % Follower flock: (5 LSU/30 LSU) x 100 = 17%

This means that the adjusted stocking rate of breeding ewes per hectare pasture on the farm would be:

- For Systems E, F and G: 4 ewes per hectare x 83% = 3.32 ewes per hectare, and
- For System H: 4.5 ewes per hectare x 83% = 3.74 ewes per hectare

These adjusted stocking rates were used to calculate the number of other sheep on the farm:

- Lambs:
  - At 150% lambing:
    - Systems E, F and G would carry: 3.32 x 1.5 = 4.98 lambs per hectare, and
    - System H would carry: 3.74 x 1.5 = 5.61 lambs per hectare.
  - At 100% weaning:
    - Systems E, F and G would wean: 3.32 x 1 =3.32 lambs per hectare, and
    - System H would wean: 3.74 x 1 = 3.74 lambs per hectare.
- The follower flock:
  - Systems E, F and G would carry: 0.83 replacement ewes per hectare (3.32 x 0.25), as well as 0.1 rams per hectare (3.32 x 3%), while
  - System H would carry: 0.94 replacement ewes per hectare (3.74 x 0.25), as well as 0.11 rams per hectare (3.74 x 3%).

The following information was important when the wool and carcass yields were being calculated.

When calculating the wool yield per hectare, a 12-month wool yield was used, i.e. shearing took place once per year, normally in September or October. The adjusted stocking rate of breeding ewes per hectare pasture was used for all systems.

Each fleece was weighed and the average greasy wool mass per breeding ewe was calculated for each system. A “mid-rib” wool sample was obtained from each fleece. These samples were sent to the SA Fleece Testing Centre in Middelburg, Eastern Cape.

The average price for the average quality clean wool from all shorn ewes, irrespective of the system (based on average micron and length) for November, was obtained from BKB. The greasy wool price was calculated by multiplying the clean yield price by the average percentage clean yield of all ewes shorn.

Therefore, the wool production income (PI) per hectare per year was calculated for each system as follows:

PI = A x B x C,[1] where:

A =Adjusted breeding ewes per hectare,

B = Average fleece mass per ewe, and

C= Average greasy wool price.

When calculating the carcass yield per hectare per year, the following information is of relevance: For lambs, the average carcass mass of the lambs in each system was used (i.e. variations in average carcass mass between systems are taken into account). The average price (R/kg) was the same for all systems. As 75% of lambs from each system was sold and a 100% weaning percentage was assumed, 2.49 lamb carcasses per hectare should be sold from each of Systems E, F and G (3.32 x 75%), while 2.81 lamb carcasses per hectare should be sold from System H (3.74 x 75%). The total average lamb carcass mass sold from a system (kg/ha) was calculated by multiplying the average carcass mass for the particular system with the number of lambs sold (from a particular system).

For ewes, the average carcass mass per ewe for all systems was used. As for the lambs, the average price (R/kg) is the same for all systems. Assuming a 100% survival rate of breeding ewes, 25% of breeding ewes was sold. This means that for each of Systems E, F and G there were 0.83 ewe

[1] Wool produced by replacement ewes and rams was used to cover replacement ram financing costs and was therefore not included in the calculation.

carcasses per hectare sold (25% x 3.32), while there were 0.94 ewe carcasses sold per hectare in System H (25% x 3.74). To calculate the total carcass weight sold (kg/ha) for a particular system, the average carcass mass for all systems was multiplied with the number of ewes sold per hectare in a particular system.

The sheep in the trial consumed both purchased feed and farm produced fodder. The purchased feed can be categorised as supplements, or hay and other additional feed. Supplements were fed only to pregnant ewes in late gestation and directly after lambing. The adjusted stocking rates were used to capture the supplement expenses, i.e. 3.32 ewes per hectare in Systems E, F and G, and 3.74 ewes per hectare in System H. The amount fed to each ewe per day is multiplied by the number of days the supplement was fed to the ewes. The number of days may differ from year to year as the availability of other feed sources varies.

In a general scenario where the replacement ewes and rams were accommodated in the system, purchased hay or other additional feed would have been fed to all sheep, including rams and replacement ewes. As rams and replacement ewes were not accommodated in the trial design, the adjusted total stocking rate of each system was used for this calculation. In the period that purchased hay or other additional feed was fed to the sheep, 4.25 sheep were fed per hectare per day in Systems E, F and G, and 4.79 sheep are fed per hectare per day in System H. To calculate the amount of hay and other additional feed that were fed to the animals in the trial, two approaches could be followed: the first would be to multiply the average weight fed to each ewe per day with the number of days that they were fed. The second approach would be to simply take the average weight or number of bales provided per hectare over the period.

For calculations regarding the farm produced fodder, the important assumption that underlies all the calculations was that the rams and replacement ewes were maintained on a separate pasture at the same stocking rate as for the breeding ewes. Pastures for the replacement ewes and rams, in a particular system, therefore had the same input costs as the breeding ewe pastures in the same system. Pasture input costs (Rand per hectare) were carried over to the gross margin analysis of the livestock component of the system.

For veterinarian and dosing costs, the scan, sponge and PMSG activities applied only to the number of breeding ewes per hectare, i.e. 3.32 ewes per hectare in Systems E, F and G, and 3.74 ewes per hectare in System H. For dosing and inoculation expenses, the rams and replacement ewes were included in the calculation, therefore 4.25 sheep were dosed and inoculated per hectare in Systems E, F and G, while 4.79 sheep were dosed and inoculated per hectare in System H. For dosing and inoculating lambs, the assumption was made that at a lambing percentage of 150%, all lambs would survive long enough to be provided with all their dosing and inoculation requirements. This meant 4.98 (3.32 x 150%) lambs were dosed and inoculated per hectare in Systems E, F and G, while 5.61 (3.74 x 150%) were dosed and inoculated per hectare in System H. Furthermore, a weaning percentage of 100% was assumed, along with the assumption that 75% of lambs was marketed and one ewe lamb is retained as a replacement ewe. It has to be noted that these dosage and inoculation guidelines are an over estimation of input costs for this activity.

Other costs that were relevant to the sheep component in the trials included shearing costs, wool bale costs and transport costs. For the shearing costs, rams and replacement ewes were all included in the calculation. Therefore 4.25 sheep were shorn per hectare in Systems E, G and F, and 4.79 sheep were shorn per hectare in System H.

The point of departure for calculating the wool bale costs was the assumption that the estimated mass of a wool bale when full is 150 kg. It's important to note that the replacement ewes and rams were included in the calculation, i.e. a total of 4.25 sheep per hectare in Systems E, F and G, and 4.79 sheep per hectare in System H. To get the total wool bale cost per hectare, the greasy wool yield per hectare per system had to be calculated first. This was done by multiplying the average greasy wool mass per breeding ewe in a particular system with the total number of sheep per hectare (including rams and replacement ewes) in that system. This was then divided by 150 to get the number of bales per hectare in each system, which was ultimately multiplied by the price of an empty wool bale.

To calculate the transport costs, it's assumed that the cost (Rand per head) was the same for lambs and ewes. In Systems E, F and G, 3.32 sheep per hectare were transported (25% of 3.32 fallout ewes plus 2.49 lambs). In System H a total of 3.75 sheep per hectare were transported (25% of 3.74 fallout ewes plus 2.81 lambs). The transport cost per hectare for a particular system was therefore the transport cost per head multiplied with the total number of sheep transported per hectare in that system.

3.5.2 Sheep income and expenditure data capturing methodology from 2009 onwards

As mentioned in the beginning of the previous section, two different breeding flock management approaches have been followed to capture sheep income and expenditure data from Langgewens. While the previous section explained the approach used prior to 2009, this section attempts to explain the approach followed since 2009.

The most important difference between the two approaches is that replacement ewes were not accounted for in the whole farm analysis post 2009. The reason for this was that a terminal-cross sheep management approach had been followed post 2009. This assumed that replacement ewes were either supplied from other breeding flocks on the farm or that they were available from neighbouring farms.

As both prior- and post 2009 strategies have been followed on exactly the same trial area and plots, there were no differences in terms of the size of the pastures for each system or the composition of the "farm": The 19% fallout land was sufficient to accommodate the 50% crop – 50% pasture division applicable on the arable land with two hectare pastures used in Systems E, F and G, while an additional 0.25 hectares were planted with saltbush for System H.

The carrying capacity of the pastures in each of the systems remained the same as prior to 2009, with the only difference being the introduction of Dohne Merino ewes into the trial. Since a terminal-cross management strategy was followed, the carrying capacity of trial plots was divided between the two breeds present on the farm. Two SA Meat Merino (SAMM) ewes and two Dohne Merino ewes were mated per hectare pasture in Systems E, F and G, and 2.25 SAMM and 2.25 Dohne Merino ewes in System H. As the stocking rates were the same prior and post 2009, the stocking rates for Systems E, F and G were 4 ewes per hectare pasture, while being 4.5 per hectare pasture for System H.

There were no adjustments made to the lambing and weaning percentages when the strategy was changed in 2009. Thus, a lambing percentage of 150% and a weaning percentage of 100% still held true post 2009. Other factors that also remained unchanged after 2009 were the annual ewe replacement strategy and shearing intervals. A ewe replacement strategy of 25% had been maintained and the sheep were still shorn once per year at weaning.

As explained in the previous section for the period prior to 2009, the trial design did not accommodate a follower flock required to maintain the breeding ewe flock. Therefore, in order to capture any financial data for the post 2009 period, the number of ewes on each system had to be adjusted to accommodate the follower flock in the economic and financial analyses. However, in the post 2009 period, the follower flock only consisted of rams. This was because post 2009 all lambs were marketed and replacement ewes were not carried in the trial itself.

To make the necessary adjustments, a hypothetical breeding ewe flock of 100 ewes was used. For every 100 breeding ewes, three rams were required. The above information with regards to lambing, weaning and ewe replacement was further used as a basis.

By using the Meissner Tables for dual purpose sheep, the LSU equivalents of the sheep could be calculated (Meissner *et al.*, 1983):

- A ram: 0.25 LSU
- A lactating ewe: 0.25 LSU

Therefore the total LSU for the 100 breeding ewe-flock would be:

- Three rams: 3 x 0.25 LSU= 0.75 LSU
- 100 Breeding ewes: 100 x 0.25 LSU = 25 LSU

This meant the total flock size for 100 breeding ewes was 25.75 (25 + 0.75) LSU, with breeding ewes and rams being 97% and 3% of the total flock size respectively.

The adjusted stocking rates of the systems in the trial could thus be calculated as follows:

- For Systems E, F and G: 4 ewes per hectare x 97% = 3.88 ewes per hectare pasture; and
- For System H: 4.5 ewes per hectare x 97% = 4.37 ewes per hectare pasture.

In order to determine the other important numbers of sheep, such as lambs and follower flock for each of the systems, the basic information described in the beginning of this section is relevant. As a lambing percentage of 150% was maintained in the trial, Systems E, F and G would carry 5.82 (3.88 x 150%) lambs per hectare pasture. As System H carried slightly more breeding ewes per hectare pasture than the other systems in the trial, it also carried more lambs, i.e. 6.56 (4.37 x 150%).

The number of lambs weaned in each system was also calculated by using the adjusted number of ewes per hectare pasture. In Systems E, F and G, 3.88 (3.88 x 100%) lambs were weaned per hectare pasture per year. In System H 4.37 (4.37 x 100%) lambs were weaned per hectare pasture per year.

Different to the period prior to 2009, rams comprised 100% of the follower flock in the post 2009 trial period. The total follower flock in Systems E, F and G would thus be 0.12 (3% x 4) rams per hectare pasture. In System H the total follower flock would be 0.13 (3% x 4.5) rams per hectare pasture.

The calculation of wool and carcass yields for the post 2009 trial period was to a large extent exactly the same as described for the period before 2009. When calculating the wool yield, the only difference was that a distinction was made between the two sheep breeds present in the trial. This distinction only played a role in determining the greasy wool price for each breed. This was done by multiplying the clean yield price by the average percentage clean yield of all ewes shorn of each breed. As there might be a difference in the greasy wool price between the two breeds, this distinction manifested in the ultimate wool production income per hectare. The calculation for the production income of wool per hectare in the post 2009 period, was done exactly as it was done prior to 2009, i.e. by first obtaining the average fleece mass per hectare (average fleece mass per ewe x adjusted ewes per hectare pasture), and then by multiplying this with the average greasy wool price. It has to be noted that the adjusted stocking rate per breed would be 1.94 (3.88/2) ewes per breed per hectare in Systems E, F and G, and 2.19 (4.37/2) ewes per breed per hectare pasture in System H.

Similar to the period before 2009, the wool produced from rams was excluded from financial analysis on the trial as the wool produced from the rams was used to finance ram replacements.

For the carcass yield per hectare in the post 2009 period, the only difference in the calculation from the period prior to 2009 was that all lambs were marketed and not just 75% as was the case before 2009. At a 100% weaning percentage, this meant that in Systems E, F and G 1.94 (1.94 SAMM ewes x 100%) SAMM lamb carcasses and 1.94 (1.94 Dohne ewes x 100%) Dohne lamb carcasses were marketed per hectare. In System H this increased to 2.19 lamb carcasses (2.19 ewes x 100%) for each breed per hectare. In order to calculate the carcass yield for a particular system (kg/ha) the number of lamb carcasses sold per hectare was multiplied by the mean carcass mass per breed for the system.

It's assumed that the income received from the sale of old fallout ewes pays for the replacement ewe. This assumption was justified by the fact that a fallout ewe had a high carcass mass relative to the replacement ewe and that one could expect that the cost of a replacement ewe would be equal to the value of its carcass plus 20%.

As stated in the previous section, the sheep in the trial consumed both farm produced fodder as well as supplements and other purchased feed. Just as in the previous management strategy, supplements were only fed to mated ewes in late gestation and directly after lambing. For Systems E, F and G, supplements were thus fed to 3.88 ewes per hectare and to 4.37 ewes per hectare in System H. Hay and other additional purchased feed were fed to breeding ewes and rams. In Systems E, F and G, 4 sheep were fed hay or additional feeds per hectare per day, and in System H 4.5 sheep were fed hay or additional feeds per hectare per day. These were however fed to the sheep only when necessary, hence only for a certain number of days in a year.

For farm produced fodder, the pasture input costs were carried over to the gross margin analysis for the livestock component of a system. It was assumed that rams were maintained on a separate pasture at the same stocking rate as breeding ewes. The pastures for the rams had the same input costs as the system the rams were allocated to.

With regards to veterinarian and dosage costs, the scan, sponge and PMSG costs were only applicable to the number of ewes mated per hectare, i.e. 3.88 for Systems E, F and G, and 4.37 ewes in System H. For dosage and inoculation, rams were included in the calculations as they also required these activities. This meant that 4 sheep were dosed and inoculated per hectare in Systems E, F and G, while 4.5 sheep were dosed and inoculated per hectare in System H. At the 150% lambing percentage, 5.82 lambs (3.88 x 150%) were dosed and inoculated in Systems E, F and G, with 6.56 (4.37 x 150%) lambs dosed and inoculated in System H. It was assumed that all lambs survived long enough to be provided with all their dosage and inoculation requirements. In the final dosing, which took place just before marketing the lambs, only the breeding ewes were dosed (3.88 per hectare for Systems E, F and G, and 4.37 per hectare for System H).

Both ewes and rams were shorn each year, meaning that 4 sheep were shorn per hectare in Systems E, F and G, while 4.5 sheep were shorn per hectare in System H. The wool bale costs were calculated by multiplying the number of wool bales filled per hectare with the price of an empty bale. The number of wool bales per hectare was calculated by dividing the greasy wool yield per hectare (average greasy wool mass per ewe in a particular system x the number of sheep shorn per hectare in that system) by 150.

In order to calculate the transport costs of lambs and ewes slaughtered from the trial per year, the same cost per head was assumed for both lambs and ewes. As it was only fallout ewes that were transported for slaughtering each year, there were 0.97 ewes transported per hectare per year for Systems E, F and G, and 1.09 ewes transported per hectare per year for System H. In Systems E, F and G there were 3.88 lambs transported per hectare per year, while 4.37 lambs were transported per hectare per year in System H. This gave a total number of sheep transported per hectare per year of 4.85 for Systems E, F and G, and 5.46 for System H.

3.6 Formulation of trial data to financial budgets

The technical data of the long-term crop rotation trials at Langgewens was financially expressed in terms of annual budgets. These financial budgets have been compiled for every year from 2002-2015. Accurate record keeping of all activities conducted on the trials was important to achieve accurate financial assessment of the crop rotation systems. All information on activities such as planting, spraying and harvesting, as well as all inputs used on the trials, was well-documented and kept for purposes of financial and physical-biological analyses.

For each year, an excel workbook was compiled by using all the data of inputs, activities and outputs of each crop rotation system and trial plot. Ultimately, gross margins were calculated in these workbooks for each trial plot. The workbooks consisted of various sheets, all representing a component necessary for calculation of the gross margins. This included cropping systems, mechanisation, monthly mechanisation costs, prices and costs, trial plot gross margin calculations and a summary of crop rotation system gross margins. The cropping system sheet gave an outline of all the crop rotation systems in the trial as explained in Paragraph 3.4. The mechanisation sheet comprised of machinery cost information. The information was derived from the Department of Agriculture, Forestry and Fisheries (DAFF) of South Africa's annual "Guide to machinery costs". (Refer to Annexure C for the guide to machinery costs for mechanisation required by Langgewens). The monthly machinery costs sheet contained all the information on activities conducted in each month of the particular year. In the prices and costs spreadsheet, the prices of all inputs and outputs such as livestock feed, fertilisers, chemicals, and commodity prices were captured for a particular year. The trial plot gross margin sheet showed all the gross margin calculations for a particular trial plot (refer to Annexure D for an example), while the summary of costs and gross margins provided comparative costs and gross margin calculations for the different crop rotation systems.

In order to compare the Langgewens crop rotation systems financially, the gross margins of the trial plots had been organised in a different worksheet per crop rotation system. This allowed for relative gross margin analysis of the crop rotation systems from 2002 to 2015. Prices of inputs used in the trial were exactly the same across all systems and plots. As the exact same inflation assumptions were in place, this allowed for financial comparison of systems over time. Figure 3.1 shows the average gross margin above all allocatable costs for the different crop rotation systems in the Langgewens trial from 2002 to 2015. All the rotation systems showed a relatively higher average gross margin than wheat monoculture. From Figure 3.1 the significance of a livestock component becomes clear, since the crop-pasture systems tend to have relatively higher average gross margins than the cash crop systems.

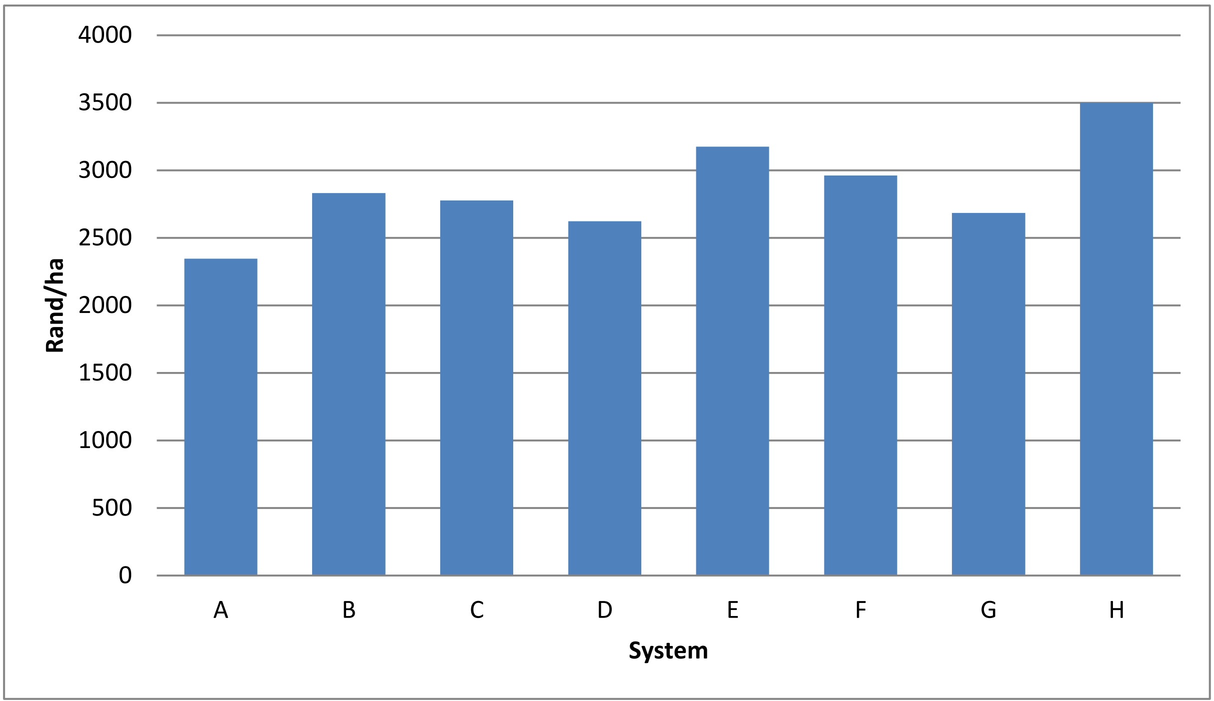

Figure 3.1: Average gross margin above all allocatable costs: 2002-2015.

Gross margins are affected by both the input and output side of production. In the Swartland, unpredictable deviations from normal rainfall patterns may lead to increased risk for lower yields. This may, therefore, translate into reduced gross production values (a factor of output quantity and price). The management of input costs, therefore, becomes an important instrument in limiting the reductive effect lower yields may have on a gross margin.

The crop growth cycle at Langgewens is between April and October, with 80% of the annual precipitation occurring between April and September (refer to Figure 2.1.) (Meadows, 2003). Deviations from normal rainfall can occur at any point in this period, with September often being the most crucial month. For example, in a year where normal precipitation had been experienced until the end of August, whereafter the rain cuts off in September, any crops that had not flowered and matured before the rain stopped, are likely to achieve poor yields. The critical role of sufficient rain in September in order to achieve an average to good yield was emphasised by the producers in the group discussion. Producers do not necessarily know at the time of applying chemicals and fertiliser how the raining season will eventually turn out. Consequently, input costs are difficult to manage according to the season's climatic conditions. In other words, the higher the input requirements of a particular crop or cropping system are, the higher the risk would be for achieving lower gross margins or even losses in a year with insufficient precipitation. Figure 3.2 shows the average allocatable variable costs for each crop rotation system for the period 2002 to 2015. From Figure 3.2 it is clear that the crop-pasture rotation systems have relatively low input requirements when compared to the cash crop rotation systems. Systems E and H show the lowest allocatable variable costs of all the systems, with Systems F and G slightly higher than Systems E and H.

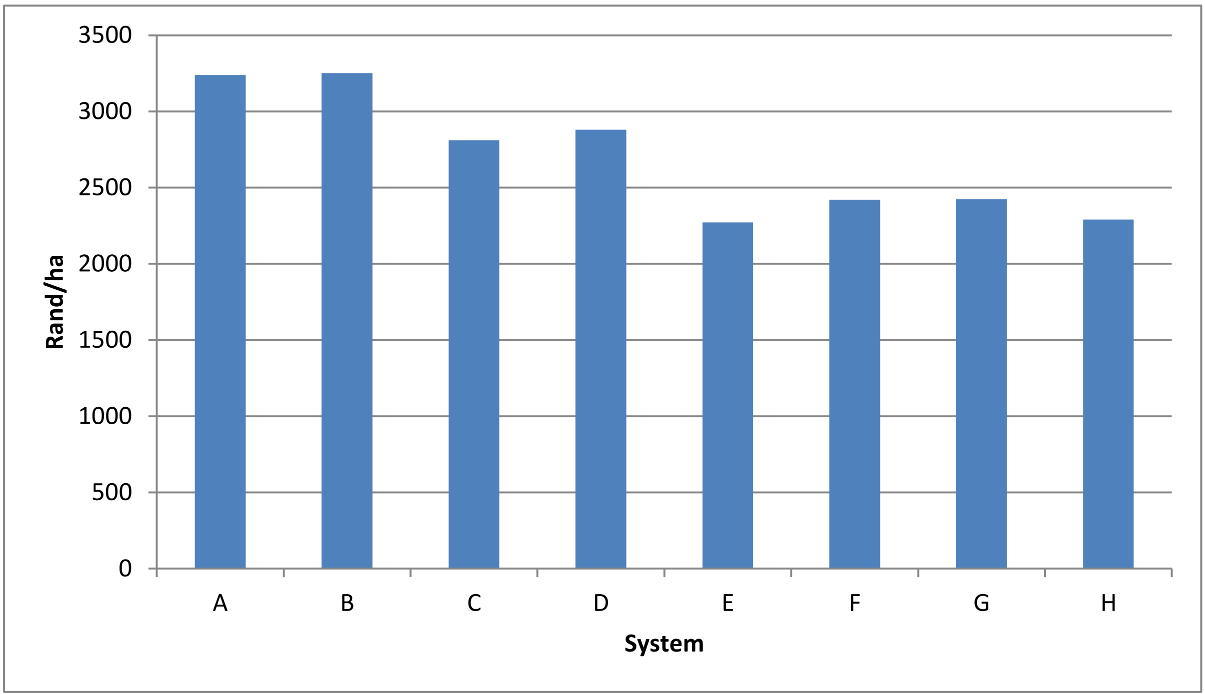

Figure 3.2: Average allocatable variable costs: 2002-2015.

The crop yields of all the trial plots have been organised in a separate worksheet, similar to the analysis of the average gross margins, for the period from 2002 – 2015. From this, an average yield for the period 2002 -2015 had been calculated for each crop in each system. Wheat remains the key crop in these systems – being produced in all eight systems in the trial. By organising the crop yields for the total period allowed for comparing annual wheat yields among the different systems.

The role of crop rotation systems as one of the fundamental principles of CA is emphasised by Figure 3.3 and Figure 3.4. CA advocates increased and improved yields as a result of more effective weed management through crop rotation. Ryegrass has increasingly become a threat to wheat yields in the Swartland, mainly as a result of increased herbicide resistance due to the continuous use of herbicides with the same active ingredients. In the case of continuous usage of the same herbicide, the herbicide may become ineffective within twelve years (Knott, 2015). However, to extend the effective periods of the herbicide and to reduce the population of weed seeds over time, crop rotation systems such as the wheat-medic and clover system proved to be successful. This is as a result of the possibility to use different herbicides in the wheat and pasture phases on a particular piece of land. Ultimately the broadleaf weeds are targeted and controlled during the wheat production phase using certain broadleaf herbicides, while the grass weeds are targeted during the alternative broad-leaf rotation crop phase with different herbicides. This results in reduced competition from grass weeds during the subsequent cash crop year due to suppression of the seed bank in the previous year.

The effect of herbicide resistance and effectiveness of crop rotation systems to control weeds are illustrated by Figure 3.3 and Figure 3.4 . The reason for the significant drop in wheat yield for the monoculture system in 2007 (Figure 3.3) was because the wheat had been outcompeted by ryegrass in the monoculture. Figure 3.3 shows the annual yield for wheat in a monoculture and wheat in a rotation system with a medic and clover mix during the pasture phase. The data of 2003 had been excluded from the figure because of a severely dry year, resulting in wheat trial plots being baled for hay instead of harvested. From the figure it’s clear that the wheat monoculture system’s yields are consistently below the alternative crop-pasture rotation system. Figure 3.4 shows the average yields of wheat after wheat, canola, lupins and medics. It is clear that wheat yields are positively affected when produced in rotation with other broad-leaf crops, with a wheat/medic rotation proving to be most favourable.

Figure 3.3: Wheat yields (t/ha) in a monoculture and wheat-medic + clover

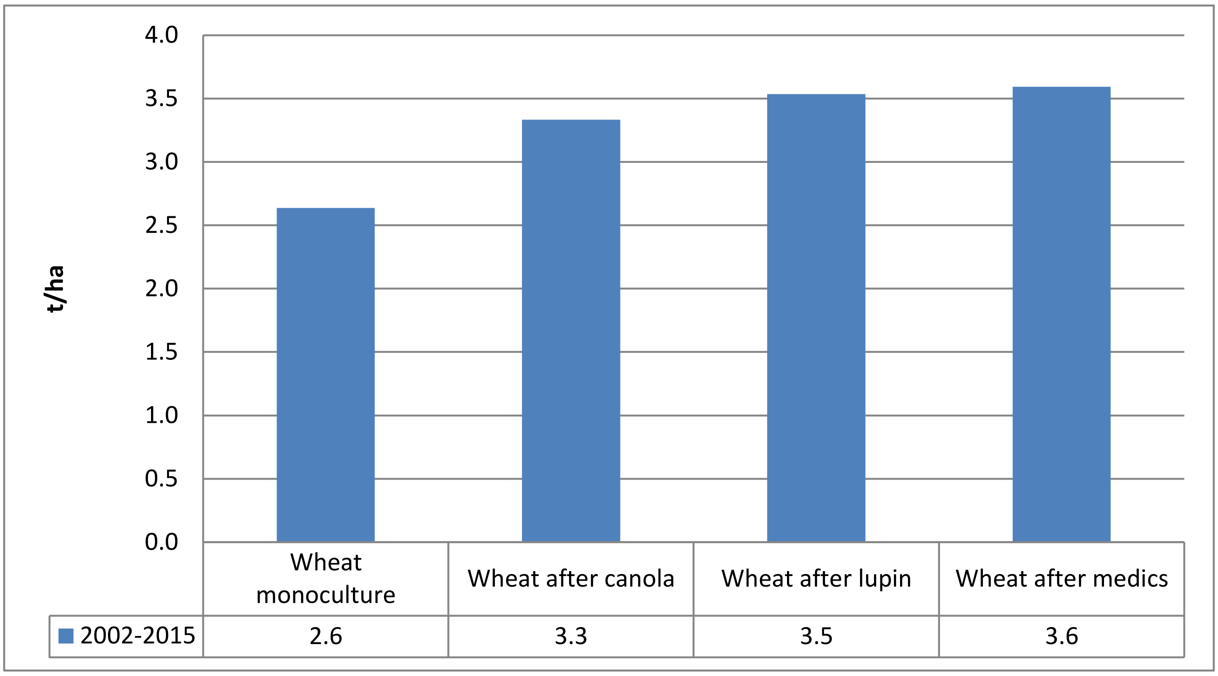

Figure 3.4: Average wheat yield (t/ha) after different rotation crops: 2002-2015.

When considering the relative success of a wheat and medic crop rotation system, in terms of the gross margins of the systems as well as wheat yields, the role of livestock in these systems should not be overlooked. Livestock form an integral part of the crop-pasture systems in the Langgewens trial and are therefore large contributors to the financial success of these systems.

There is a difference between the average gross margins of the four different crop-pasture rotation systems. For purposes of this study, the most important difference was noted between the gross margins of Systems F (WMcWMc) and H (WMc+sWMc+s). The only practical difference between these two systems in the trial was the way livestock were managed. Any differences in gross margins or subsequent cash crop yield – in this case wheat – can be attributed to the differences in livestock management approaches in the systems.

As described earlier in this chapter, the only difference between Systems F and H was the additional incorporation of a saltbush pasture. The saltbush pasture was established on fallout land on the farm. The practical implication of the addition of a salt bush pasture in System H, is that the sheep were not allowed onto the medics pasture in the trial shortly after germination, as in the case of System F. Instead the sheep were kept in the saltbush pasture until the medics have established properly. This results in a slightly higher carrying capacity per hectare pasture in System H, along with having livestock on the pasture for a shorter period than would be the case in System F. The slight increase in stocking rate in System H, from 3.88 ewes per hectare pasture in System F to 4.37

in System H, along with a relatively higher wheat yield recorded in System H proved to be the reason for a higher gross margin of System H.

The technical personnel at Langgewens that are responsible for the practical execution of all activities on the trial, including marketing lambs, noted that lambs produced in System H were ready for marketing approximately two weeks earlier than lambs from other systems (Strauss, 2016). In terms of the subsequent wheat yield, the underlying reason for the difference between wheat yields of Systems F and H is the fact that the sheep were kept on the pasture in the previous year for a shorter period than in System F.

3.7 Interpretation of trial results

In Chapter Two it was concluded that pasture rest periods are important to prevent soil compaction due to livestock trampling. Also clear from Chapter Two is that stocking rates have a less significant impact on soil compaction. This was confirmed in the Langgewens trial and was captured in the gross margin and wheat yield differences between System F and System H.

The difference in the grazing period on the medics pasture between Systems F and H was approximately 6-8 weeks. In all the crop-pasture systems, the sheep were allowed onto the medic or medic-clover pastures shortly after germination of the medics or medic-clovers, with System H being the exception. This six to eight week lag period in System H prior to the sheep being allowed onto the pasture, ensured that pasture establishment was optimal before grazing. During the six to eight weeks that System H's medics were germinating, producing biomass and fixing nitrogen into the soil, the medic plants in the other systems had already been grazed on and were therefore relatively suppressed. This led to slower nitrogen fixation by the medic plants, lower levels of biomass produced and also relatively poor establishment because the sheep could easily pull young medic plants out of the soil. Therefore, since CA has many possible benefits, such as increased wheat yields and gross margins as shown in the figures above, it does require sufficient implementation of its core principles. With regards to the CA principle of having maximum levels of soil cover, from the figures above it became clear that withholding the livestock from the pasture for short periods and thereby having medic pastures producing relatively higher levels of biomass, and therefore organic material or soil cover, the negative effects livestock may have on the soil surface can be prevented.

At the time of this study, grain and extensive livestock farming in the Swartland were based on dryland production systems. Consequently the success of farming systems in the Swartland was dependent on the quantitative and spatial distribution of rainfall in the area. Furthermore, is the Swartland known for its variable, unpredictable and often deficient rainfall (Tolmay, Agenbag & Hardy, 2010). When these unfavourable rainfall characteristics and the relatively shallow soils

(Botha, 2013) are combined with traditionally low levels of organic matter content and an A-horizon that is typically poorly-structured (Agenbag & Maree, 1989), it becomes clear that grain and livestock producers in the Swartland could be exposed to significant risk.

CA provides possible risk reduction opportunities, as well as improvements in farm financial stability and profitability – all of which are achieved in a sustainable manner. The Langgewens trial data as well as the mere adoption of CA practices by producers in the Swartland over the past two decades substantiate the notion that CA can help Swartland producers achieve these risk-reductive outcomes. CA is a holistic approach, therefore the correct implementation of all its principles is required in order to capitalise on the possible benefits of CA. This is shown in the differences in gross margins and subsequent wheat yields between the different crop rotation systems being evaluated in the Langgewens trial. The greater the extent to which CA principles are applied in each system, the higher its relative success. The challenge for the mixed crop-livestock CA producer in the Swartland is, therefore, to find a production strategy that allows for successful and sustainable grain and livestock production, while successfully implementing CA practices to gain the benefits thereof. This led to the theoretical development of different crop-livestock integration strategies within a CA production context. The conceptual formulation of the three strategies being proposed and evaluated in this study was based on the principle of achieving optimal implementation of CA.

3.8 Description of livestock management approaches

The long-term crop rotation trials at Langgewens have made significant contributions to various research topics over the duration of the trial. Livestock optimisation strategies within a typical Swartland CA farming system have, however, not been developed or challenged in the trial.

During the group discussion session held at Langgewens on 15 June 2016, three different approaches to livestock were proposed and developed. There were clear differences between producers' opinions on the role of sheep in their CA systems. These differences led to the development of new strategies that may become increasingly important as more producers switch to CA practices in particular areas. It is important to note that the main reason for the differences in opinions was the differences in the farming environments of the producers. These differences in environments encompass, among others, the quality of the soil on their farms, the distribution of rainfall, and the relative temperatures. This emphasises the heterogeneity of the Swartland region.

