An analysis of financial implications of switching between crop production systems in Middle Swartland

By

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Declaration

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Abstract

Sustainability issues and the structural over-supply of wheat in the Western Cape since the middle 1990's have caused the introduction of alternative crop rotation systems in the Middle Swartland, a dry-land winter cereal production area of the Western Cape. Crop rotation systems typically consist of cereals and oilseed crops and pastures. Alternative crop rotations systems are currently scientifically evaluated at the Langgewens Experimental farm. Currently more than half the cultivated area in the Swartland is still under wheat production, a third of which is wheat monoculture. An issue regarding the adoption of such a crop rotation system is the cash flow and affordability of implementing such an alternative system. The goal of this study is to determine the cash-flow implications of a shift from wheat monoculture to a crop rotation system. Typical strategies available to producers to support such a shift are investigated. The complexity of farm systems as well as the interrelationships between crops within such a crop rotation system necessitates the implementation of a systems approach. A multi-period, whole-farm budget model was constructed to capture the interrelationships of the farm system and to express the financial performance thereof in standard profitability criteria.

The farm model is based on a typical farm for the Middle Swartland. The model was used to determine the expected profitability of various crop rotation systems and to evaluate alternative strategies to accommodate the shift to alternative systems. The Langgewens crop rotation trial results are used to determine expected profitability of various crop rotation systems. A wheat-monoculture system serves as basis for the shift to alternative systems with the focus on the practical implications of such as shift.

The profitability calculations show that various crop rotation systems are expected to be more profitable than wheat monoculture. The most profitable system is one year canola followed by three years of wheat, followed by a wheat/medic system with Dohne Merino sheep on the medic pastures. The shift from wheat monoculture is simulated by four scenarios. The first evaluated the financial implications of a shift form monoculture to the three year wheat and one year canola system. The second simulates a shift from monoculture to a wheat/medic system within two years and using own funds. The third scenario simulate the same shift with own funding, but over a ten year period. The fourth is similar to the second, but borrowed money is used to fund the shift.

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Lower input costs and consistently higher yields results in higher expected gross margins for the crop rotation systems, especially with nitrogen fixing plants. The inclusion of medic and medic/clover pastures and alternative cash crops such as canola and lupins show a higher yield on investment than wheat monoculture. Insight into the factors that producers should consider was also generated by this study, concerning changes to crop rotation systems. These factors include; time period over which a shift is planned and the availability of financing options. It seems that a quicker shift, using borrowed funds, is more profitable over the longer term.

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Opsomming

Volhoubaarheidskwessies, en die strukturele ooraanbod van koring in die Wes-Kaap, het sedert die middel 1990's, gelei tot alternatiewe gewasproduksiestelsels in die Swartland, 'n droëland wintergraanproduserende area van die Wes-Kaap. Gewasproduksiestelsels bestaan tipies uit graan- en oliesaad- en weidings gewasse. Alternatiewe gewas-wisselboustelsels word wetenskaplik gevalueer op die Langgewens proefplaas. Tans is meer as die helfte van die area in die Swartland steeds onder koring produksie, 'n derde daarvan is koring monokultuur. 'n Bekommernis rakende die aanneem van wisselboustelsels is die kontantvloei en bekostigbaarheid van die implementering van so 'n alternatiewe stelsel.

Die doel van hierdie studie is om te bepaal wat die kontantvloei implikasies van 'n skuif van 'n koringmonokultuurstelsel na 'n wisselboustelsel is. Tipiese strategieë beskikbaar aan produsente om so skuif te finansier is ook ondersoek. Die kompleksiteit van boerderystelsels en die interverwantskap tussen gewasse in 'n wisselboustelsel noodsaak die insluiting van 'n stelselsbenadering. 'n Multi-periode, geheelplaasbegrotingsmodel is ontwikkel om die interverwantskap van die boerdery te verenig en finansiële prestasie uit te druk in erkende winsgewendheid kriteria.

Die boerderymodel is gebaseer op 'n tipiese plaas vir die Middel-Swartland. Die model is gebruik om die winsgewendheid van verskillende wisselboustelsels te bepaal en om verskillende strategieë te assesseer wat die oorgang van wisselboustelsel kan akkommodeer. Die Langgewens wisselbouproefdata is gebruik om die winsgewendheid van verskillende wisselboustelsels te bepaal. 'n Koringmonokultuurstelsel dien as basis vir die oorskakeling na alternatiewe wisselboustelsels, met die fokus op die praktiese implikasies van so 'n skuif.

Die winsgewendheid bepaling wys dat verskeie wisselboustelsels meer winsgewend is as koring monokultuur. Die mees belowende stelsels is een jaar canola gevolg deur drie jaar koring en 'n koring/medic stelsel met Dohne Merino skape op die medic weidings. Die oorskakeling vanaf koring monokultuur is gesimuleer deur vier scenario's. Die eerste scenario evalueer die finansiële implikasie van 'n skuif van koringmonokultuur na 'n wisselboustelsel met een jaar canola. Die tweede scenario evalueer 'n skuif na 'n koring medic stelsel binne twee jaar met eie fondse. Die derde scenario simuleer dieselfde skuif maar oor 'n tien jaar tydperk, met eie fondse. Die vierde scenario simuleer dieselfde skuif na koring/medics maar oor 'n twee jaar periode met geleende fondse.

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Laer insetkoste en konstante hoër opbrengste lewer hoër brutomarges vir die wisselboustelsels, veral die met stikstofbindende weidingsgewasse. Die insluiting van medic en medic/klawer weidings en alternatiewe kontantgewasse soos canola en lupiene wys ʼn beter opbrengs op kapitaal investering in vergelyking met koringmonokultuur. Bykomende daartoe verskaf die resultate van die studie insig in die faktore wat graanprodusente behoort te oorweeg wanneer ʼn oorskakeling na alternatiewe wisselboustelsels oorweeg word. Die faktore sluit in, die tydperk waaroor die oorskakeling beoog word en die beskikbare finansieringsopsies. Dit blyk dat ʼn vinniger oorskakeling, selfs teen die koste van finansiering, oor die langtermyn meer winsgewend is.

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"...it always seem impossible until it's done....Nelson Mandela"

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Dedication

I would like to dedicate this MSc thesis to my late father, Mr Alfred Mavhungu Makhuvha, who instilled the love of education in me. I am grateful for his immense contribution to my education, i cherish the values and ethos i learned from you dad.

I love you daddy.

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Chapter 1 :
Introduction

1.1. Background

In South Africa's nine provinces wheat is mainly produced in three provinces under Dryland conditions in winter rainfall region of Western Cape and summer rainfall region of Free State as well as under Irrigated conditions in the Northern Cape. The Western Cape and Free produce 64% of the total production. Wheat is imported to meet domestic requirements as insufficient volumes are produced. The Western Cape wheat industry consists of mainly two production regions, namely, the Swartland and the Southern Cape. The province produces about 42 per cent of the South African wheat crop of 1.9 million tons per annum with Swartland and Southern Cape contributing 85 per cent and rest being produced in marginal areas of the province (South African Grain Information Service, 2008). By contrast, the sector's regulatory policies and structural suitability poses threats to the sustainability and profitability of farming, this mostly because of the lack of alternative crops to producers.