The heterogeneity of the Swartland led to the development of the three most likely sheep optimization strategies that could be followed in the area. The likeliness of a strategy in a particular geographical space within the Swartland is dependent on the factors influencing the particular farm's context and physical environment, i.e. factors such as soil type, soil quality and rainfall.

The Langgewens crop rotation trial formed the basis of the data used in this study. Consequently, it was important that the livestock integration and optimization strategies proposed during the group discussion were reconcilable with the rotation systems in the Langgewens trial. The cash crop systems in the trial could not accommodate any livestock. For the purposes of this study, a producer following any of the four cash crop systems on his farm would not be able to adopt any of the livestock integration strategies. This means the livestock integration strategies were all based on the crop-pasture rotation systems of the Langgewens trial.

The three livestock integration strategies proposed in this study were all based on the crop-pasture systems in the Langgewens trial, and therefore relied on the inclusion of medics. In essence then, the livestock approaches can be considered strategies to optimise the medics financially, while achieving optimal implementation of CA principles. There are three main approaches that could be followed to achieve direct financial gains from medic pastures – two of which entail having no livestock on the pastures and one where medic pastures are grazed by livestock.

Of the two approaches where no livestock are held on the pastures, one is reliant on the livestock enterprises of neighbouring farms for financial gain. In that case, the medics would be treated as a cash crop where it would be mowed, windrowed and baled in September or October each year, after which the medic bales would be sold as feed to neighbouring farms with livestock enterprises. The success of this approach will depend on many factors, including, among others: the nature and intensity of livestock enterprises in the area, the availability and prices of substitute feeds such as lucerne, and in some cases the availability of natural grazing.

The second strategy that involves no livestock on the pastures is an intensification strategy where speculation lambs are being bought in, rounded off and sold to an abattoir after a certain period of time. In a case where this strategy is followed, the lambs are kept in alternative sheds and camps established on the main farmyard and other fallout land on the farm. As in the first strategy, the medics will be mowed, windrowed and baled in September or October each year. The medic bales will then be used in a total mixed ration fed to the speculation lambs. The success of the latter strategy depends mainly on the purchase price of lambs, the carcass price of lambs at the time of slaughter, the average weight gained per day and the prices of feed. Although the prices and availability of alternative hay sources for the mixed ration will impact the feasibility of this strategy, the purchase price and selling price of the lambs and carcasses remain the two most important drivers of feasibility and profitability of such an approach (Van Zyl, 2016).

The third proposed approach to utilise medic pastures is a fairly normal grazing approach typical for the Swartland. The livestock are allowed on the medic pastures. However, during the group discussion with experts in the industry, concern about the Langgewens trial's stocking rates not being typical to the Swartland had been expressed. The general consensus was that in order to implement CA principles successfully - particularly minimal soil disturbance and maximum levels of soil cover, the pre-adjustment stocking rate of 4 ewes per hectare in Systems E, F and G, and 4.5 ewes per hectare in System H had to be adapted downwards. The experts agreed that a stocking rate of one breeding ewe per hectare pasture was more realistic given the objective of successful CA implementation and being typical to the area.

3.8.1 Strategy one: Grazing approach

The first strategy to integrate sheep into a crop-pasture CA system is a grazing approach, primarily based on the way it was being done in the Langgewens trial. The first important aspect of the grazing approach developed for this study was establishing the stocking rate. The stocking rate had to be typical to similar production systems in the area. The original data of the Langgewens trial have been presented to the group of experts and consensus had been reached that the stocking rates had to be reduced significantly. Consensus had been reached on one breeding ewe per hectare pasture for Systems E, F and G. It was decided to assign a stocking rate of 1.5 breeding ewes per hectare pasture to System H. The opportunity to increase the stocking rate for System H was realised as a result of the relatively insignificant effect of stocking rate on soil compaction when it was combined with adequate rest periods. This was established through an overview of the literature in Chapter Two and the financial analysis of the Langgewens trial. The CA principle of maintaining sufficient levels of soil cover was considered the main limiting factor on stocking rate. During the expert group discussion the importance of sufficient levels of biomass and soil cover for moisture retention was reiterated.

The second aspect important for the development of the grazing approach was the herd composition. With the input of animal scientists and experts in the animal husbandry industry, consensus has been reached on a herd composition with the following assumptions:

- Ram/ewe ratio: 3 Rams per 100 ewes.
- Replacement ewes: 25%
- Lambing %: 150%
- Weaning %: 100%

In the grazing approach 75% of lambs are marketed. The other 25% will be held back as replacement ewes and forms part of the follower flock. Dosage and inoculation activities are applicable to all animals in the herd. Respective lamb and ewe packages have been compiled from the Langgewens trial data. These packages comprise all the dosage and inoculation requirements of lambs and ewes, respectively. Purchased feed and other supplements are fed to pregnant ewes in late gestation and directly after lambing.

Systems E, F, G and H comprise of 50% medic pastures in any given year. In Systems E, F and G the sheep will be added to the medic camps mid to late April. This is when planting of the cash crop on the other 50% of the farm will take place. The medic seeds should germinate with the first rains of April and provide fodder for the sheep. In System H the sheep will be moved to the additional saltbush pastures when at the beginning of the planting period. The sheep will be kept in the saltbush pastures for six to eight weeks. During this period the medics in the pastures should have germinated and established well. After the six to eight weeks in the saltbush pasture, the sheep will be added to the medic camps.

3.8.2 Strategy two: Intensive speculation approach

The second proposed strategy to incorporate a livestock component into a CA farming system is to follow a feedlot-speculation approach. This strategy has been developed as a way to keep all livestock off the soil. Although the sheep are held and fed in a feedlot setup, the potential number of sheep that could be kept on the farm is still based on the number of hectares pastures in a year. When following this strategy, no medic and/or medic-clover pastures will be grazed by livestock in the pasture year. Instead, the medics or medic-clover mixes will be mowed and baled when ready. The medic or medic-clover hay yield (in terms of tonnes hay per hectare) will determine how many speculation lambs could be carried in the feedlot in a particular year. All other feed, except the forage, are bought in. The total mixed ration is then mixed and pilled on the farm. The "carrying capacity" in this strategy is therefore derived from the portion forage (in this case medic or medic-clover hay of the total mixed ration.

This strategy involves no breeding, and therefore no ewes, rams, or other factors regarding herd composition; such as lambing and weaning percentages or ewe replacements policies. In practice this strategy would entail young lambs being bought in from other farms in the area. These lambs are then kept in sheds and camps on the farmyard where they are fed for the whole period before being marketed.

The most suitable sheep breed for such a speculation approach in the Swartland is Dohne Merinos (Van Zyl, 2016). Dohne Merinos are dual purpose sheep, i.e. they are suitable for both wool and mutton production. This allows for a single shearing of each lamb and additional income from the wool. The shearing of lambs would happen as soon as possible after their arrival on the farm. The lambs have to be shorn at the beginning of the feeding period because lambs tend to gain less weight or gain weight relatively slow when carrying too much wool.

Many factors contribute to the financial success of this strategy. These include the purchase price of lambs, the selling price of the carcasses at the end of the feeding period, the price of feed and the daily weight gained. Subsequently the number of days a lamb has to be fed to be ready for the market is important. Some of these factors, such as the purchase and selling prices of the lambs and carcasses can't be controlled, but there are aspects that could be controlled. For instance, while the price of a total mixed ration from the major suppliers can't be controlled, significant costs can be saved when raw feed materials are bought separately and then mixed and pilled on the farm. For purposes of this study, it's assumed that the portion of forage required for the ration is entirely made up from farm produced medic or mixed medic-clover hay. All other feed components such as vitamins and minerals will be bought from a local supplier who mixes and delivers it to the farm.

In the speculation strategy lambs will each typically weigh 28 kilograms when they are purchased and arrive on the farm. They are marketed to the closest abattoir when they weigh around 45 kilograms. The typical average weight gained per day in such a system is 350 grams (Van Zyl, 2016). This comes down to a 50-day cycle from the day a lamb of 28 kg is purchased until it is sold again to the abattoir at 45 kg.

Theoretically it will be possible to repeat this cycle seven times a year. However, the practical feasibility of seven 50-day cycles a year mainly depends on two factors: First the availability of weaned Dohne Merino lambs of roughly 28 kg each, and secondly, the availability of farm produced hay. With regards to the former, one has to consider the supply side of these lambs. Ideally the lambs should come from the Swartland area or other parts of the Western Cape where Dohne Merino production is common. These include the Overberg and Rûens areas of the Western Cape Province. When considering the lambing frequencies and periods in these two production areas, it was proposed by the expert group to rather have two cycles in a year. This would ensure the availability of lambs with the correct weight and age twice a year.

The focus is on the Swartland as the main supply area of lambs in such a speculation setup. There is a degree of contradiction for proposing a speculation approach to optimise a livestock component in the area. This is because the supply of lambs is dependent on the presence of breeding approaches in the same area. This does not mean that the speculation strategy should not be theoretically modelled and financially assessed. The fact that some producers in the Swartland area are able to implement such a speculation approach successfully does not necessarily mean all the producers in the area with the appropriate farming systems can do it. This approach would require a significant degree of precisely optimised management. The differences between producers' management abilities would create the possibility for this strategy to be successfully implemented on one farm but not on the neighbouring farm.

With regards to the availability of farm produced hay, the hay is generally baled during September and October each year. Therefore the hay availability would be at its highest in those months, and decrease as consumption continues throughout the year until the next year's hay is baled again. To simplify the process of determining the number of lambs carried in each cycle, for the purposes of this study, the number of lambs in this system remains the same for both cycles. This number would be determined by taking into account the portion of the full feed ration the hay comprises and the total annual hay yield.

3.8.3 Strategy three: Sell medics

In a farming system where 50% of the arable land is under medic production, half of the farm's financial performance depends on livestock. The "sell-medics" approach has been proposed by CA producers in the Swartland area during the expert discussion. The expert group agreed that by selling medics, one could create the opportunity to reap the benefits of crop-pasture rotation systems without the concern of the livestock component.

The expert group expressed concern about the profitability of a grazing approach with low stocking rates (as proposed by them). Although higher stocking rates may be more profitable, the expert group agreed that stocking rates greater than the agreed rates would impose challenges in practicing CA principles adequately. The stocking rates agreed on by the expert group were one breeding ewe per hectare pasture for Systems E, F and G, and one and a half breeding ewes per hectare pasture for System H. Concern had also been expressed regarding the challenges of the practical execution of an intensive approach as described in Paragraph 3.8.2. The result was an approach where medic hay is produced and sold.

The medics are mowed and baled in September or October each year. The bales are then sold to other producers in the area. The market for medic hay in the area is mainly driven by dairy producers or producers with mixed crop-livestock farming systems. The Swartland is the one of the main milk producing areas of the Western Cape. Milk production systems in the Swartland are mainly TMR (total mixed ration) systems, which require a significant amount of forage. Due to a lack of forage supply in the area, many producers have to buy forage in from other areas in South Africa (Gertenbach, 2007).

The sell-medics approach eliminates the risk of livestock induced compaction on the soil. While providing an opportunity to achieve financial gain from medic pastures in the absence of livestock in the same farming system, the sell-medic approach also provides sufficient levels of medic residue retention and soil cover.

3.9 Conclusion

Crop rotation is one of the core principles of CA. Different crop rotation systems have been developed and researched over the last 20 year at the Langgewens experimental farm. This chapter focused on the experimental design of the long-term crop rotation trial at Langgewens. The geographical and physical-biological context in which Langgewens is situated has been described. This chapter has also attempted to explain how sheep are treated in the long-term crop rotation trial, with a specific focus on how the sheep data are captured from the trial for purposes of economic and financial analysis.

The livestock management approaches proposed and developed by the expert group and through consultation with other industry experts were also discussed in this chapter. These approaches are a grazing approach, an intensive speculation approach and an approach where medic hay is sold.

Livestock is an inherent part of the crop-pasture rotation systems of the Langgewens trial. Adaptations to the technical data of the crop-pasture systems of Langgewens have to be made in order to simulate these rotation systems in conjunction with various livestock management approaches on whole-farm level.

In order to simulate and compare different strategies of livestock integration on whole-farm level, the technical data of the Langgewens trial had been financially analysed. Crop rotation proved to be more profitable than monoculture on a per-hectare basis. The lowest variable costs were achieved in the crop-pasture rotation systems of the Langgewens trial.

Chapter 4: Financial evaluation of livestock management approaches on the typical farm

4.1 Introduction

The Swartland area of the Western Cape experienced a number of new trends in the dryland production systems over the last 20 years. New production systems and farming practices were adopted in the area during this period for two reasons. Firstly, the deregulation of South African agriculture in the late 1990s where subsidy policies and the old marketing boards have been abolished was a catalyst for diversification (Hoffmann, 2001). Secondly, the need to find alternative ways of controlling grass weeds, especially ryegrass, led to the adoption of no-till planting practices to allow for the use of pre-emergent herbicides (Knott, 2015).

This chapter has two sections. The development of the typical farm budget model is discussed in the first section. The physical environment, parameters and assumptions characterising the farm as typical to the Swartland are also outlined and discussed in the first section. The first section of this chapter also describes the calculation model, as well as the dynamics of the model.

The second section of this chapter focuses on the results and findings of the financial evaluation of the livestock approaches and crop rotation systems built into the typical farm budget model. The different strategies are compared in terms of their financial performance on whole-farm level. The second section of this chapter also includes an analysis of the sensitivity of the different strategies to uncontrollable variables.

4.2 Background

Swartland producers were struggling to produce wheat competitively since the deregulation of agriculture because they had to compete against relatively low international prices. The use of conventional tillage and sowing practices only allowed the application of post-emergent chemicals to control grass weeds. The continuous use of the same chemicals resulted in ryegrass becoming resistant to some of the chemicals in the herbicides. Wheat is easily outcompeted by ryegrass if ryegrass is not controlled effectively, as explained in Paragraph 3.6.

The decline in wheat's competitiveness in the Swartland, as well as the increased difficulty with controlling ryegrass led to crop diversification through crop rotation systems. Crop rotation systems have shown higher profitability when compared to wheat monoculture in the Swartland (Hoffmann, 2001). Weeds could be controlled more effectively with alternative herbicides during the legume pasture phase and pre-emergent herbicides such as Trifluralin. The application of these pre-emergent herbicides was made possible by using no-till practices where the soil was not disturbed prior to planting. The use of no-till planting practices along with annual legume pastures in crop rotation systems have resulted in Swartland producers having more biomass left on the soil as cover or mulch. Eventually, even though producers have adopted the core principles of CA (crop rotation, minimal soil disturbance and maximum soil cover) individually over a period of time and for different reasons, they ended up with practicing the holistic approach of CA.

Out of all the new trends in grain production systems in the Swartland, the adoption of annual legume pastures in crop rotation systems has had one important characteristic: The ability to accommodate livestock. Adding a livestock component to a farming system that is under pressure, due to decreased competitiveness and increased exposure to grain price fluctuations, could mean increased diversity (therefore lower risk), increased profitability and increased financial stability. However, there is concern that livestock may impact CA based systems negatively (Bell *et al.*, 2011; Greenwood & McKenzie, 2001). From the literature reviewed in Chapter Two and the financial analysis of the Langgewens trials in Chapter Three, it can be concluded that the integration of livestock into a CA system in the Swartland may be possible under the following conditions: When following a grazing strategy, it is beneficial to carry a relatively lower stocking rate and to make use of fallout camps to accommodate livestock in order to withhold them from the annual legume pastures until the legumes have established properly. The main purpose of the former would be to retain sufficient levels of soil cover, while the latter is important to avoid soil compaction. Alternatively, the livestock should not be allowed onto the pastures at all. An evaluation of the financial implications and performance of these different approaches to achieve crop-livestock integration in a Middle Swartland CA system has to be done in order to understand what the implications and outcomes of each will be.

The Langgewens research data provided valuable information on the financial performance of the crop rotation systems discussed in Chapter Three on a per-hectare basis. However, the Langgewens trials are conducted on a small scale, are limited by a time period and are conducted with particular agronomic goals in mind. Furthermore, the financial data from the Langgewens trial does not reflect the capital investments and other whole-farm implications of the different crop rotation systems. In order to mimic the financial performance of the Langgewens rotation systems combined with the proposed livestock management approaches on whole-farm level, a whole-farm budget model was developed.

4.3 Development of the typical whole-farm multi-period budget

The typical farm represented in the budget model lies within a particular physical-biological context. Through the literature review in Chapter Two and the inputs of industry experts, including, among others, producers, agribusiness extension officers and scientists, the relevant Langgewens trial data had been adapted and converted into input data that can be regarded as typical for the area. The inputs from the industry experts were obtained through the expert group discussion described in Chapter Two.

4.3.1 Physical extent of the typical farm

To develop a typical farm model, the homogeneous physical context in which the farm is situated has to be identified. The aim of identifying a homogeneous context for the typical farm is to form a basis to which producers in the area can relate. This is achieved by incorporating the most common physical characteristics and parameters found in the relevant area into the model.

The Langgewens research farm is situated in the Middle Swartland and the technical data from the long-term crop rotation trial on Langgewens formed the basis of the typical farm model. For purposes of this study, Langgewens served as a basis to establish the homogeneous grain producing area. The homogeneity of the area was defined by various characteristics, including the soil types, climatic conditions, production practices and terrain.

The Swartland has a great variety of soil types, where in many cases the soil types and the quality thereof may differ significantly between areas on a single farm. This may result in some producers practising different production activities on the different areas of their farm. However, despite the common variations in soil types, the soils in the Middle Swartland are predominantly sandy-loam soils that are relatively shallow. This has been characterised as Malmesbury shale (Hoffmann, 2001). The Middle Swartland has a typical Mediterranean climate with hot, dry summers and cold, wet winters. The average rainfall in the area ranges from 250-450 mm per year (Knott, 2015), with a long term average of 386 mm at Langgewens (Meadows, 2003). Small grain production in the Middle Swartland is solely based on dryland production. Wheat remains the main cash crop in the area and is often rotated with canola, lupins or medic pastures with sheep for diversification and weed management purposes (Hoffmann, 2001). The terrain is predominantly characterised as rolling plains with moderate gradients (Knott, 2015).

When determining the physical extent and parameters of the farm, the farm size is of significant importance as it forms the basis for many other factors. These factors include, among others: Arable area, land utilisation practices, labour requirements, mechanisation requirements and investment in fixed improvements.

The typical farm size in the Middle Swartland is 850 hectares. This was proposed and validated on the basis of consensus during the expert group discussion. On all farms there are portions of land not suitable for certain production practices. For the Middle Swartland farm, the producers present at the expert group discussion agreed on an 85% arable portion. This means 15% of the total farm size of 850 ha is excluded from the cultivated area. The farmyard, buildings and saltbush pastures in the relevant rotation systems all form part of this 15%. For the 850 ha farm in the model, 722.5 ha are arable and 127 ha are considered fallout land. The model does accommodate changes in the land utilisation pattern. Excel formulas will automatically make the necessary adjustments to the number of hectares under each crop in a particular crop rotation system.

An inventory was used to express the farm size and the infrastructure in financial terms. The farm inventory included the value of the land, the infrastructure and fixed improvements, machinery and equipment, as well as livestock. The value of the land was assumed to be R 30 000 per ha. This was validated through contact with local agri-business extension officers and the expert group discussion (Heunis, 2016). The value of the fixed improvements, machinery and livestock on the typical farm will differ between crop rotation systems and livestock management approaches. The inventories for the different combinations of crop rotation systems and livestock approaches are shown in Annexure E.

The aim of the whole farm budget model was to evaluate and compare the financial performance of different combinations of crop rotation systems and livestock approaches on whole-farm level. It was, therefore, agreed that the farm will be divided in equal proportions. In all systems wheat was rotated with a medics or medic-clover pastures, except System G where canola was added as a cash crop. In Systems E, F and H, the 722.5 arable ha of the farm have been split in two portions of 50% each. In System G, the arable area had been split in four portions of 25% each.

4.3.2 Crop yields and stocking rate

Grain production systems in the Middle Swartland are dryland based and, therefore, dependent on annual precipitation. Seasonal variations in crop yields due to uncertain rainfall are common in the area and have to be taken into account in the whole-farm model. In order to do this, the frequency of good, average and poor years had to be identified. This had been done for the Middle Swartland in previous studies (Hoffmann, 2001; Hoffmann & Kleynhans, 2011). By comparing rainfall patterns obtained from local weather stations with the identified patterns of Hoffmann & Kleynhans (2011), a more recent study on the same area concluded that the same frequency of good, average and poor years is likely to continue (Knott, 2015). These patterns were presented during the expert discussion as a basis and the outcomes for wheat and canola and medics were as follows: In a ten year period, wheat and canola production experiences two good years, seven average years and one poor year. Producers and scientists present at the expert discussion agreed on two good, six average and two poor years for medic production. The yields of wheat and canola in good, average and poor years are presented in Table 4.1 and Table 4.2. These yield numbers were taken from the Langgewens trial data. Rolling averages of four good, average and poor years were calculated for wheat and canola in each system.

Table 4.1: Wheat yields as captured in the model.

Wheat yields as in the model			
System	**Good**	**Average**	**Poor**
E	4.83	3.69	2.01
F	4.48	3.32	1.88
G	4.93	3.75	1.93
H	4.85	3.69	2.10

Table 4.2: Canola yields as captured in the model.

Canola yields as in the model			
System	**Good**	**Average**	**Poor**
G	2.01	1.48	0.71

Generally, for crop-pasture systems grazed by sheep, the yield of medics is expressed in terms of stocking rates. For medics to experience a poor year, the grazing capacity has to be limited by poor medic growth as a result of poor rainfall. During the expert discussion producers and agribusiness extension officers in the area raised concern over stocking rates commonly used as the norm in the area being too high. To limit the possibility of over-grazing medic pastures in poor years, and with the goal of achieving optimal CA benefits by limiting the possible negative effects livestock may have on CA outcomes, the experts agreed on a relatively low stocking rate of one breeding ewe per ha pasture. The experts argued that in order to achieve maximum CA benefits while following a grazing approach to livestock management, and to assume a generic stocking rate for the rotation systems across good, average and poor years, one breeding ewe per ha pasture was the highest possible stocking rate.

For the purposes of this study, the production yield of medics was given in terms of hay production. As described in section 3.8, hay production is applicable on the intensive livestock approach or in the case where medic hay is sold. The medic hay yields as used in the model were 2.5 tonnes per ha in a good year, 2.1 tonnes in an average year and 1.5 tonnes in a poor year. These yields have been validated through consultation with medic producers in the area (Steyn, 2016; Van Heerden, 2016).

It was previously established that withholding the sheep for a longer period from the medics in a separate saltbush pasture had a positive effect on the subsequent wheat yield, as well as the profitability of the system. The enhanced positive effect on the subsequent wheat yield can be attributed to a combination of relatively higher amounts of biomass and organic material available in the pasture, as well as a shorter period of trampling hooves on the soil than in System F, i.e. a pasture rest period. To mimic this on whole-farm level, the same approach was followed on the typical farm. As in the Langgewens trial, a higher stocking rate was used on the typical farm in System H. The expert group agreed that System H could carry the equivalent of one half of a breeding ewe more than Systems E, F and G. The typical herd composition of the Middle Swartland farm is presented in Table 4.3.

Table 4.3: Grazing herd composition and stocking rate of the Middle Swartland for each system.

System	Breeding ewes/ha	Ewe's/ram	Replacement %	Lambing %	Weaning %
E	1	33	25	150	100
F	1	33	25	150	100
G	1	33	25	150	100
H	1.5	33	25	150	100

As discussed in Chapter Two, an alternative livestock approach may be necessary to have a fully functional CA grain production system with an optimised livestock component. An intensive speculation strategy as described in Chapter Three may be an attractive approach to follow in this regard.

When following an intensive lamb speculation strategy, the only limit to carrying capacity becomes the portion of the total mixed ration comprising of medic hay. The lambs in the speculation strategy are fed a total mixed ration. The ration is mixed on the farm. All the facilities and equipment for mixing the ration and providing it to the sheep are accounted for in the model. The mixed ration as it is in the model has been formulated by experts consulted (Basson, 2016; Gerber, 2016; Van Zyl, 2016). Farm produced medic hay makes up the total portion of forage in the ration, with other sources of energy, minerals and vitamins being separately purchased from local suppliers. The total cost of the mixed ration is R 3321 per tonne at the time of this study. The model accommodates changes in ingredients in the ration, as well as any changes in the price of an ingredient or the portion the ingredient comprises of the total mixed ration. Any changes will result in changes in the cost per tonne, and consequently the cost per head per day, as well as the total number of lambs that can be accommodated on the farm given medic hay production in a particular year. Table 4.4

presents the maximum number of lambs that can be accommodated on the farm in each of the crop rotation systems under an intensive speculation approach.

Table 4.4: Maximum number of lambs in each system with an intensive livestock approach.

System	Lambs/cycle			Lambs/year		
	Good	Average	Poor	Good	Average	Poor
E	11150	9477	6690	22299	18954	13380
F	11150	9477	6690	22299	18954	13380
G	11150	9477	6690	22299	18954	13380
H	11150	9477	6690	22299	18954	13380

The maximum number of lambs that can be accommodated when an intensive approach to livestock is followed is the same for all the rotation systems. This is because the farm had been divided into equal portions for each of the systems (50% for Systems E, F and H, and 25% for System G). Although System G is divided in portions of 25%, half of the farm will be in medics production, with 25% planted to wheat and 25% to canola in any particular year.

4.3.3 Prices and costs

Input prices and product prices are organised in a data sheet in the budget model. With a set of excel formulas the relevant price and product data is used to calculate gross margins. For each of input items, the following information is given in the data sheet: Name of the item, purchasing unit, and price per unit. The product prices for each input in the model were taken from the latest purchases made by the Langgewens research farm (2015).

Livestock production costs include all dosing and sponging, feeding and shearing costs. The livestock production costs for the grazing strategy had been taken from the most recent data of Langgewens. The dosage costs of the intensive speculation approach had been derived from cost information provided by experts in the industry. The cost accounted for medic hay in the total mixed ration for the speculation lambs was the cost of producing a tonne of medic hay on the farm. This will vary between good, average and poor years by becoming relatively more expensive in poor medic years because of lower medic hay yields while the production cost per hectare remains constant. The prices of all the other ingredients such as maize, urea and fishmeal have been provided by local suppliers. These costs have all been validated by experts either during the group discussion or through consultation.

Running costs for machinery were taken from a version of the “guide to machinery costs” that was specifically adapted for the Western Cape. The guide was developed and released by local agribusinesses in the Western Cape (Guide to machinery costs for Western Cape grain production, 2015). The running cost calculation for each activity is based on a particular combination of a power source (tractor) and implement.

The product prices of cash crops produced on the farm were calculated as a three year average price received by the Langgewens trial farm. Livestock output prices were determined through consultation with agribusiness representatives, and validated during the expert group discussion. The price for medic hay was derived from the 2014 and 2015 prices producers in the Middle Swartland received for their bales (per tonne). Table 4.5 presents the prices Langgewens received for wheat and canola from 2013 to 2015, as well as the three year average that was used as the price for these commodities in the model.

Table 4.5: Prices Langgewens received for cash crops (average: 2013 - 2015).

Crop	2013	2014	2015	Average
Wheat	3 374	3 517	4 332	3 741
Canola	4 475	4 300	5 518	4 764

The purpose of the model was to compare different livestock management approaches on the same crop rotation systems. There does not exist sufficient data to substantiate the possibility that some broadleaf crops such as canola or medics improve the subsequent wheat quality. Hence, no distinction has been made between the grain quality grades of the different systems.

The price and cost data of all the inputs (i.e. seed costs, fertiliser costs, chemical costs, fuel costs, livestock production costs and contractors cost), along with other costs such as silo costs and crop insurance, were used to calculate allocatable variable costs. This, together with the commodity prices and yield data were used for per hectare gross margin calculations.

4.3.4 Mechanisation

There are many activities involved in the production of small grain and livestock commodities in the Swartland. These activities include planting, fertiliser application, weed, pest and disease control and harvesting. With the inputs of producers in the area, the mechanisation requirements to perform the activities on the typical farm have been established.

The mechanisation requirements of the typical farm were based on best practices. The importance of timeliness for planting and harvesting activities had been expressed in previous studies (Hoffmann, 2001; Hoffmann & Kleynhans, 2011; Knott, 2015). Along with the timeliness of hay making activities, this was reiterated by producers consulted during this study.

Producers in the area agreed on a 22 day window for planting and harvesting. Planting must take place between the 15th of April and the 15th of May every year. During this period, provision for five lost working days is made. Planting after the 15th of May is likely to cause losses in yield as the crops don't reach full growth potential during the winter rainfall season. Working days could typically be interrupted by breakdowns or rain. The same goes for hay making activities in September. Mowing, raking and baling of medic hay will take place from the 3rd of September to the 3rd of October. Rain in September is crucial for a good wheat and canola yield, but can prevent the windrowed medic hay from sufficiently drying out before being baled. Grain harvesting takes place between the 20th of October and the 20th of November. Wheat moisture levels have to be below 13% in order to avoid additional drying costs. The wheat moisture contents depend on morning and evening dew, which limits the harvesting time. Provision for five working days lost due to breakdowns and moisture content in the wheat is included in the period between 20 October and 20 November.

To determine the mechanisation requirements of the typical farm, the working speed, working width and efficiency of each implement and tool are needed. The efficiency variable enables one to account for the portion of working time lost to, among others, turning, refuelling and refilling. With these variables the area a particular machine, or combination of machine and implement, can work within an hour, could be determined. By simply multiplying the time it takes for one implement to work one ha with the total number of ha relevant to that particular activity, the total number of machine hours needed to execute an activity on the total area is calculated. Given the importance of timeliness of certain activities, there is a time limit to these activities, as explained in the previous Paragraph. The total number of hours available per implement set for each activity can be determined. By dividing the total number of hours it takes to complete one activity by the number of hours one implement set provides during the activity window, the number of implement sets for the particular activity can be calculated. Table 4.6 presents the calculation of the number of tractor and planter combination sets to plant the area under cash crops in all the systems of the typical farm within a 22 day time frame. It also serves as an example of how the mechanisation requirements for each activity were calculated. The alternative hectares that are not planted to cash crops are in medic production, which self-establishes each year. Therefore, in effect, only half of the typical farm's 722.5 hectares should be planted every year.

Table 4.6: Calculation of the number of planters to plant 361 hectares.

Activity: Planting of 361 hectares										
Power source	Planter width (m)	Working speed (km/h)	Effectiveness	Hectares	Days available	Hours per day	Hours per hectare per planter	Planter hours needed	Planter hours available	Number of planters required for 361 hectares
120KW 4X4	4.8	7	70%	361	22	8	0.43	153.59	176.00	1

Different crop rotation systems and livestock approaches are simulated on the typical farm in the model. Many of the activities related to crop production are the same across the crop rotation systems. Some activities related to livestock production only relate to a specific approach. The assumption was made that the same machines and implements are used for an activity across all systems and approaches where that activity is applicable. For example, in all the strategies where sheep are fed a total mixed ration, a horizontal feed wagon will be powered by a 110kw 4x4 tractor.

The main differences between farm inventories used in the model are brought about by the different mechanization requirements of the livestock management approaches. For example, in any of the crop rotation systems, when an intensive speculation strategy is followed, there are additional mechanization requirements. These include, among others, a feed wagon, pellet machine, a 110kw tractor and an auger. The differences between the inventories of the various livestock approaches and crop rotation systems can be seen in Annexure E.

4.3.5 Inventories

A farm inventory or asset register is a data sheet that consists of three main components. The components are land and fixed improvements, machinery and livestock. The inventory contains physical and financial descriptions of all the asset items of the typical farm. The capacity, current age, annual usage, number of items in each category, replacement value, depreciation and current value are typical information expressed in an inventory for each item. Ultimately the farm inventory can be considered a register of the required capital for sustainable operation of the whole farm. The sum of all the farm assets represents the total capital requirement of the whole farm. The sum of the land and fixed improvements items is regarded the long-term capital requirement, while machinery and livestock form the intermediate capital investment amount.

For determining the land value of a typical Middle Swartland farm, it's important to note that the production value of land in the area can differ significantly. Other commodities with a relatively higher potential production value, for example, wine grapes, are also commonly produced in the area. Therefore, for purposes of this study, it is important to determine a land value typical to a small grain producing farm in the area. To simply use the average value of land in the Middle Swartland would not reflect the typical land value of a small grain producing farm, and would be misleading. A farm of 850 ha has been validated as typical to the Middle Swartland area by the expert group. A land price of R30 000 per ha has been used in the model. This land price has been obtained and validated through consultation with local agribusiness representatives and the expert group.

Local agribusinesses developed and released an adapted version of the "guide to machinery costs". The adapted version has been specifically developed for the Western Cape due to a lack of consistency and discrepancies in prices. Prices of machinery and implements used in the model were derived from the adapted "Guide to machinery costs for the Western Cape". As explained in Paragraph 4.3.4, the machinery required for the typical farm to operate was based on best practices in the area, with Langgewens providing a point of departure for determining tillage and planting practices. The mechanisation required, as well as its size and capacity depend on the size of the typical farm, the crop rotation system and livestock management approach in practise. The guide to machinery costs suggests a machinery replacement period of twelve years. Annual use of machinery is based on 1000 hours according to the guide.

Investment in livestock differs between livestock management approaches, as does the investment in fixed improvements and machinery. The investment in livestock for the different approaches is derived as follows:

- **Firstly**, for the grazing approach to livestock, the investment in livestock depends on the herd size, which depends on the available land under pasture and the grazing capacity, and herd composition. The herd size and composition for the grazing approach were derived from assumptions accepted by the expert group. These included a stocking rate of one breeding ewe per ha pasture and a ewe to ram ratio of 33:1 for Systems E, F and G, whereas the stocking rate for System H increases to one and a half breeding ewes per ha. These stocking rates are considerably lower than those maintained at the Langgewens trial and used in previous studies on these systems (Hoffmann, 2001; Hoffmann & Kleynhans, 2011; Knott, 2015). Livestock may negate some of the benefits of CA by diminishing the positive effects of soil cover or mulch when they feed on the stubble, and possible soil compaction can occur due to livestock trampling. This may lead to lower wheat or canola yields in the systems modelled, as it could decrease soil moisture retention capacity due to reduced soil aggregate stability (Derpsch *et al.*, 2010). Hence, the expert group agreed that in order to avoid this and achieve maximum gains from CA, the stocking rate could not be higher than described above.
- **Secondly**, for the intensive speculation approach, the investment in livestock depends on the number of speculation lambs the farm can accommodate in one cycle. This number depends on the medic hay yield, the portion medic hay comprises of the total mixed ration and the number of cycles in a year. The number of cycles in a year was derived from the cyclical availability of Dohne Merino lambs. This was explained in Paragraph 3.8.2.

The output values for the livestock component of the whole farm, as well as the value of the herd have been determined through consultation with local agribusiness representatives and the use Langgewens trial data. The output values for the intensive speculation approach were entirely provided by experts in the animal husbandry industry, while Langgewens trial data contributed to determining herd values for the grazing approach. The different inventories for the livestock management approaches and crop rotation systems simulated in this study are depicted in Annexure E.

4.3.6 Outline of the calculation model

The physical description of the farm, land utilisation patterns, crop yield and livestock stocking rate information, product prices and cost data all contribute to the input component of the model. The relevant information from the input component of the model is taken to the calculation component by a sequence of Excel equations. The calculation component, which consists of various sequences of interrelated calculations, forms the core structure of the model. This component is based on two principles. First, the accurate simulation of practices and processes on the simulated farm in order to achieve trustworthy outcomes in terms of the whole-farm impacts of certain factors. In this case, this refers to the impacts CA principles have on livestock components, and vice versa. The second is the generation of financial results that can be universally compared. This was achieved by structuring and arranging all the physical-biological factors and interrelationships into formats based on standard accounting principles.

4.3.6.1 Gross margin calculations

Gross margin calculations are done for each crop on a per-hectare basis. The data for the gross margin calculations was taken from the Langgewens trial data. After it was presented and validated during the expert group discussion, it was incorporated into the whole-farm model. Annexure D shows a typical example of a gross margin calculation on a per hectare basis.

To account for the prevalence of good, average and poor years, a per-hectare gross margin had been calculated for every crop on the typical farm for each of these scenarios. The yields, depending on crops in good, average and poor years, were used to calculate the gross production value, and therefore gross margin, for every crop in each scenario.

The land utilisation pattern determines the number of hectares planted to each crop in any given year. The sequence of the seasonal variability, as described in Paragraph 4.3.1, was assigned to the multi-period budget. The multi-period budget would then calculate the total gross margin for the whole farm in a particular year. Within this calculation, the per-hectare gross margin of each crop corresponding to the seasonal variability sequence assigned to the multi-period budget, is multiplied by the number of hectares planted to that particular crop. The sum of all the total crop gross margins represents the total farm gross margin for a particular year. Although the sequence of seasonal variability has been validated by the expert group, it was agreed that the sequence is unpredictable and that any other sequence is just as likely to occur. The multi-period budget allows for this sequence to be altered, in which case all the total farm gross margins will be updated accordingly.

4.3.6.2 Overhead and fixed costs

Overhead and fixed costs are part of every farming business. Overhead and fixed costs include, among others, maintenance on fixed improvements, insurance and licenses on equipment, electricity, and permanent labour, as well as admin fees such as communication, accounting and banking fees. Overhead and fixed costs were obtained from study group results and validated by the expert group. It was decided to accept these costs as typical, although it may differ between farms. The outcome of the system implications is mostly affected at gross margin level. The values of overhead and fixed costs for each crop rotation system and livestock management approach combination can be found in the multi-period budgets in Annexure F.

4.3.7 Profitability analysis and net cash flow

All the input data and information in the model are taken to through the calculation component to a multi-period whole-farm budget. Certain financial indicators are built into this budget, serving as the outputs of the model. These indicators allow for comparison of the various crop rotation systems and livestock approaches in terms of the whole farm profitability and affordability of foreign capital.

All costs are accounted for in the multi-period budget. Distinction is made between long-term capital items and intermediate capital items. The multi-period budget runs over a 20 year period. The long simulation period allows for repeating crop rotation systems, as well as incorporation of machinery replacements. Purchases of land, fixed improvements, machinery, equipment and livestock are treated as outflows. The expected lifespan of machinery in the model is twelve years, after which the item is automatically replaced in the budget. The values of all capital items at the end of the 20 year simulation period are accounted for as an inflow. This accounts for the total inflow value of the current capital investment.

The net annual flow is calculated for each of the 20 years in the multi-period budget. The sum of overhead and fixed costs and total capital expenditure is subtracted from the whole-farm gross margin to calculate the net annual flow of funds. This series of annual net flows are used to calculate the internal rate of return on capital (IRR) and net present value (NPV) for the 20 year simulation period of each combination of rotation system and livestock approach.

In this study, various strategies are simulated, with each being a combination of a particular crop rotation system and livestock approach. The main difference between the various strategies is the required capital investment for each. To take this into account and measure the profitability of the different strategies, the IRR and NPV measurements are ideal. Growth generated by the cash flow is represented by the IRR. The IRR is expressed as a percentage return on the initial capital investment over the 20 year simulation period. The NPV represents a present value of an expected future cash flow in monetary terms. The NPV and IRR measurements, therefore, indicate the attractiveness of the investment for each strategy. The NPV and IRR indicators for the different strategies are shown in Annexure F.

Farm profitability alone is not sufficient to determine which strategy is best. Since the strategies have different capital investment requirements, the affordability of borrowed capital can play a significant role in the success of a strategy. The affordability of borrowed capital is expressed in terms of a cash flow budget. In a cash flow budget only cash items are taken into account. The total flow of capital requirements are, therefore, not taken into consideration. A certain portion of the long-term and intermediate capital investments is financed with borrowed capital. However, the provision of capital investments has a certain cash implication, i.e. a payment. In the cash flow budget, the annual cash flow is calculated by subtracting all the cash outflows from the cash inflow, i.e. subtracting the sum of the payments on borrowed capital, foreign factor cost and overhead and fixed costs from the total farm gross margin (including capital sales). This generates a total before interest. Interest is earned on a positive flow before interest, and paid on a negative flow before interest. Constant prices were used in the model, and therefore the nominal interest rate should be converted to a real interest rate. The following formula was used for the conversion from a nominal to real interest rate:

Real interest rate = {[(1+ nominal interest rate) / (1 + inflation rate)]-1} * 100

The total cash flow after interest resembles the closing bank balance at the end of a particular year, and the opening bank balance at the beginning of the following year. The cash flow budget can be seen under the heading “cash flow” in Annexure F.

4.4 Results and findings

The aim of this chapter is to compare the financial performance of different crop rotation systems and livestock management approaches in terms of their long-term profitability. In order to do this, a whole-farm multi-period budget has been developed. The whole-farm model consists of an input component, a calculation component and an output component. Through the use of various formulas, different input variables, descriptions, parameters and data were converted into financial profitability indicators.

The trial data of the long-term crop rotation trial at the Langgewens experimental farm served as the basis for the scientific data used in the model. The Langgewens data had to be converted to a typical whole-farm context. This was achieved through a multi-disciplinary expert discussion group and consultation with industry experts. The process of converting the relevant trial data to typical whole-farm level was explained in the previous section of this chapter. The said section also comprised of a detailed description of the physical extent of the typical farm, as well as detailed explanations of how the whole-farm multi-period budget was developed, how the parameters and variables were obtained and validated, and how the dynamics of the budget work.

In this section of Chapter Four the results and outputs of the whole-farm multi-period model will be discussed. There will be particularly focused on how the different crop-pasture rotation systems perform when combined with three different livestock approaches. This section also encompasses a sensitivity analysis of the different strategies to evaluate how the strategies are affected by alterations in certain variables.

4.4.1 Capital investment

4.4.1.1 Long-term capital investment

The long-term capital investment of a farming business refers to the portion of the total capital investment that is fixed in the short and medium term. The long-term capital investment is comprised by the land and fixed improvements, which includes housing and infrastructure such as fencing, sheds, and other buildings.

It was explained in the previous section that the typical farm in the Middle Swartland has a size of 850 hectares at the time of this study, of which 85% is arable. The value of the land has been accepted as R 30 000 per hectare, with no distinction made between arable and non-arable portions of land.

The four crop rotation systems modelled on the typical farm in this study are all fairly similar (see Paragraph 3.4 for a detailed outline of each). However, the three approaches to livestock integration mimicked in the whole-farm multi-period budget model had different infrastructure requirements. The different infrastructure requirements of each combination of crop rotation system and livestock management approach are presented in Table 4.7.

Table 4.7: Expected Long-term capital requirement of each strategy.

System	Approach	Expected long-term capital investment (R)	Long-term PMT (R)
E	Intensive	35 298 024	1 286 542
	Grazing	32 100 024	1 169 981
	Sell Medics	30 968 512	1 128 740
F	Intensive	35 298 024	1 286 542
	Grazing	32 100 024	1 169 981
	Sell Medics	30 968 512	1 128 740
G	Intensive	35 298 024	1 286 542
	Grazing	32 100 024	1 169 981
	Sell Medics	30 968 512	1 128 740
H	Intensive	35 298 024	1 286 542
	Grazing	32 100 024	1 169 981
	Sell Medics	30 968 512	1 128 740

Source: Summary of Annexure E.

The differences in infrastructure requirements of the different livestock approaches are mainly due to the higher need for fencing and feedlot- or other livestock facilities. The approach where medics are baled and sold to neighbouring producers, therefore, has the lowest long-term capital requirement. While the sell-medics approach has no livestock housing or feeding requirements, the intensive speculation approach has the highest long-term capital requirement. The grazing approach only requires a ram shed and sheepfold, whereas the intensive approach requires an additional lamb shed, a feedlot, and two camps. These camps are to be fully equipped with feed- and water troughs.

Although the expected long-term capital investment varies between livestock approaches, it remains the same for a particular approach across all the crop rotation systems. This is because the houses, sheds, boreholes and other fixed improvements that do not differ between livestock approaches, are considered common to all the crop rotation systems, and are therefore not impacted by a particular crop rotation system. The long-term capital investment for the typical intensive speculation approach is R 35 298 024, with the grazing approach's long-term investment being R 32 100 024. When medics are baled and sold, and thus effectively treated as a cash crop, the long-term capital investment is R 30 968 512 (refer to Annexure E).

The relevant annual payment for each strategy is also presented in Table 4.7. The payments were calculated by assuming that 30% of the total capital investment is borrowed, with 70% being own capital. The borrowed portion of the long-term capital investment is paid off with annual payments over a 20 year period. These payments are of importance for the financial evaluation of the different strategies as they represent the cost of availability of capital and are taken into account when calculating the annual cash flow of the whole farm. The annual payments on long-term capital for the different livestock approaches are as follows: R 1 286 542 for the intensive speculation approach, R 1 169 981 for the grazing approach and R 1 128 740 for the approach where medics are sold.

4.4.1.2 Intermediate capital investment

Intermediate capital forms part of the total capital investment of the typical farm. The intermediate capital investment consists of the relatively less valuable items included in the capital investment. The items comprising the intermediate capital investment are generally replaced in the short and medium term. It is also relatively easier to convert these items to cash. Intermediate capital items include all machinery and equipment such as tractors, combine harvesters, other tools and vehicles, and livestock. Livestock that are considered part of the intermediate capital investment only encompasses the initial breeding herd or first cycle, depending on the approach – for the grazing approach, only the breeding ewes and rams are considered to be intermediate capital items. Lambs and replacement ewes that are bred and sold over the duration of the farming operation do not form part of intermediate capital. For the intensive speculation approach, the value of the lambs purchased in one cycle forms the livestock component's part of the intermediate capital investment. This is also the reason why the values of the initial capital requirements differ from those in the inventories of Annexure E.

The intermediate capital investment required for each strategy differs mainly due to differences in the livestock approaches and not the crop rotation systems. This is because crop rotation systems are all relatively the same and the mechanisation requirements of each strategy are influenced by the livestock approach rather than the crop rotation system.

The first factor influencing the intermediate capital investment is the number and type of livestock required by each strategy. For example, the grazing approach requires breeding ewes and rams, while the intensive approach requires weaned lambs. The number of each required in each strategy is derived from the applicable stocking rate and herd composition for the grazing approach, and the medic hay yield and composition of the mixed ration for the intensive speculation approach. All the information required for this had been validated as explained in Paragraph 4.3.2.

The second factor that causes differences in intermediate capital investment requirements of the various strategies, is the mechanisation requirements of each. The grazing approach requires considerably less mechanisation than the intensive speculation and "sell medic" approaches. These differences are mainly attributed to the need for baling medics in both the intensive approach and when medics are sold. Table 4.8 presents the expected intermediate capital requirement of each strategy. Refer to Annexure E for the different intermediate capital items.

Table 4.8: Expected intermediate capital requirement of each strategy.

System	Approach	Expected intermediate capital investment (R)	Intermediate capital PMT (R)
E	Intensive	20 209 222	1 619 823
	Grazing	9 225 029	739 411
	Sell Medics	11 876 379	951 923
F	Intensive	20 209 222	1 619 823
	Grazing	9 225 029	739 411
	Sell Medics	11 876 379	951 923
G	Intensive	20 209 222	1 619 823
	Grazing	9 225 029	739 411
	Sell Medics	11 876 379	951 923
H	Intensive	20 209 222	1 619 823
	Grazing	9 369 584	750 997
	Sell Medics	11 876 379	951 923

Source: Summary of Annexure E.

The intermediate capital investments required for the intensive approach and when medics are sold are R 20 209 222 and R 11 876 379, respectively. These remain the same for the intensive and "sell medics" approaches across all the crop rotation system because the intermediate capital items required for these two approaches are mutual and, therefore, the crop rotation systems do not affect the intermediate capital items required for these two approaches.

In all of the crop rotation systems, half of the typical farm is under medics in any given year. The number of sheep carried in the intensive speculation approach is derived from the medic hay yield and the portion of medics in the total mixed feed ration. The salt bush pastures in System H do not affect any of these in the intensive speculation approach and, therefore, there are no differences in the carrying capacity between the crop rotation systems. The effect of the saltbush pastures in System H on the intermediate capital investment only becomes a factor when the grazing approach is being followed. From Table 4.8 it is clear that, due to the increased carrying capacity of System H under a grazing approach as a result of the saltbush pastures, System H has a relatively greater intermediate capital investment under a grazing approach than Systems E, F and G. Under a grazing approach, Systems E, F and G all require an intermediate capital investment of R 9 225 029, whereas System H requires R 9 369 584.

Intermediate capital items are paid with annual payments over a five year period. The effect of replacing capital items on the net annual flow can be seen in Annexure F. The payments on intermediate capital investments are also taken into account when calculating the annual cash flow of the whole-farm. The payments for intermediate capital investments of the systems and livestock approaches are also presented in Table 4.8. However, these only reflect the payments on the initial intermediate capital requirement and not those of capital replacements that take place during the 20-year simulation period. The annual payment on intermediate capital investment for the intensive approach to livestock is R 1 619 823. This amount remains the same for the intensive approach, irrespective of the crop rotation system it's applied to. The same goes for when medics are sold as a cash crop, in which case the annual payment will be R 951 923. The payment on the intermediate capital investment of the grazing approach is R 739 411 when applied to Systems E, F and G, and R750 997 in System H.

The intermediate capital investment required for each strategy is not affected by the crop rotation system when an intensive approach to livestock is followed or when medics are sold as a cash crop. The mechanisation requirement, as well as the nature and number of livestock required are determined by the livestock management approaches and are the same for each approach across all the rotation systems. Should there be any changes in the land utilisation pattern that lead to differences in the area under a particular crop between the systems, the systems may alter or influence the intermediate capital requirement. For example, when System E is planted to 75% of wheat and 25% of medics in a certain year, while the other systems remain with 50% under medics, another planter and tractor may be required to complete the planting activities in time. However, for the purposes of this study, the area under medics was assumed to be 50% of the arable land for all the rotation systems.

4.4.2 Gross margins

The gross margins of twelve different strategies have been calculated in the whole-farm multi-period budget. Each strategy consists of two components: A crop rotation system and a livestock management approach. The four crop-pasture rotation systems of the Langgewens trial, as discussed in Paragraph 3.4, have been developed to typical whole-farm level in the budget model. Any of the livestock management approaches discussed in Paragraph 3.8 can be applied to any one of the crop rotation systems. The budget model first calculates the per hectare gross margin of each crop by subtracting the direct allocatable variable costs from the gross production value. The per-hectare gross margin is then multiplied by the number of hectares planted to the particular crop. The total gross margins of all the crops in a particular year are then added together to calculate the whole-farm gross margin. Seasonal variations depicted as good, average and poor years have been built in to mimic the effect of rainfall variation on crop yields.

Crop rotation, as one of the key principals of CA, lowers the production costs of subsequent cash crops (Hoffmann, 2001). The effects of crop rotation on production costs are captured in the production records of the Langgewens trial. These effects have been incorporated into this budget model by using the Langgewens input data to specify the input costs of each rotation system simulated in the model. The whole-farm gross margins of the strategies simulated in the budget model are presented in Table 4.9.

Table 4.9: Whole-farm gross margins.

Whole-farm gross margin (R)								
System	Scenario:	Wheat and canola: Good		Wheat and canola: Average			Wheat and canola: Poor	
		Medics:		Medics:			Medics:	
	Approach	Average	Poor	Good	Average	Poor	Good	Average
E	Intensive	7 661 455	6 949 992	6 786 064	6 359 186	5 647 723	3 918 621	3 491 744
	Grazing	5 061 878	5 061 878	3 759 610	3 759 610	3 759 610	892 167	892 167
	Sell Medics	6 555 895	5 991 442	5 592 299	5 253 627	4 689 174	2 724 856	2 386 184
F	Intensive	7 237 390	6 525 927	6 281 232	5 854 355	5 142 892	3 823 425	3 396 547
	Grazing	4 769 625	4 769 625	3 386 590	3 386 590	3 386 590	928 782	928 782
	Sell Medics	6 086 674	5 522 221	5 042 311	4 703 639	4 139 186	2 584 503	2 245 831
G	Intensive	5 884 431	5 172 968	5 182 634	4 755 756	4 044 293	2 975 567	2 548 689
	Grazing	3 461 822	3 461 822	2 333 147	2 333 147	2 333 147	126 080	126 080
	Sell Medics	4 778 871	4 214 418	3 988 868	3 650 196	3 085 743	1 781 801	1 443 129
H	Intensive	7 911 832	7 199 404	7 005 549	6 578 092	5 865 664	4 291 719	3 864 262
	Grazing	5 794 769	5 794 769	4 461 028	4 461 028	4 461 028	1 747 199	1 747 199
	Sell Medics	6 761 695	6 197 242	5 766 627	5 427 955	4 863 502	3 052 797	2 714 125

Source: Annexure F.

The whole-farm gross margins as shown above in Table 4.9 have been calculated for different scenarios. The expert group agreed that wheat and canola generally experience the same seasonal variability, i.e. a good year for wheat would generally also mean a good year for canola. Seasonal variability for medics was difficult to establish from Langgewens data as medic yields have never been recorded on the farm. However, it was of importance for this study in order to incorporate the effect of seasonal variability of medics on the intensive and "sell medics" approaches. With the input of producers that follow the latter on their farms, it was accepted that the two extremes of medic and wheat/canola yields are not achieved in the same year. Therefore, when wheat and canola experience a good year, medic yields can only be average or poor; and when wheat and canola experience a poor year, medic yields can only be good or average. This emphasizes the diversification factor crop-pasture systems bring to a whole-farm system.

In terms of the whole-farm gross margin, the intensive approach is the highest achiever across all the rotation systems and seasonal variability scenarios. The “sell medics” approach has the second highest whole-farm gross margin across all the rotation systems and scenarios, with the grazing approach having the lowest whole-farm gross margin in every system and scenario. The effect of the higher stocking rate due to the salt bush pastures in System H can clearly be seen in the relatively narrower gap between the gross margins of the grazing approach and the “sell medics” approach in System H, compared to the other systems.

In a poor wheat and canola year, the livestock component does not provide a buffer when a grazing approach is followed. The low gross margins of the grazing approach is mainly attributed to the significantly low stocking rate of one breeding ewe per ha in Systems E, F and G, and 1.5 in System H. Therefore, when a grazing approach is followed, the profitability of any of the systems may become increasingly dependent on the cash crop enterprise.

4.4.3 IRR and NPV

The profitability of the different strategies on whole-farm level is indicated by the internal rate of return on capital (IRR) and the net present value (NPV). The net annual flows generated over the 20 year simulation period are used to calculate the IRR and NPV of the whole-farm system. The budget model generates these outcomes for any strategy selected on the first spreadsheet, i.e. any combination of crop rotation system and livestock approach. This process was discussed in detail in Paragraph 4.3.7. The IRR and NPV of each strategy are calculated in the multi-period budget and can be seen in Annexure F.

The IRR and NPV of each strategy are presented in real terms. The nominal interest rate used was 10.5%, the inflation rate 6.3%, and the real interest rate 3.95% (South African Reserve Bank, 2016). Figure 4.1 shows the IRR of the different strategies simulated in the model, while Figure 4.2 presents the NPVs of the different strategies. Each strategy is represented by the symbol of the rotation system used and the applied livestock approach, where “I” represents the intensive speculation approach, “G” the grazing approach, and “SM” the approach where medics are sold. For example, “F-I” represents a strategy where rotation System F is followed with an intensive speculation approach.

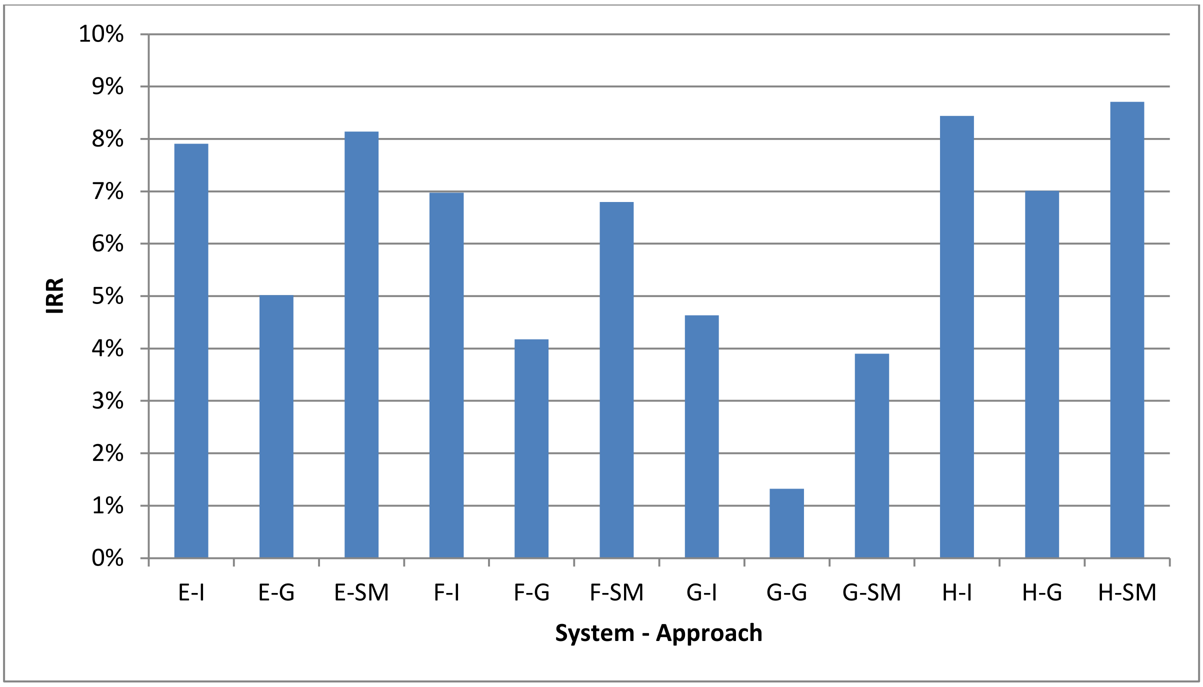

Figure 4.1: IRR of different livestock management approaches and rotation systems.
Key: System-Livestock management approach, where: I = Intensive speculation approach, G = Grazing approach, SM = Sell Medics.
Source: Annexure F.

Strategy H-SM, representing System H and medics being sold as a cash crop, has the highest expected IRR of all the strategies. For each rotation system, the lowest expected IRR is constantly achieved when following the grazing approach. This is due to the low carry capacity prescribed by the group of experts in order to avoid negation of the CA benefits and aims through compaction by livestock. The effect of having livestock on the medic pastures for a shorter period of time can be seen in the relatively smaller difference between the IRRs of H-G and the other strategies based on System H, when compared to the differences in IRR of the grazing and other approaches in Systems E, F and G. System G has the lowest IRR of all the systems, irrespective of the livestock approach. The main reason for this is the relative profitability of wheat as a cash crop, compared to canola. Half of the arable land allocated to cash crop production in System G is planted to canola.

Across all the rotation systems, the intensive livestock approach has the highest NPV of the livestock approaches. Strategy H-I, representing crop rotation System H with an intensive speculation approach, has the greatest NPV of all the strategies. The intensive approach is the only approach achieving a positive NPV when rotation System G is followed. The NPVs of System G are negative when a grazing approach is followed or medics are sold. The negative NPVs are because of the IRRs being below the real interest rate of 3.95%. These strategies are therefore unattractive investments.

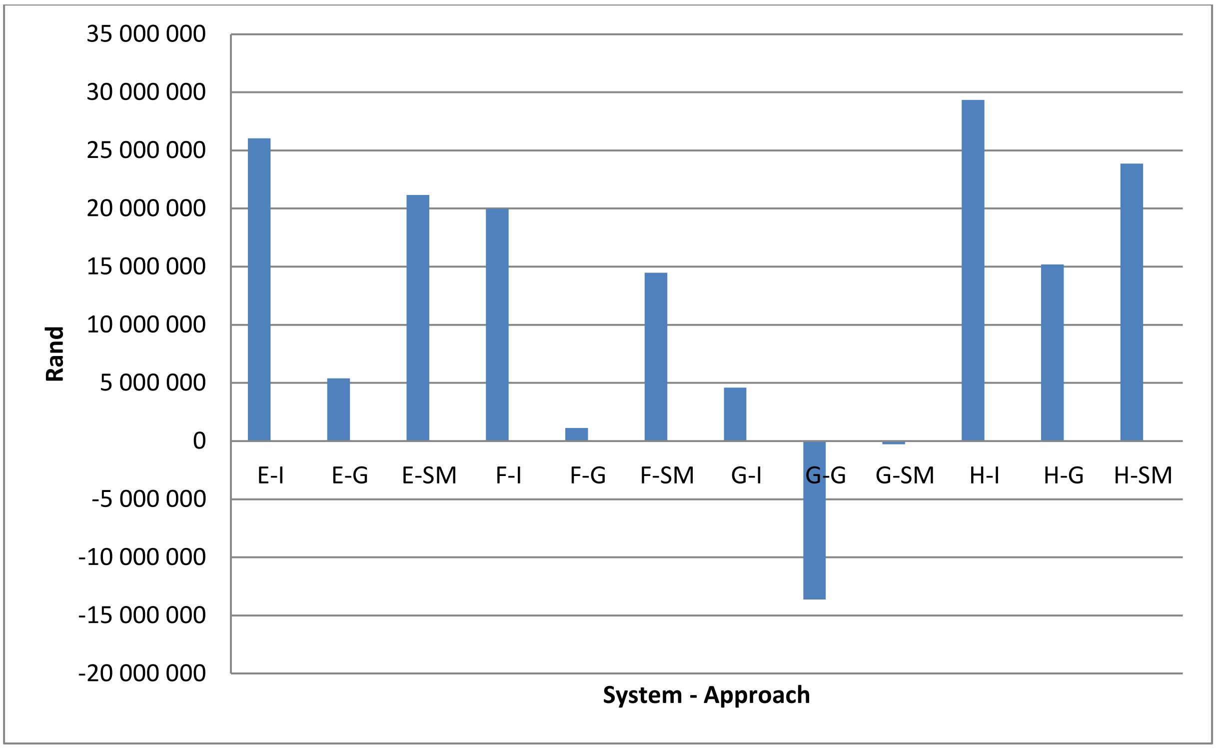

Figure 4.2: NPV of different livestock management approaches and rotation systems.
Key: System-Livestock management approach, where: I = Intensive speculation approach, G = Grazing approach, SM = Sell Medics.
Source: Annexure F.

As was the case with the IRRs, the grazing approach achieves the lowest NPV in every system. The relatively poor performance of System G can again be attributed to canola being relatively less profitable than wheat as a cash crop. This means that Systems E, F and H have a greater ability to capitalise on the profitability of wheat in good years because the area under wheat in these systems is double the area under wheat in System G.

Canola does, however, have a place in crop rotation systems in terms of its usefulness in controlling weeds. This is clear from the relatively high wheat yields achieved in System G at the Langgewens trials. In terms of financial performance, however, it does make more sense to use medics as the only broadleaf crop in rotation with wheat to control grass weeds. Medics also contribute to the nitrogen levels in the soil, resulting in possible lower fertilisation input requirements the following year.

It is important to note that the performance of the systems is influenced by the yield and input data of the Langgewens trial. Saltbush pastures are only applicable to System H when a grazing approach is followed. Consequently, in practice, Systems F and H would achieve the same financial performance under the intensive speculation approach or when medics are sold. In the model, however, the intensive speculation and "sell medics" approaches applied to System F are affected negatively by the deviations in crop yield and input data caused by the grazing approach followed on System F in the trial.

4.4.4 Analysis of financial sensitivity through scenarios

The whole-farm budget model described in this chapter has been used to determine and compare the financial performance of different strategies that can be used to integrate a livestock component into a mixed CA-based crop-livestock farming system. The parameters and assumptions used to specify the typical farm for the Middle Swartland in the model were obtained and validated through various forms of consultation with industry experts. The typical farm used in the model is, however, not representative of all farming operations in the particular area. Developing a typical farm model to represent every individual situation is impossible. Instead, by relaxing or altering some of the parameters and assumptions that influence the performance of the strategies in the model, the sensitivity of the different strategies could be determined.

The relaxation or alteration of the assumptions and parameters would be done through scenarios, which are commonly used in research to evaluate the effects of "what if" situations. By applying a *ceteris paribus*[2] principle, the impact changes in one single variable have on the whole-farm profitability can be assessed.

The aim of a sensitivity analysis is to identify the external factors of the farming system that may cause increased vulnerability of the strategies. By focussing on the factors that producers have no or little control over, the sensitivity analysis can contribute valuable information to the process of identifying the most suitable strategy. The scenarios included for the sensitivity analysis are changes in the price of wheat, changes in the price of meat (mutton), and changes in the prevalence of good, average and poor production years.

4.4.4.1 Changes in the wheat price

Wheat remains a big contributor to the financial performance of the strategies modelled in this study. In Systems E, F and H half of the arable area of the typical farm is planted to wheat, with 25% in System G. Producers have little or no control over external economic factors such as the wheat price. Changes in the wheat price will impact the whole-farm profitability of each strategy. In order to assess these impacts, the different levels of change in the wheat price have been incorporated into the model. Table 4.10 and Table 4.11 show the adapted IRR and the relative change in IRR of each strategy at a 10%, 20% and 30% increase and decrease in the wheat price, respectively.

[2] *Ceteris paribus* refers to "holding all other things constant" (Knott, 2015).

Table 4.10: The impact of an increase in wheat price on whole-farm IRR.

System	Approach	Current Situation		Scenario: An increase in wheat price					
		Wheat price: R 3741 per ton		+10%	R 4 115.10	+20%	R 4 489.20	+30%	R 4 863.30
		IRR	NPV	IRR	Relative change	IRR	Relative change	IRR	Relative change
E	Intensive	7.91%	26028674	9.29%	17%	10.71%	35%	12.17%	54%
	Grazing	5.02%	5379553	6.78%	35%	8.60%	71%	10.48%	109%
	Sell Medics	8.14%	21156461	9.98%	23%	11.86%	46%	13.82%	70%
F	Intensive	6.97%	19978721	8.21%	18%	9.47%	36%	10.77%	55%
	Grazing	4.17%	1128747	5.75%	38%	7.38%	77%	9.06%	117%
	Sell Medics	6.79%	14490153	8.42%	24%	10.09%	49%	11.81%	74%
G	Intensive	4.63%	4603297	5.29%	14%	5.95%	29%	6.63%	43%
	Grazing	1.32%	-13630322	2.16%	63%	3.00%	127%	3.86%	192%
	Sell Medics	3.90%	-268916	4.76%	22%	5.61%	44%	6.48%	66%
H	Intensive	8.44%	29334390	9.84%	17%	11.28%	34%	12.76%	51%
	Grazing	7.01%	15199770	8.84%	26%	10.74%	53%	12.71%	81%
	Sell Medics	8.71%	23854683	10.57%	21%	12.49%	44%	14.49%	66%

Table 4.11: The impact of a decrease in wheat price on whole-farm level.

System	Approach	Current Situation		Scenario: A decrease in wheat price					
		Wheat price: R 3741 per ton		-10%	R 3 366.90	-20%	R 2 992.80	-30%	R 2 618.70
		IRR	NPV	IRR	Relative change	IRR	Relative change	IRR	Relative change
E	Intensive	7.91%	26028674	6.56%	-17%	5.25%	-34%	3.96%	-50%
	Grazing	5.02%	5379553	3.31%	-34%	1.65%	-67%	0.02%	-100%
	Sell Medics	8.14%	21156461	6.40%	-21%	4.70%	-42%	3.05%	-63%
F	Intensive	6.97%	19978721	5.76%	-17%	4.58%	-34%	3.42%	-51%
	Grazing	4.17%	1128747	2.64%	-37%	1.13%	-73%	-0.34%	-108%
	Sell Medics	6.79%	14490153	5.24%	-23%	3.72%	-45%	2.24%	-67%
G	Intensive	4.63%	4603297	3.98%	-14%	3.34%	-28%	2.70%	-42%
	Grazing	1.32%	-13630322	0.50%	-62%	-0.32%	-124%	-1.13%	-185%
	Sell Medics	3.90%	-268916	3.08%	-21%	2.26%	-42%	1.45%	-63%
H	Intensive	8.44%	29334390	7.07%	-16%	5.74%	-32%	4.43%	-47%
	Grazing	7.01%	15199770	5.24%	-25%	3.52%	-50%	1.85%	-74%
	Sell Medics	8.71%	23854683	6.94%	-20%	5.21%	-40%	3.54%	-59%

Initially System H has the highest expected IRRs for all the livestock approaches. This trend continues across all three levels of price change, for both increasing and decreasing wheat prices. The order of profitability of the livestock management approaches remains the same as in the initial stage when wheat prices increase. Initially System H is the most profitable when medics are sold. This remains the case as long as wheat prices increase.

As soon as wheat prices begin to decline the order of approaches, in terms of profitability, changes. From a 10% decrease in wheat prices, an intensive livestock approach applied to System H becomes the most profitable strategy. This shows that when favourable wheat prices are experienced, livestock play a relatively smaller role than when wheat prices decrease. In case of the latter, an integrated intensive speculation livestock component acts as a buffer.

The relative change in expected IRR for an approach where medics are sold is greater across all rotation systems and price change levels than the relative change in IRR for the intensive approach.

Therefore, when medics are sold, the whole-farm system achieves greater gains from a wheat price increase than an intensive approach. Conversely, when wheat prices decline, the intensive approach is less affected by the wheat price decrease, leading to a higher IRR than when medics are sold. The grazing approach shows the greatest sensitivity to wheat price changes with the greatest relative change in IRR for all the systems when prices increase and decrease. However, despite the significant changes in IRR of the grazing approaches, the grazing approach remains the least profitable. The low profitability of the grazing approach is attributable to the low stocking rate. In System H the profitability of the grazing approach is relatively closer to that of the other two approaches as a result of an increased stocking rate. There is only a 0.05% difference in the IRRs of the intensive and grazing approaches in System H under a 30% wheat price increase.

Figure 4.3 shows the trends in wheat production, domestic use, net imports and price. It is important to note that normal weather conditions have been assumed for the forecast period (2016 onwards). According to Figure 4.3 the wheat price can be expected to increase with roughly a thousand rand per tonne over the next ten years.