Before 1996, wheat prices in South Africa were controlled by the Wheat Marketing Board. This meant that producer prices were fixed on a production cost-plus basis which tended to favour producers under the protectionist government policy of self-sufficiency (Hoffmann, 2010). As a result, the price risk involved in producing wheat was reduced resulting in a shift towards wheat monoculture practices in South Africa particularly in the Western Cape (Kleynhans *et al.*, 2008). In 1996 the Wheat Marketing Board was abolished after the agricultural sector was deregulated. The shift towards less government intervention resulted in a decrease in wheat production, an increase in the production of canola, oats, lupins and pastures, and a greater exposure to volatile markets, a direct consequence of deregulation (Hoffmann, 2010). It also brought about an increase in the complexity of production systems due to crop rotation and an expansion of the farm-level decision-making environment in the Western Cape (Hoffmann, 2010).

The Swartland region is located within a Mediterranean climatic zone characterised by unpredictable fluctuations in the temporal and spatial distribution and amount of rainfall with high production risk associated with this Dry land production (Hardy, 1998). As a result the area planted under wheat in South Africa by the 2000s decreased by approximately 60 per cent compared with the 1980s. The area planted under wheat in the Western Cape decreased by 61 percent over a twenty nine year period from 800 000 ha in the 1980s to 315 000 ha in 2009 (Hardy, 2010). These

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decreases were caused by implementing cropping systems that were aimed at minimising the business and financial risks confronting grain farmers.

In response a long-term crop and crop/pasture rotation trial was established at the Langgewens Research Farm (LRF) in 1996. The project was introduced with the aim of achieving the following objectives in the Swartland region (Hardy et al., 2012):

- Increasing crop yield.
- Improving margins in the production system.
- Increasing protein and oilseed production.
- Increasing the diversification of the farm for greater financial stability.
- Reducing input costs.

Adopting the rotation system was relatively quick, but currently 56 per cent of the Swartland area remains under the wheat monoculture production system. Among farmers who have adopted some form of rotation system, there is a tendency to keep approximately 30 per cent of land cultivated under wheat, and some producers still focus mainly on wheat monoculture production (Coetzee, 2014). A further trend currently noticed is that due to the relatively high wheat prices in the past three years, farmers are shifting away from pastures and livestock towards wheat production. The wheat market, because of its exposure to international trends, will remain volatile over the longer term and input price inflation will gradually decrease the profit margin (Coetzee, 2014).

1.2. Research motivation

Western Cape wheat producers are caught in a risky position and the industry profitability is stagnant. This is mainly because of the structural oversupply; that is, the province produces more than is consumed locally and therefore has to deal with the high cost of transporting wheat to the interior of the country (BFAP, 2005). The Bureau for Food and Agricultural Policy (BFAP) study of the profitability and competitiveness of wheat production in the Western Cape confirmed that producers who are less dependent on income from wheat, because of diversification into alternative crops, are more resilient in terms of their ability to manage external shocks. A comparison of the Southern Cape and Swartland show that Southern Cape wheat producers have diversified their wheat production to a greater extent than Swartland and, therefore, are comparatively less vulnerable to external shocks in the wheat sector. This is mostly due to the restrictions that the typical, severe, summer drought in the Swartland place on alternative options. A cooler climate and more even dispersion of rainfall between summer and winter also allows for other pasture crops,

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like lucern, to be used in the Southern Cape (Strauss, 2014). In 2009, 56 per cent of the total production area in the Swartland region was allocated to wheat production, compared with 22 per cent in the Southern Cape (Hardy, 2010).

Globally several studies have been conducted on the economic and environmental implications based on the approach and method of typical farm modelling and system thinking, of adopting crop rotation in grain production systems (Hardy, 2006; Hoffmann, 2010; Laubscher et al., 2011; Sulc & Tracy, 2007). There is however very few studies in the literature on the financial implications of including a livestock component and other grains, such as canola, in the crop rotation systems specifically strategies employed by farmers to lessen or mitigate the sunk cost and associated period of low profitability.

Moreover, a study piloted in the American Corn Belt by Sulc and Tracy (2007) concluded that there is a critical need to fund the development of research teams dedicated to system-level research on diversifying crop production with livestock. They further suggested that scientists, advisors, and producers in countries where government price support is limited or non-existent should recognise the economic and biological interactions possible through mixing crop and livestock production, as it increases efficiency and sustainability of production systems.

Adopting crop and crop/pasture rotation systems helps farmers to remain solvent and enables them to compete in global agricultural markets. This study could be useful in assessing profitability and affordability of adopting crop rotation systems, as well as for including a livestock component and other grains, such as canola. The strategies analysed in this study might be useful for maximising the profitability of the Western Cape winter grain industry. Further, these strategies could be implemented by various institutions offering agricultural finance. They could do this to improve their services and provide tailor-made facilities to suit the needs of farmers wishing to adopt crop and crop/pasture rotation systems.

1.3. Problem statement

Including a number of grain and oilseed crops, as well as pasture, with the possibility of livestock, increases the complexity of farm management systems and further complicates the farmers' decision-making environment. Constant pressure on farmers regarding farm-level profitability remains a reality. Unfortunately, due to biological and physical constraints, farmers' options to overcome this pressure are limited. Based on the Langgewens Research Farm trial results, crop and crop/pasture rotation systems can improve farm-level profitability.

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The typical fixity of assets on the farm, as well the risks involved in adopting or switching between crop rotation systems place the farmer in the predicament of not being able to alter the farm system. This may cause severe damage to the farm's financial position. Risk balancing in farm business management implies that it is often necessary to undergo an initial period of high financial risk to reach sustained lower business risk. This strongly reflects the issue of affordability.

The adoption of crop rotation systems presents an opportunity for increased productivity and profitability. In addition the introduction of a livestock component presents numerous advantages in terms of its role in the crop rotation system. The problem, in financial terms, is a switch in crop production systems and/or including a livestock component presents a period of relatively lower profitability and a resulting impact on the farm's financial leverage capacity. This study is aimed at evaluating the various strategies that farmers typically implement to lessen or overcome the period of less cash flow. The profitability of each system is not the focus of this study, but needs to be determined to serve as a basis for deciding which systems could improve profitability. The main problem is thus a lack of knowledge of the affordability of a shift from a wheat monoculture system to alternative crop production systems.

From the abovementioned problem statement, the research question thus is what are the financial implications of, and the considerations for adopting alternative crop production systems in the Middle Swartland.

1.4. Research objectives

The following are the specific objectives:

- To determine the profitability of different typical crop rotation systems in the Middle Swartland.

- To identify and describe the financial performance of the crop rotation systems in terms of a typical grain farm in the Middle Swartland.

- To evaluate the affordability of a switch in crop production systems.

1.5. Research method

This research was conducted through personal interviews with experts from the industry and research institutions, crop rotation trial data and literature reviews. Semi-structured questionnaires were used to collect relevant data. Literature reviews were conducted on crop rotation systems in sustainable and profitable production systems, sequencing and management decision-making in crop rotation systems, and the impact of crop rotation on total farm risk. A theoretical background of systems thinking is given, and this serves as a general approach to the research. Strategies and alternative production techniques that can be used by commercial wheat farmers in the Western Cape were identified in the literature and from empirical evidence from the crop rotation trial.

Primary data on the crop rotation systems in the Middle Swartland was obtained from the Langgewens Research Farm trial. A typical farm in the Middle Swartland was constructed based on production data that included gross margins, direct allocable cost and production values); financial statements from farmers' study groups located in the Middle Swartland, and Langgewens Research Farm trial data (obtained from the Department of Agriculture) (Strauss, 2013). The most general financing option available and accessible to a typical grain farm was identified through personal communications with relevant stakeholders and discussed in terms of its application procedures, amount, repayment period and requirements.

A multi-period, whole-farm budget model was developed for a typical grain farm in the Middle Swartland to evaluate profitability and affordability. Four scenarios of possible crop production system adoption strategies were simulated and evaluated. Assumptions about the own-to-borrowed capital ratio, mechanisation alterations and length of the transition period were evaluated using the multi-period budget model.