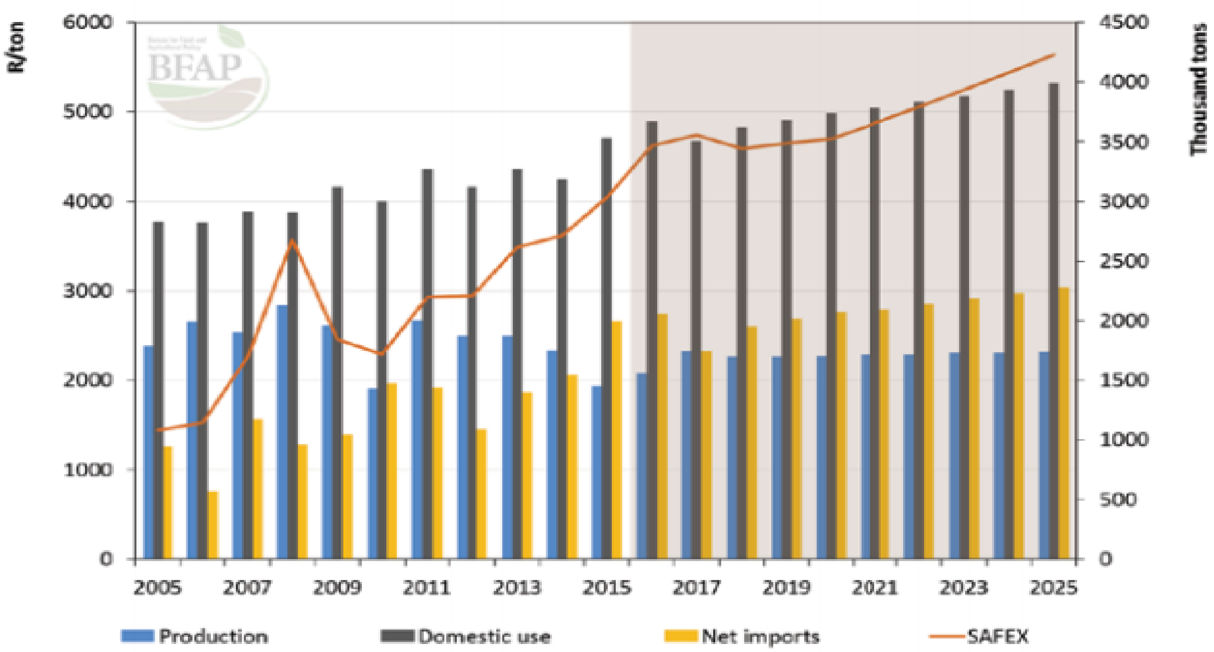

Figure 4.3: Trends in wheat production, domestic use, net imports and price.
Source: BFAP (2016).

4.4.4.2 Changes in the meat price

Medics comprise half of the arable area in any particular year in all the crop rotations that were modelled. The financial success of the medic enterprise is directly dependent on the profitability of livestock, irrespective of the approach. As is the case for the wheat enterprise, producers have no or very little control over the meat prices. Changes in meat prices may impact the various approaches differently, as the nature of the approaches differs. For example, an increase in meat price would affect the purchasing and selling prices of sheep. Therefore, the intensive approach will be affected on the input and output side, and consequently the profitability of the medic enterprise will be impacted differently than when a grazing approach is followed where the price increase only affects the output side. To evaluate the effects of changes in the meat price on the whole-farm profitability of the different strategies, three levels of price increases and decreases have been incorporated into the model. These levels are a 10%, 20% and 30% change in meat price. The meat price changes have been applied to the price received for old ewes (live weight price per kg), the purchase price of weaned lambs for the intensive approach (live weight price per kg), and the carcass price obtained for lambs sold.

Table 4.12 shows the impact of an increase in meat price on the whole-farm profitability of each strategy in terms of IRR, while Table 4.13 presents the impacts of a meat price decrease. The price changes are applied to all meat prices used in the model simultaneously, as explained in the first Paragraph of this section. Only the carcass price of lambs is shown in the tables below to serve as an example.

Table 4.12: The impact of an increase in meat price on whole-farm IRR.

System	Approach	Current Situation		Scenario: An increase in meat price					
		Carcass price: R56 per kg		+10%	R 61.60	+20%	R 67.20	+30%	R 72.80
		IRR	NPV	IRR	Relative change	IRR	Relative change	IRR	Relative change
E	Intensive	7.91%	26028674	9.69%	23%	11.49%	45%	13.29%	68%
	Grazing	5.02%	5379553	5.12%	2%	5.22%	4%	5.32%	6%
	Sell Medics	8.14%	21156461	Not Applicable					
F	Intensive	6.97%	19978721	8.74%	25%	10.52%	51%	12.31%	77%
	Grazing	4.17%	1128747	4.32%	4%	4.47%	7%	4.62%	11%
	Sell Medics	6.79%	14490153	Not Applicable					
G	Intensive	4.63%	4603297	6.36%	37%	8.10%	75%	9.84%	112%
	Grazing	1.32%	-13630322	1.46%	11%	1.60%	21%	1.74%	32%
	Sell Medics	3.90%	-268916	Not Applicable					
H	Intensive	8.44%	29334390	10.23%	21%	12.04%	43%	13.86%	64%
	Grazing	7.01%	15199770	7.24%	3%	7.47%	7%	7.71%	10%
	Sell Medics	8.71%	23854683	Not Applicable					

The intensive and grazing approaches are the only approaches directly affected by meat price changes. When medics are sold, the financial performance of the medic enterprise depends on the medic hay price on the output side, and the production cost of medics on the input side. Although the medic hay price is also influenced by livestock profitability of neighbouring farms, this effect was not incorporated into the model. The medic hay price was thus assumed constant over the budget period, with the input costs of producing a tonne of medic hay varying between good, average and poor medic years.

The intensive approach is the most sensitive to meat price changes, as can be expected due to price impacts on the input and output side. The grazing approach is only impacted on the output side when the meat price changes. Hence, the relative change in expected IRR of the intensive approach is significantly greater than the relative change in expected IRR of the grazing approach. This is in contrast to what happens under conditions of wheat price changes.

Table 4.13: The impact of a decrease in meat price on whole-farm IRR.

System	Approach	Current Situation		Scenario: A decrease in meat price					
		Carcass price: R56 per kg		-10%	R 50.40	-20%	R 44.80	-30%	R 39.20
		IRR	NPV	IRR	Relative change	IRR	Relative change	IRR	Relative change
E	Intensive	7.91%	26028674	6.13%	-22%	4.36%	-45%	2.60%	-67%
	Grazing	5.02%	5379553	4.92%	-2%	4.82%	-4%	4.72%	-6%
	Sell Medics	8.14%	21156461	Not Applicable					
F	Intensive	6.97%	19978721	5.21%	-25%	3.45%	-51%	1.69%	-76%
	Grazing	4.17%	1128747	4.03%	-4%	3.88%	-7%	3.74%	-10%
	Sell Medics	6.79%	14490153	Not Applicable					
G	Intensive	4.63%	4603297	2.91%	-37%	1.18%	-74%	-0.54%	-112%
	Grazing	1.32%	-13630322	1.18%	-11%	1.04%	-21%	0.90%	-32%
	Sell Medics	3.90%	-268916	Not Applicable					
H	Intensive	8.44%	29334390	6.65%	-21%	4.87%	-42%	3.09%	-63%
	Grazing	7.01%	15199770	6.78%	-3%	6.56%	-7%	6.33%	-10%
	Sell Medics	8.71%	23854683	Not Applicable					

The greater sensitivity to meat price changes of the intensive approach is favourable when the meat price increases. This is due to the equal proportionate change in meat prices resulting in an increased gain in profitability as the price increases, i.e. the increase in carcass (output) price is greater than the increase in the purchasing (input) price of weaned lambs. For example, when the initial carcass price of lambs is R56 per kg and the initial purchasing price of a weaned lamb is R25 per kg (live weight), a 10% meat price increase will lead to a net gain of R3.10 per kg. Conversely, net losses are experienced per kg by the intensive approach when meat prices decrease as the reduction in carcass price is greater than the gain of a lower purchasing price. Under conditions of meat price decreases, the intensive approach's relative greater sensitivity makes it considerably more risky, especially since the grazing strategy becomes more profitable than the intensive approach from a 10% decrease in meat price in System H. In Systems E and F the grazing approach surpasses the intensive approach in terms of expected IRR from a 20% decrease in meat price. In System G, the grazing approach only becomes more profitably than the intensive approach at a 30% decrease in the meat price.

Ultimately System H still proves to be the most profitable under meat price increases as well as decreases. The only change in strategy comes in when the meat price begins to decline, in which case strategy H-G becomes more profitable than H-I. Although the effect of meat price changes on the "sell medics" approach has not been modelled, selling medics should still be considered a valid alternative - especially because of the similar mechanization requirements of the intensive and sell-medics approaches. In practice, during periods of meat price decreases, this would enable a producer to rather sell a portion of his medic bales (originally produced to use in feed for speculation lambs under the intensive approach) as a means to counter the decline in profitability caused by the meat price decreases, and use the profit generated from the medic sales to buy speculation lambs again when meat prices have normalised. In other words, the similar mechanization requirements of the intensive and sell-medics approaches may enable a producer to alternate between the two systems as conditions may require. However, this has not been considered a possible strategy and was therefore not modelled.

Figure 4.4 shows the projections of domestic production, domestic consumption and net imports of sheep meat. The projections were done by the Bureau for Food and Agricultural Policy (BFAP) in 2015. According to Figure 4.4 it can be expected that domestic sheep meat consumption will increase slightly over the next eight years, while net imports can be expected to remain relatively constant. This means that domestic production has to also increase slightly in order to supply the increased quantity demanded. It is, however, important to note that the reason for the straight line trend on the projections is because normal weather conditions were assumed (BFAP, 2015). Any deviations away from normal weather conditions may result in feasibility of sheep meat production as the availability of feed will influence feed prices and may even lead to sporadic fluctuations in sheep meat prices.

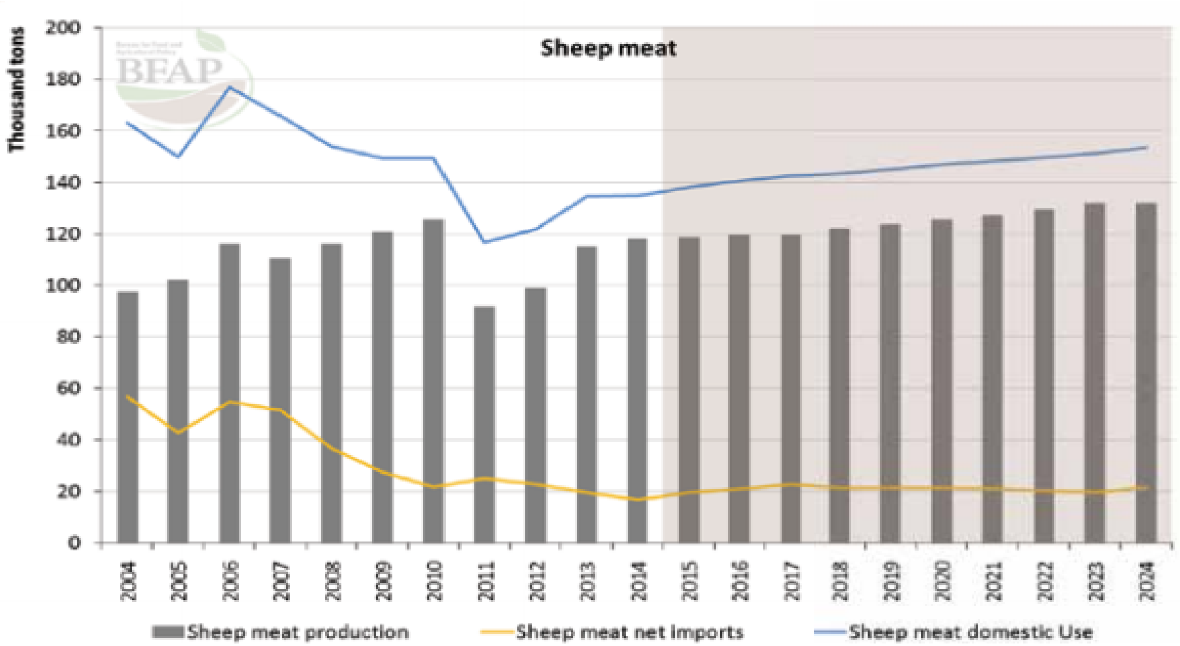

Figure 4.4: Domestic consumption, production and net imports of sheep meat.
Source: BFAP (2015).

4.4.4.3 Changes in the prevalence of seasonal variability

The dependency of Middle Swartland cereal cropping systems on winter rain has been discussed in Chapters Two and Three. Data from the Langgewens trial farm and feedback from the expert group emphasises the effect that seasonal variability in terms of annual rainfall has on the profitability of a farming system. The profitability is directly affected by changes in income as a result of different crop yields achieved. Typical yields for each of the crops included in the model have been established for each of the systems in years depicted as good, average or poor. The yields have been obtained from the Langgewens trial farm and industry experts. A typical frequency of good, average and poor years has been established by the expert group. However, it has been reiterated during the expert group that the frequency is unpredictable and likely to change.

Any changes in the frequency of good, average or poor years over the simulation period will have significant impacts on each strategy's whole-farm profitability. In order to assess the whole-farm impacts of changes in the frequency of seasonal variability, two alternative scenarios were incorporated into the model. In each of these scenarios the frequency of good, average and poor years has been changed. The first scenario represented a situation worse than the original and had the following frequency: One good year, six average years and three poor years. The second scenario represented a more favourable situation than the original and included three good years, six average years and one poor year. Table 4.14 presents the IRRs of the different strategies as they were impacted by the two scenarios.

Table 4.14: The impact of changes in frequency of seasonal variability on whole-farm IRR.

System	Approach	Current Situation		Scenario 1: 1 Good year, 6 average years and 3 poor years		Scenario 2: 3 Good years, 6 average years and 1 poor year	
		IRR	NPV	IRR	Relative change	IRR	Relative change
E	Intensive	7.91%	26028674	6.55%	-17%	8.13%	3%
	Grazing	5.02%	5379553	3.21%	-36%	5.33%	6%
	Sell Medics	8.14%	21156461	6.39%	-22%	8.45%	4%
F	Intensive	6.97%	19978721	5.76%	-17%	7.21%	3%
	Grazing	4.17%	1128747	2.55%	-39%	4.51%	8%
	Sell Medics	6.79%	14490153	5.22%	-23%	7.12%	5%
G	Intensive	4.63%	4603297	3.57%	-23%	4.83%	4%
	Grazing	1.32%	-13630322	-0.10%	-107%	1.60%	21%
	Sell Medics	3.90%	-268916	2.53%	-35%	4.18%	7%
H	Intensive	8.44%	29334390	7.13%	-15%	8.67%	3%
	Grazing	7.01%	15199770	5.27%	-25%	7.32%	4%
	Sell Medics	8.71%	23854683	7.02%	-19%	9.02%	4%

The sensitivity of each strategy is indicated by the relative change in IRR according to each scenario. From Table 4.14 it is notable that strategy G-G, which represents a grazing approach in rotation System G, has a negative IRR in the first scenario. This shows that producing canola as a cash crop is more risky than producing wheat when rainfall patterns are uncertain. Not only is the initial IRR of strategy G-G relatively low when compared to the other grazing strategies, but its relative change in IRR is also the greatest. Thus, strategy G-G shows the greatest sensitivity for changes in seasonal variability, making it the most risky strategy overall.

System H performs the best overall in terms of IRR, with the “sell medics” approach achieving the highest expected IRR. The strategies based on System H also experience the smallest relative changes in expected IRR when the frequency of the seasonal variability is changed, indicating the least amount of risk towards seasonal variability.

4.5 Conclusion

Through financial analysis of the Langgewens trials, medic-wheat crop rotation systems with sheep seem to be more profitable than wheat monoculture. However, there is concern around the stocking rates in the Langgewens trial being too high for optimal achievement of CA goals. Three livestock management approaches that could be implemented without mitigating CA outcomes have been developed and applied to the crop-pasture systems of the Langgewens trial. These combinations, or strategies, have been incorporated into a whole-farm multi-period budget to assess the whole-farm financial performance of each strategy.

The whole-farm, multi-period budget has been developed for the typical Middle Swartland farm by using technical data from the Langgewens trial and inputs from industry experts. It is important to note that although many experts have been involved in the study, the model does not represent every individual farming operation in the particular area.

The assumptions and parameters of the typical farm have been described in the first section of this chapter. The physical extent and attributes of the farm have been outlined and discussed. The first section of this chapter also included a thorough description of the calculation model.

The second section of this chapter focused on how the different strategies compared on whole-farm level. The profitability of each strategy was determined through a series of financial results, specified as outcomes in the model. The impact uncontrollable external factors have on whole-farm level have been assessed through scenarios. The scenarios used for assessing the whole-farm sensitivity encompassed price changes and seasonal variability.

Overall System H combined with a sell-medics approach performs the best on whole-farm level. Between a grazing and intensive speculation approach, the intensive approach performs the best, regardless of the system. The grazing approach is the most sensitive for changes in wheat prices, whereas the intensive approach is the least sensitive. However, with regards to changes in meat prices, the intensive approach is the most sensitive as a result of its dependence on the purchasing price of lambs. The grazing approach proves to be the most sensitive to changes in the prevalence of good, average and poor years, with the “sell-medic” approach with the second highest sensitivity to changes in seasonal variability. The intensive approach is the least sensitive to changes in seasonal variability.

Chapter 5: Conclusions, summary and recommendations

5.1 Conclusions

Worldwide the, *per capita* available land is decreasing due to significant population growth. It is estimated that global food production needs to increase by 70% over the next 35 years, while the availability of natural resources such as water is decreasing. Food production becomes increasingly dependent on responsible and sustainable production practices by producers.

CA is globally promoted as the most holistic approach to sustainable agricultural production. CA consists of three basic principles which are all interrelated and synergistic. The first is permanent reduction in or minimum disturbance of the soil. Second is maintaining maximum levels of soil cover. The third is crop diversification through crop rotation systems. It is globally advocated that CA enhances the natural resource base and the sustainable management thereof, while increasing productivity and sustaining the livelihood of the producer.

The Swartland area of the Western Cape is one of the key agricultural production areas of South Africa. The Swartland is characterised by a typical Mediterranean climate. Cereal production in the Swartland is predominantly based on dryland production systems. Wheat has been the main cereal crop in the Middle Swartland for a few decades. However, the competitiveness of wheat production in the Swartland has declined after the deregulation of agriculture in the 1990s. This, along with other challenges, including the difficulty to control grass weeds due to increased herbicide resistance experienced by grain producers in the area, led to the uptake of certain CA practices by some producers. Different CA practices have been initially adopted by producers for different reasons, but it resulted in the holistic CA concept being practised by many producers in the area today.

After the deregulation of agriculture in the 1990s and the increased difficulty in ryegrass control, annual legume pastures have become especially common in the crop rotation systems of Swartland producers. The incorporation of annual legume pastures enabled producers to effectively control grass weeds during the pasture phase, while providing significant diversification opportunities. Diversification opportunities brought by the introduction of legume pastures not only encompassed diversification in terms of crops produced, but also included the opportunity for enterprise diversification.

By implementing crop–pasture rotation systems, Swartland producers had the opportunity to integrate a livestock component into their farming system. This provides them with reduced exposure to market-related risks in the grain industry. However, the presence of livestock in a mixed crop-livestock farming system impacts the extent to which CA principles are followed. In a crop-pasture rotation system, grazing livestock feed off the crop residues and biomass produced by the annual legumes during the pasture phase, resulting in reduced levels of soil cover. The possibility of soil compaction caused by livestock trampling also poses a threat to successfully practicing CA since tillage may be required to alleviate compaction.

CA practices are increasingly implemented by Swartland producers for its long-term benefits, including increased yields, profitability and lower risk. These benefits mainly occur as a result of increased soil moisture retention capability and increased soil health. At the same time, Swartland producers continue to realise the potential benefits of an integrated livestock component in their farming system.

The challenges of CA remain site-specific. Given this and the challenges of the parallel uptake of CA practices and livestock integration by Swartland producers, there exists a need for the development of livestock integration strategies specifically for the Swartland area. It also required an analysis of the financial performance of these strategies.

In order to establish the financial significance of a livestock component integrated in CA systems, trial data from the Langgewens crop rotation trial had been financially assessed. The Langgewens trial data had been formulated into financial budgets for this purpose. Subsequently, per-hectare gross margin and yield analyses were done. Crop rotation proved to be more profitable than monoculture, with the crop-pasture rotation systems performing the best. This provides substance to the argument for livestock integrated in CA based crop rotation systems, because livestock form an integral part of the crop-pasture systems in the Langgewens trial.

There are many interrelated factors and variables in a farming system. Each of these factors and variables contribute to the complexity of the farming system the decision maker operates in. Ultimately these factors are determined by the extent and nature of the farming system being implemented. It is also influenced by various other external factors. In order to capture the impact and interrelatedness of the variables, a whole-farm analysis of each farming system was required.

The original data of the Langgewens crop rotation trial served as point of departure for developing the strategies. Due to the scientific nature of the Langgewens trial, the data had to be adapted to whole-farm level. This led to the need for developing a 'typical farm' for the Middle Swartland production area to serve as basis for comparison. An expert group discussion was used to convert the initial trial data to typical whole-farm level. This method drew inputs from experts across many different disciplines, including scientists, agricultural economists, industry experts and producers.

The expert group contributed significantly to the development of the different approaches to livestock management that could be followed to achieve successful crop-livestock integration within a CA context.

The strategies developed through the expert group and subsequent consultation with members of the experts' panel, as well as other industry experts, were incorporated as farming systems into a whole-farm, multi-period budget model. The multi-period budget simulated the financial performance of each strategy over a 20-year budgeting period. The interrelatedness of, and differences between, variables in the different strategies are captured in the multi-period budget. The whole-farm multi-period budget was successful in comparing the financial performance, profitability and sensitivity of the different strategies.

The sensitivity of the strategies was assessed through the incorporation of scenarios. Each scenario represented changes in the most important external factors that will influence the financial performance of the strategies. These external factors are uncontrollable by the producer and exposure to any of the external factors may lead to increased risk. The external factors represented in the scenarios encompass changes in the wheat price, meat price, and the frequency of seasonal variability.

The research methods used in this study have successfully answered the research question. The financial analysis of the Langgewens trial data proved the highest per-hectare gross margins for Systems E, F and H. This shows that livestock do provide the opportunity for increased profitability as the three top performing systems in the Langgewens trial are all crop-pasture systems with sheep. Although a grazing approach is followed in the Langgewens trial, the whole-farm profitability of the typical farm is relatively low when a grazing approach is followed. Whole-farm profitability improves under an intensive speculation approach or when medics are sold. The intensive speculation approach achieves the highest whole-farm gross margin and NPV across all the crop-pasture systems. System H performs the best overall with the highest whole-farm gross margins, NPVs and IRRs across all the livestock approaches. When System H is followed, the greatest IRR is achieved when medics are sold. In practice, Systems F and H would achieve the same financial performance under the intensive speculation approach or when medics are sold. In the model, however, the intensive speculation and "sell medics" approaches applied to System F are affected negatively by the deviations in crop yield and input data caused by the grazing approach followed on System F in the Langgewens trial.

In terms of changes in the wheat price, the whole-farm profitability of selling medics is more sensitive than the intensive speculation approach. This results in the intensive speculation approach also achieving the highest IRR in System H as soon as wheat prices decrease by 10% or more. With regards to meat price changes, the greater sensitivity of the intensive speculation approach can lead to the grazing approach achieving a higher expected IRR from a 10% meat price decrease.

When considering changes in the frequency of seasonal variability, and subsequent impacts on crop yields, System H is least sensitive, indicating the lowest amount of perceived risk. Ultimately it can be concluded that stocking rates are of significant importance for whole-farm profitability of a grazing approach. The stocking rates that were incorporated in accordance with CA practices and sustainable Middle Swartland norms for a grazing approach in the whole-farm model were too low to actively compete with the other approaches in Systems E, F and G. The combination of an increased stocking rate and sufficient pasture rest periods in System H increased the competitiveness of the grazing approach.

5.2 Summary

Chapter One has emphasised the need for alternative sustainable agricultural production systems. CA has been identified as an ideal approach to sustainable agriculture. CA is a holistic approach which encompasses three basic principles, namely: (1) Minimal soil disturbance, (2) maximum or permanent levels of soil cover and (3) crop diversification through crop rotation systems. Chapter One also briefly discussed the concerning issues regarding livestock's impacts on soil compaction and the implications thereof for CA practices. The research question and objectives of this study regarding integration strategies for crop-livestock production systems were formulated as: What are the financial implications of adopting CA and an integrated livestock component, and can the farm business afford to invest in expensive means necessary for successful integration?

The first part of Chapter Two consists of a literature review. The homogenous Middle Swartland production area was discussed, along with the rationale behind the continuous and increased adoption of CA in the Middle Swartland since the late 1990s. The evolvement of CA as the holistic approach to sustainable agriculture it is today is related to the core concepts of CA, the current global adoption status, as well as the possible benefits and constraints of adopting CA. The main focus of the literature review in Chapter Two was to assess the interaction between livestock and CA practices. Annual legume pastures can provide beneficial possibilities with regards to subsequent cash crop production, including lower financial risk by obtaining higher or similar gross margins with lower input costs. This required an assessment of the interrelatedness of CA principles, as well as the impacts of livestock on each. This provided a point of departure for developing livestock approaches that could be followed to successfully achieve mixed crop-livestock integration in CA systems in the Middle Swartland.

The methods that were used to answer the research question and reach the objectives of this study are focused on the systems approach. The need for systems thinking and a systems approach has been identified by emphasizing the interrelatedness of variables and complexity within a farming system. In order to capture the impacts of the interrelated variables and complexity of the proposed strategies, the development of a whole-farm multi-period budged for the typical Swartland farm was required. To develop the typical farm, scientific data from the Langgewens trial had to be converted to typical whole-farm level. A multi-disciplinary discussion group had been identified as the suitable research method for this purpose.

In order to identify and develop suitable strategies to integrate crop and livestock components within CA systems in the Middle Swartland, the Langgewens long-term crop rotation trial served as basis for determining the crop rotation systems. The financial role of livestock in crop rotation systems in the Middle Swartland was assessed through a financial analysis of the Langgewens crop rotation trial data. In Chapter Three the Langgewens crop rotation trial relevant to this study was described thoroughly. The description of the trial encompassed many factors, including the management of the trial, the different crop rotation systems included in the trial and the methodology used for capturing sheep data in the trial. The trial data was formulated into financial budgets, and a financial analysis of the different crop rotation systems in the trial on a per-hectare basis was conducted. All the rotation systems show a higher average gross margin than wheat monoculture. The significance of a livestock component is emphasised since the crop-pasture systems tend to have relatively higher average gross margins than the cash crop systems. Chapter Three concludes with a description of the livestock management approaches specifically developed for purposes of this study.

The financial evaluation of the different livestock management approaches were conducted in Chapter Four. In the first section of Chapter Four, the development of the typical farm budget model was discussed. This discussion included the physical and financial extent of the typical farm, assumptions and parameters regarding stocking rates and crop yields, prices and costs of inputs and products, and the mechanisation requirements. The calculation model accommodates calculations on gross margins, overhead and fixed costs and profitability analysis. It is a dynamic model that allows immediate analysis of changes in important variables.

The financial performance of the different strategies incorporated into the model was evaluated in terms of a whole-farm gross margin analysis, as well as the IRR and NPV as profitability indicators. The strategies are also evaluated in terms of differences in the required capital investment for each. The effect of having livestock on the medic pastures for a shorter period of time can be seen in the relatively smaller difference between the IRRs of strategy H-G (System H with a grazing approach) and the other strategies based on System H, when compared to the differences in IRR of the grazing and other approaches in Systems E, F and G. Across all the rotation systems, the intensive livestock approach had the highest NPV of the livestock approaches. Strategy H-I, representing crop rotation System H with an intensive speculation approach, had the greatest NPV of all the strategies. Ultimately, the risk factor in each strategy is captured through the use of different scenarios. These scenarios represented changes in certain external variables and factors which are uncontrollable by the decision-maker. These scenarios included price changes, encompassing both wheat and meat prices, as well as changes in the prevalence of good, average and poor years. The grazing approach proves to be the most sensitive to changes in the prevalence of good, average and poor years, with the “sell-medic” approach with the second highest sensitivity to changes in seasonal variability. The intensive approach is the least sensitive to changes in seasonal variability.

5.3 Recommendations

The main purpose of this study was to provide a detailed analysis of integrating crop-livestock enterprises. The need for the study originated from concern about livestock’s impacts on soil properties within a CA system. The financial implications and whole-farm profitability of reduced stocking rates and alternative feeding systems were assessed. A whole-farm budget model was developed through the use of scientific data from the Langgewens trial and multi-disciplinary expert group discussions. The model assessed the financial performance of different livestock management approaches integrated in different crop rotation systems within a CA context. The Middle Swartland served as the homogeneous production area on which this study was focused. However, due to the site-specific nature of a CA approach to sustainable agriculture, there is a need for greater farm, producer and site specific knowledge.

The livestock used in this study were Dohne Merinos. Dohne Merinos are dual-purpose sheep that produce good quality wool and meat. Dohne Merinos are well-adapted to the Swartland area and fit perfectly into the grazing and intensive speculation approaches modelled in this study. However, the outcomes of this study are likely to be influenced by the nature of the livestock component. Further study into the implication of different livestock types or sheep breeds is recommended. This could be useful in determining future integration strategies for newly adopting CA producers.

This study analysed the rotation systems as implemented in the Langgewens trial. However, there might be future limitations to the addition of saltbush pastures in the Middle Swartland due to certain regulatory implications applicable to "Category 2" alien plant species in South Africa (SANBI, 2016). This would result in practical implications such as the incorporation of cover crop pastures into crop rotation systems to allow for rest or withholding periods of livestock from legume pastures as practised in System H. As the withholding periods of System H proved to be beneficial, further studies on the implications of cover crop pastures in addition to cash crops and annual legumes in rotation systems are recommended. These could include different utilization techniques of cover crops as well as the financial implications of each.

Medics and clovers re-establish themselves when managed properly. When the intensive speculation approach is followed, or when medics are sold, the timeliness of haymaking activities is important for ensuring the availability of sufficient pods for proper re-establishment. Due to a lack of data, the impact of possible resowing to strengthen medic or clover pastures was not incorporated in this study. Further studies on resowing techniques of pastures and the financial implications of each are recommended.

CA is a holistic approach to sustainable agriculture and has been adopted in the Western Cape Province of South Africa for various reasons over the last 20 years. There are different driving forces behind the adoption of CA in the grain producing areas of the Western Cape. Detailed analysis, research and knowledge on the various driving forces are necessary. This would contribute positively to the adoption of CA systems amongst new producers. A policy framework analysis may also be required to assess the extent to which government or NGO policies could be utilised to promote CA amongst producers.

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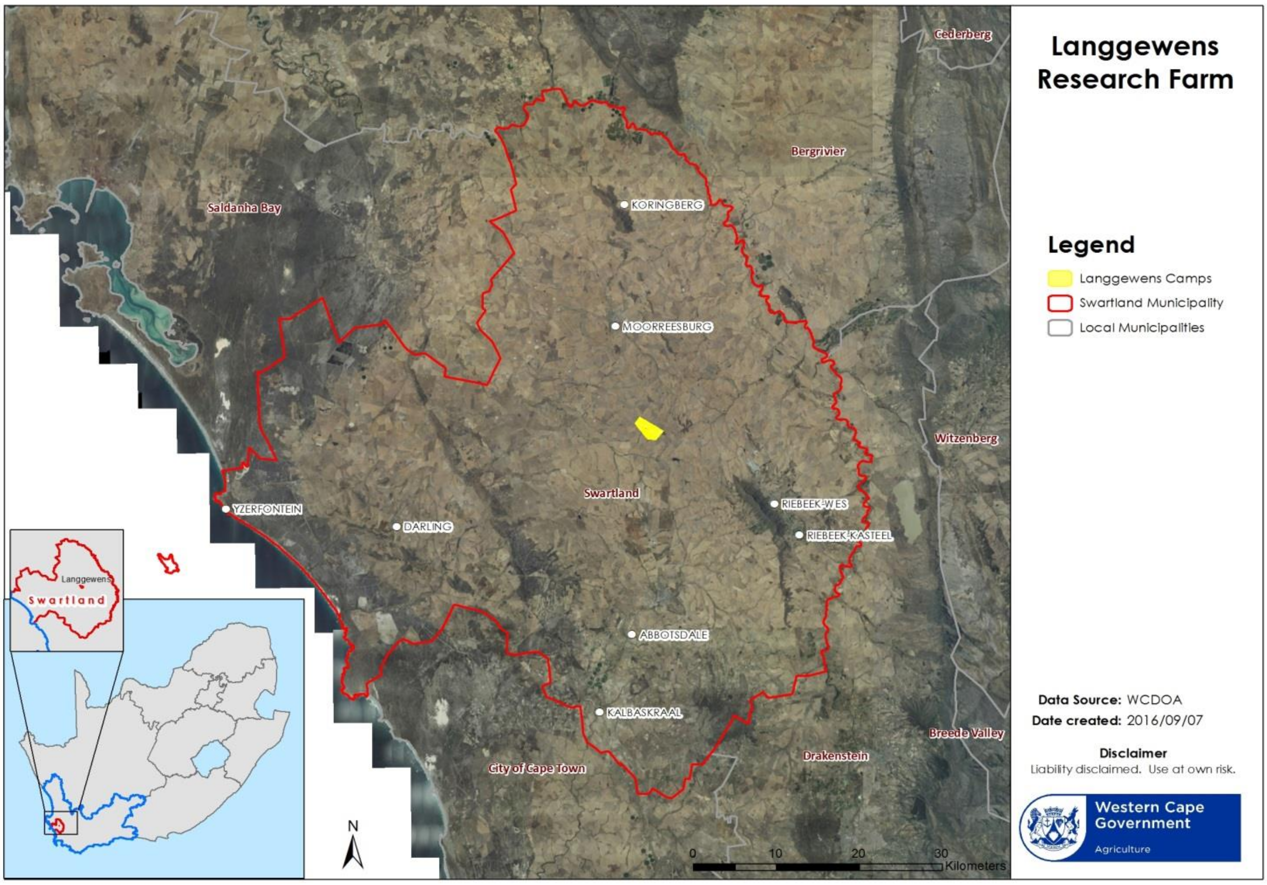
Annexures

Annexure A: Map indicating the position of the Langgewens crop rotation trial plots in the Middle Swartland.

Parameters of the Middle Swartland grain production area of the Western Cape



Annexure B: Langgewens crop rotation systems, sequences and repetitions.

Table depicting the crop rotation systems, sequences and repetitions of the Langgewens trial

System	Year 1	Year 2	Year 3	Year 4
A	W	W	W	W
B	W	W	W	C
B	W	W	C	W
B	W	C	W	W
B	C	W	W	W
C	W	C	W	L
C	C	W	L	W
C	W	L	W	C
C	L	W	C	W
D	W	W	L	C
D	W	L	C	W
D	L	C	W	W
D	C	W	W	L
E	W	M	W	M
E	M	W	M	W
F	W	Mc	W	Mc
F	Mc	W	Mc	W
G	M	W	M	C
G	W	M	C	M
G	M	C	M	W
G	C	M	W	M
H	W	Mc+S	W	Mc+S
H	Mc+S	W	Mc+S	W

Annexure C: Guide to machinery costs and costs of relevant activities.