1.6. Limitations of the study

Due to the study objectives and the study area, the study was limited to the following aspects:

- The study uses data from the long-term (50 ha) crop and crop-pasture rotation that has been running on the Langgewens Research Farm since 1996.

- Scenarios are simulated on a positivistic approach; that is, the study does not attempt to describe what should happen to the farm, but rather what is likely to happen given the current combination of the farm activities, management practices as well as the financial position.

- The study is limited to commercial wheat production.
- The study is not an attempt at a statistical analysis of the impact of conservation agriculture practices on business and financial risk.

1.7. Definition of key terms

Concepts and terms used consistently in this study are ambiguous. The following section aims to give definitions to those terms and concepts as they are used in this context.

Conservation agriculture (CA): According to FAO (2010) "… *is a way of managing agro-ecosystems to achieve higher, sustained productivity, increased profits and food security while enhancing the environment* …" It constitutes three principles; namely, minimum soil disturbance, permanent soil cover and diversified crop association.

Crop rotation: is an agronomic term used to describe a practice of growing a sequence of different crops and/or pastures on the same land from one growing season to the next (Hardy, 2010).

Monocropping: in contrast to crop rotation, monocropping is the repeated planting of the same crop or crops in the same place, season after season (Thierfelder et al., 2014).

Financial analysis: is a method applied to assess the commercial profitability of the proposed enterprise (Perkins, 1994).

Crop sequence: refers to the yield, allocable variable costs, gross income and gross margin related to a specific crop (or livestock output) in the system.

Rotation system: refers to per-year-hectare allocable variable costs, gross income and gross margin, averaged over all four phases of the rotation system.

1.8. Outline of the study

The next chapter provides a brief overview of winter grain production in the Western Cape. Chapter 3 reviews literature on conservation agriculture focusing on crop rotation and in particular associated business and financial risks thereof. Chapter 4 describes the approach and method applied in this study. In Chapter 5, an analysis of financial implications associated with switching between cropping systems is presented. Results are provided in Chapter 5 evaluate, by simulating scenarios, the various adoption strategies that farmers may apply with regard to affordability or

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financing options. The last chapter, Chapter 6, summarises and concludes the study with key recommendations.

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Chapter 2 :
Overview of winter grain production in the Western Cape Province

2.1. Introduction

The main goal of the study is to determine the financial implications of, and considerations for adopting alternative crop rotation systems in the Middle Swartland wheat-producing area. The complexity of the wheat industry, brought about by the increase in product mix after the abolition of the Wheat Marketing Board, left producers in a precarious position, characterised by constant pressure on farm-level profitability. Furthermore, a constantly growing awareness of environmental responsibility has added an ecological dimension to the farmers' objectives.

The 2005 Bureau for Food and Agricultural Policy (BFAP) report on the profitability and competitiveness of wheat production in the Western Cape recommended farm-level diversification as one of the strategies that could boost the wheat industry. Diversification, as one of the crop rotation components, maximises farm-level profitability, minimises farm business risk and promotes sustainable farming practices. Crop rotation has been the main cornerstone of successful, traditional agricultural production systems in many parts of the world for the past three decades.

This study focuses on the crop rotation systems that incorporate pasture and a livestock component. Livestock holds specific advantages for such systems in terms of profitable and sustainable farming in the Western Cape. Of the two major wheat-producing regions in the Western Cape, the Southern Cape region has diversified its wheat production more, with approximately only 22 per cent of its productive land left under wheat monoculture. Approximately 56 per cent of the productive land in the Middle Swartland was still allocated to wheat monoculture in the 2008/09 production year. It has increased recently because of the relatively high wheat price over the past three years. Substantial research on this subject has been conducted to test the effectiveness of crop rotation systems in terms of profit and sustainable practices. In most cases, farmers still speculate around the issue of total farm risk balancing in crop rotation practices. In short, it is important for farmers to understand that crop rotation reduces business risk and increases farm sustainability and profitability.

This chapter provides background information on South Africa's grain industry, with special reference to the Western Cape wheat industry, in terms of production, consumption and production financing. The first part of Chapter 2 provides a brief overview of the wheat industry. The scene is set for the modelling of the financial implications of adopting crop rotation systems, which is done in the following chapters. Subsequently, the Middle Swartland wheat sector is described. The chapter also reviews the literature on crop rotation systems in sustainable and profitable production systems, sequencing and management decision-making in crop rotation systems, and the impact of crop rotation risk. This section enhances the significance of the study to both farmers and financial providers. Special reference is made to the role of finance, as this is part of the typical strategy to adopt a different crop rotation system. The second part of Chapter 2 briefly evaluates the financing instruments and financial products available to grain farmers in South Africa.

2.2. Background to the South African grain industry

The agricultural sector is the cornerstone of the South African economy, contributing approximately 2.6 per cent to the annual gross domestic product in 2012 (DAFF, 2013). South Africa is divided into a number of farming regions based on climatic conditions, natural vegetation, soil type, as well as farming practices. Agricultural activities range from intensive crop production and mixed farming in winter rainfall and summer rainfall areas to cattle ranching in the bushveld, and sheep farming in more arid regions.

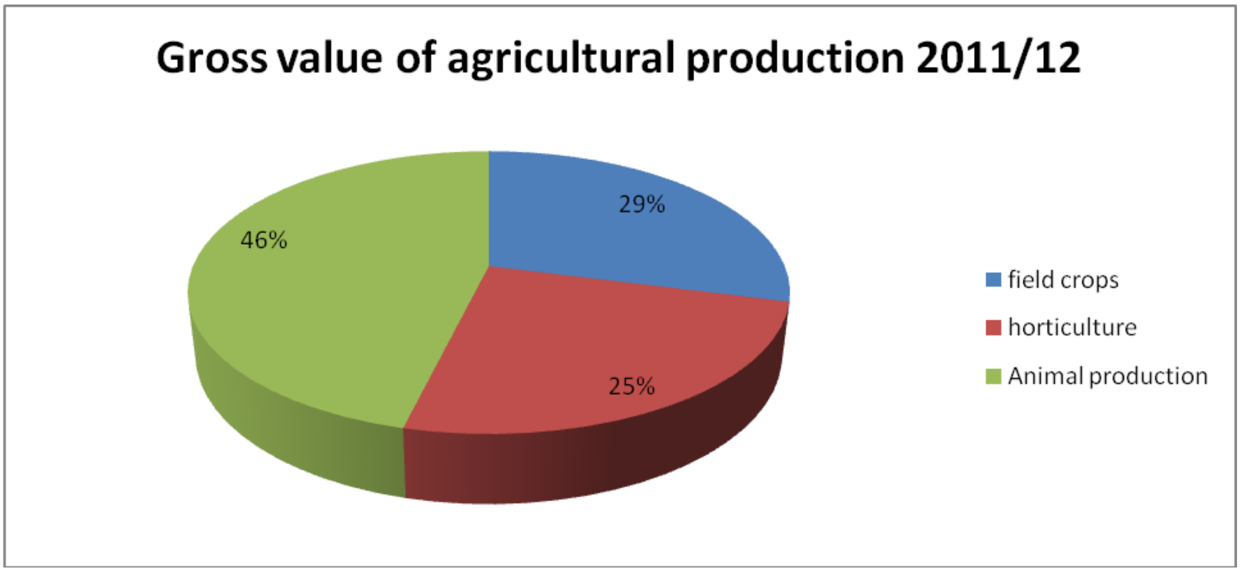

Figure 2.1: Gross value of agricultural production for the year 2011/12

Source: DAFF, 2013

The grain industry is one of South Africa's largest agricultural industries, producing between approximately 25 per cent and 33 per cent of the country's total gross agricultural production (Figure 2.1); R 4 773 479 was contributed by wheat production (DAFF, 2013).