Guide used to determine machinery costs and costs of relevant activities

MECHANIZATION INFORMATION:

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 =	10%	of average investment / hours per annum
	Repairs & maintenance =	120%	of purchase price/ lifetime (hrs)
Power	**Fuel price =**		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
59	12000	1000	566500	56650	311575	42.49	6.23	31.16	79.88	48.72	56.65	0.00	56.65	136.53	105.37	8.26	4000.00	12000.00	0.33
74	12000	1000	708000	70800	389400	53.10	7.79	38.94	99.83	60.89	70.80	0.00	70.80	170.63	131.69	10.36	4000.00	12000.00	0.33
86	12000	1000	802000	80200	441100	60.15	8.82	44.11	113.08	68.97	80.20	0.00	80.20	193.28	149.17	12.04	6000.00	12000.00	0.50
86	12000	1000	802000	80200	441100	60.15	8.82	44.11	113.08	68.97	80.20	0.00	80.20	193.28	149.17	12.04	6000.00	12000.00	0.50
86	12000	1000	802000	80200	441100	60.15	8.82	44.11	113.08	68.97	80.20	0.00	80.20	193.28	149.17	12.04	6000.00	12000.00	0.50
86	12000	1000	802000	80200	441100	60.15	8.82	44.11	113.08	68.97	80.20	0.00	80.20	193.28	149.17	12.04	6000.00	12000.00	0.50
86	12000	1000	802000	80200	441100	60.15	8.82	44.11	113.08	68.97	80.20	0.00	80.20	193.28	149.17	12.04	6000.00	12000.00	0.50
86	12000	1000	802000	80200	441100	60.15	8.82	44.11	113.08	68.97	80.20	0.00	80.20	193.28	149.17	12.04	6000.00	12000.00	0.50
86	12000	1000	802000	80200	441100	60.15	8.82	44.11	113.08	68.97	80.20	0.00	80.20	193.28	149.17	12.04	6000.00	12000.00	0.50
86	12000	1000	802000	80200	441100	60.15	8.82	44.11	113.08	68.97	80.20	0.00	80.20	193.28	149.17	12.04	6000.00	12000.00	0.50
86	12000	1000	802000	80200	441100	60.15	8.82	44.11	113.08	68.97	80.20	0.00	80.20	193.28	149.17	12.04	6000.00	12000.00	0.50
86	12000	1000	802000	80200	441100	60.15	8.82	44.11	113.08	68.97	80.20	0.00	80.20	193.28	149.17	12.04	6000.00	12000.00	0.50
86	12000	1000	802000	80200	441100	60.15	8.82	44.11	113.08	68.97	80.20	0.00	80.20	193.28	149.17	12.04	6000.00	12000.00	0.50
86	12000	1000	802000	80200	441100	60.15	8.82	44.11	113.08	68.97	80.20	0.00	80.20	193.28	149.17	12.04	6000.00	12000.00	0.50
86	12000	1000	802000	80200	441100	60.15	8.82	44.11	113.08	68.97	80.20	0.00	80.20	193.28	149.17	12.04	6000.00	12000.00	0.50
86	12000	1000	802000	80200	441100	60.15	8.82	44.11	113.08	68.97	80.20	0.00	80.20	193.28	149.17	12.04	6000.00	12000.00	0.50
86	12000	1000	802000	80200	441100	60.15	8.82	44.11	113.08	68.97	80.20	0.00	80.20	193.28	149.17	12.04	6000.00	12000.00	0.50
86	12000	1000	802000	80200	441100	60.15	8.82	44.11	113.08	68.97	80.20	0.00	80.20	193.28	149.17	12.04	6000.00	12000.00	0.50
	12000	1000	802000	80200	441100	60.15	8.82	44.11	113.08	68.97	80.20	0.00	80.20	193.28	149.17	0.00	6000.00	12000.00	0.50
Harvesters:																			
120	12000	1000	2275000	227500	1251250	170.63	25.03	125.13	320.78	195.65	227.50	0.00	227.50	548.28	423.15	16.80			
120	12000	1000	2275000	227500	1251250	170.63	25.03	125.13	320.78	195.65	227.50	0.00	227.50	548.28	423.15	16.80			

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 1000 liter, mounted	2500	250	178415	17841.5	98128.25	64.2294	39.2513	103.4807	64.2294	30%	21.4098	21.4098	124.8905	85.6392
102	Planter, DBS 3m	2500	250	408197	40819.7	224508.35	146.95092	89.80334	236.75426	146.95092	30%	48.98364	48.98364	285.7379	195.93456
103	Spreader, Fertilizer Ddisc 1000l	2500	250	99800	9980	54890	35.928	21.956	57.884	35.928	30%	11.976	11.976	69.86	47.904
104	Spreader,Lime Ddisc 3t	2500	250	85270	8527	46898.5	30.6972	18.7594	49.4566	30.6972	30%	10.2324	10.2324	59.689	40.9296
105	Tyres	500	10	0	0	0	0	0	0	0	30%	0	0	0	0
106	Planter 10m no till	2500	250	1250000	125000	687500	450	275	725	450	30%	150	150	875	600
107	Planter 10m no till	2500	250	1250000	125000	687500	450	275	725	450	30%	150	150	875	600
108	Planter 10m no till	2500	250	1250000	125000	687500	450	275	725	450	30%	150	150	875	600
109	Planter 10m no till	2500	250	1250000	125000	687500	450	275	725	450	30%	150	150	875	600
110	Planter 10m no till	2500	250	1250000	125000	687500	450	275	725	450	30%	150	150	875	600
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	74	101	Spayer 1000 liter, mounted	12	5.8	85%	5.916	0.17	1.97	0.00	11.97	3.62	0.3267974
Medium	2	Spray: Insecticide	74	101	Spayer 1000 liter, mounted	12	5.8	85%	5.916	0.17	1.97	0.00	11.97	3.62	0.3267974
Medium	3	Spray: Fungicide	74	101	Spayer 1000 liter, mounted	12	5.8	85%	5.916	0.17	1.97	0.00	11.97	3.62	0.3267974
High	4	Plant	86	102	Planter, DBS 3m	3.3	5.5	85%	1.543	0.65	10.03	0.00	51.99	31.75	1.7825312
Medium	5	Spread: fertilizer	74	103	Spreader, Fertilizer Ddisc 1000l	10	14	85%	11.9	0.08	0.98	0.00	5.95	1.01	0.3921569
Medium	6	Spread lime	74	104	Spreader,Lime Ddisc 3t	10	14	85%	11.9	0.08	0.98	0.00	5.95	0.86	0.3921569
Medium	7	Stubble Spreading	59	105	Tyres	4	10	85%	3.4	0.29	2.73	0.00	16.66	0.00	0.9803922
Medium	8	Spray: Trace elements	74	101	Spayer 1000 liter, mounted	12	5.8	85%	5.916	0.17	1.97	0.00	11.97	3.62	0.3267974
Medium	9	Spray: Fung & Insect	74	101	Spayer 1000 liter, mounted	12	5.8	85%	5.916	0.17	1.97	0.00	11.97	3.62	0.3267974
High	10	Harvest	120		#N/A	5	5	83%	2.075	0.48	10.41	0.00	109.64	#N/A	1.2048193
Medium	11	Spray: Herb & Insect	74	101	Spayer 1000 liter, mounted	12	5.8	85%	5.916	0.17	1.97	0.00	11.97	3.62	0.3267974
High	12	Harvest Slow	120		#N/A	5	3.334	83%	1.38361	0.72	15.61	0.00	164.42	#N/A	1.2048193
Medium	13	Spray: Herb & Fung	74	101	Spayer 1000 liter, mounted	12	5.8	85%	5.916	0.17	1.97	0.00	11.97	3.62	0.3267974
Medium	14	Spread: Snailpellets	74	103	Spreader, Fertilizer Ddisc 1000l	10	14	85%	11.9	0.08	0.98	0.00	5.95	1.01	0.3921569

Annexure D: Example of gross margin calculations for the Langgewens trial.

A gross margin calculation for one of the Langgewens wheat camps in system H

GROSS MARGIN & MARGIN ABOVE SPECIFIED COSTS:							
Crop:	**Wheat**			**Date:**	**15-Sep-16**		
				YEAR	**2015**		
Counrty:	**SA**						
Province:	**Western Cape**						
Location:	**Langgewens**						
Comment:	**Swartland crop rotation trials**						
Camp:	43	**System:**	**H**				
Wheat-Medic/clover-Wheat-Medic/clover (With Ouman-soutbos pastures)							
			Price/unit				
		Unit	**Rand**	**Quantity**	**R per ha**	**R/yield unit**	
							Code:
Gross Income							
Product income:							
Wheat							
Wheat: B1		ton	4332.00	2.52	10894.98	4332.00	100
Marketing cost:							
Gross income minus marketing cost					**10894.98**	**4332.00**	
ALLOCATABLE VARIABLE COSTS:					**4009.29**	**1606.71**	
Directly Allocatable Variable Costs:					**3757.84**	**1506.73**	
Pre Harvest Cost:					**3598.86**	**1430.96**	
Plant material:							
Seed							
SST 056		kg	8.03	75.00	602.25	239.46	200
Fertilizer:							
Geoflo 42		t	3586.60	0.23	835.68	332.28	316
Cura A44		t	6117.20	0.14	844.17	335.66	315
#N/A		#N/A	#N/A		0.00	0.00	
#N/A		#N/A	#N/A		0.00	0.00	
#N/A		#N/A	#N/A		0.00	0.00	
#N/A		#N/A	#N/A		0.00	0.00	
#N/A		#N/A	#N/A		0.00	0.00	
#N/A		#N/A	#N/A		0.00	0.00	
#N/A		#N/A	#N/A		0.00	0.00	
Lime & Gypsum							
#N/A		#N/A	#N/A		0.00	0.00	
#N/A		#N/A	#N/A		0.00	0.00	
Weed Control:							
Sakura		gram	4.05	125.00	506.25	201.29	410
Resolve		liter	295.26	0.75	221.45	88.05	403
Brush-Off		gram	2.19	4.00	8.76	3.48	404
Bladbuff		liter	68.40	0.12	8.21	3.26	418
#N/A		#N/A	#N/A		0.00	0.00	
#N/A		#N/A	#N/A		0.00	0.00	
#N/A		#N/A	#N/A		0.00	0.00	
#N/A		#N/A	#N/A		0.00	0.00	
#N/A		#N/A	#N/A		0.00	0.00	
#N/A		#N/A	#N/A		0.00	0.00	
Pest Control:							
Mospilan		gram	0.71	50.00	35.50	14.12	431
#N/A		#N/A	#N/A		0.00	0.00	
#N/A		#N/A	#N/A		0.00	0.00	
#N/A		#N/A	#N/A		0.00	0.00	
#N/A		#N/A	#N/A		0.00	0.00	
#N/A		#N/A	#N/A		0.00	0.00	
#N/A		#N/A	#N/A		0.00	0.00	
Fungicide control:							
Abacus		liter	355.11	1.00	355.11	141.20	422
Duett		liter	226.86	0.80	181.49	72.16	424
#N/A		#N/A	#N/A		0.00	0.00	
#N/A		#N/A	#N/A		0.00	0.00	
#N/A		#N/A	#N/A		0.00	0.00	
Hire							
#N/A		#N/A	#N/A		0.00	0.00	
#N/A		#N/A	#N/A		0.00	0.00	
#N/A		#N/A	#N/A		0.00	0.00	
#N/A		#N/A	#N/A		0.00	0.00	
#N/A		#N/A	#N/A		0.00	0.00	
#N/A		#N/A	#N/A		0.00	0.00	
Harvest cost:					158.97	75.77	
Grain							
Transport:		R/ton	63.21	2.52	158.97	75.77	501
MARGIN ABOVE DIRECTLY ALLOCATABLE COSTS:					**7137.14**	**2825.27**	
In Directly Allocatable costs:					**251.45**	**99.98**	
PRE HARVEST COST:					**140.61**	**55.91**	
Energy					0.00	0.00	
Repairs and Maintenance					137.45	54.65	
Tyres					3.16	1.25	
HARVEST COST:					**110.84**	**44.07**	
Energy					0.00	0.00	
Repairs and maintenance					109.64	43.59	
Tyres					1.20	0.48	
TOTAL PRE HARVEST COSTS					**3739.47**	**1486.87**	
TOTAL HARVEST COSTS					**269.82**	**107.28**	
GROSS MARGIN ABOVE ALL ALLOCATABLE COSTS:					**6885.69**	**2737.85**	

Annexure E: Farm inventories under different crop rotation systems and livestock management approaches.

Middle Swartland typical farm inventory – Systems E, F, G and H, Intensive speculation approach

Item	Amount (ha)	R/unit	Value
Land: (a)	**850**	**30000**	**25500000**

Fixed improvements: (b)	Replacement Value	Current age (years)	Expected lifetime	Depreciation	Value
Main farm house	1800000	4	25	288000	1512000
Shed 1	765000	2	25	61200	703800
Shed 2	1360000	3	25	163200	1196800
Dam	1000000	3	25	120000	880000
Borehole 1	120000	5	25	24000	96000
Borehole 2	120000	5	25	24000	96000
Reservoir	80000	4	25	12800	67200
Workers' house 1	400000	5	25	80000	320000
Workers' house 2	400000	5	25	80000	320000
Workers' house 3	325000	2	25	26000	299000
Workers' house 4	325000	2	25	26000	299000
Workers' house 5	325000	2	25	26000	299000
Pump house	16800	4	25	2688	14112
Cement trough 1	4725	3	25	567	4158
Cement trough 2	4725	3	25	567	4158
Cement trough 3	4725	3	25	567	4158
Cement trough 4	4725	3	25	567	4158
Sheepfold	240000	3	25	28800	211200
Feedlot	2550000	4	25	408000	2142000
Lamb shed 1	306000	3	25	36720	269280
Lamb shed 2	400000	3	25	48000	352000
Camp 1 ("Kraal")	400000	3	25	48000	352000
Camp 2 ("Kraal")	400000	3	25	48000	352000
Total fixed improvements:					**9798024**

Equipment: (c)	Replacement Value	Current age (years)	Expected lifetime	Depreciation	Value
Bakkies:					
3.0D-4D Xtra Cab	346491	3	12	79404	267087
Tractors					
120KW 4X4	1502500	8	12	918194	584306
70KW 4X4	734000	7	12	392486	341514
100KW 4X4	1170500	6	12	536479	634021
110KW 4X4	1332500	7	12	712517	619983
Sprayers					
Boom sprayer : 3200L, 24m, towed	903523	6	12	414115	489408
Trailers					
Trailer : 8 Tonne, 4 wheel	129145	4	12	39461	89684
Trailer : 10 Tonne, 4 wheel	140185	4	12	42834	97351
Grain overloader : 15 Tonne with auger	330000	3	12	75625	254375
Trailer : 15 Tonne, 4 wheel, air brakes	242000	5	12	92431	149569
Trailer : 12 Tonne, 4 wheel, air brakes	224225	5	12	85642	138584
Water trailer - 1000 L (also for diesel)	49105	6	12	22506	26599
Trucks					
29 Tonne truck	1730750	5	12	661050	1069700
Combine Harvester					
Combine harverster with cutter and pick-up (290KW, 7.62m)	5520000	4	12	1686667	3833333
Other implements and tools					
Haybine: 8-disk 4.0m, towed, Roller, middle-tow	749704	4	12	229076	520628
Wheel rake : 8-wheel, 5.45m, 3-point, V-type	40663	4	12	12425	28238
Auger (18kw)	15000	3	12	3438	11563
Loader/fork lift (fits on 100kw tractor)	263390	6	12	120720	142670
Big pack square baler (120 X 70) (Standard)	2218791	3	12	508473	1710318
Air seeder : 17t x 285mm, 4.8m	788297	4	12	240868	547428
Other tools	25000	7	12	13368	11632
Welding and gas equipment	15000	7	12	8021	6979
Pump (18 KW)	24000	6	12	11000	13000
Pump (18 KW)	24000	6	12	11000	13000
Horisontal feedwagon : 7m³ (2.45t) (with scale)	455049	3	12	104282	350767
Hammer mill (medic bales) 70kw	50000	3	12	11458	38542
Hammer mill (maize and grains) 70kw	80000	3	12	18333	61667
Fertiliser spreader : Double disc, 1500L, 10-36m, 3-point	123262	8	12	75327	47935
Pellet machine	85000	3	12	19479	65521
Heavy duty clod roller (9m)	79515	3	12	18222	61293
Swather : 25 feet, 7.62m	287588	5	12	109843	177745
Total equiment:					**12404438**

Livestock (d)	Number	R/SSU	Value
Speculation lambs	11150	700	7804784
Total sheep:			**7804784**

Total Assets (a+b+c+d)	**55507246**

Middle Swartland typical farm inventory – Systems E, F and G, Grazing approach

Item	Amount (ha)	R/unit	Value
Land: (a)	850.00	30 000.00	25 500 000.00

Fixed improvements: (b)	Replacement Value	Current age (years)	Expected lifetime	Depreciation	Value
Main farm house	1 800 000.00	4.00	25.00	288 000.00	1 512 000.00
Shed 1	765 000.00	2.00	25.00	61 200.00	703 800.00
Shed 2	1 360 000.00	3.00	25.00	163 200.00	1 196 800.00
Dam	1 000 000.00	3.00	25.00	120 000.00	880 000.00
Borehole 1	120 000.00	5.00	25.00	24 000.00	96 000.00
Borehole 2	120 000.00	5.00	25.00	24 000.00	96 000.00
Reservoir	80 000.00	4.00	25.00	12 800.00	67 200.00
Workers' house 1	400 000.00	5.00	25.00	80 000.00	320 000.00
Workers' house 2	400 000.00	5.00	25.00	80 000.00	320 000.00
Workers' house 3	325 000.00	2.00	25.00	26 000.00	299 000.00
Workers' house 4	325 000.00	2.00	25.00	26 000.00	299 000.00
Workers' house 5	325 000.00	2.00	25.00	26 000.00	299 000.00
Pump house	16 800.00	4.00	25.00	2 688.00	14 112.00
Cement trough 1	4 725.00	3.00	25.00	567.00	4 158.00
Cement trough 2	4 725.00	3.00	25.00	567.00	4 158.00
Cement trough 3	4 725.00	3.00	25.00	567.00	4 158.00
Cement trough 4	4 725.00	3.00	25.00	567.00	4 158.00
Ramshed	306 000.00	3.00	25.00	36 720.00	269 280.00
Sheepfold	240 000.00	3.00	25.00	28 800.00	211 200.00
Total fixed improvements:					**6 600 024.00**

Equipment: (c)	Replacement Value	Current age (years)	Expected lifetime	Depreciation	Value
Bakkies:					
3.0D-4D Xtra Cab	346491	3	12	79404	267087
Tractors					
120KW 4X4	1502500	8	12	918194	584306
70KW 4X4	734000	7	12	392486	341514
100KW 4X4	1170500	6	12	536479	634021
Sprayers					
Boom sprayer : 3200L, 24m, towed	903523	6	12	414115	489408
Trailers					
Trailer : 8 Tonne, 4 wheel	129145	4	12	39461	89684
Trailer : 10 Tonne, 4 wheel	140185	4	12	42834	97351
Grain overloader : 15 Tonne with auger	330000	3	12	75625	254375
Trailer : 15 Tonne, 4 wheel, air brakes	242000	5	12	92431	149569
Trailer : 12 Tonne, 4 wheel, air brakes	224225	5	12	85642	138584
Water trailer - 1000 L (also for diesel)	49105	6	12	22506	26599
Trucks					
29 Tonne truck	1730750	5	12	661050	1069700
Combine Harvester					
Combine harverster with cutter and pick-up (290KW, 7.62m)	5520000	4	12	1686667	3833333
Other implements and tools					
Loader/fork lift (fits on 100kw tractor)	263390	6	12	120720	142670
Air seeder : 17t x 285mm, 4.8m	788297	4	12	240868	547428
Other tools	25000	7	12	13368	11632
Welding and gas equipment	15000	7	12	8021	6979
Pump (18 KW)	24000	6	12	11000	13000
Pump (18 KW)	24000	6	12	11000	13000
Fertiliser spreader: Double disk, 1500L, 10-36m, 3-point	123262	8	12	75327	47935
Swather: 25 feet, 7.62m	287588	5	12	109843	177745
Total equipment:					**8935920**

Livestock (d)	Number	R/SSU	Value
Breeding ewes	301	900	270869
Replacement ewes	75	800	60193
Lambs	376	700	263345
Rams	9	2000	18240
Total sheep:			**612648**
Total Assets (a+b+c+d)			**41648591**

Middle Swartland typical farm inventory – System H, Grazing approach

Item	Amount (ha)	R/unit	Value
Land: (a)	850	30000	25500000

Fixed improvements: (b)	Replacement Value	Current age (years)	Expected lifetime	Depreciation	Value
Main farm house	1800000	4	25	288000	1512000
Shed 1	765000	2	25	61200	703800
Shed 2	1360000	3	25	163200	1196800
Dam	1000000	3	25	120000	880000
Borehole 1	120000	5	25	24000	96000
Borehole 2	120000	5	25	24000	96000
Reservoir	80000	4	25	12800	67200
Workers' house 1	400000	5	25	80000	320000
Workers' house 2	400000	5	25	80000	320000
Workers' house 3	325000	2	25	26000	299000
Workers' house 4	325000	2	25	26000	299000
Workers' house 5	325000	2	25	26000	299000
Pump house	16800	4	25	2688	14112
Cement trough 1	4725	3	25	567	4158
Cement trough 2	4725	3	25	567	4158
Cement trough 3	4725	3	25	567	4158
Cement trough 4	4725	3	25	567	4158
Ramshed	306000	3	25	36720	269280
Sheepfold	240000	3	25	28800	211200
Total fixed improvements:					**6600024**

Equipment: (c)	Replacement Value	Current age (years)	Expected lifetime	Depreciation	Value
Bakkies:					
3.0D-4D Xtra Cab	346491	3	12	79404	267087
Tractors					
120KW 4X4	1502500	8	12	918194	584306
70KW 4X4	734000	7	12	392486	341514
100KW 4X4	1170500	6	12	536479	634021
Sprayers					
Boom sprayer : 3200L, 24m, towed	903523	6	12	414115	489408
Trailers					
Trailer : 8 Tonne, 4 wheel	129145	4	12	39461	89684
Trailer : 10 Tonne, 4 wheel	140185	4	12	42834	97351
Grain overloader : 15 Tonne with auger	330000	3	12	75625	254375
Trailer : 15 Tonne, 4 wheel, air brakes	242000	5	12	92431	149569
Trailer : 12 Tonne, 4 wheel, air brakes	224225	5	12	85642	138584
Water trailer - 1000 L (also for diesel)	49105	6	12	22506	26599
Trucks					
29 Tonne truck	1730750	5	12	661050	1069700
Combine Harvester					
Combine harverster with cutter and pick-up (290KW, 7.62m)	5520000	4	12	1686667	3833333
Other implements and tools					
Loader/fork lift (fits on 100kw tractor)	263390	6	12	120720	142670
Air seeder : 17t x 285mm, 4.8m	788297	4	12	240868	547428
Other tools	25000	7	12	13368	11632
Welding and gas equipment	15000	7	12	8021	6979
Pump (18 KW)	24000	6	12	11000	13000
Pump (18 KW)	24000	6	12	11000	13000
Fertiliser spreader: Double disk, 1500L, 10-36m, 3-point	123262	8	12	75327	47935
Swather: 25 feet, 7.62m	287588	5	12	109843	177745
Total equipment:					**8935920**

Livestock (d)	Number	R/SSU	Value
Breeding ewes	451	900	406304
Replacement ewes	113	800	90290
Lambs	564	700	395017
Rams	14	2000	27361
Total sheep:			**918971**

Total Assets (a+b+c+d)	**41954915**

Middle Swartland typical farm inventory – Systems E, F, G and H, Sell medics

Item	Amount (ha)	R/unit	Value
Land: (a)	850	30000	25500000

Fixed improvements: (b)	Replacement Value	Current age (years)	Expected lifetime	Depreciation	Value
Main farm house	1800000	4	25	288000	1512000
Shed 1	630000	2	25	50400	579600
Shed 2	1120000	3	25	134400	985600
Dam	1000000	3	25	120000	880000
Borehole 1	120000	5	25	24000	96000
Borehole 2	120000	5	25	24000	96000
Reservoir	80000	4	25	12800	67200
Workers' house 1	400000	5	25	80000	320000
Workers' house 2	400000	5	25	80000	320000
Workers' house 3	325000	2	25	26000	299000
Workers' house 4	325000	2	25	26000	299000
Pump house	16800	4	25	2688	14112
Total fixed improvements:					**5468512**

Equipment: (c)	Replacement Value	Current age (years)	Expected lifetime	Depreciation	Value
Bakkies:					
3.0D-4D Xtra Cab	346491	3	12	79404	267087
Tractors					
120KW 4X4	1502500	8	12	918194	584306
70KW 4X4	734000	7	12	392486	341514
100KW 4X4	1170500	6	12	536479	634021
110KW 4X4	1332500	7	12	712517	619983
Sprayers					
Boom sprayer : 3200L, 24m, towed	903523	6	12	414115	489408
Trailers					
Trailer : 8 Tonne, 4 wheel	129145	4	12	39461	89684
Trailer : 10 Tonne, 4 wheel	140185	4	12	42834	97351
Grain overloader : 15 Tonne with auger	330000	3	12	75625	254375
Trailer : 15 Tonne, 4 wheel, air brakes	242000	5	12	92431	149569
Trailer : 12 Tonne, 4 wheel, air brakes	224225	5	12	85642	138584
Water trailer - 1000 L (also for diesel)	49105	6	12	22506	26599
Trucks					
29 Tonne truck	1730750	5	12	661050	1069700
Combine Harvester					
Combine harverster with cutter and pick-up (290KW, 7.62m)	5520000	4	12	1686667	3833333
Other implements and tools					
Haybine: 8-disk 4.0m, towed, Roller, middle-tow	749704	4	12	229076	520628
Wheel rake : 8-wheel, 5.45m, 3-point, V-type	40663	4	12	12425	28238
Loader/fork lift (fits on 100kw tractor)	263390	6	12	120720	142670
Big pack square baler (120 X 70) (Standard)	2218791	3	12	508473	1710318
Air seeder : 17t x 285mm, 4.8m	788297	4	12	240868	547428
Other tools	25000	7	12	13368	11632
Welding and gas equipment	15000	7	12	8021	6979
Pump (18 KW)	24000	6	12	11000	13000
Pump (18 KW)	24000	6	12	11000	13000
Fertiliser spreader : Double disc, 1500L, 10-36m, 3-point	123262	8	12	75327	47935
Heavy duty clod roller (9m)	79515	3	12	18222	61293
Swather : 25 feet, 7.62m	287588	5	12	109843	177745
Total equiment:					**11876379**

Total Assets (a+b+c+d)	**42844891**

Annexure F: Whole-farm multi-period budgets of different crop rotation systems and livestock approaches.

Whole-farm multi-period budget: System E, Intensive speculation approach.

Year		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
Scenario (Wheat/Canola)		Good	Average	Poor	Average	Average	Good	Average	Average	Average	Average	Good	Average	Average	Poor	Average	Good	Average	Average	Average	Average	
Scenario (Medics/Clover)		Poor	Average	Good	Good	Average	Average	Average	Average	Average	Poor	Average	Average	Good	Average	Poor	Average	Average	Average	Poor	Good	
Gross Margin																						
Wheat on Wheat		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Wheat on Canola		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Wheat on Medics		5739324	4437055	1569612	4437055	4437055	5739324	4437055	4437055	4437055	4437055	5739324	4437055	4437055	1569612	4437055	5739324	4437055	4437055	4437055	4437055	
Medics/medics Clover		1210668	1922131	2349009	2349009	1922131	1922131	1922131	1922131	1922131	1210668	1922131	1922131	2349009	1922131	1210668	1922131	1922131	1922131	1210668	2349009	
Canola		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Capital sales		0	0	0	0	162576	210650	243452	248456	736799	365985	0	0	0	0	0	0	162576	210650	243452	248456	
Whole-farm gross margin		**6949992**	**6359186**	**3918621**	**6786064**	**6521763**	**7872105**	**6602638**	**6607643**	**7095986**	**6013708**	**7661455**	**6359186**	**6786064**	**3491744**	**5647723**	**7661455**	**6521763**	**6569836**	**5891175**	**7034520**	
Overhead and fixed costs																						
Water system		12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	
Fencing and camps		12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	
Water fees		50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	
Property tax		8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	
Accounting fees		65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	
Banking fees		16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	
Admin		18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	
Telephone and Postage		20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	
Electricity		176970	176970	176970	176970	176970	176970	176970	176970	176970	176970	176970	176970	176970	176970	176970	176970	176970	176970	176970	176970	
Licenses and insurance		210850	210850	210850	210850	210850	210850	210850	210850	210850	210850	210850	210850	210850	210850	210850	210850	210850	210850	210850	210850	
Employee wages		150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	
Reparations on fixed improvements		113517	113517	113517	113517	113517	113517	113517	113517	113517	113517	113517	113517	113517	113517	113517	113517	113517	113517	113517	113517	
Owner's remuneration		300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	
Miscellaneous costs		51897	51897	51897	51897	51897	51897	51897	51897	51897	51897	51897	51897	51897	51897	51897	51897	51897	51897	51897	51897	
Total overhead and fixed costs		**1205159**	**1205159**	**1205159**	**1205159**	**1205159**	**1205159**	**1205159**	**1205159**	**1205159**	**1205159**	**1205159**	**1205159**	**1205159**	**1205159**	**1205159**	**1205159**	**1205159**	**1205159**	**1205159**	**1205159**	
Margin above overhead and fixed costs		**5744833**	**5154027**	**2713462**	**5580905**	**5316604**	**6666946**	**5397479**	**5402484**	**5890827**	**4808549**	**6456296**	**5154027**	**5580905**	**2286585**	**4442564**	**6456296**	**5316604**	**5364677**	**4686016**	**5829361**	
Capital																						
Long-term																						**Resale value:**
Land and fixed improvements		35298024	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	35298024
Intermediate																						
Bakkies:																						
3.0D-4D Xtra Cab	3	267087	0	0	0	0	0	0	0	0	346491	0	0	0	0	0	0	0	0	0	0	230994
Tractors																						
120 KW 4X4	8	584306	0	0	0	1502500	0	0	0	0	0	0	0	0	0	0	0	1502500	0	0	0	1126875
70KW 4X4	7	341514	0	0	0	0	734000	0	0	0	0	0	0	0	0	0	0	0	734000	0	0	611667
100KW 4X4	6	634021	0	0	0	0	0	1170500	0	0	0	0	0	0	0	0	0	0	0	1170500	0	1072958
110KW 4X4	7	619983	0	0	0	0	1332500	0	0	0	0	0	0	0	0	0	0	0	1332500	0	0	1110417
Sprayers:																						
Boom sprayer : 3200L, 24m, towed	6	489408	0	0	0	0	0	903523	0	0	0	0	0	0	0	0	0	0	0	903523	0	828230

Trailers																						
Trailer : 8 Tonne, 4 wheel	4	89684	0	0	0	0	0	0	0	129145	0	0	0	0	0	0	0	0	0	0	0	96859
Trailer : 10 Tonne, 4 wheel	4	97351	0	0	0	0	0	0	0	140185	0	0	0	0	0	0	0	0	0	0	0	105139
Grain overloader : 15 Tonne with auger	3	254375	0	0	0	0	0	0	0	0	330000	0	0	0	0	0	0	0	0	0	0	220000
Trailer : 15 Tonne, 4 wheel, air brakes	5	149569	0	0	0	0	0	0	242000	0	0	0	0	0	0	0	0	0	0	0	242000	201667
Trailer : 12 Tonne, 4 wheel, air brakes	5	138584	0	0	0	0	0	0	224225	0	0	0	0	0	0	0	0	0	0	0	224225	186854
Water trailer - 1000 L (also for diesel)	6	26599	0	0	0	0	0	49105	0	0	0	0	0	0	0	0	0	0	0	49105	0	45013
Trucks:																						
29 Tonne truck	5	1069700	0	0	0	0	0	0	1730750	0	0	0	0	0	0	0	0	0	0	0	1730750	1442292
Combine Harvester:																						
Combine harverster with cutter and pick-up (290KW, 7.62m)	4	3833333	0	0	0	0	0	0	0	5520000	0	0	0	0	0	0	0	0	0	0	0	4140000
Other implements and tools:																						
Haybine: 8-disk 4.0m, towed, Roller, middle-tow	4	520628	0	0	0	0	0	0	0	749704	0	0	0	0	0	0	0	0	0	0	0	562278
Wheel rake : 8-wheel, 5.45m, 3-point, V-type	4	28238	0	0	0	0	0	0	0	40663	0	0	0	0	0	0	0	0	0	0	0	30497
Auger (18kw)	3	11563	0	0	0	0	0	0	0	0	15000	0	0	0	0	0	0	0	0	0	0	10000
Loader/fork lift (fits on 100kw tractor)	6	142670	0	0	0	0	0	263390	0	0	0	0	0	0	0	0	0	0	0	263390	0	241441
Big pack square baler (120 X 70) (Standard)	3	1710318	0	0	0	0	0	0	0	0	2218791	0	0	0	0	0	0	0	0	0	0	1479194
Air seeder : 17t x 285mm, 4.8m	4	547428	0	0	0	0	0	0	0	788297	0	0	0	0	0	0	0	0	0	0	0	591223
Other tools	7	11632	0	0	0	0	25000	0	0	0	0	0	0	0	0	0	0	0	25000	0	0	20833
Welding and gas equipment	7	6979	0	0	0	0	15000	0	0	0	0	0	0	0	0	0	0	0	15000	0	0	12500
Pump (18 KW)	6	13000	0	0	0	0	0	24000	0	0	0	0	0	0	0	0	0	0	0	24000	0	22000
Pump (18 KW)	6	13000	0	0	0	0	0	24000	0	0	0	0	0	0	0	0	0	0	0	24000	0	22000
Horisontal feedwagon : 7m³ (2.45t) (with scale)	3	350767	0	0	0	0	0	0	0	0	455049	0	0	0	0	0	0	0	0	0	0	303366
Hammer mill (medic bales) 70kw	3	38542	0	0	0	0	0	0	0	0	50000	0	0	0	0	0	0	0	0	0	0	33333
Hammer mill (maize and grains) 70kw	3	61667	0	0	0	0	0	0	0	0	80000	0	0	0	0	0	0	0	0	0	0	53333
Fertiliser spreader : Double disc, 1500L, 10-36m, 3-point	8	47935	0	0	0	123262	0	0	0	0	0	0	0	0	0	0	0	123262	0	0	0	92447
Pellet machine	3	65521	0	0	0	0	0	0	0	0	85000	0	0	0	0	0	0	0	0	0	0	56667
Heavy duty clod roller (9m)	3	61293	0	0	0	0	0	0	0	0	79515	0	0	0	0	0	0	0	0	0	0	53010
Swather : 25 feet, 7.62m	5	177745	0	0	0	0	0	0	287588	0	0	0	0	0	0	0	0	0	0	0	287588	239657
Livestock:		7804784																				7804784
Total intermediate capital:		**12404438**	**0**	**0**	**0**	**1625762**	**2106500**	**2434518**	**2484563**	**7367994**	**3659846**	**0**	**0**	**0**	**0**	**0**	**0**	**1625762**	**2106500**	**2434518**	**2484563**	**15242742**
Total capital:		**55507246**	**0**	**0**	**0**	**1625762**	**2106500**	**2434518**	**2484563**	**7367994**	**3659846**	**0**	**0**	**0**	**0**	**0**	**0**	**1625762**	**2106500**	**2434518**	**2484563**	**58345550**
Net annual flow:		**-49762412**	**5154027**	**2713462**	**5580905**	**3690841**	**4560446**	**2962961**	**2917920**	**-1477167**	**1148703**	**6456296**	**5154027**	**5580905**	**2286585**	**4442564**	**6456296**	**3690841**	**3258177**	**2251498**	**61690348**	

Cash flow:	**Year**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Opening balance		0	2841139	5093589	4905298	7586969	9571841	13968204	16446987	18268671	18610473	17325331	18251613	18526328	19893019	19933976	23111720	28308080	31933791	35047697	36834178
Inflow		6949992	6359186	3918621	6786064	6521763	7872105	6602638	6607643	7095986	6013708	7661455	6359186	6786064	3491744	5647723	7661455	6521763	6569836	5891175	7034520
Outflow		4111523	4111523	4111523	4111523	4545887	3488870	4139313	4803128	6771675	7315132	6752327	6101884	5438069	3469522	2491701	2491701	2926064	3488870	4139313	4803128
Flow before interest		2838469	5088802	4900688	7579839	9562845	13955076	16431529	18251501	18592982	17309048	18234459	18508916	19874323	19915241	23089999	28281475	31903778	35014758	36799559	39065570
Interest		2670	4787	4610	7131	8996	13128	15458	17170	17491	16283	17154	17412	18696	18735	21722	26605	30013	32940	34619	36750
Closing balance		2841139	5093589	4905298	7586969	9571841	13968204	16446987	18268671	18610473	17325331	18251613	18526328	19893019	19933976	23111720	28308080	31933791	35047697	36834178	39102321

IRR	7.91%
NPV	26028674

Whole-farm multi-period budget: System E, Grazing approach.