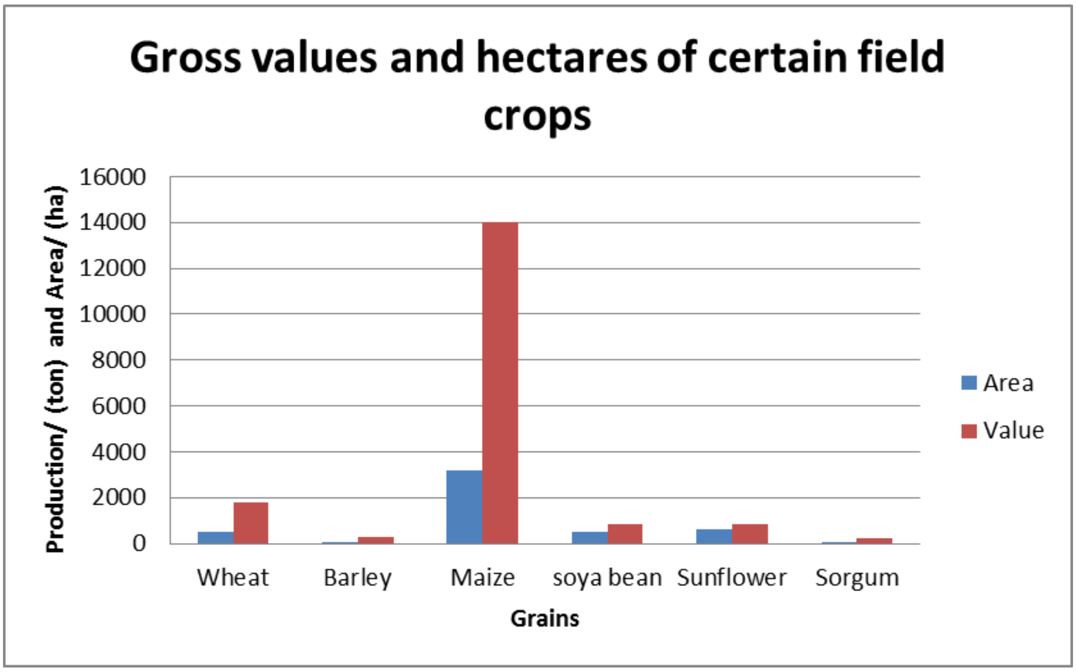

Figure 2.2: Gross value and hectares harvested of certain field crops

Source: Mundi index, 2014

The grain industry includes all grain and oilseed industries, such as barley, oats, maize, wheat, and canola. Figure 2.2 shows the gross value and hectares harvested of certain field crops. The industry comprises a number of key stakeholders including input suppliers, farmers, silo owners, traders, processors, bakers, as well as financiers. Within the grain industry there are various institutional and legislative frameworks for industry regulation, as well as financing; for instance, the South African Futures Exchange on the JSE for marketing, and the governmental acts regulating grain handling and packaging. Grain producers in South Africa are key role players in ensuring food security. Food insecurity constitutes a global crisis, and South Africa, as a developing country, plays a vital role in ensuring food security and assisting producers to increase production substantially to meet future local needs (Middelberg, 2013).

2.3. Overview of the South African wheat industry

2.3.1. Importance of the wheat industry

Among all field crops produced in South Africa, wheat is the second most important crop, following maize, in terms of value of production. It is the most important winter cereal crop planted in South Africa. Wheat is mainly produced for human consumption, with residues being processed for animal feed and seed (DAFF, 2012). During the 2011/12 season, wheat contributed approximately 11 per cent to the gross value of field crops, as shown in Figure 2.3.

The average annual gross value of wheat in the five years up to 2011/12 amounted to R4 185 million, compared with R17 985 million for maize, which is the most important field crop (DAFF, 2012). Wheat producers provide employment to approximately 28 000 people. However, since deregulating the wheat industry in 1996, South African wheat farmers have struggled to produce wheat profitably. The pressure on the profit margins has caused the majority of local farmers to scale down on wheat production and to switch wheat fields to other crops, such as canola, oats and barley, or to increase livestock production on pastures. Figure 2.3 illustrates the gross value contribution of each of these. The wheat industry in certain local areas, such as the Swartland region of the Western Cape, is a key industry in the economy of the community.

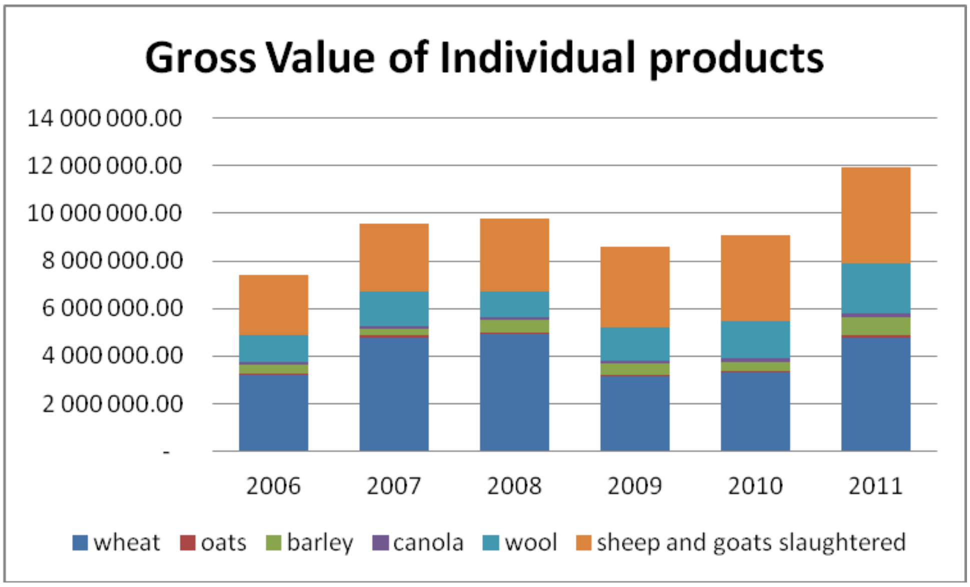

Figure 2.3 : Gross value of crops and livestock production in SA form 2006-2011

Source: DAFF, 2013: Abstract of Agricultural Statistics

2.3.2. Domestic production and area planted of wheat

South Africa (made up of nine provinces) is divided into 36 crop production regions and wheat is planted in 32 of these regions. There are three distinct wheat producing areas in South Africa, each with its own challenges and specific requirements. Winter wheat is planted in the dryland (rainfed) conditions of the Free State Province, while Dryland Spring wheat is grown in the Mediterranean climate of the Western Cape Province, and irrigated spring wheat types are grown along to major rivers in the summer rainfall areas (Van Niekerk, 2001 cited in Smit et al., 2010).

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In South Africa, wheat is produced in both winter and summer rainfall areas. In 2013, approximately 80 per cent of wheat was produced in the Western Cape, Northern Cape and Free State. 80 per cent of wheat produced in South Africa is cultivated under dryland conditions, with 20 per cent cultivated under irrigation (DAFF, 2013). Table 2.1 shows the area planted and production figures of wheat in South Africa.

Table 2.1: Area planted and production in South Africa

Marketing years	Area planted (ha)	Yield (Tons/ha)	Production (tons)
2008/09(Actual)	748		2,149,000
2009/10(Actual)	642		1,967,000
2010/11(Actual)	778		1,436,000
2011/12 (Actual)	605	3.3	2,005,000
2012/13 (Estimate)	511	3.7	1,915,310
2013/14(Forecast)	480	3.3	1,600,000

Source: DAFF, 2013: Abstract of agricultural statistics

During the 2012/13 season, South African wheat farmers produced a total of 1 915 310 tons on approximately 511,200 ha (Table 2.1). The average yield for the year was 3.7 t/ha (SAGL, 2013). The total production is not sufficient to meet domestic demand; as a result, South Africa annually imports the shortfall required for domestic consumption (Smit et al., 2010).

2.3.3. Domestic consumption of wheat

Wheat consumption has been increasing steadily over the years. In 2011/12, South Africa's wheat consumption increased by 9 per cent to 3.2 million tons, because of an increase in the prices of maize products (which is a perfect substitute for wheat) when the price of maize reached record highs. After reaching highs, maize prices started to decrease while wheat prices increased; hence, there was only a marginal increase in wheat consumption in the 2012/13 marketing year to 3.3 million tons, as shown in Table 2.2. Figure 2.4 shows domestic per capita consumption of wheat from 1960 to 2014.

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Table 2.2: Wheat consumption in South Africa

Wheat Consumption (1 000 tons)					
Marketing Year	**Human**	**Animal**	**Seed**	**Other**	**Total**
2011/12 (actual)	3,065	136	18	11	3,230
2012/13(estimate)	3,100	140	15	20	3,275
2013/14(forecast)	3,325	140	15	20	3,500

Source: SAGIS, 2013

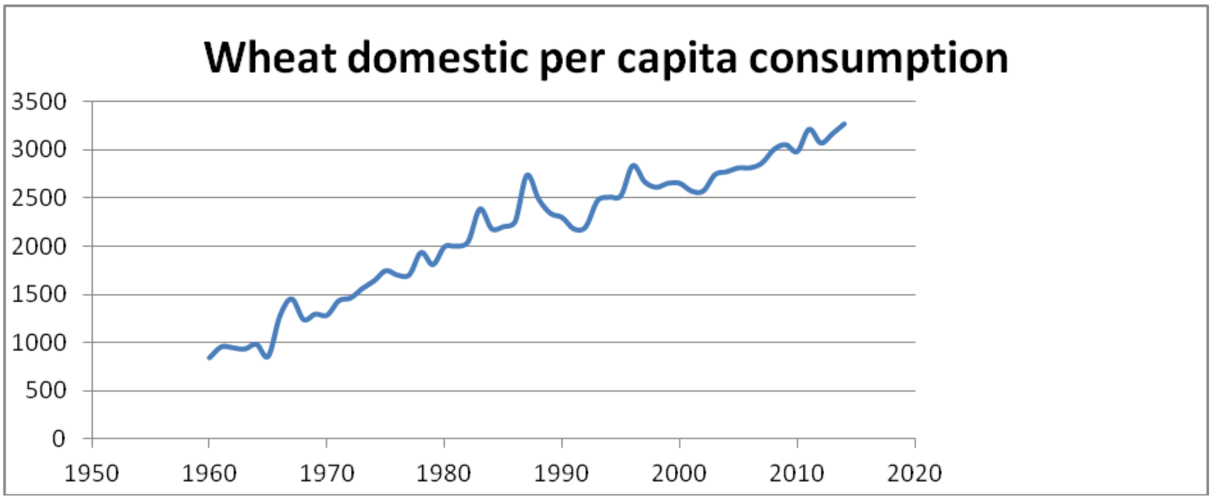

Figure 2.4: Wheat domestic per capita consumption

Source: Mundi Index, 2014

2.3.4. Regional production and consumption of wheat

Table 2.3 provides an overview of wheat production in the Western Cape for the period 2003–2012. The estimated surplus or shortage of wheat in South African is also shown in the table. The Western Cape wheat producers produce surplus wheat to meet local requirements. Rotating wheat with other grains or legumes is not likely to decrease supply to a level that will not meet consumers' demand. Despite the shift in grain production away from wheat, the surplus supply in the Western Cape is likely to remain.

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Table 2.3: Comparison of wheat consumption between Western Cape and the rest of the country

SOUTH AFRICA				WESTERN CAPE		
YEAR	PRODUCTION (1000 t)	CONSUMPTION (1000 t)	SURPLUS (1 000 t)	PROD. (1000 t)	CONS.	SURP.
2003	1,541	2,689	-1148.00	530		
2004	1,680	2,761	-1081.00	520		
2005	1,906	2,819	-913.00	645		
2006	2,105	2,837	-732.00	730		
2007	1,905	2,907	-1002.00	812		
2008	2,130	2,883	-753.00	860		
2009	1,958	3,076	-1118.00	714		
2010	1,430	2,987	-1557.00	530		
2011	2,005	3,249	-1244.00	710		
2012	1,915	3,134	-1219.00	884		

2.4. Wheat sector in the Western Cape

The Western Cape wheat industry is unique compared with the rest of South Africa; this is due to mainly its climatic conditions and the structure of the local market. Unlike the other wheat-producing regions in South Africa, the Western Cape is a typical Mediterranean climate zone, and receives winter rainfall. One of the main challenges facing the Western Cape wheat industry is structural oversupply in the local market. The industry produces more than is consumed in the province (BFAP, 2005). As a consequence the wheat producers have to deal with the high cost of transporting wheat to the interior of the country, and high competition in the export markets (BFAP, 2005).

The total hectares (ha) planted under wheat in the Western Cape has shown a downward trend for the last decade. However, in the last three years, hectares planted have stablised at approximately 400 000 ha l. Apart from wheat, the Western Cape is also the largest producer of barley and canola in South Africa. Over the last five years, it produced, on average, 73 per cent of the national barley crop. Most barley in the Western Cape is exclusively produced in the Southern Cape.

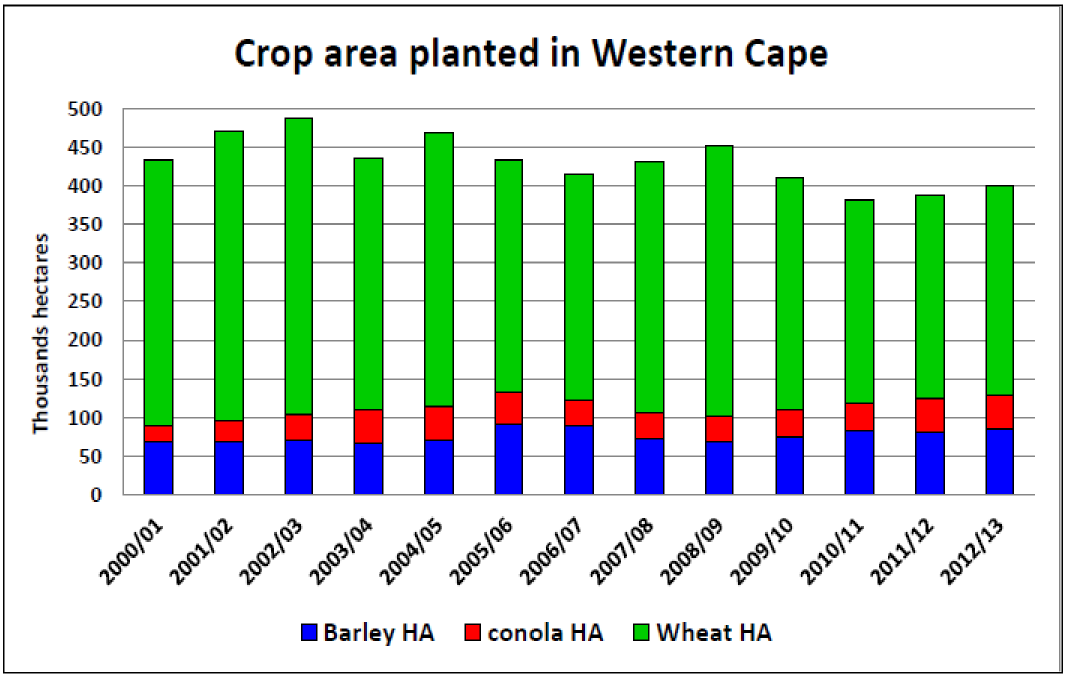

Figure 2.5: Crop area planted in Western Cape

Source: SAGIS, 2013: Crop Estimate Committee

The Western Cape produces approximately 95 per cent of the South African canola crop. The Western Cape grain producers have shown a renewed interest in canola over the last five years, during which time the price of wheat was relatively low compared with that of oilseeds.The international prices of oilseeds showed a relative increase compared with that of grains. Canola also presents an added benefit to crop rotation systems (Van der Vyver, 2013). Figure 2.5 includes the hectares planted under canola in the Western Cape for the 2000/01 to 2012/13 production seasons.