Year		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
Scenario (Wheat/Canola)		Good	Average	Poor	Average	Average	Good	Average	Average	Average	Average	Good	Average	Average	Poor	Average	Good	Average	Average	Average	Average	
Scenario (Medics/Clover)		Poor	Average	Good	Good	Average	Average	Average	Average	Average	Poor	Average	Average	Good	Average	Poor	Average	Average	Average	Poor	Good	
Gross Margin																						
Wheat on Wheat		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Wheat on Canola		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Wheat on Medics		5799137	4496868	1629426	4496868	4496868	5799137	4496868	4496868	4496868	4496868	5799137	4496868	4496868	1629426	4496868	5799137	4496868	4496868	4496868	4496868	
Medics/medics Clover		-737259	-737259	-737259	-737259	-737259	-737259	-737259	-737259	-737259	-737259	-737259	-737259	-737259	-737259	-737259	-737259	-737259	-737259	-737259	-737259	
Canola		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Capital sales		0	0	0	0	162576	77400	243452	248456	657763	67649	0	0	0	0	0	0	162576	77400	243452	248456	
Whole-farm gross margin		**5061878**	**3759610**	**892167**	**3759610**	**3922186**	**5139278**	**4003062**	**4008066**	**4417372**	**3827259**	**5061878**	**3759610**	**3759610**	**892167**	**3759610**	**5061878**	**3922186**	**3837010**	**4003062**	**4008066**	
Overhead and fixed costs																						
Water system		12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	
Fencing and camps		12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	
Water fees		50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	
Property tax		8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	
Accounting fees		65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	
Banking fees		16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	
Admin		18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	
Telephone and Postage		20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	
Electricity		39458	39458	39458	39458	39458	39458	39458	39458	39458	39458	39458	39458	39458	39458	39458	39458	39458	39458	39458	39458	
Licenses and insurance		158037	158037	158037	158037	158037	158037	158037	158037	158037	158037	158037	158037	158037	158037	158037	158037	158037	158037	158037	158037	
Employee wages		150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	
Reparations on fixed improvements		76017	76017	76017	76017	76017	76017	76017	76017	76017	76017	76017	76017	76017	76017	76017	76017	76017	76017	76017	76017	
Owner's remuneration		300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	
Miscellaneous costs		41645	41645	41645	41645	41645	41645	41645	41645	41645	41645	41645	41645	41645	41645	41645	41645	41645	41645	41645	41645	
Total overhead and fixed costs		**967081**	**967081**	**967081**	**967081**	**967081**	**967081**	**967081**	**967081**	**967081**	**967081**	**967081**	**967081**	**967081**	**967081**	**967081**	**967081**	**967081**	**967081**	**967081**	**967081**	
Margin above overhead and fixed costs		**4094797**	**2792529**	**-74914**	**2792529**	**2955105**	**4172197**	**3035980**	**3040985**	**3450291**	**2860178**	**4094797**	**2792529**	**2792529**	**-74914**	**2792529**	**4094797**	**2955105**	**2869929**	**3035980**	**3040985**	
Capital																						
Long-term																						**Resale value:**
Land and fixed improvements		32100024	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	32100024
Intermediate																						
Bakkies:																						
3.0D-4D Xtra Cab	3	267087	0	0	0	0	0	0	0	0	346491	0	0	0	0	0	0	0	0	0	0	230994
Tractors																						
120 KW 4X4	8	584306	0	0	0	1502500	0	0	0	0	0	0	0	0	0	0	0	1502500	0	0	0	1126875
70KW 4X4	7	341514	0	0	0	0	734000	0	0	0	0	0	0	0	0	0	0	0	734000	0	0	611667
100KW 4X4	6	634021	0	0	0	0	0	1170500	0	0	0	0	0	0	0	0	0	0	0	1170500	0	1072958
Sprayers:																						
Boom sprayer : 3200L, 24m, towed	6	489408	0	0	0	0	0	903523	0	0	0	0	0	0	0	0	0	0	0	903523	0	828230

Trailers																						
Trailer : 8 Tonne, 4 wheel	4	89684	0	0	0	0	0	0	0	129145	0	0	0	0	0	0	0	0	0	0	0	96859
Trailer : 10 Tonne, 4 wheel	4	97351	0	0	0	0	0	0	0	140185	0	0	0	0	0	0	0	0	0	0	0	105139
Grain overloader : 15 Tonne with auger	3	254375	0	0	0	0	0	0	0	0	330000	0	0	0	0	0	0	0	0	0	0	220000
Trailer : 15 Tonne, 4 wheel, air brakes	5	149569	0	0	0	0	0	0	242000	0	0	0	0	0	0	0	0	0	0	0	242000	201667
Trailer : 12 Tonne, 4 wheel, air brakes	5	138584	0	0	0	0	0	0	224225	0	0	0	0	0	0	0	0	0	0	0	224225	186854
Water trailer - 1000 L (also for diesel)	6	26599	0	0	0	0	0	49105	0	0	0	0	0	0	0	0	0	0	0	49105	0	45013
Trucks:																						
29 Tonne truck	5	1069700	0	0	0	0	0	0	1730750	0	0	0	0	0	0	0	0	0	0	0	1730750	1442292
Combine Harvester:																						
Combine harvester with cutter and pick-up (290KW, 7.62m)	4	3833333	0	0	0	0	0	0	0	5520000	0	0	0	0	0	0	0	0	0	0	0	4140000
Other implements and tools:																						
Loader/fork lift (fits on 100kw tractor)	6	142670	0	0	0	0	0	263390	0	0	0	0	0	0	0	0	0	0	0	263390	0	241441
Air seeder : 17t x 285mm, 4.8m	4	547428	0	0	0	0	0	0	0	788297	0	0	0	0	0	0	0	0	0	0	0	591223
Other tools	7	11632	0	0	0	0	25000	0	0	0	0	0	0	0	0	0	0	0	25000	0	0	20833
Welding and gas equipment	7	6979	0	0	0	0	15000	0	0	0	0	0	0	0	0	0	0	0	15000	0	0	12500
Pump (18 KW)	6	13000	0	0	0	0	0	24000	0	0	0	0	0	0	0	0	0	0	0	24000	0	22000
Pump (18 KW)	6	13000	0	0	0	0	0	24000	0	0	0	0	0	0	0	0	0	0	0	24000	0	22000
Fertiliser spreader : Double disc, 1500L, 10-36m, 3-point	8	47935	0	0	0	123262	0	0	0	0	0	0	0	0	0	0	0	123262	0	0	0	92447
Swather : 25 feet, 7.62m	5	177745	0	0	0	0	0	0	287588	0	0	0	0	0	0	0	0	0	0	0	287588	239657
Livestock:		289109																				289109
Total intermediate capital:		**8935920**	**0**	**0**	**0**	**1625762**	**774000**	**2434518**	**2484563**	**6577627**	**676491**	**0**	**0**	**0**	**0**	**0**	**0**	**1625762**	**774000**	**2434518**	**2484563**	**11550647**
Total capital:		**41325053**	**0**	**0**	**0**	**1625762**	**774000**	**2434518**	**2484563**	**6577627**	**676491**	**0**	**0**	**0**	**0**	**0**	**0**	**1625762**	**774000**	**2434518**	**2484563**	**43939781**
Net annual flow:		**-37230256**	**2792529**	**-74914**	**2792529**	**1329342**	**3398197**	**601462**	**556421**	**-3127335**	**2183686**	**4094797**	**2792529**	**2792529**	**-74914**	**2792529**	**4094797**	**1329342**	**2095929**	**601462**	**44496202**	

Cash flow:	**Year**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Opening balance		0	2187462	3073487	1090206	1975200	2588982	4954698	5534297	5455012	4026310	2259456	1933709	955217	640244	-816425	806881	3735208	5090753	6155328	6736057
Inflow		5061878	3759610	892167	3759610	3922186	5139278	4003062	4008066	4417372	3827259	5061878	3759610	3759610	892167	3759610	5061878	3922186	3837010	4003062	4008066
Outflow		2876473	2876473	2876473	2876473	3310837	2778220	3428664	4092478	5849859	5596237	5389443	4738999	4075185	2317804	2137062	2137062	2571426	2778220	3428664	4092478
Flow before interest		2185406	3070599	1089182	1973343	2586549	4950041	5529096	5449885	4022526	2257332	1931891	954319	639642	-785393	806123	3731698	5085968	6149542	6729726	6651645
Interest		2056	2889	1025	1856	2433	4657	5201	5127	3784	2124	1817	898	602	-31032	758	3511	4785	5785	6331	6257
Closing balance		2187462	3073487	1090206	1975200	2588982	4954698	5534297	5455012	4026310	2259456	1933709	955217	640244	-816425	806881	3735208	5090753	6155328	6736057	6657902

IRR	5.02%
NPV	5379553

Whole-farm multi-period budget: System E, Sell medics.

Year		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
Scenario (Wheat/Canola)		**Good**	**Average**	**Poor**	**Average**	**Average**	**Good**	**Average**	**Average**	**Average**	**Average**	**Good**	**Average**	**Average**	**Poor**	**Average**	**Good**	**Average**	**Average**	**Average**	**Average**	
Scenario (Medics/Clover)		**Poor**	**Average**	**Good**	**Good**	**Average**	**Average**	**Average**	**Average**	**Average**	**Poor**	**Average**	**Average**	**Good**	**Average**	**Poor**	**Average**	**Average**	**Average**	**Poor**	**Good**	
Gross Margin																						
Wheat on Wheat		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Wheat on Canola		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Wheat on Medics		5714761	4412493	1545050	4412493	4412493	5714761	4412493	4412493	4412493	4412493	5714761	4412493	4412493	1545050	4412493	5714761	4412493	4412493	4412493	4412493	
Medics/medics Clover		276681	841134	1179806	1179806	841134	841134	841134	841134	841134	276681	841134	841134	1179806	841134	276681	841134	841134	841134	276681	1179806	
Canola		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Capital sales		0	0	0	0	162576	210650	243452	248456	736799	297480	0	0	0	0	0	0	162576	210650	243452	248456	
Whole-farm gross margin		**5991442**	**5253627**	**2724856**	**5592299**	**5416203**	**6766545**	**5497078**	**5502083**	**5990426**	**4986653**	**6555895**	**5253627**	**5592299**	**2386184**	**4689174**	**6555895**	**5416203**	**5464277**	**4932625**	**5840755**	
Overhead and fixed costs																						
Water system		12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	
Fencing and camps		12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	
Water fees		50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	
Property tax		8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	
Accounting fees		65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	
Banking fees		16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	
Admin		18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	
Telephone and Postage		20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	
Electricity		38208	38208	38208	38208	38208	38208	38208	38208	38208	38208	38208	38208	38208	38208	38208	38208	38208	38208	38208	38208	
Licenses and insurance		200273	200273	200273	200273	200273	200273	200273	200273	200273	200273	200273	200273	200273	200273	200273	200273	200273	200273	200273	200273	
Employee wages		120000	120000	120000	120000	120000	120000	120000	120000	120000	120000	120000	120000	120000	120000	120000	120000	120000	120000	120000	120000	
Reparations on fixed improvements		63368	63368	63368	63368	63368	63368	63368	63368	63368	63368	63368	63368	63368	63368	63368	63368	63368	63368	63368	63368	
Owner's remuneration		300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	
Miscellaneous costs		41570	41570	41570	41570	41570	41570	41570	41570	41570	41570	41570	41570	41570	41570	41570	41570	41570	41570	41570	41570	
Total overhead and fixed costs		**965344**	**965344**	**965344**	**965344**	**965344**	**965344**	**965344**	**965344**	**965344**	**965344**	**965344**	**965344**	**965344**	**965344**	**965344**	**965344**	**965344**	**965344**	**965344**	**965344**	
Margin above overhead and fixed costs		**5026098**	**4288283**	**1759512**	**4626954**	**4450859**	**5801201**	**4531734**	**4536739**	**5025082**	**4021309**	**5590551**	**4288283**	**4626954**	**1420840**	**3723829**	**5590551**	**4450859**	**4498933**	**3967281**	**4875411**	
Capital																						
Long-term																						**Resale value:**
Land and fixed improvements		30968512	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30968512
Intermediate																						
Bakkies:																						
3.0D-4D Xtra Cab	3	267087	0	0	0	0	0	0	0	0	346491	0	0	0	0	0	0	0	0	0	0	230994
Tractors																						
120 KW 4X4	8	584306	0	0	0	1502500	0	0	0	0	0	0	0	0	0	0	0	1502500	0	0	0	1126875
70KW 4X4	7	341514	0	0	0	0	734000	0	0	0	0	0	0	0	0	0	0	0	734000	0	0	611667
100KW 4X4	6	634021	0	0	0	0	0	1170500	0	0	0	0	0	0	0	0	0	0	0	1170500	0	1072958
110KW 4X4	7	619983	0	0	0	0	1332500	0	0	0	0	0	0	0	0	0	0	0	1332500	0	0	1110417
Sprayers:																						
Boom sprayer : 3200L, 24m, towed	6	489408	0	0	0	0	0	903523	0	0	0	0	0	0	0	0	0	0	0	903523	0	828230

Trailers																						
Trailer : 8 Tonne, 4 wheel	4	89684	0	0	0	0	0	0	0	129145	0	0	0	0	0	0	0	0	0	0	0	96859
Trailer : 10 Tonne, 4 wheel	4	97351	0	0	0	0	0	0	0	140185	0	0	0	0	0	0	0	0	0	0	0	105139
Grain overloader : 15 Tonne with auger	3	254375	0	0	0	0	0	0	0	0	330000	0	0	0	0	0	0	0	0	0	0	220000
Trailer : 15 Tonne, 4 wheel, air brakes	5	149569	0	0	0	0	0	0	242000	0	0	0	0	0	0	0	0	0	0	0	242000	201667
Trailer : 12 Tonne, 4 wheel, air brakes	5	138584	0	0	0	0	0	0	224225	0	0	0	0	0	0	0	0	0	0	0	224225	186854
Water trailer - 1000 L (also for diesel)	6	26599	0	0	0	0	0	49105	0	0	0	0	0	0	0	0	0	0	0	49105	0	45013
Trucks:																						
29 Tonne truck	5	1069700	0	0	0	0	0	0	1730750	0	0	0	0	0	0	0	0	0	0	0	1730750	1442292
Combine Harvester:																						
Combine harverster with cutter and pick-up (290KW, 7.62m)	4	3833333	0	0	0	0	0	0	0	5520000	0	0	0	0	0	0	0	0	0	0	0	4140000
Other implements and tools:																						
Haybine: 8-disk 4.0m, towed, Roller, middle-tow	4	520628	0	0	0	0	0	0	0	749704	0	0	0	0	0	0	0	0	0	0	0	562278
Wheel rake : 8-wheel, 5.45m, 3-point, V-type	4	28238	0	0	0	0	0	0	0	40663	0	0	0	0	0	0	0	0	0	0	0	30497
Loader/fork lift (fits on 100kw tractor)	6	142670	0	0	0	0	0	263390	0	0	0	0	0	0	0	0	0	0	0	263390	0	241441
Big pack square baler (120 X 70) (Standard)	3	1710318	0	0	0	0	0	0	0	0	2218791	0	0	0	0	0	0	0	0	0	0	1479194
Air seeder : 17t x 285mm, 4.8m	4	547428	0	0	0	0	0	0	0	788297	0	0	0	0	0	0	0	0	0	0	0	591223
Other tools	7	11632	0	0	0	0	25000	0	0	0	0	0	0	0	0	0	0	0	25000	0	0	20833
Welding and gas equipment	7	6979	0	0	0	0	15000	0	0	0	0	0	0	0	0	0	0	0	15000	0	0	12500
Pump (18 KW)	6	13000	0	0	0	0	0	24000	0	0	0	0	0	0	0	0	0	0	0	24000	0	22000
Pump (18 KW)	6	13000	0	0	0	0	0	24000	0	0	0	0	0	0	0	0	0	0	0	24000	0	22000
Fertiliser spreader : Double disc, 1500L, 10-36m, 3-point	8	47935	0	0	0	123262	0	0	0	0	0	0	0	0	0	0	0	123262	0	0	0	92447
Heavy duty clod roller (9m)	3	61293	0	0	0	0	0	0	0	0	79515	0	0	0	0	0	0	0	0	0	0	53010
Swather : 25 feet, 7.62m	5	177745	0	0	0	0	0	0	287588	0	0	0	0	0	0	0	0	0	0	0	287588	239657
Livestock:		0																				0
Total intermediate capital:		**11876379**	**0**	**0**	**0**	**1625762**	**2106500**	**2434518**	**2484563**	**7367994**	**2974797**	**0**	**0**	**0**	**0**	**0**	**0**	**1625762**	**2106500**	**2434518**	**2484563**	**14786043**
Total capital:		**42844891**	**0**	**0**	**0**	**1625762**	**2106500**	**2434518**	**2484563**	**7367994**	**2974797**	**0**	**0**	**0**	**0**	**0**	**0**	**1625762**	**2106500**	**2434518**	**2484563**	**45754555**
Net annual flow:		**-37818793**	**4288283**	**1759512**	**4626954**	**2825096**	**3694701**	**2097216**	**2052175**	**-2342912**	**1046512**	**5590551**	**4288283**	**4626954**	**1420840**	**3723829**	**5590551**	**2825096**	**2392433**	**1532763**	**48145402**	

Cash flow:	**Year**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Opening balance		0	2948206	5160676	4844078	7397321	9341933	13029472	14798762	15910287	15541262	13806403	14203966	13949465	14698153	14208815	16819713	21301545	24212055	26610089	27827171
Inflow		5991442	5253627	2724856	5592299	5416203	6766545	5497078	5502083	5990426	4986653	6555895	5253627	5592299	2386184	4689174	6555895	5416203	5464277	4932625	5840755
Outflow		3046007	3046007	3046007	3046007	3480371	3091253	3741696	4405511	6374058	6734487	6171682	5521238	4857424	2888877	2094084	2094084	2528448	3091253	3741696	4405511
Flow before interest		2945435	5155826	4839525	7390369	9333153	13017226	14784854	15895334	15526655	13793427	14190617	13936354	14684339	14195461	16803905	21281524	24189300	26585079	27801018	29262415
Interest		2771	4850	4553	6952	8780	12246	13909	14953	14606	12976	13350	13110	13814	13354	15808	20020	22756	25009	26153	27528
Closing balance		2948206	5160676	4844078	7397321	9341933	13029472	14798762	15910287	15541262	13806403	14203966	13949465	14698153	14208815	16819713	21301545	24212055	26610089	27827171	29289943

IRR 8.14%

NPV 21156461

Whole-farm multi-period budget: System F, Intensive speculation approach.

Year		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
Scenario (Wheat/Canola)		Good	Average	Poor	Average	Average	Good	Average	Average	Average	Average	Good	Average	Average	Poor	Average	Good	Average	Average	Average	Average	
Scenario (Medics/Clover)		Poor	Average	Good	Good	Average	Average	Average	Average	Average	Poor	Average	Average	Good	Average	Poor	Average	Average	Average	Poor	Good	
Gross Margin																						
Wheat on Wheat		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Wheat on Canola		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Wheat on Medics		5270102	3887067	1429259	3887067	3887067	5270102	3887067	3887067	3887067	3887067	5270102	3887067	3887067	1429259	3887067	5270102	3887067	3887067	3887067	3887067	
Medics/medics Clover		1255825	1967288	2394165	2394165	1967288	1967288	1967288	1967288	1967288	1255825	1967288	1967288	2394165	1967288	1255825	1967288	1967288	1967288	1255825	2394165	
Canola		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Capital sales		0	0	0	0	162576	210650	243452	248456	736799	365985	0	0	0	0	0	0	162576	210650	243452	248456	
Whole-farm gross margin		**6525927**	**5854355**	**3823425**	**6281232**	**6016931**	**7448040**	**6097807**	**6102811**	**6591154**	**5508876**	**7237390**	**5854355**	**6281232**	**3396547**	**5142892**	**7237390**	**6016931**	**6065005**	**5386344**	**6529689**	
Overhead and fixed costs																						
Water system		12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	
Fencing and camps		12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	
Water fees		50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	
Property tax		8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	
Accounting fees		65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	
Banking fees		16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	
Admin		18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	
Telephone and Postage		20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	
Electricity		176970	176970	176970	176970	176970	176970	176970	176970	176970	176970	176970	176970	176970	176970	176970	176970	176970	176970	176970	176970	
Licenses and insurance		210850	210850	210850	210850	210850	210850	210850	210850	210850	210850	210850	210850	210850	210850	210850	210850	210850	210850	210850	210850	
Employee wages		150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	
Reparations on fixed improvements		113517	113517	113517	113517	113517	113517	113517	113517	113517	113517	113517	113517	113517	113517	113517	113517	113517	113517	113517	113517	
Owner's remuneration		300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	
Miscellaneous costs		51897	51897	51897	51897	51897	51897	51897	51897	51897	51897	51897	51897	51897	51897	51897	51897	51897	51897	51897	51897	
Total overhead and fixed costs		**1205159**	**1205159**	**1205159**	**1205159**	**1205159**	**1205159**	**1205159**	**1205159**	**1205159**	**1205159**	**1205159**	**1205159**	**1205159**	**1205159**	**1205159**	**1205159**	**1205159**	**1205159**	**1205159**	**1205159**	
Margin above overhead and fixed costs		**5320768**	**4649196**	**2618266**	**5076074**	**4811772**	**6242881**	**4892648**	**4897652**	**5385995**	**4303717**	**6032231**	**4649196**	**5076074**	**2191388**	**3937733**	**6032231**	**4811772**	**4859846**	**4181185**	**5324530**	
Capital																						
Long-term																						**Resale value:**
Land and fixed improvements		35298024	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	35298024
Intermediate																						
Bakkies:																						
3.0D-4D Xtra Cab	3	267087	0	0	0	0	0	0	0	0	346491	0	0	0	0	0	0	0	0	0	0	230994
Tractors																						
120 KW 4X4	8	584306	0	0	0	1502500	0	0	0	0	0	0	0	0	0	0	0	1502500	0	0	0	1126875
70KW 4X4	7	341514	0	0	0	0	734000	0	0	0	0	0	0	0	0	0	0	0	734000	0	0	611667
100KW 4X4	6	634021	0	0	0	0	0	1170500	0	0	0	0	0	0	0	0	0	0	0	1170500	0	1072958
110KW 4X4	7	619983	0	0	0	0	1332500	0	0	0	0	0	0	0	0	0	0	0	1332500	0	0	1110417
Sprayers:																						
Boom sprayer : 3200L, 24m, towed	6	489408	0	0	0	0	0	903523	0	0	0	0	0	0	0	0	0	0	0	903523	0	828230

Trailers																						
Trailer : 8 Tonne, 4 wheel	4	89684	0	0	0	0	0	0	0	129145	0	0	0	0	0	0	0	0	0	0	0	96859
Trailer : 10 Tonne, 4 wheel	4	97351	0	0	0	0	0	0	0	140185	0	0	0	0	0	0	0	0	0	0	0	105139
Grain overloader : 15 Tonne with auger	3	254375	0	0	0	0	0	0	0	0	330000	0	0	0	0	0	0	0	0	0	0	220000
Trailer : 15 Tonne, 4 wheel, air brakes	5	149569	0	0	0	0	0	0	242000	0	0	0	0	0	0	0	0	0	0	0	242000	201667
Trailer : 12 Tonne, 4 wheel, air brakes	5	138584	0	0	0	0	0	0	224225	0	0	0	0	0	0	0	0	0	0	0	224225	186854
Water trailer - 1000 L (also for diesel)	6	26599	0	0	0	0	0	49105	0	0	0	0	0	0	0	0	0	0	0	49105	0	45013
Trucks:																						
29 Tonne truck	5	1069700	0	0	0	0	0	0	1730750	0	0	0	0	0	0	0	0	0	0	0	1730750	1442292
Combine Harvester:																						
Combine harverster with cutter and pick-up (290KW, 7.62m)	4	3833333	0	0	0	0	0	0	0	5520000	0	0	0	0	0	0	0	0	0	0	0	4140000
Other implements and tools:																						
Haybine: 8-disk 4.0m, towed, Roller, middle-tow	4	520628	0	0	0	0	0	0	0	749704	0	0	0	0	0	0	0	0	0	0	0	562278
Wheel rake : 8-wheel, 5.45m, 3-point, V-type	4	28238	0	0	0	0	0	0	0	40663	0	0	0	0	0	0	0	0	0	0	0	30497
Auger (18kw)	3	11563	0	0	0	0	0	0	0	0	15000	0	0	0	0	0	0	0	0	0	0	10000
Loader/fork lift (fits on 100kw tractor)	6	142670	0	0	0	0	0	263390	0	0	0	0	0	0	0	0	0	0	0	263390	0	241441
Big pack square baler (120 X 70) (Standard)	3	1710318	0	0	0	0	0	0	0	0	2218791	0	0	0	0	0	0	0	0	0	0	1479194
Air seeder : 17t x 285mm, 4.8m	4	547428	0	0	0	0	0	0	0	788297	0	0	0	0	0	0	0	0	0	0	0	591223
Other tools	7	11632	0	0	0	0	25000	0	0	0	0	0	0	0	0	0	0	0	25000	0	0	20833
Welding and gas equipment	7	6979	0	0	0	0	15000	0	0	0	0	0	0	0	0	0	0	0	15000	0	0	12500
Pump (18 KW)	6	13000	0	0	0	0	0	24000	0	0	0	0	0	0	0	0	0	0	0	24000	0	22000
Pump (18 KW)	6	13000	0	0	0	0	0	24000	0	0	0	0	0	0	0	0	0	0	0	24000	0	22000
Horisontal feedwagon : 7m³ (2.45t) (with scale)	3	350767	0	0	0	0	0	0	0	0	455049	0	0	0	0	0	0	0	0	0	0	303366
Hammer mill (medic bales) 70kw	3	38542	0	0	0	0	0	0	0	0	50000	0	0	0	0	0	0	0	0	0	0	33333
Hammer mill (maize and grains) 70kw	3	61667	0	0	0	0	0	0	0	0	80000	0	0	0	0	0	0	0	0	0	0	53333
Fertiliser spreader : Double disc, 1500L, 10-36m, 3-point	8	47935	0	0	0	123262	0	0	0	0	0	0	0	0	0	0	0	123262	0	0	0	92447
Pellet machine	3	65521	0	0	0	0	0	0	0	0	85000	0	0	0	0	0	0	0	0	0	0	56667
Heavy duty clod roller (9m)	3	61293	0	0	0	0	0	0	0	0	79515	0	0	0	0	0	0	0	0	0	0	53010
Swather : 25 feet, 7.62m	5	177745	0	0	0	0	0	0	287588	0	0	0	0	0	0	0	0	0	0	0	287588	239657
Livestock:		7804784																				7804784
Total intermediate capital:		**12404438**	**0**	**0**	**0**	**1625762**	**2106500**	**2434518**	**2484563**	**7367994**	**3659846**	**0**	**0**	**0**	**0**	**0**	**0**	**1625762**	**2106500**	**2434518**	**2484563**	**15242742**
Total capital:		**55507246**	**0**	**0**	**0**	**1625762**	**2106500**	**2434518**	**2484563**	**7367994**	**3659846**	**0**	**0**	**0**	**0**	**0**	**0**	**1625762**	**2106500**	**2434518**	**2484563**	**58345550**
Net annual flow:		**-50186478**	**4649196**	**2618266**	**5076074**	**3186010**	**4136381**	**2458129**	**2413089**	**-1981999**	**643872**	**6032231**	**4649196**	**5076074**	**2191388**	**3937733**	**6032231**	**3186010**	**2753346**	**1746666**	**61185517**	

Cash flow:	**Year**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Opening balance		0	2416675	4163420	3878967	6054366	7532489	11502470	13473626	14787208	14620428	12826226	13323811	13088584	13944853	13884928	16551676	21317400	24431228	27032770	28306404
Inflow		6525927	5854355	3823425	6281232	6016931	7448040	6097807	6102811	6591154	5508876	7237390	5854355	6281232	3396547	5142892	7237390	6016931	6065005	5386344	6529689
Outflow		4111523	4111523	4111523	4111523	4545887	3488870	4139313	4803128	6771675	7315132	6752327	6101884	5438069	3469522	2491701	2491701	2926064	3488870	4139313	4803128
Flow before interest		2414404	4159507	3875321	6048676	7525410	11491659	13460963	14773310	14606687	12814172	13311289	13076283	13931747	13871879	16536120	21297365	24408267	27007363	28279800	30032965
Interest		2271	3913	3646	5690	7079	10811	12663	13898	13741	12055	12522	12301	13106	13050	15556	20035	22962	25407	26604	28253
Closing balance		2416675	4163420	3878967	6054366	7532489	11502470	13473626	14787208	14620428	12826226	13323811	13088584	13944853	13884928	16551676	21317400	24431228	27032770	28306404	30061218

IRR	6.97%
NPV	19978721

Whole-farm multi-period budget: System F, Grazing approach.

Year		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	
Scenario (Wheat/Canola)		**Good**	**Average**	**Poor**	**Average**	**Average**	**Good**	**Average**	**Average**	**Average**	**Average**	**Good**	**Average**	**Average**	**Poor**	**Average**	**Good**	**Average**	**Average**	**Average**	**Average**	
Scenario (Medics/Clover)		**Poor**	**Average**	**Good**	**Good**	**Average**	**Average**	**Average**	**Average**	**Average**	**Poor**	**Average**	**Average**	**Good**	**Average**	**Poor**	**Average**	**Average**	**Average**	**Poor**	**Good**	
Gross Margin																						
Wheat on Wheat		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Wheat on Canola		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Wheat on Medics		5329916	3946881	1489073	3946881	3946881	5329916	3946881	3946881	3946881	3946881	5329916	3946881	3946881	1489073	3946881	5329916	3946881	3946881	3946881	3946881	
Medics/medics Clover		-560291	-560291	-560291	-560291	-560291	-560291	-560291	-560291	-560291	-560291	-560291	-560291	-560291	-560291	-560291	-560291	-560291	-560291	-560291	-560291	
Canola		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Capital sales		0	0	0	0	162576	77400	243452	248456	657763	67649	0	0	0	0	0	0	162576	77400	243452	248456	
Whole-farm gross margin		**4769625**	**3386590**	**928782**	**3386590**	**3549166**	**4847025**	**3630042**	**3635046**	**4044352**	**3454239**	**4769625**	**3386590**	**3386590**	**928782**	**3386590**	**4769625**	**3549166**	**3463990**	**3630042**	**3635046**	
Overhead and fixed costs																						
Water system		12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	
Fencing and camps		12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	
Water fees		50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	
Property tax		8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	
Accounting fees		65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	
Banking fees		16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	
Admin		18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	
Telephone and Postage		20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	
Electricity		39458	39458	39458	39458	39458	39458	39458	39458	39458	39458	39458	39458	39458	39458	39458	39458	39458	39458	39458	39458	
Licenses and insurance		158037	158037	158037	158037	158037	158037	158037	158037	158037	158037	158037	158037	158037	158037	158037	158037	158037	158037	158037	158037	
Employee wages		150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	
Reparations on fixed improvements		76017	76017	76017	76017	76017	76017	76017	76017	76017	76017	76017	76017	76017	76017	76017	76017	76017	76017	76017	76017	
Owner's remuneration		300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	
Miscellaneous costs		41645	41645	41645	41645	41645	41645	41645	41645	41645	41645	41645	41645	41645	41645	41645	41645	41645	41645	41645	41645	
Total overhead and fixed costs		**967081**	**967081**	**967081**	**967081**	**967081**	**967081**	**967081**	**967081**	**967081**	**967081**	**967081**	**967081**	**967081**	**967081**	**967081**	**967081**	**967081**	**967081**	**967081**	**967081**	
Margin above overhead and fixed costs		**3802544**	**2419509**	**-38299**	**2419509**	**2582085**	**3879944**	**2662960**	**2667965**	**3077271**	**2487158**	**3802544**	**2419509**	**2419509**	**-38299**	**2419509**	**3802544**	**2582085**	**2496909**	**2662960**	**2667965**	
Capital																						
Long-term																						**Resale value:**
Land and fixed improvements		32100024	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	32100024
Intermediate																						
Bakkies:																						
3.0D-4D Xtra Cab	3	267087	0	0	0	0	0	0	0	0	346491	0	0	0	0	0	0	0	0	0	0	230994
Tractors																						
120 KW 4X4	8	584306	0	0	0	1502500	0	0	0	0	0	0	0	0	0	0	0	1502500	0	0	0	1126875
70KW 4X4	7	341514	0	0	0	0	734000	0	0	0	0	0	0	0	0	0	0	0	734000	0	0	611667
100KW 4X4	6	634021	0	0	0	0	0	1170500	0	0	0	0	0	0	0	0	0	0	0	1170500	0	1072958
Sprayers:																						
Boom sprayer : 3200L, 24m, towed	6	489408	0	0	0	0	0	903523	0	0	0	0	0	0	0	0	0	0	0	903523	0	828230

Trailers																						
Trailer : 8 Tonne, 4 wheel	4	89684	0	0	0	0	0	0	0	129145	0	0	0	0	0	0	0	0	0	0	0	96859
Trailer : 10 Tonne, 4 wheel	4	97351	0	0	0	0	0	0	0	140185	0	0	0	0	0	0	0	0	0	0	0	105139
Grain overloader : 15 Tonne with auger	3	254375	0	0	0	0	0	0	0	0	330000	0	0	0	0	0	0	0	0	0	0	220000
Trailer : 15 Tonne, 4 wheel, air brakes	5	149569	0	0	0	0	0	0	242000	0	0	0	0	0	0	0	0	0	0	0	242000	201667
Trailer : 12 Tonne, 4 wheel, air brakes	5	138584	0	0	0	0	0	0	224225	0	0	0	0	0	0	0	0	0	0	0	224225	186854
Water trailer - 1000 L (also for diesel)	6	26599	0	0	0	0	0	49105	0	0	0	0	0	0	0	0	0	0	0	49105	0	45013
Trucks:																						
29 Tonne truck	5	1069700	0	0	0	0	0	0	1730750	0	0	0	0	0	0	0	0	0	0	0	1730750	1442292
Combine Harvester:																						
Combine harvester with cutter and pick-up (290KW, 7.62m)	4	3833333	0	0	0	0	0	0	0	5520000	0	0	0	0	0	0	0	0	0	0	0	4140000
Other implements and tools:																						
Loader/fork lift (fits on 100kw tractor)	6	142670	0	0	0	0	0	263390	0	0	0	0	0	0	0	0	0	0	0	263390	0	241441
Air seeder : 17t x 285mm, 4.8m	4	547428	0	0	0	0	0	0	0	788297	0	0	0	0	0	0	0	0	0	0	0	591223
Other tools	7	11632	0	0	0	0	25000	0	0	0	0	0	0	0	0	0	0	0	25000	0	0	20833
Welding and gas equipment	7	6979	0	0	0	0	15000	0	0	0	0	0	0	0	0	0	0	0	15000	0	0	12500
Pump (18 KW)	6	13000	0	0	0	0	0	24000	0	0	0	0	0	0	0	0	0	0	0	24000	0	22000
Pump (18 KW)	6	13000	0	0	0	0	0	24000	0	0	0	0	0	0	0	0	0	0	0	24000	0	22000
Fertiliser spreader : Double disc, 1500L, 10-36m, 3-point	8	47935	0	0	0	123262	0	0	0	0	0	0	0	0	0	0	0	123262	0	0	0	92447
Swather : 25 feet, 7.62m	5	177745	0	0	0	0	0	0	287588	0	0	0	0	0	0	0	0	0	0	0	287588	239657
Livestock:		289109																				289109
Total intermediate capital:		**8935920**	**0**	**0**	**0**	**1625762**	**774000**	**2434518**	**2484563**	**6577627**	**676491**	**0**	**0**	**0**	**0**	**0**	**0**	**1625762**	**774000**	**2434518**	**2484563**	**11550647**
Total capital:		**41325053**	**0**	**0**	**0**	**1625762**	**774000**	**2434518**	**2484563**	**6577627**	**676491**	**0**	**0**	**0**	**0**	**0**	**0**	**1625762**	**774000**	**2434518**	**2484563**	**43939781**
Net annual flow:		**-37522510**	**2419509**	**-38299**	**2419509**	**956322**	**3105944**	**228442**	**183402**	**-3500355**	**1810667**	**3802544**	**2419509**	**2419509**	**-38299**	**2419509**	**3802544**	**956322**	**1722909**	**228442**	**44123182**	

Cash flow:	**Year**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Opening balance		0	1894933	2407313	460054	971084	1210551	3282441	3487097	3032515	1228163	-949941	-1631782	-3102099	-3940467	-5540062	-4460057	-1899700	-958387	-283389	-85251
Inflow		4769625	3386590	928782	3386590	3549166	4847025	3630042	3635046	4044352	3454239	4769625	3386590	3386590	928782	3386590	4769625	3549166	3463990	3630042	3635046
Outflow		2876473	2876473	2876473	2876473	3310837	2778220	3428664	4092478	5849859	5596237	5389443	4738999	4075185	2317804	2137062	2137062	2571426	2778220	3428664	4092478
Flow before interest		1893152	2405050	459622	970171	1209413	3279356	3483819	3029665	1227009	-913835	-1569759	-2984191	-3790694	-5329489	-4290534	-1827494	-921960	-272617	-82011	-542683
Interest		1781	2263	432	913	1138	3085	3277	2850	1154	-36106	-62022	-117908	-149773	-210572	-169523	-72206	-36427	-10771	-3240	-21442
Closing balance		1894933	2407313	460054	971084	1210551	3282441	3487097	3032515	1228163	-949941	-1631782	-3102099	-3940467	-5540062	-4460057	-1899700	-958387	-283389	-85251	-564125

IRR 4.17%

NPV 1128747

Whole-farm multi-period budget: System F, Sell medics approach.