The Western Cape grain producers have, for the past two decades, adopted a livestock production component. Including the wool and mutton sheep breeds, such as Dohne Merino, is a common practice for the producers closer to the markets. A number of producers include dairies; this is, however, a limited number. Including the livestock production component is due to the stability of the livestock industry,which is more stable in terms of producer prices. Over the 2004/05 period, the livestock component in the Western Cape grain-producing areas has shown a steady increase until

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year 2009/10. Producers have been increasingly planting livestock pastures on previously wheat-producing fields. Contributing to this is the sharp rise in mutton prices since 2011, relative to wheat prices (Van der Vyver, 2013).

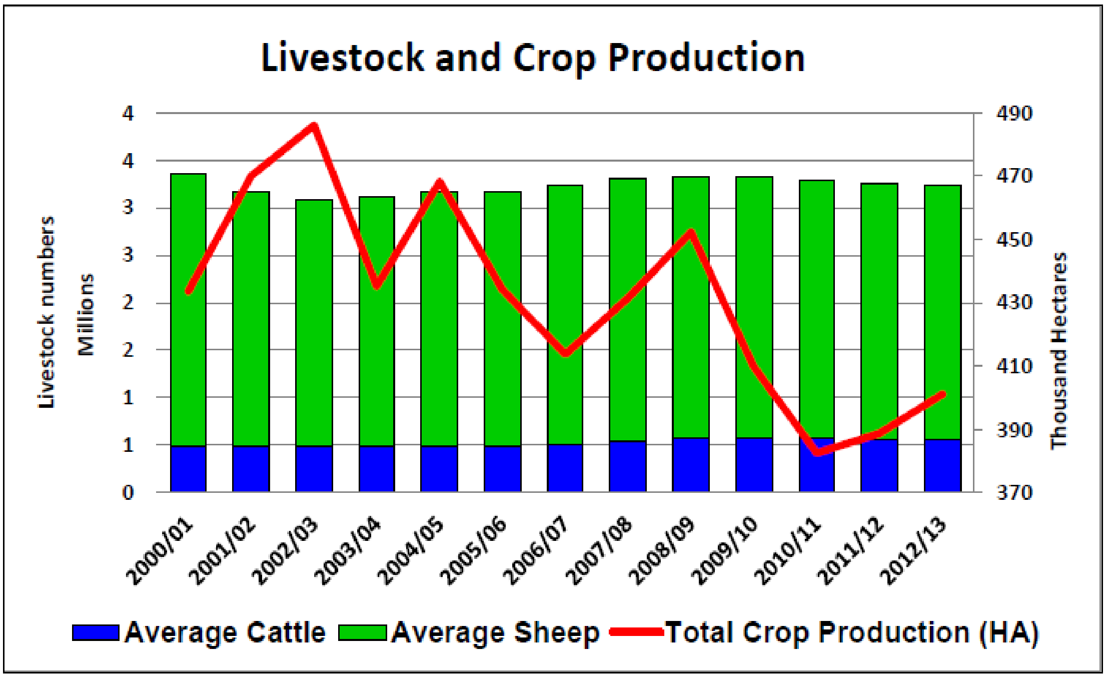

Figure 2.6: Livestock and crop production in the Western Cape Province

Source: SAGIS, 2013: Crop Estimate Committee

Figure 2.6 depicts the number of hectares allocated for wheat, barley and canola relative to livestock numbers of sheep and cattle. Hectares allocated to crop production have decreased, with a slight increase in the number of livestock in the 2004/05 season.

2.4.1. Western Cape wheat-producing regions

On a sub-regional basis, the Western Cape is divided into the following areas, from the Swartland to the Southern Cape (DAFF, 2010 cited in Van der Vyver, 2013):

- West Coast: Bitterfontein, Clanwilliam, Malmesbury, Koringberg, Reitpoort, Vredendal, Swartland.
- Boland: Matroosberg TRC, Breërivier, Witzenberg, Paarl.
- Overberg: Overberg, Swellendam, Hermanus, Caledon.
- Cape Town: Blaauwberg, Tygerberg, Helderberg, Oostenberg, South Peninsula.

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The two main wheat-producing regions in the Western Cape are the Swartland and the Southern Cape. These two regions produce approximately 85 per cent of the 42 per cent national wheat crop produced by the Western Cape (SAGIS, 2013). The Swartland region, also known as the breadbasket of the Western Cape (Swartland LED, 2007), is located on the west coast of the province and has been the main wheat-producing area for the past decades (Strauss and Laubscher, 2014).

The Swartland region is a typical winter rainfall region, with a Mediterranean climate. Conditions are characterised by cool, moist winters and hot, dry summers, with a mean annual rainfall ranging between 200 and 500 mm (Hardy, 1998). According to Troskie et al. (1998) cited in Hardy (1998), except for a narrow coastal strip in the north-west of the region, the Swartland has a moderate-to-high resource potential for wheat production. Added to the production potential, the government, prior to introducing a deregulated production and marketing system, provided the producers with both guaranteed prices and drought relief incentives. These factors led to a well-established infrastructure for wheat handling and storing, as well as for grain processing in the area.

The Southern Cape region is characterised by a warm summer rainfall and stretches from the Bot River to Riversdale, between the coastline and the Sonderend and Langeberg mountain ranges. Rainfall in the Southern Cape is more dispersed, with the Goue Ruens area receiving approximately 70 per cent of its rain in winter, and 30 per cent in summer. The map in Figure 2.7 shows plant production, or productivity areas, for winter cereal and oilseed crops in the Western Cape. The production areas as well as the average yields are shown.