Year		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
Scenario (Wheat/Canola)		**Good**	**Average**	**Poor**	**Average**	**Average**	**Good**	**Average**	**Average**	**Average**	**Average**	**Good**	**Average**	**Average**	**Poor**	**Average**	**Good**	**Average**	**Average**	**Average**	**Average**	
Scenario (Medics/Clover)		**Poor**	**Average**	**Good**	**Good**	**Average**	**Average**	**Average**	**Average**	**Average**	**Poor**	**Average**	**Average**	**Good**	**Average**	**Poor**	**Average**	**Average**	**Average**	**Poor**	**Good**	
Gross Margin																						
Wheat on Wheat		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Wheat on Canola		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Wheat on Medics		5245540	3862505	1404697	3862505	3862505	5245540	3862505	3862505	3862505	3862505	5245540	3862505	3862505	1404697	3862505	5245540	3862505	3862505	3862505	3862505	
Medics/medics Clover		276681	841134	1179806	1179806	841134	841134	841134	841134	841134	276681	841134	841134	1179806	841134	276681	841134	841134	841134	276681	1179806	
Canola		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Capital sales		0	0	0	0	162576	210650	243452	248456	736799	297480	0	0	0	0	0	0	162576	210650	243452	248456	
Whole-farm gross margin		**5522221**	**4703639**	**2584503**	**5042311**	**4866215**	**6297324**	**4947091**	**4952095**	**5440438**	**4436665**	**6086674**	**4703639**	**5042311**	**2245831**	**4139186**	**6086674**	**4866215**	**4914289**	**4382638**	**5290767**	
Overhead and fixed costs																						
Water system		12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	
Fencing and camps		12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	
Water fees		50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	
Property tax		8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	
Accounting fees		65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	
Banking fees		16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	
Admin		18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	
Telephone and Postage		20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	
Electricity		38208	38208	38208	38208	38208	38208	38208	38208	38208	38208	38208	38208	38208	38208	38208	38208	38208	38208	38208	38208	
Licenses and insurance		200273	200273	200273	200273	200273	200273	200273	200273	200273	200273	200273	200273	200273	200273	200273	200273	200273	200273	200273	200273	
Employee wages		120000	120000	120000	120000	120000	120000	120000	120000	120000	120000	120000	120000	120000	120000	120000	120000	120000	120000	120000	120000	
Reparations on fixed improvements		63368	63368	63368	63368	63368	63368	63368	63368	63368	63368	63368	63368	63368	63368	63368	63368	63368	63368	63368	63368	
Owner's remuneration		300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	
Miscellaneous costs		41570	41570	41570	41570	41570	41570	41570	41570	41570	41570	41570	41570	41570	41570	41570	41570	41570	41570	41570	41570	
Total overhead and fixed costs		**965344**	**965344**	**965344**	**965344**	**965344**	**965344**	**965344**	**965344**	**965344**	**965344**	**965344**	**965344**	**965344**	**965344**	**965344**	**965344**	**965344**	**965344**	**965344**	**965344**	
Margin above overhead and fixed costs		**4556877**	**3738295**	**1619159**	**4076967**	**3900871**	**5331980**	**3981747**	**3986751**	**4475094**	**3471321**	**5121330**	**3738295**	**4076967**	**1280487**	**3173842**	**5121330**	**3900871**	**3948945**	**3417293**	**4325423**	
Capital																						
Long-term																						**Resale value:**
Land and fixed improvements		30968512	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30968512
Intermediate																						
Bakkies:																						
3.0D-4D Xtra Cab	3	267087	0	0	0	0	0	0	0	0	346491	0	0	0	0	0	0	0	0	0	0	230994
Tractors																						
120 KW 4X4	8	584306	0	0	0	1502500	0	0	0	0	0	0	0	0	0	0	0	1502500	0	0	0	1126875
70KW 4X4	7	341514	0	0	0	0	734000	0	0	0	0	0	0	0	0	0	0	0	734000	0	0	611667
100KW 4X4	6	634021	0	0	0	0	0	1170500	0	0	0	0	0	0	0	0	0	0	0	1170500	0	1072958
110KW 4X4	7	619983	0	0	0	0	1332500	0	0	0	0	0	0	0	0	0	0	0	1332500	0	0	1110417
Sprayers:																						
Boom sprayer : 3200L, 24m, towed	6	489408	0	0	0	0	0	903523	0	0	0	0	0	0	0	0	0	0	0	903523	0	828230

Trailers																						
Trailer : 8 Tonne, 4 wheel	4	89684	0	0	0	0	0	0	0	129145	0	0	0	0	0	0	0	0	0	0	0	96859
Trailer : 10 Tonne, 4 wheel	4	97351	0	0	0	0	0	0	0	140185	0	0	0	0	0	0	0	0	0	0	0	105139
Grain overloader : 15 Tonne with auger	3	254375	0	0	0	0	0	0	0	0	330000	0	0	0	0	0	0	0	0	0	0	220000
Trailer : 15 Tonne, 4 wheel, air brakes	5	149569	0	0	0	0	0	0	242000	0	0	0	0	0	0	0	0	0	0	0	242000	201667
Trailer : 12 Tonne, 4 wheel, air brakes	5	138584	0	0	0	0	0	0	224225	0	0	0	0	0	0	0	0	0	0	0	224225	186854
Water trailer - 1000 L (also for diesel)	6	26599	0	0	0	0	0	49105	0	0	0	0	0	0	0	0	0	0	0	49105	0	45013
Trucks:																						
29 Tonne truck	5	1069700	0	0	0	0	0	0	1730750	0	0	0	0	0	0	0	0	0	0	0	1730750	1442292
Combine Harvester:																						
Combine harverster with cutter and pick-up (290KW, 7.62m)	4	3833333	0	0	0	0	0	0	0	5520000	0	0	0	0	0	0	0	0	0	0	0	4140000
Other implements and tools:																						
Haybine: 8-disk 4.0m, towed, Roller, middle-tow	4	520628	0	0	0	0	0	0	0	749704	0	0	0	0	0	0	0	0	0	0	0	562278
Wheel rake : 8-wheel, 5.45m, 3-point, V-type	4	28238	0	0	0	0	0	0	0	40663	0	0	0	0	0	0	0	0	0	0	0	30497
Loader/fork lift (fits on 100kw tractor)	6	142670	0	0	0	0	0	263390	0	0	0	0	0	0	0	0	0	0	0	263390	0	241441
Big pack square baler (120 X 70) (Standard)	3	1710318	0	0	0	0	0	0	0	0	2218791	0	0	0	0	0	0	0	0	0	0	1479194
Air seeder : 17t x 285mm, 4.8m	4	547428	0	0	0	0	0	0	0	788297	0	0	0	0	0	0	0	0	0	0	0	591223
Other tools	7	11632	0	0	0	0	25000	0	0	0	0	0	0	0	0	0	0	0	25000	0	0	20833
Welding and gas equipment	7	6979	0	0	0	0	15000	0	0	0	0	0	0	0	0	0	0	0	15000	0	0	12500
Pump (18 KW)	6	13000	0	0	0	0	0	24000	0	0	0	0	0	0	0	0	0	0	0	24000	0	22000
Pump (18 KW)	6	13000	0	0	0	0	0	24000	0	0	0	0	0	0	0	0	0	0	0	24000	0	22000
Fertiliser spreader : Double disc, 1500L, 10-36m, 3-point	8	47935	0	0	0	123262	0	0	0	0	0	0	0	0	0	0	0	123262	0	0	0	92447
Heavy duty clod roller (9m)	3	61293	0	0	0	0	0	0	0	0	79515	0	0	0	0	0	0	0	0	0	0	53010
Swather : 25 feet, 7.62m	5	177745	0	0	0	0	0	0	287588	0	0	0	0	0	0	0	0	0	0	0	287588	239657
Livestock:		0																				0
Total intermediate capital:		**11876379**	**0**	**0**	**0**	**1625762**	**2106500**	**2434518**	**2484563**	**7367994**	**2974797**	**0**	**0**	**0**	**0**	**0**	**0**	**1625762**	**2106500**	**2434518**	**2484563**	**14786043**
Total capital:		**42844891**	**0**	**0**	**0**	**1625762**	**2106500**	**2434518**	**2484563**	**7367994**	**2974797**	**0**	**0**	**0**	**0**	**0**	**0**	**1625762**	**2106500**	**2434518**	**2484563**	**45754555**
Net annual flow:		**-38288015**	**3738295**	**1619159**	**4076967**	**2275109**	**3225480**	**1547228**	**1502188**	**-2892900**	**496525**	**5121330**	**3738295**	**4076967**	**1280487**	**3173842**	**5121330**	**2275109**	**1842445**	**982775**	**47595415**	

Cash flow:	**Year**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Opening balance		0	2478543	4140066	3682022	5683668	7076163	10291907	11508117	12066041	11142894	8853393	8776633	7966521	8159076	7523101	9577204	13582560	15935304	17775046	18433312
Inflow		5522221	4703639	2584503	5042311	4866215	6297324	4947091	4952095	5440438	4436665	6086674	4703639	5042311	2245831	4139186	6086674	4866215	4914289	4382638	5290767
Outflow		3046007	3046007	3046007	3046007	3480371	3091253	3741696	4405511	6374058	6734487	6171682	5521238	4857424	2888877	2094084	2094084	2528448	3091253	3741696	4405511
Flow before interest		2476214	4136175	3678562	5678326	7069512	10282234	11497301	12054701	11132421	8845072	8768385	7959034	8151408	7516030	9568203	13569794	15920327	17758340	18415987	19318568
Interest		2329	3891	3461	5342	6651	9673	10816	11340	10473	8321	8249	7487	7668	7071	9001	12766	14977	16706	17325	18174
Closing balance		2478543	4140066	3682022	5683668	7076163	10291907	11508117	12066041	11142894	8853393	8776633	7966521	8159076	7523101	9577204	13582560	15935304	17775046	18433312	19336741

IRR	6.79%
NPV	14490153

Whole-farm multi-period budget: System G, Intensive speculation approach.

Year		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
Scenario (Wheat/Canola)		Good	Average	Poor	Average	Average	Good	Average	Average	Average	Average	Good	Average	Average	Poor	Average	Good	Average	Average	Average	Average	
Scenario (Medics/Clover)		Poor	Average	Good	Good	Average	Average	Average	Average	Average	Poor	Average	Average	Good	Average	Poor	Average	Average	Average	Poor	Good	
Gross Margin																						
Wheat on Wheat		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Wheat on Canola		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Wheat on Medics		3033575	2354966	801768	2354966	2354966	3033575	2354966	2354966	2354966	2354966	3033575	2354966	2354966	801768	2354966	3033575	2354966	2354966	2354966	2354966	
Medics/medics Clover		1210668	1922131	2349009	2349009	1922131	1922131	1922131	1922131	1922131	1210668	1922131	1922131	2349009	1922131	1210668	1922131	1922131	1922131	1210668	2349009	
Canola		928724	478659	-175210	478659	478659	928724	478659	478659	478659	478659	928724	478659	478659	-175210	478659	928724	478659	478659	478659	478659	
Capital sales		0	0	0	0	162576	210650	243452	248456	736799	365985	0	0	0	0	0	0	162576	210650	243452	248456	
Whole-farm gross margin		**5172968**	**4755756**	**2975567**	**5182634**	**4918332**	**6095081**	**4999208**	**5004212**	**5492555**	**4410278**	**5884431**	**4755756**	**5182634**	**2548689**	**4044293**	**5884431**	**4918332**	**4966406**	**4287745**	**5431090**	
Overhead and fixed costs																						
Water system		12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	
Fencing and camps		12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	
Water fees		50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	
Property tax		8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	
Accounting fees		65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	
Banking fees		16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	
Admin		18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	
Telephone and Postage		20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	
Electricity		176970	176970	176970	176970	176970	176970	176970	176970	176970	176970	176970	176970	176970	176970	176970	176970	176970	176970	176970	176970	
Licenses and insurance		210850	210850	210850	210850	210850	210850	210850	210850	210850	210850	210850	210850	210850	210850	210850	210850	210850	210850	210850	210850	
Employee wages		150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	
Reparations on fixed improvements		113517	113517	113517	113517	113517	113517	113517	113517	113517	113517	113517	113517	113517	113517	113517	113517	113517	113517	113517	113517	
Owner's remuneration		300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	
Miscellaneous costs		51897	51897	51897	51897	51897	51897	51897	51897	51897	51897	51897	51897	51897	51897	51897	51897	51897	51897	51897	51897	
Total overhead and fixed costs		**1205159**	**1205159**	**1205159**	**1205159**	**1205159**	**1205159**	**1205159**	**1205159**	**1205159**	**1205159**	**1205159**	**1205159**	**1205159**	**1205159**	**1205159**	**1205159**	**1205159**	**1205159**	**1205159**	**1205159**	
Margin above overhead and fixed costs		**3967809**	**3550597**	**1770408**	**3977475**	**3713173**	**4889922**	**3794049**	**3799053**	**4287396**	**3205119**	**4679272**	**3550597**	**3977475**	**1343530**	**2839134**	**4679272**	**3713173**	**3761247**	**3082586**	**4225931**	
Capital																						
Long-term																						**Resale value:**
Land and fixed improvements		35298024	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	35298024
Intermediate																						
Bakkies:																						
3.0D-4D Xtra Cab	3	267087	0	0	0	0	0	0	0	0	346491	0	0	0	0	0	0	0	0	0	0	230994
Tractors																						
120 KW 4X4	8	584306	0	0	0	1502500	0	0	0	0	0	0	0	0	0	0	0	1502500	0	0	0	1126875
70KW 4X4	7	341514	0	0	0	0	734000	0	0	0	0	0	0	0	0	0	0	0	734000	0	0	611667
100KW 4X4	6	634021	0	0	0	0	0	1170500	0	0	0	0	0	0	0	0	0	0	0	1170500	0	1072958
110KW 4X4	7	619983	0	0	0	0	1332500	0	0	0	0	0	0	0	0	0	0	0	1332500	0	0	1110417
Sprayers:																						
Boom sprayer : 3200L, 24m, towed	6	489408	0	0	0	0	0	903523	0	0	0	0	0	0	0	0	0	0	0	903523	0	828230

Trailers																						
Trailer : 8 Tonne, 4 wheel	4	89684	0	0	0	0	0	0	0	129145	0	0	0	0	0	0	0	0	0	0	0	96859
Trailer : 10 Tonne, 4 wheel	4	97351	0	0	0	0	0	0	0	140185	0	0	0	0	0	0	0	0	0	0	0	105139
Grain overloader : 15 Tonne with auger	3	254375	0	0	0	0	0	0	0	0	330000	0	0	0	0	0	0	0	0	0	0	220000
Trailer : 15 Tonne, 4 wheel, air brakes	5	149569	0	0	0	0	0	0	242000	0	0	0	0	0	0	0	0	0	0	0	242000	201667
Trailer : 12 Tonne, 4 wheel, air brakes	5	138584	0	0	0	0	0	0	224225	0	0	0	0	0	0	0	0	0	0	0	224225	186854
Water trailer - 1000 L (also for diesel)	6	26599	0	0	0	0	0	49105	0	0	0	0	0	0	0	0	0	0	0	49105	0	45013
Trucks:																						
29 Tonne truck	5	1069700	0	0	0	0	0	0	1730750	0	0	0	0	0	0	0	0	0	0	0	1730750	1442292
Combine Harvester:																						
Combine harverster with cutter and pick-up (290KW, 7.62m)	4	3833333	0	0	0	0	0	0	0	5520000	0	0	0	0	0	0	0	0	0	0	0	4140000
Other implements and tools:																						
Haybine: 8-disk 4.0m, towed, Roller, middle-tow	4	520628	0	0	0	0	0	0	0	749704	0	0	0	0	0	0	0	0	0	0	0	562278
Wheel rake : 8-wheel, 5.45m, 3-point, V-type	4	28238	0	0	0	0	0	0	0	40663	0	0	0	0	0	0	0	0	0	0	0	30497
Auger (18kw)	3	11563	0	0	0	0	0	0	0	0	15000	0	0	0	0	0	0	0	0	0	0	10000
Loader/fork lift (fits on 100kw tractor)	6	142670	0	0	0	0	0	263390	0	0	0	0	0	0	0	0	0	0	0	263390	0	241441
Big pack square baler (120 X 70) (Standard)	3	1710318	0	0	0	0	0	0	0	0	2218791	0	0	0	0	0	0	0	0	0	0	1479194
Air seeder : 17t x 285mm, 4.8m	4	547428	0	0	0	0	0	0	0	788297	0	0	0	0	0	0	0	0	0	0	0	591223
Other tools	7	11632	0	0	0	0	25000	0	0	0	0	0	0	0	0	0	0	0	25000	0	0	20833
Welding and gas equipment	7	6979	0	0	0	0	15000	0	0	0	0	0	0	0	0	0	0	0	15000	0	0	12500
Pump (18 KW)	6	13000	0	0	0	0	0	24000	0	0	0	0	0	0	0	0	0	0	0	24000	0	22000
Pump (18 KW)	6	13000	0	0	0	0	0	24000	0	0	0	0	0	0	0	0	0	0	0	24000	0	22000
Horisontal feedwagon : 7m³ (2.45t) (with scale)	3	350767	0	0	0	0	0	0	0	0	455049	0	0	0	0	0	0	0	0	0	0	303366
Hammer mill (medic bales) 70kw	3	38542	0	0	0	0	0	0	0	0	50000	0	0	0	0	0	0	0	0	0	0	33333
Hammer mill (maize and grains) 70kw	3	61667	0	0	0	0	0	0	0	0	80000	0	0	0	0	0	0	0	0	0	0	53333
Fertiliser spreader : Double disc, 1500L, 10-36m, 3-point	8	47935	0	0	0	123262	0	0	0	0	0	0	0	0	0	0	0	123262	0	0	0	92447
Pellet machine	3	65521	0	0	0	0	0	0	0	0	85000	0	0	0	0	0	0	0	0	0	0	56667
Heavy duty clod roller (9m)	3	61293	0	0	0	0	0	0	0	0	79515	0	0	0	0	0	0	0	0	0	0	53010
Swather : 25 feet, 7.62m	5	177745	0	0	0	0	0	0	287588	0	0	0	0	0	0	0	0	0	0	0	287588	239657
Livestock:		7804784																				7804784
Total intermediate capital:		**12404438**	**0**	**0**	**0**	**1625762**	**2106500**	**2434518**	**2484563**	**7367994**	**3659846**	**0**	**0**	**0**	**0**	**0**	**0**	**1625762**	**2106500**	**2434518**	**2484563**	**15242742**
Total capital:		**55507246**	**0**	**0**	**0**	**1625762**	**2106500**	**2434518**	**2484563**	**7367994**	**3659846**	**0**	**0**	**0**	**0**	**0**	**0**	**1625762**	**2106500**	**2434518**	**2484563**	**58345550**
Net annual flow:		**-51539437**	**3550597**	**1770408**	**3977475**	**2087411**	**2783422**	**1359530**	**1314490**	**-3080598**	**-454727**	**4679272**	**3550597**	**3977475**	**1343530**	**2839134**	**4679272**	**2087411**	**1654747**	**648068**	**60086918**	

Cash flow:	Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Opening balance		0	1062443	1708281	572863	1645520	2019863	4630426	5495486	5701929	4426970	1523547	656268	-717117	-1010979	-2008139	-473546	2921931	4918821	6402375	6556969
Inflow		5172968	4755756	2975567	5182634	4918332	6095081	4999208	5004212	5492555	4410278	5884431	4755756	5182634	2548689	4044293	5884431	4918332	4966406	4287745	5431090
Outflow		4111523	4111523	4111523	4111523	4545887	3488870	4139313	4803128	6771675	7315132	6752327	6101884	5438069	3469522	2491701	2491701	2926064	3488870	4139313	4803128
Flow before interest		1061445	1706676	572325	1643974	2017965	4626075	5490321	5696570	4422809	1522115	655651	-689860	-972552	-1931811	-455547	2919185	4914198	6396358	6550807	7184931
Interest		999	1606	538	1547	1898	4352	5165	5359	4161	1432	617	-27257	-38426	-76327	-17999	2746	4623	6017	6163	6759
Closing balance		1062443	1708281	572863	1645520	2019863	4630426	5495486	5701929	4426970	1523547	656268	-717117	-1010979	-2008139	-473546	2921931	4918821	6402375	6556969	7191690

IRR	4.63%
NPV	4603297

Whole-farm multi-period budget: System G, Grazing approach.

Year		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
Scenario (Wheat/Canola)		Good	Average	Poor	Average	Average	Good	Average	Average	Average	Average	Good	Average	Average	Poor	Average	Good	Average	Average	Average	Average	
Scenario (Medics/Clover)		Poor	Average	Good	Good	Average	Average	Average	Average	Average	Poor	Average	Average	Good	Average	Poor	Average	Average	Average	Poor	Good	
Gross Margin																						
Wheat on Wheat		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Wheat on Canola		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Wheat on Medics		3063482	2384873	831675	2384873	2384873	3063482	2384873	2384873	2384873	2384873	3063482	2384873	2384873	831675	2384873	3063482	2384873	2384873	2384873	2384873	
Medics/medics Clover		-560291	-560291	-560291	-560291	-560291	-560291	-560291	-560291	-560291	-560291	-560291	-560291	-560291	-560291	-560291	-560291	-560291	-560291	-560291	-560291	
Canola		958631	508565	-145304	508565	508565	958631	508565	508565	508565	508565	958631	508565	508565	-145304	508565	958631	508565	508565	508565	508565	
Capital sales		0	0	0	0	162576	77400	243452	248456	657763	67649	0	0	0	0	0	0	162576	77400	243452	248456	
Whole-farm gross margin		**3461822**	**2333147**	**126080**	**2333147**	**2495723**	**3539222**	**2576599**	**2581604**	**2990910**	**2400796**	**3461822**	**2333147**	**2333147**	**126080**	**2333147**	**3461822**	**2495723**	**2410547**	**2576599**	**2581604**	
Overhead and fixed costs																						
Water system		12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	
Fencing and camps		12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	
Water fees		50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	
Property tax		8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	
Accounting fees		65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	
Banking fees		16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	
Admin		18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	
Telephone and Postage		20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	
Electricity		39458	39458	39458	39458	39458	39458	39458	39458	39458	39458	39458	39458	39458	39458	39458	39458	39458	39458	39458	39458	
Licenses and insurance		158037	158037	158037	158037	158037	158037	158037	158037	158037	158037	158037	158037	158037	158037	158037	158037	158037	158037	158037	158037	
Employee wages		150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	
Reparations on fixed improvements		76017	76017	76017	76017	76017	76017	76017	76017	76017	76017	76017	76017	76017	76017	76017	76017	76017	76017	76017	76017	
Owner's remuneration		300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	
Miscellaneous costs		41645	41645	41645	41645	41645	41645	41645	41645	41645	41645	41645	41645	41645	41645	41645	41645	41645	41645	41645	41645	
Total overhead and fixed costs		**967081**	**967081**	**967081**	**967081**	**967081**	**967081**	**967081**	**967081**	**967081**	**967081**	**967081**	**967081**	**967081**	**967081**	**967081**	**967081**	**967081**	**967081**	**967081**	**967081**	
Margin above overhead and fixed costs		**2494741**	**1366066**	**-841001**	**1366066**	**1528642**	**2572141**	**1609518**	**1614522**	**2023829**	**1433715**	**2494741**	**1366066**	**1366066**	**-841001**	**1366066**	**2494741**	**1528642**	**1443466**	**1609518**	**1614522**	
Capital																						
Long-term																						**Resale value:**
Land and fixed improvements		32100024	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	32100024
Intermediate																						
Bakkies:																						
3.0D-4D Xtra Cab	3	267087	0	0	0	0	0	0	0	0	346491	0	0	0	0	0	0	0	0	0	0	230994
Tractors																						
120 KW 4X4	8	584306	0	0	0	1502500	0	0	0	0	0	0	0	0	0	0	0	1502500	0	0	0	1126875
70KW 4X4	7	341514	0	0	0	0	734000	0	0	0	0	0	0	0	0	0	0	0	734000	0	0	611667
100KW 4X4	6	634021	0	0	0	0	0	1170500	0	0	0	0	0	0	0	0	0	0	0	1170500	0	1072958
Sprayers:																						
Boom sprayer : 3200L, 24m, towed	6	489408	0	0	0	0	0	903523	0	0	0	0	0	0	0	0	0	0	0	903523	0	828230

Trailers																						
Trailer : 8 Tonne, 4 wheel	4	89684	0	0	0	0	0	0	0	129145	0	0	0	0	0	0	0	0	0	0	0	96859
Trailer : 10 Tonne, 4 wheel	4	97351	0	0	0	0	0	0	0	140185	0	0	0	0	0	0	0	0	0	0	0	105139
Grain overloader : 15 Tonne with auger	3	254375	0	0	0	0	0	0	0	0	330000	0	0	0	0	0	0	0	0	0	0	220000
Trailer : 15 Tonne, 4 wheel, air brakes	5	149569	0	0	0	0	0	0	242000	0	0	0	0	0	0	0	0	0	0	0	242000	201667
Trailer : 12 Tonne, 4 wheel, air brakes	5	138584	0	0	0	0	0	0	224225	0	0	0	0	0	0	0	0	0	0	0	224225	186854
Water trailer - 1000 L (also for diesel)	6	26599	0	0	0	0	0	49105	0	0	0	0	0	0	0	0	0	0	0	49105	0	45013
Trucks:																						
29 Tonne truck	5	1069700	0	0	0	0	0	0	1730750	0	0	0	0	0	0	0	0	0	0	0	1730750	1442292
Combine Harvester:																						
Combine harvester with cutter and pick-up (290KW, 7.62m)	4	3833333	0	0	0	0	0	0	0	5520000	0	0	0	0	0	0	0	0	0	0	0	4140000
Other implements and tools:																						
Loader/fork lift (fits on 100kw tractor)	6	142670	0	0	0	0	0	263390	0	0	0	0	0	0	0	0	0	0	0	263390	0	241441
Air seeder : 17t x 285mm, 4.8m	4	547428	0	0	0	0	0	0	0	788297	0	0	0	0	0	0	0	0	0	0	0	591223
Other tools	7	11632	0	0	0	0	25000	0	0	0	0	0	0	0	0	0	0	25000	0	0	0	20833
Welding and gas equipment	7	6979	0	0	0	0	15000	0	0	0	0	0	0	0	0	0	0	15000	0	0	0	12500
Pump (18 KW)	6	13000	0	0	0	0	0	24000	0	0	0	0	0	0	0	0	0	0	0	24000	0	22000
Pump (18 KW)	6	13000	0	0	0	0	0	24000	0	0	0	0	0	0	0	0	0	0	0	24000	0	22000
Fertiliser spreader : Double disc, 1500L, 10-36m, 3-point	8	47935	0	0	0	123262	0	0	0	0	0	0	0	0	0	0	0	123262	0	0	0	92447
Swather : 25 feet, 7.62m	5	177745	0	0	0	0	0	0	287588	0	0	0	0	0	0	0	0	0	0	0	287588	239657
Livestock:		289109																				289109
Total intermediate capital:		**8935920**	**0**	**0**	**0**	**1625762**	**774000**	**2434518**	**2484563**	**6577627**	**676491**	**0**	**0**	**0**	**0**	**0**	**0**	**1625762**	**774000**	**2434518**	**2484563**	**11550647**
Total capital:		**41325053**	**0**	**0**	**0**	**1625762**	**774000**	**2434518**	**2484563**	**6577627**	**676491**	**0**	**0**	**0**	**0**	**0**	**0**	**1625762**	**774000**	**2434518**	**2484563**	**43939781**
Net annual flow:		**-38830312**	**1366066**	**-841001**	**1366066**	**-97120**	**1798141**	**-825000**	**-870041**	**-4553798**	**757224**	**2494741**	**1366066**	**1366066**	**-841001**	**1366066**	**2494741**	**-97120**	**669466**	**-825000**	**43069740**	

Cash flow:	**Year**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Opening balance		0	585900	42615	-2814765	-3490771	-4476013	-3861794	-4900107	-6664285	-9899504	-13612336	-16153954	-19293119	-21866273	-25008548	-25792823	-25434817	-26518461	-27948427	-29938422
Inflow		3461822	2333147	126080	2333147	2495723	3539222	2576599	2581604	2990910	2400796	3461822	2333147	2333147	126080	2333147	3461822	2495723	2410547	2576599	2581604
Outflow		2876473	2876473	2876473	2876473	3310837	2778220	3428664	4092478	5849859	5596237	5389443	4738999	4075185	2317804	2137062	2137062	2571426	2778220	3428664	4092478
Flow before interest		585349	42574	-2707778	-3358090	-4305884	-3715011	-4713859	-6410981	-9523233	-13094944	-15539957	-18559806	-21035156	-24057996	-24812463	-24468063	-25510519	-26886133	-28800491	-31449296
Interest		551	40	-106987	-132681	-170129	-146783	-186248	-253303	-376271	-517392	-613996	-733313	-831116	-950551	-980361	-966753	-1007941	-1062293	-1137931	-1242587
Closing balance		585900	42615	-2814765	-3490771	-4476013	-3861794	-4900107	-6664285	-9899504	-13612336	-16153954	-19293119	-21866273	-25008548	-25792823	-25434817	-26518461	-27948427	-29938422	-32691884

IRR	1.32%
NPV	-13630322

Whole-farm multi-period budget: System G, Sell medics approach.