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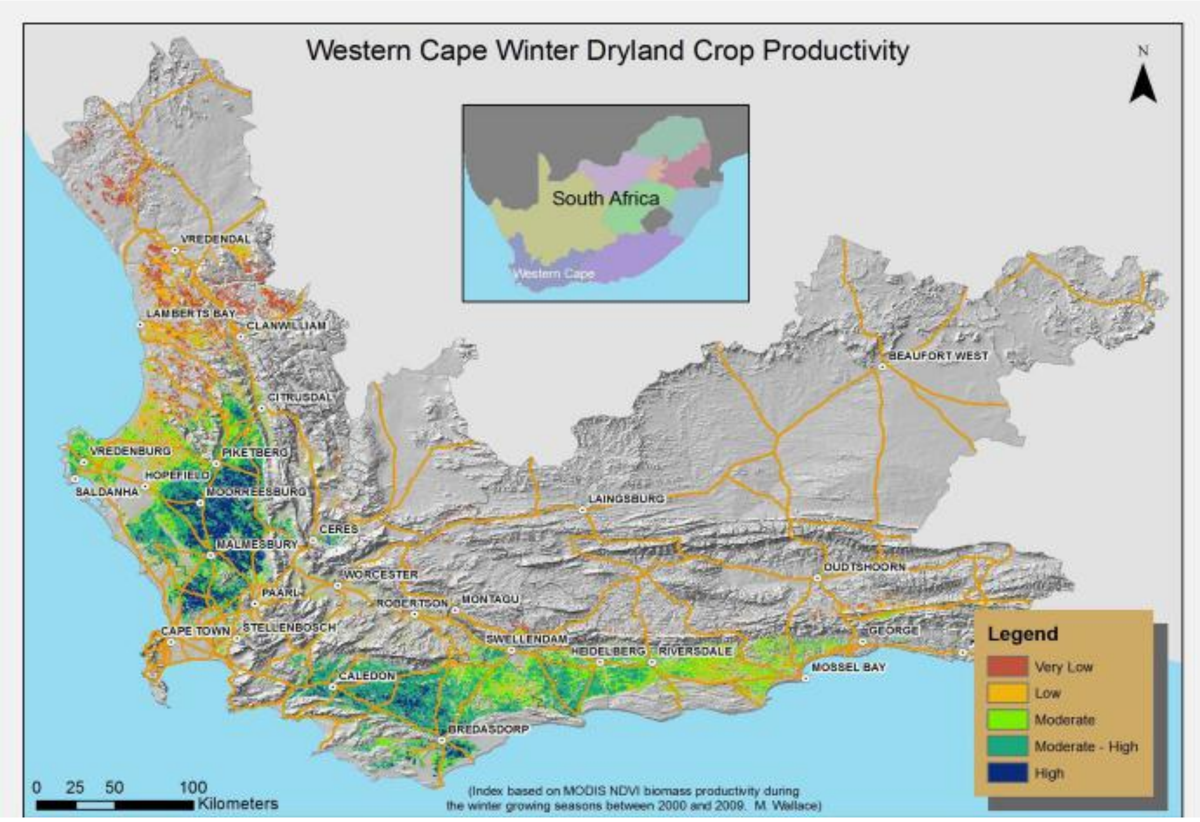

Figure 2.7: Western Cape winter dryland crop productivity

Source: DAFF, Western Cape cited in Van der Vyver, 2013

Regional production and yield estimates, on average in a normal year, for the Western Cape are shown in Table 2.4 (Du Plessis, 2013 cited in Van der Vyver, 2013). WPK, MKB, and PLK are the previous names; these organisations are currently known as KAAP Agri (WPK), Overberg Agri, and KAAP Agri (PLK), respectively.

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Table 2.4: Regional production and yield, estimated

Region	Ex Co-op area	Tons	Yield (tons/ha)
Swartland		+/- 500 000	
	KAAP Agri (WPK)	+/- 160 000	2.8
	Overberg (MKB)	180-200 000	2.8
	KAAP Agri (PLK)	+/- 160 000	2.5
Southern Cape		+/- 200 000	
	Overberg incl. Bredasdorp	130-140 000	2.5
	SSK	+/- 50 000	2.4
	Tuinroete Agri	+/- 20 000	2.2

Source: Du Plessis, 2013 cited in Van der Vyver, 2013

2.4.2. Western Cape wheat production systems

Prior to the abolition of the Wheat Marketing Board, wheat was produced mostly using monoculture practices. This was influenced by government policies that supported, with price control policies, producing wheat. However, the downward shift in government intervention resulted in a decrease in wheat production, with other grain crops gaining relative importance in the industry. This brought an increase in the complexity of the crop production systems due to crop rotation and expanding the farm-level decision-making environment in the Western Cape.

2.4.2.1. Wheat monoculture

Monoculture is defined as the practice of growing the same crop on the same land from one growing season to the next (Hardy, 2010). Wheat monoculture was, and still is, widely practiced on farms in the Swartland region, mainly because of the inherent wheat-production potential and, previously, due to government subsidies. The unpredictable fluctuations in the temporal and spatial distribution and amount of rainfall make the profitability of dry land wheat production in the

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Swartland region inherently uncertain, particularly in a deregulated, free-market economy where volatile prices are common(Hardy, 1998).

In most regions, wheat production using monocropping was sustained by increasing input usage, such as fertilizers, pesticides, herbicides and fungicides. The economic viability of producing wheat in the Swartland declined due to constantly increasing input costs, competitive and volatile world market prices and unpredictable rainfall (Hardy, 1998). A further cause of pressure on the profitability of wheat production was the increasing prevalence of tolerance of weeds to herbicides. This presented an opportunity to introduce new crops into the production system. Wheat, however, remains the central cash crop in the Swartland. According to Hardy (1998), introducing alternative crops and cropping systems in the region was done not only to build up the organic matter and fertility of the soil, but also to provide natural breaks in the life cycles of weeds and diseases, and to reduce input costs, which decrease risk.

2.4.2.2. Crop rotation systems

Table 2.5 depicts a general picture of the proportions of different crops and pastures that were cultivated on the farms in the Western Cape in 2010. The table shows crop rotation adoption in both regions. The Southern Cape diversified its production systems to a greater extent compared with the Swartland. In the Southern Cape, of the area cultivated in 2010, an estimated 22 per cent was planted under wheat, 12.5 per cent under barley and 5 per cent under canola. Some farms had both lucerne and medics (annual clover pastures), but most of the farms had either lucerne or medics/clover.

In the same year, 2010, of the total cultivated land in the Swartland region, 56 per cent of land was allocated to wheat. Annual legume pastures and forage made up the next highest proportion. The remaining area was allocated to alternative cash crops such as canola and lupin. Recent data on the Swartland region indicates that approximately 30 per cent of the cultivated land is still allocated to wheat monoculture (Coetzee, 2014).

Table 2.5: Hectares allocation per crops in Swartland and Southern Cape regions

Crop/Pasture	Percentage in Southern Cape	Percentage in Swartland
Wheat	22,3 %	56,1%
Barley (malt)	12,5 %	0 %
Canola	5,3 %	3,5 %
Lupin	0,8 %	2,4 %
Lucerne	36,1 %	0 %
Medics/clover	8,1 %	11,2 %
Cereal/hay/pasture	14,9 %	26,7 %

Source: Hardy, 2010

Winter cereal production has formed the basis of Western Cape dryland production systems since the 1700s (Strauss & Laubscher, 2014).Wheat in the Western Cape was traditionally produced in monoculture systems with an occasional break, either fallow or with oats as pasture. After several attempts following the land improvement scheme in the 1970s and 1980s, a crop and crop/pasture rotation trial was established in 1996 at the Langgewens Research Farm in the Central Swartland (Strauss & Laubscher, 2014). The trial runs on a 50 ha site. The trial includes, in four-year cycles, four continuous cropping's and four crop/pasture rotations. It was initially aimed at determining the impact of selected crop rotation systems on crop and crop/pasture production in the middle Swartland (Hardy et al, 2012). The following crop rotation systems are evaluated (Hardy, 1998):

Continuous cropping rotations in four-year cycles **(System A to D):**

- System A – wheat monoculture **(WWWW)**
- System B – canola; wheat; wheat; wheat **(CWWW)**
- System C – canola; wheat; lupin; wheat **(CWLW)**
- System D – lupin; canola; wheat; wheat **(LCWW)**

Crop/pasture rotations in four-year cycles **(System E to H):**

- System E – medics; wheat; medics; wheat **(MWMW)**
- System F – medics/clover; wheat; medics/clover; wheat **(McWMcW) - 1**

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- System G – medics; canola; medics; wheat **(MCMW)**
- System H – medics/clover; wheat; medics/clover; wheat **(McWMcW) – 2**

Canola (*Brassica napus*) is the highest-yielding crop produced for oil and animal feed. The oilseed is edible and of high quality. Canola meal is a high-quality livestock feed (Arkcoll, 1988 cited in Hardy, 1998). For these crop rotation systems, canola is rotated in wheat production because it reduces diseases, weeds, and pests in the subsequent crop and also because its extensive root system can improve soil structure (Hardy, 1998). Lupins (*Lupinus albus* and *L. angustifolius*), increase the mineral nitrogen available for the subsequent cereal crop, reduce soil density and stabilise soil aggregates, thus increasing wheat yields.