Year		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
Scenario (Wheat/Canola)		Good	Average	Poor	Average	Average	Good	Average	Average	Average	Average	Good	Average	Average	Poor	Average	Good	Average	Average	Average	Average	
Scenario (Medics/Clover)		Poor	Average	Good	Good	Average	Average	Average	Average	Average	Poor	Average	Average	Good	Average	Poor	Average	Average	Average	Poor	Good	
Gross Margin																						
Wheat on Wheat		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Wheat on Canola		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Wheat on Medics		3021294	2342685	789487	2342685	2342685	3021294	2342685	2342685	2342685	2342685	3021294	2342685	2342685	789487	2342685	3021294	2342685	2342685	2342685	2342685	
Medics/medics Clover		276681	841134	1179806	1179806	841134	841134	841134	841134	841134	276681	841134	841134	1179806	841134	276681	841134	841134	841134	276681	1179806	
Canola		916443	466377	-187492	466377	466377	916443	466377	466377	466377	466377	916443	466377	466377	-187492	466377	916443	466377	466377	466377	466377	
Capital sales		0	0	0	0	162576	210650	243452	248456	736799	297480	0	0	0	0	0	0	162576	210650	243452	248456	
Whole-farm gross margin		**4214418**	**3650196**	**1781801**	**3988868**	**3812773**	**4989521**	**3893648**	**3898653**	**4386996**	**3383223**	**4778871**	**3650196**	**3988868**	**1443129**	**3085743**	**4778871**	**3812773**	**3860846**	**3329195**	**4237325**	
Overhead and fixed costs																						
Water system		12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	
Fencing and camps		12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	
Water fees		50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	
Property tax		8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	
Accounting fees		65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	
Banking fees		16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	
Admin		18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	
Telephone and Postage		20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	
Electricity		38208	38208	38208	38208	38208	38208	38208	38208	38208	38208	38208	38208	38208	38208	38208	38208	38208	38208	38208	38208	
Licenses and insurance		200273	200273	200273	200273	200273	200273	200273	200273	200273	200273	200273	200273	200273	200273	200273	200273	200273	200273	200273	200273	
Employee wages		120000	120000	120000	120000	120000	120000	120000	120000	120000	120000	120000	120000	120000	120000	120000	120000	120000	120000	120000	120000	
Reparations on fixed improvements		63368	63368	63368	63368	63368	63368	63368	63368	63368	63368	63368	63368	63368	63368	63368	63368	63368	63368	63368	63368	
Owner's remuneration		300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	
Miscellaneous costs		41570	41570	41570	41570	41570	41570	41570	41570	41570	41570	41570	41570	41570	41570	41570	41570	41570	41570	41570	41570	
Total overhead and fixed costs		**965344**	**965344**	**965344**	**965344**	**965344**	**965344**	**965344**	**965344**	**965344**	**965344**	**965344**	**965344**	**965344**	**965344**	**965344**	**965344**	**965344**	**965344**	**965344**	**965344**	
Margin above overhead and fixed costs		**3249074**	**2684852**	**816457**	**3023524**	**2847428**	**4024177**	**2928304**	**2933309**	**3421652**	**2417879**	**3813527**	**2684852**	**3023524**	**477785**	**2120399**	**3813527**	**2847428**	**2895502**	**2363851**	**3271980**	
Capital																						
Long-term																						**Resale value:**
Land and fixed improvements		30968512	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30968512
Intermediate																						
Bakkies:																						
3.0D-4D Xtra Cab	3	267087	0	0	0	0	0	0	0	0	346491	0	0	0	0	0	0	0	0	0	0	230994
Tractors																						
120 KW 4X4	8	584306	0	0	0	1502500	0	0	0	0	0	0	0	0	0	0	0	1502500	0	0	0	1126875
70KW 4X4	7	341514	0	0	0	0	734000	0	0	0	0	0	0	0	0	0	0	0	734000	0	0	611667
100KW 4X4	6	634021	0	0	0	0	0	1170500	0	0	0	0	0	0	0	0	0	0	0	1170500	0	1072958
110KW 4X4	7	619983	0	0	0	0	1332500	0	0	0	0	0	0	0	0	0	0	0	1332500	0	0	1110417
Sprayers:																						
Boom sprayer : 3200L, 24m, towed	6	489408	0	0	0	0	0	903523	0	0	0	0	0	0	0	0	0	0	0	903523	0	828230

Trailers																						
Trailer : 8 Tonne, 4 wheel	4	89684	0	0	0	0	0	0	0	129145	0	0	0	0	0	0	0	0	0	0	0	96859
Trailer : 10 Tonne, 4 wheel	4	97351	0	0	0	0	0	0	0	140185	0	0	0	0	0	0	0	0	0	0	0	105139
Grain overloader : 15 Tonne with auger	3	254375	0	0	0	0	0	0	0	0	330000	0	0	0	0	0	0	0	0	0	0	220000
Trailer : 15 Tonne, 4 wheel, air brakes	5	149569	0	0	0	0	0	0	242000	0	0	0	0	0	0	0	0	0	0	0	242000	201667
Trailer : 12 Tonne, 4 wheel, air brakes	5	138584	0	0	0	0	0	0	224225	0	0	0	0	0	0	0	0	0	0	0	224225	186854
Water trailer - 1000 L (also for diesel)	6	26599	0	0	0	0	0	49105	0	0	0	0	0	0	0	0	0	0	0	49105	0	45013
Trucks:																						
29 Tonne truck	5	1069700	0	0	0	0	0	0	1730750	0	0	0	0	0	0	0	0	0	0	0	1730750	1442292
Combine Harvester:																						
Combine harvester with cutter and pick-up (290KW, 7.62m)	4	3833333	0	0	0	0	0	0	0	5520000	0	0	0	0	0	0	0	0	0	0	0	4140000
Other implements and tools:																						
Haybine: 8-disk 4.0m, towed, Roller, middle-tow	4	520628	0	0	0	0	0	0	0	749704	0	0	0	0	0	0	0	0	0	0	0	562278
Wheel rake : 8-wheel, 5.45m, 3-point, V-type	4	28238	0	0	0	0	0	0	0	40663	0	0	0	0	0	0	0	0	0	0	0	30497
Loader/fork lift (fits on 100kw tractor)	6	142670	0	0	0	0	0	263390	0	0	0	0	0	0	0	0	0	0	0	263390	0	241441
Big pack square baler (120 X 70) (Standard)	3	1710318	0	0	0	0	0	0	0	0	2218791	0	0	0	0	0	0	0	0	0	0	1479194
Air seeder : 17t x 285mm, 4.8m	4	547428	0	0	0	0	0	0	0	788297	0	0	0	0	0	0	0	0	0	0	0	591223
Other tools	7	11632	0	0	0	0	25000	0	0	0	0	0	0	0	0	0	0	0	25000	0	0	20833
Welding and gas equipment	7	6979	0	0	0	0	15000	0	0	0	0	0	0	0	0	0	0	0	15000	0	0	12500
Pump (18 KW)	6	13000	0	0	0	0	0	24000	0	0	0	0	0	0	0	0	0	0	0	24000	0	22000
Pump (18 KW)	6	13000	0	0	0	0	0	24000	0	0	0	0	0	0	0	0	0	0	0	24000	0	22000
Fertiliser spreader : Double disc, 1500L, 10-36m, 3-point	8	47935	0	0	0	123262	0	0	0	0	0	0	0	0	0	0	0	123262	0	0	0	92447
Heavy duty clod roller (9m)	3	61293	0	0	0	0	0	0	0	0	79515	0	0	0	0	0	0	0	0	0	0	53010
Swather : 25 feet, 7.62m	5	177745	0	0	0	0	0	0	287588	0	0	0	0	0	0	0	0	0	0	0	287588	239657
Livestock:		0																				0
Total intermediate capital:		**11876379**	**0**	**0**	**0**	**1625762**	**2106500**	**2434518**	**2484563**	**7367994**	**2974797**	**0**	**0**	**0**	**0**	**0**	**0**	**1625762**	**2106500**	**2434518**	**2484563**	**14786043**
Total capital:		**42844891**	**0**	**0**	**0**	**1625762**	**2106500**	**2434518**	**2484563**	**7367994**	**2974797**	**0**	**0**	**0**	**0**	**0**	**0**	**1625762**	**2106500**	**2434518**	**2484563**	**45754555**
Net annual flow:		**-39595817**	**2684852**	**816457**	**3023524**	**1221666**	**1917677**	**493786**	**448745**	**-3946342**	**-556918**	**3813527**	**2684852**	**3023524**	**477785**	**2120399**	**3813527**	**1221666**	**789002**	**-70667**	**46541972**	

Cash flow:	**Year**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Opening balance		0	1169510	1775368	511643	1455872	1789956	3691694	3847262	3343546	1357759	-2072270	-3601990	-5689276	-6816937	-8589150	-7897674	-5418852	-4297885	-3667697	-4241411
Inflow		4214418	3650196	1781801	3988868	3812773	4989521	3893648	3898653	4386996	3383223	4778871	3650196	3988868	1443129	3085743	4778871	3812773	3860846	3329195	4237325
Outflow		3046007	3046007	3046007	3046007	3480371	3091253	3741696	4405511	6374058	6734487	6171682	5521238	4857424	2888877	2094084	2094084	2528448	3091253	3741696	4405511
Flow before interest		1168411	1773699	511162	1454504	1788274	3688224	3843646	3340403	1356483	-1993505	-3465081	-5473032	-6557832	-8262684	-7597490	-5212886	-4134527	-3528292	-4080199	-4409597
Interest		1099	1669	481	1368	1682	3470	3616	3142	1276	-78765	-136908	-216244	-259105	-326465	-300183	-205965	-163359	-139406	-161212	-174227
Closing balance		1169510	1775368	511643	1455872	1789956	3691694	3847262	3343546	1357759	-2072270	-3601990	-5689276	-6816937	-8589150	-7897674	-5418852	-4297885	-3667697	-4241411	-4583824

IRR	3.90%
NPV	-268916

Whole-farm multi-period budget: System H, Intensive speculation approach.

Year		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
Scenario (Wheat/Canola)		Good	Average	Poor	Average	Average	Good	Average	Average	Average	Average	Good	Average	Average	Poor	Average	Good	Average	Average	Average	Average	
Scenario (Medics/Clover)		Poor	Average	Good	Good	Average	Average	Average	Average	Average	Poor	Average	Average	Good	Average	Poor	Average	Average	Average	Poor	Good	
Gross Margin																						
Wheat on Wheat		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Wheat on Canola		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Wheat on Medics		5941264	4607523	1893694	4607523	4607523	5941264	4607523	4607523	4607523	4607523	5941264	4607523	4607523	1893694	4607523	5941264	4607523	4607523	4607523	4607523	
Medics/medics Clover		1258141	1970568	2398025	2398025	1970568	1970568	1970568	1970568	1970568	1258141	1970568	1970568	2398025	1970568	1258141	1970568	1970568	1970568	1258141	2398025	
Canola		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Capital sales		0	0	0	0	162576	210650	243452	248456	736799	365985	0	0	0	0	0	0	162576	210650	243452	248456	
Whole-farm gross margin		**7199404**	**6578092**	**4291719**	**7005549**	**6740668**	**8122482**	**6821544**	**6826548**	**7314891**	**6231649**	**7911832**	**6578092**	**7005549**	**3864262**	**5865664**	**7911832**	**6740668**	**6788742**	**6109116**	**7254005**	
Overhead and fixed costs																						
Water system		12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	
Fencing and camps		12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	
Water fees		50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	
Property tax		8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	
Accounting fees		65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	
Banking fees		16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	
Admin		18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	
Telephone and Postage		20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	
Electricity		176970	176970	176970	176970	176970	176970	176970	176970	176970	176970	176970	176970	176970	176970	176970	176970	176970	176970	176970	176970	
Licenses and insurance		210850	210850	210850	210850	210850	210850	210850	210850	210850	210850	210850	210850	210850	210850	210850	210850	210850	210850	210850	210850	
Employee wages		150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	
Reparations on fixed improvements		113517	113517	113517	113517	113517	113517	113517	113517	113517	113517	113517	113517	113517	113517	113517	113517	113517	113517	113517	113517	
Owner's remuneration		300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	
Miscellaneous costs		51897	51897	51897	51897	51897	51897	51897	51897	51897	51897	51897	51897	51897	51897	51897	51897	51897	51897	51897	51897	
Total overhead and fixed costs		**1205159**	**1205159**	**1205159**	**1205159**	**1205159**	**1205159**	**1205159**	**1205159**	**1205159**	**1205159**	**1205159**	**1205159**	**1205159**	**1205159**	**1205159**	**1205159**	**1205159**	**1205159**	**1205159**	**1205159**	
Margin above overhead and fixed costs		**5994246**	**5372933**	**3086560**	**5800390**	**5535509**	**6917323**	**5616385**	**5621389**	**6109732**	**5026490**	**6706673**	**5372933**	**5800390**	**2659103**	**4660505**	**6706673**	**5535509**	**5583583**	**4903957**	**6048846**	
Capital																						
Long-term																						**Resale value:**
Land and fixed improvements		35298024	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	35298024
Intermediate																						
Bakkies:																						
3.0D-4D Xtra Cab	3	267087	0	0	0	0	0	0	0	0	346491	0	0	0	0	0	0	0	0	0	0	230994
Tractors																						
120 KW 4X4	8	584306	0	0	0	1502500	0	0	0	0	0	0	0	0	0	0	0	1502500	0	0	0	1126875
70KW 4X4	7	341514	0	0	0	0	734000	0	0	0	0	0	0	0	0	0	0	0	734000	0	0	611667
100KW 4X4	6	634021	0	0	0	0	0	1170500	0	0	0	0	0	0	0	0	0	0	0	1170500	0	1072958
110KW 4X4	7	619983	0	0	0	0	1332500	0	0	0	0	0	0	0	0	0	0	0	1332500	0	0	1110417
Sprayers:																						
Boom sprayer : 3200L, 24m, towed	6	489408	0	0	0	0	0	903523	0	0	0	0	0	0	0	0	0	0	0	903523	0	828230

Trailers																						
Trailer : 8 Tonne, 4 wheel	4	89684	0	0	0	0	0	0	0	129145	0	0	0	0	0	0	0	0	0	0	0	96859
Trailer : 10 Tonne, 4 wheel	4	97351	0	0	0	0	0	0	0	140185	0	0	0	0	0	0	0	0	0	0	0	105139
Grain overloader : 15 Tonne with auger	3	254375	0	0	0	0	0	0	0	0	330000	0	0	0	0	0	0	0	0	0	0	220000
Trailer : 15 Tonne, 4 wheel, air brakes	5	149569	0	0	0	0	0	0	242000	0	0	0	0	0	0	0	0	0	0	0	242000	201667
Trailer : 12 Tonne, 4 wheel, air brakes	5	138584	0	0	0	0	0	0	224225	0	0	0	0	0	0	0	0	0	0	0	224225	186854
Water trailer - 1000 L (also for diesel)	6	26599	0	0	0	0	0	49105	0	0	0	0	0	0	0	0	0	0	0	49105	0	45013
Trucks:																						
29 Tonne truck	5	1069700	0	0	0	0	0	0	1730750	0	0	0	0	0	0	0	0	0	0	0	1730750	1442292
Combine Harvester:																						
Combine harverster with cutter and pick-up (290KW, 7.62m)	4	3833333	0	0	0	0	0	0	0	5520000	0	0	0	0	0	0	0	0	0	0	0	4140000
Other implements and tools:																						
Haybine: 8-disk 4.0m, towed, Roller, middle-tow	4	520628	0	0	0	0	0	0	0	749704	0	0	0	0	0	0	0	0	0	0	0	562278
Wheel rake : 8-wheel, 5.45m, 3-point, V-type	4	28238	0	0	0	0	0	0	0	40663	0	0	0	0	0	0	0	0	0	0	0	30497
Auger (18kw)	3	11563	0	0	0	0	0	0	0	0	15000	0	0	0	0	0	0	0	0	0	0	10000
Loader/fork lift (fits on 100kw tractor)	6	142670	0	0	0	0	0	263390	0	0	0	0	0	0	0	0	0	0	0	263390	0	241441
Big pack square baler (120 X 70) (Standard)	3	1710318	0	0	0	0	0	0	0	0	2218791	0	0	0	0	0	0	0	0	0	0	1479194
Air seeder : 17t x 285mm, 4.8m	4	547428	0	0	0	0	0	0	0	788297	0	0	0	0	0	0	0	0	0	0	0	591223
Other tools	7	11632	0	0	0	0	25000	0	0	0	0	0	0	0	0	0	0	0	25000	0	0	20833
Welding and gas equipment	7	6979	0	0	0	0	15000	0	0	0	0	0	0	0	0	0	0	0	15000	0	0	12500
Pump (18 KW)	6	13000	0	0	0	0	0	24000	0	0	0	0	0	0	0	0	0	0	0	24000	0	22000
Pump (18 KW)	6	13000	0	0	0	0	0	24000	0	0	0	0	0	0	0	0	0	0	0	24000	0	22000
Horisontal feedwagon : 7m³ (2.45t) (with scale)	3	350767	0	0	0	0	0	0	0	0	455049	0	0	0	0	0	0	0	0	0	0	303366
Hammer mill (medic bales) 70kw	3	38542	0	0	0	0	0	0	0	0	50000	0	0	0	0	0	0	0	0	0	0	33333
Hammer mill (maize and grains) 70kw	3	61667	0	0	0	0	0	0	0	0	80000	0	0	0	0	0	0	0	0	0	0	53333
Fertiliser spreader : Double disc, 1500L, 10-36m, 3-point	8	47935	0	0	0	123262	0	0	0	0	0	0	0	0	0	0	0	123262	0	0	0	92447
Pellet machine	3	65521	0	0	0	0	0	0	0	0	85000	0	0	0	0	0	0	0	0	0	0	56667
Heavy duty clod roller (9m)	3	61293	0	0	0	0	0	0	0	0	79515	0	0	0	0	0	0	0	0	0	0	53010
Swather : 25 feet, 7.62m	5	177745	0	0	0	0	0	0	287588	0	0	0	0	0	0	0	0	0	0	0	287588	239657
Livestock:		7804784																				7804784
Total intermediate capital:		**12404438**	**0**	**0**	**0**	**1625762**	**2106500**	**2434518**	**2484563**	**7367994**	**3659846**	**0**	**0**	**0**	**0**	**0**	**0**	**1625762**	**2106500**	**2434518**	**2484563**	**15242742**
Total capital:		**55507246**	**0**	**0**	**0**	**1625762**	**2106500**	**2434518**	**2484563**	**7367994**	**3659846**	**0**	**0**	**0**	**0**	**0**	**0**	**1625762**	**2106500**	**2434518**	**2484563**	**58345550**
Net annual flow:		**-49513000**	**5372933**	**3086560**	**5800390**	**3909747**	**4810823**	**3181866**	**3136826**	**-1258262**	**1366644**	**6706673**	**5372933**	**5800390**	**2659103**	**4660505**	**6706673**	**3909747**	**3477083**	**2469439**	**61909833**	

Cash flow:	**Year**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Opening balance		0	3090786	5562583	5748181	8650336	10855320	15503504	18202842	20245290	20808063	19743134	20922303	21418642	23007745	23424502	26823675	32274140	36122694	39459652	41468429
Inflow		7199404	6578092	4291719	7005549	6740668	8122482	6821544	6826548	7314891	6231649	7911832	6578092	7005549	3864262	5865664	7911832	6740668	6788742	6109116	7254005
Outflow		4111523	4111523	4111523	4111523	4545887	3488870	4139313	4803128	6771675	7315132	6752327	6101884	5438069	3469522	2491701	2491701	2926064	3488870	4139313	4803128
Flow before interest		3087881	5557355	5742779	8642206	10845118	15488933	18185734	20226262	20788506	19724579	20902640	21398512	22986122	23402486	26798465	32243807	36088744	39422566	41429455	43919306
Interest		2905	5228	5402	8130	10202	14571	17108	19028	19556	18556	19664	20130	21624	22016	25210	30333	33950	37086	38974	41316
Closing balance		3090786	5562583	5748181	8650336	10855320	15503504	18202842	20245290	20808063	19743134	20922303	21418642	23007745	23424502	26823675	32274140	36122694	39459652	41468429	43960622

IRR	8.44%
NPV	29334390

Whole-farm multi-period budget: System H, Grazing approach.

Year		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
Scenario (Wheat/Canola)		**Good**	**Average**	**Poor**	**Average**	**Average**	**Good**	**Average**	**Average**	**Average**	**Average**	**Good**	**Average**	**Average**	**Poor**	**Average**	**Good**	**Average**	**Average**	**Average**	**Average**	
Scenario (Medics/Clover)		**Poor**	**Average**	**Good**	**Good**	**Average**	**Average**	**Average**	**Average**	**Average**	**Poor**	**Average**	**Average**	**Good**	**Average**	**Poor**	**Average**	**Average**	**Average**	**Poor**	**Good**	
Gross Margin																						
Wheat on Wheat		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Wheat on Canola		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Wheat on Medics		6001077	4667337	1953507	4667337	4667337	6001077	4667337	4667337	4667337	4667337	6001077	4667337	4667337	1953507	4667337	6001077	4667337	4667337	4667337	4667337	
Medics/medics Clover		-206308	-206308	-206308	-206308	-206308	-206308	-206308	-206308	-206308	-206308	-206308	-206308	-206308	-206308	-206308	-206308	-206308	-206308	-206308	-206308	
Canola		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Capital sales		0	0	0	0	162576	77400	243452	248456	657763	67649	0	0	0	0	0	0	162576	77400	243452	248456	
Whole-farm gross margin		**5794769**	**4461028**	**1747199**	**4461028**	**4623605**	**5872169**	**4704480**	**4709485**	**5118791**	**4528678**	**5794769**	**4461028**	**4461028**	**1747199**	**4461028**	**5794769**	**4623605**	**4538428**	**4704480**	**4709485**	
Overhead and fixed costs																						
Water system		12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	
Fencing and camps		12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	
Water fees		50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	
Property tax		8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	
Accounting fees		65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	
Banking fees		16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	
Admin		18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	
Telephone and Postage		20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	
Electricity		39458	39458	39458	39458	39458	39458	39458	39458	39458	39458	39458	39458	39458	39458	39458	39458	39458	39458	39458	39458	
Licenses and insurance		158037	158037	158037	158037	158037	158037	158037	158037	158037	158037	158037	158037	158037	158037	158037	158037	158037	158037	158037	158037	
Employee wages		150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	
Reparations on fixed improvements		76017	76017	76017	76017	76017	76017	76017	76017	76017	76017	76017	76017	76017	76017	76017	76017	76017	76017	76017	76017	
Owner's remuneration		300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	
Miscellaneous costs		41645	41645	41645	41645	41645	41645	41645	41645	41645	41645	41645	41645	41645	41645	41645	41645	41645	41645	41645	41645	
Total overhead and fixed costs		**967081**	**967081**	**967081**	**967081**	**967081**	**967081**	**967081**	**967081**	**967081**	**967081**	**967081**	**967081**	**967081**	**967081**	**967081**	**967081**	**967081**	**967081**	**967081**	**967081**	
Margin above overhead and fixed costs		**4827688**	**3493947**	**780118**	**3493947**	**3656524**	**4905088**	**3737399**	**3742404**	**4151710**	**3561596**	**4827688**	**3493947**	**3493947**	**780118**	**3493947**	**4827688**	**3656524**	**3571347**	**3737399**	**3742404**	
Capital																						
Long-term																						**Resale value:**
Land and fixed improvements		32100024	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	32100024
Intermediate																						
Bakkies:																						
3.0D-4D Xtra Cab	3	267087	0	0	0	0	0	0	0	0	346491	0	0	0	0	0	0	0	0	0	0	230994
Tractors																						
120 KW 4X4	8	584306	0	0	0	1502500	0	0	0	0	0	0	0	0	0	0	0	1502500	0	0	0	1126875
70KW 4X4	7	341514	0	0	0	0	734000	0	0	0	0	0	0	0	0	0	0	0	734000	0	0	611667
100KW 4X4	6	634021	0	0	0	0	0	1170500	0	0	0	0	0	0	0	0	0	0	0	1170500	0	1072958
Sprayers:																						
Boom sprayer : 3200L, 24m, towed	6	489408	0	0	0	0	0	903523	0	0	0	0	0	0	0	0	0	0	0	903523	0	828230

Trailers																						
Trailer : 8 Tonne, 4 wheel	4	89684	0	0	0	0	0	0	0	129145	0	0	0	0	0	0	0	0	0	0	0	96859
Trailer : 10 Tonne, 4 wheel	4	97351	0	0	0	0	0	0	0	140185	0	0	0	0	0	0	0	0	0	0	0	105139
Grain overloader : 15 Tonne with auger	3	254375	0	0	0	0	0	0	0	0	330000	0	0	0	0	0	0	0	0	0	0	220000
Trailer : 15 Tonne, 4 wheel, air brakes	5	149569	0	0	0	0	0	0	242000	0	0	0	0	0	0	0	0	0	0	0	242000	201667
Trailer : 12 Tonne, 4 wheel, air brakes	5	138584	0	0	0	0	0	0	224225	0	0	0	0	0	0	0	0	0	0	0	224225	186854
Water trailer - 1000 L (also for diesel)	6	26599	0	0	0	0	0	49105	0	0	0	0	0	0	0	0	0	0	0	49105	0	45013
Trucks:																						
29 Tonne truck	5	1069700	0	0	0	0	0	0	1730750	0	0	0	0	0	0	0	0	0	0	0	1730750	1442292
Combine Harvester:																						
Combine harvester with cutter and pick-up (290KW, 7.62m)	4	3833333	0	0	0	0	0	0	0	5520000	0	0	0	0	0	0	0	0	0	0	0	4140000
Other implements and tools:																						
Loader/fork lift (fits on 100kw tractor)	6	142670	0	0	0	0	0	263390	0	0	0	0	0	0	0	0	0	0	0	263390	0	241441
Air seeder : 17t x 285mm, 4.8m	4	547428	0	0	0	0	0	0	0	788297	0	0	0	0	0	0	0	0	0	0	0	591223
Other tools	7	11632	0	0	0	0	25000	0	0	0	0	0	0	0	0	0	0	0	25000	0	0	20833
Welding and gas equipment	7	6979	0	0	0	0	15000	0	0	0	0	0	0	0	0	0	0	0	15000	0	0	12500
Pump (18 KW)	6	13000	0	0	0	0	0	24000	0	0	0	0	0	0	0	0	0	0	0	24000	0	22000
Pump (18 KW)	6	13000	0	0	0	0	0	24000	0	0	0	0	0	0	0	0	0	0	0	24000	0	22000
Fertiliser spreader : Double disc, 1500L, 10-36m, 3-point	8	47935	0	0	0	123262	0	0	0	0	0	0	0	0	0	0	0	123262	0	0	0	92447
Swather : 25 feet, 7.62m	5	177745	0	0	0	0	0	0	287588	0	0	0	0	0	0	0	0	0	0	0	287588	239657
Livestock:		433664																				433664
Total intermediate capital:		**8935920**	**0**	**0**	**0**	**1625762**	**774000**	**2434518**	**2484563**	**6577627**	**676491**	**0**	**0**	**0**	**0**	**0**	**0**	**1625762**	**774000**	**2434518**	**2484563**	**11550647**
Total capital:		**41469608**	**0**	**0**	**0**	**1625762**	**774000**	**2434518**	**2484563**	**6577627**	**676491**	**0**	**0**	**0**	**0**	**0**	**0**	**1625762**	**774000**	**2434518**	**2484563**	**44084335**
Net annual flow:		**-36641920**	**3493947**	**780118**	**3493947**	**2030761**	**4131088**	**1302881**	**1257840**	**-2425917**	**2885105**	**4827688**	**3493947**	**3493947**	**780118**	**3493947**	**4827688**	**2030761**	**2797347**	**1302881**	**45342176**	
Cash flow:	**Year**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	
Opening balance		0	2909444	4486630	3348917	4926517	6233557	9336281	10622081	11249660	10528488	9469829	9884445	9615511	10010764	9449039	11784081	15456314	17524963	19303314	20598490	
Inflow		5794769	4461028	1747199	4461028	4623605	5872169	4704480	4709485	5118791	4528678	5794769	4461028	4461028	1747199	4461028	5794769	4623605	4538428	4704480	4709485	
Outflow		2888059	2888059	2888059	2888059	3322423	2778220	3428664	4092478	5849859	5596237	5389443	4738999	4075185	2317804	2137062	2137062	2571426	2778220	3428664	4092478	
Flow before interest		2906710	4482413	3345770	4921887	6227698	9327506	10612097	11239087	10518593	9460929	9875155	9606474	10001355	9440159	11773005	15441787	17508493	19285172	20579131	21215497	
Interest		2734	4217	3147	4630	5859	8775	9983	10573	9895	8900	9290	9037	9409	8881	11075	14527	16471	18142	19359	19958	
Closing balance		2909444	4486630	3348917	4926517	6233557	9336281	10622081	11249660	10528488	9469829	9884445	9615511	10010764	9449039	11784081	15456314	17524963	19303314	20598490	21235455	

IRR 7.01%

NPV 15199770

Whole-farm multi-period budget: System H, Sell medics approach.

Year		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
Scenario (Wheat/Canola)		Good	Average	Poor	Average	Average	Good	Average	Average	Average	Average	Good	Average	Average	Poor	Average	Good	Average	Average	Average	Average	
Scenario (Medics/Clover)		Poor	Average	Good	Good	Average	Average	Average	Average	Average	Poor	Average	Average	Good	Average	Poor	Average	Average	Average	Poor	Good	
Gross Margin																						
Wheat on Wheat		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Wheat on Canola		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Wheat on Medics		5916702	4582961	1869132	4582961	4582961	5916702	4582961	4582961	4582961	4582961	5916702	4582961	4582961	1869132	4582961	5916702	4582961	4582961	4582961	4582961	
Medics/medics Clover		280541	844994	1183666	1183666	844994	844994	844994	844994	844994	280541	844994	844994	1183666	844994	280541	844994	844994	844994	280541	1183666	
Canola		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Capital sales		0	0	0	0	162576	210650	243452	248456	736799	297480	0	0	0	0	0	0	162576	210650	243452	248456	
Whole-farm gross margin		**6197242**	**5427955**	**3052797**	**5766627**	**5590531**	**6972345**	**5671407**	**5676411**	**6164754**	**5160982**	**6761695**	**5427955**	**5766627**	**2714125**	**4863502**	**6761695**	**5590531**	**5638605**	**5106954**	**6015083**	
Overhead and fixed costs																						
Water system		12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	
Fencing and camps		12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	
Water fees		50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	
Property tax		8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	8925	
Accounting fees		65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	65000	
Banking fees		16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	
Admin		18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	18000	
Telephone and Postage		20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	
Electricity		38208	38208	38208	38208	38208	38208	38208	38208	38208	38208	38208	38208	38208	38208	38208	38208	38208	38208	38208	38208	
Licenses and insurance		200273	200273	200273	200273	200273	200273	200273	200273	200273	200273	200273	200273	200273	200273	200273	200273	200273	200273	200273	200273	
Employee wages		120000	120000	120000	120000	120000	120000	120000	120000	120000	120000	120000	120000	120000	120000	120000	120000	120000	120000	120000	120000	
Reparations on fixed improvements		63368	63368	63368	63368	63368	63368	63368	63368	63368	63368	63368	63368	63368	63368	63368	63368	63368	63368	63368	63368	
Owner's remuneration		300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	300000	
Miscellaneous costs		41570	41570	41570	41570	41570	41570	41570	41570	41570	41570	41570	41570	41570	41570	41570	41570	41570	41570	41570	41570	
Total overhead and fixed costs		**965344**	**965344**	**965344**	**965344**	**965344**	**965344**	**965344**	**965344**	**965344**	**965344**	**965344**	**965344**	**965344**	**965344**	**965344**	**965344**	**965344**	**965344**	**965344**	**965344**	
Margin above overhead and fixed costs		**5231898**	**4462611**	**2087453**	**4801283**	**4625187**	**6007001**	**4706063**	**4711067**	**5199410**	**4195637**	**5796351**	**4462611**	**4801283**	**1748781**	**3898158**	**5796351**	**4625187**	**4673261**	**4141610**	**5049739**	
Capital																						
Long-term																						**Resale value:**
Land and fixed improvements		30968512	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30968512
Intermediate																						
Bakkies:																						
3.0D-4D Xtra Cab	3	267087	0	0	0	0	0	0	0	0	346491	0	0	0	0	0	0	0	0	0	0	230994
Tractors																						
120 KW 4X4	8	584306	0	0	0	1502500	0	0	0	0	0	0	0	0	0	0	0	1502500	0	0	0	1126875
70KW 4X4	7	341514	0	0	0	0	734000	0	0	0	0	0	0	0	0	0	0	0	734000	0	0	611667
100KW 4X4	6	634021	0	0	0	0	0	1170500	0	0	0	0	0	0	0	0	0	0	0	1170500	0	1072958
110KW 4X4	7	619983	0	0	0	0	1332500	0	0	0	0	0	0	0	0	0	0	0	1332500	0	0	1110417
Sprayers:																						
Boom sprayer : 3200L, 24m, towed	6	489408	0	0	0	0	0	903523	0	0	0	0	0	0	0	0	0	0	0	903523	0	828230

Trailers																						
Trailer : 8 Tonne, 4 wheel	4	89684	0	0	0	0	0	0	0	129145	0	0	0	0	0	0	0	0	0	0	0	96859
Trailer : 10 Tonne, 4 wheel	4	97351	0	0	0	0	0	0	0	140185	0	0	0	0	0	0	0	0	0	0	0	105139
Grain overloader : 15 Tonne with auger	3	254375	0	0	0	0	0	0	0	0	330000	0	0	0	0	0	0	0	0	0	0	220000
Trailer : 15 Tonne, 4 wheel, air brakes	5	149569	0	0	0	0	0	0	242000	0	0	0	0	0	0	0	0	0	0	0	242000	201667
Trailer : 12 Tonne, 4 wheel, air brakes	5	138584	0	0	0	0	0	0	224225	0	0	0	0	0	0	0	0	0	0	0	224225	186854
Water trailer - 1000 L (also for diesel)	6	26599	0	0	0	0	0	49105	0	0	0	0	0	0	0	0	0	0	0	49105	0	45013
Trucks:																						
29 Tonne truck	5	1069700	0	0	0	0	0	0	1730750	0	0	0	0	0	0	0	0	0	0	0	1730750	1442292
Combine Harvester:																						
Combine harvester with cutter and pick-up (290KW, 7.62m)	4	3833333	0	0	0	0	0	0	0	5520000	0	0	0	0	0	0	0	0	0	0	0	4140000
Other implements and tools:																						
Haybine: 8-disk 4.0m, towed, Roller, middle-tow	4	520628	0	0	0	0	0	0	0	749704	0	0	0	0	0	0	0	0	0	0	0	562278
Wheel rake : 8-wheel, 5.45m, 3-point, V-type	4	28238	0	0	0	0	0	0	0	40663	0	0	0	0	0	0	0	0	0	0	0	30497
Loader/fork lift (fits on 100kw tractor)	6	142670	0	0	0	0	0	263390	0	0	0	0	0	0	0	0	0	0	0	263390	0	241441
Big pack square baler (120 X 70) (Standard)	3	1710318	0	0	0	0	0	0	0	0	2218791	0	0	0	0	0	0	0	0	0	0	1479194
Air seeder : 17t x 285mm, 4.8m	4	547428	0	0	0	0	0	0	0	788297	0	0	0	0	0	0	0	0	0	0	0	591223
Other tools	7	11632	0	0	0	0	25000	0	0	0	0	0	0	0	0	0	0	0	25000	0	0	20833
Welding and gas equipment	7	6979	0	0	0	0	15000	0	0	0	0	0	0	0	0	0	0	0	15000	0	0	12500
Pump (18 KW)	6	13000	0	0	0	0	0	24000	0	0	0	0	0	0	0	0	0	0	0	24000	0	22000
Pump (18 KW)	6	13000	0	0	0	0	0	24000	0	0	0	0	0	0	0	0	0	0	0	24000	0	22000
Fertiliser spreader : Double disc, 1500L, 10-36m, 3-point	8	47935	0	0	0	123262	0	0	0	0	0	0	0	0	0	0	0	123262	0	0	0	92447
Heavy duty clod roller (9m)	3	11876379	0	0	0	0	0	0	0	0	79515	0	0	0	0	0	0	0	0	0	0	53010
Swather : 25 feet, 7.62m	5	177745	0	0	0	0	0	0	287588	0	0	0	0	0	0	0	0	0	0	0	287588	239657
Livestock:		0																				0
Total intermediate capital:		**11876379**	**0**	**0**	**0**	**1625762**	**2106500**	**2434518**	**2484563**	**7367994**	**2974797**	**0**	**0**	**0**	**0**	**0**	**0**	**1625762**	**2106500**	**2434518**	**2484563**	**14786043**
Total capital:		**42844891**	**0**	**0**	**0**	**1625762**	**2106500**	**2434518**	**2484563**	**7367994**	**2974797**	**0**	**0**	**0**	**0**	**0**	**0**	**1625762**	**2106500**	**2434518**	**2484563**	**45754555**
Net annual flow:		**-37612993**	**4462611**	**2087453**	**4801283**	**2999425**	**3900501**	**2271544**	**2226504**	**-2168584**	**1220841**	**5796351**	**4462611**	**4801283**	**1748781**	**3898158**	**5796351**	**2999425**	**2566761**	**1707091**	**48319731**	

Cash flow:	**Year**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Opening balance		0	3154200	5541356	5553365	8281769	10401705	14296234	16241209	17528584	17335572	15776895	16382305	16304345	17229741	17071034	19859117	24549802	27637861	30213609	31608574
Inflow		6197242	5427955	3052797	5766627	5590531	6972345	5671407	5676411	6164754	5160982	6761695	5427955	5766627	2714125	4863502	6761695	5590531	5638605	5106954	6015083
Outflow		3046007	3046007	3046007	3046007	3480371	3091253	3741696	4405511	6374058	6734487	6171682	5521238	4857424	2888877	2094084	2094084	2528448	3091253	3741696	4405511
Flow before interest		3151235	5536148	5548146	8273985	10391929	14282798	16225945	17512109	17319280	15762067	16366908	16289021	17213548	17054990	19840453	24526729	27611885	30185213	31578867	33218146
Interest		2964	5208	5219	7784	9776	13436	15264	16474	16293	14828	15397	15324	16193	16044	18665	23073	25975	28396	29707	31249
Closing balance		3154200	5541356	5553365	8281769	10401705	14296234	16241209	17528584	17335572	15776895	16382305	16304345	17229741	17071034	19859117	24549802	27637861	30213609	31608574	33249396

IRR	8.71%
NPV	23854683