Medics (*Medicsago spp.)* and clover (*Trifolium subterraneum* and *T. balansae*) contribute soil organic matter and provide 40 to 100 kg of N/ha/a to the soil profile, up to 40 per cent of which is available to the subsequent crop (Hardy, 1998). Furthermore, they reduce cost and grass-weed competition and contamination, which, in turn, increases yields in the subsequent wheat crop. Medics and medics/clover pastures provide sheep with quality fodder. Pasture dry-matter residue and mature pods are used well by sheep during the dry summer months (Wasserman, 1980 cited in Hardy, 1998).

2.5. Crop and pasture rotation

There is a significant body of literature on crop rotation within farm system management research globally focused on integrating crop and livestock systems as well as, rotating crops and pasture much-studied research topic (Hardy, 2010). Studies analysing integrating of pastures into crops specifically within rotation of grain crops have demonstrated benefits. Such as increase in yield, lower production costs, improve soil conditions and increase in net farm income (Hardy, 2010). In the northern Great Plains of North America the diversification of crop-livestock system with pasture for pasture resulted in an increase in grain crop yields, a reduction in pasture weed and an improvement in soil quality (Entz et al., 2002 cited in Sulc & Tracy, 2007). In Australia, a crop-livestock integration system provides benefits such as risk management, both financial and business risk, and a 25–75 per cent yield increase in both crop and livestock production with a minimal increase in inputs (Bell et al., 2013).Uruguayan researchers found that a crop-pasture rotations were more economically and climatically sustainable compared with monoculture, due to their higher diversity (Gracia-prechac et al., 2004 cited in Sulc & Tracy, 2007).

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In South Africa similar studies have been conducted on government owned research farms by Hardy (2010) and Botha et al. (1999). that formed the basis for Data financial evaluation of crop rotation systems in the Middle Swartland wheat production region by Hoffmann & Laubscher, 2002 using data from the Langgewens Research Farm. Another study was on the impact of crop rotation on profitability and production risk in the Free State (Nel & Loubser, 2004) using data from the two crop rotation trials: one at Viljoenskroon and the other at Bethlehem.

This shows the extent of research done on crop rotation and including pastures in the grain rotation, in South Africa and elsewhere in the world.

2.5.1. Advantages and challenges of adopting crop rotations

2.5.1.1. Advantages of crop rotation for sustainable farming

Crop rotations offer distinct advantages to farmers and may be categorised as economic and environmental benefits (Frengley, 1983; Garcıa-Préchac et al., 2004; Hardy, 2010; Sulc & Tracy, 2007). Furthermore, including livestock enterprises in crop and crop/pasture rotations enhances the economic and environmental benefits of crop rotation systems. Conservation Agriculture (CA), as an agricultural mode, was introduced with a production goal that matched with the resources base to achieve both profitability and environmental benefits (Russelle et al., 2007). Hence, the benefits of crop rotation are categorised into two groups: economic/profitability benefits and environmental benefits (Table 2.6).

Table 2.6: Summary of environmental and economic benefits of crop rotations

Environmental benefits

- Reduced soil erosion
- Improvement in soil physical properties
- Increased soil organic matter
- Improved water and nutrient effeciences
- Reduced risk of environment damage by nitrate leaching
- Improved wildlife habitat

Profitability/economic benefits

- Increased grain crop yield
- Reduced input cost through disruption of insect, weed, and disease cycles
- Changes in machinery investment and cost
- Changes in labour cost
- Provide greater financial stability to the farming system as a whole
- Improve gross margins

2.5.1.2. Challenges of adopting crop rotation systems

Although rotating crops offers distinct benefits and advantages to grain farmers, there are some challenges and costs that characterise adopting such systems, and they play a major role in farmers' decision-making. When adopting crop rotation systems, farmers need to consider elements such as short-term profit (crop yield); multi-year factors (rotation benefits); whole-farm factors (farm size and spatial distribution of fields); risk factors; and sustainability factors (persistence of perennials).

The extensiveness of factors that need to be considered before, and when adopting crop rotation indicate a high degree of management skills required (Russelle et al., 2007). This also forms part of the challenges farmers face when making decisions about crop rotations. One of the main concerns characterising implementing crop rotation systems is the transition period between implementation and realising benefits. There is a high degree of uncertainty and financial risk during the transition period, and farmers tend to realise less acceptable monthly cash flows.

Farmers often find it very difficult to decide on adopting crop rotation, considering the initial investment required, the sunk cost and less cash flow, and this is mainly due to the level of farm debt. The level of farm debt was proven to be a hindering factor in adopting new crop rotation practices in Atlantic Canada in the potato industry (Eastern Canada Soil and Water Conservation Centre, 1993).

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Farmers face various challenges when deciding about adopting crop rotation systems (Pannell, 2003; Sulc & Tracy, 2007), including:

- Present, or current, investment in plant and machinery (sunk cost)
- Lack of direct payoff from implementation
- High implementation cost
- Ease of management and support programmes that favour large-scale grain cropping systems over more complex, diversified production systems
- Lack of appreciation and understanding among many producers for system-level performance; that is, performance of the individual components of a production system is valued more than the overall system's performance
- Limited incentives for greater diversity and environmental conservation in production systems
- Lack of physical and human capital
- Lack of sufficient "stewardship" ethic among farmers
- Farming subcultures and social pressures
- Lack of suitable regulatory framework
- Risk and uncertainty

Table 2.7 gives a list of information required for crop and crop-pasture rotation systems depicting the high degree of management skills required.

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Table 2.7: Information requirements for integrated crop-livestock systems

Consideration	Information required
Short-term-profit	Crop yield Crop residue and feeding value Amount and distribution of pasture yield input cost Output value (market, government programme payments, other payments)
Multi-year factors	Rotation benefits (reduced need for N and pesticides, improved soil conditions) Symbiotic N_2 fixation Residual fertilizer Weed populations
Whole-farm factors	Farm size and spatial distribution of fields (rented and owned) Machinery size and availability for different enterprises Labour availability, ability, and cost Financing (availability, flexibility of banker, cost) Livestock feed (requirements, availability, cost)
Risk factors	Yield variability (edaphic, climatic, and biotic constraints) Price variability (market, hedging opportunities, price stability programmes, covariance with yield, insurance) Risk acceptance or aversion Responsiveness (flexibility, willingness to adopt new practices)
Sustainability factors	Persistence of perennials (reseeding and purchases feed cost) Weed populations (herbicide resistance and herbicide residue) Soil conditions and sensitivity (erosion, soil organic

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	matter content, salinity, acidification) Off-site impacts (water quality, total maximum daily load limits, salinity, wildlife, aesthetics)

Source: Adapted from Pannell, 1996; Ewing and Flugge, 2004 cited in Russelle et al., 2007

2.5.2. Crop sequencing and management decisions of crop rotations in sustainable production systems

Francis and Clegg (1990) referred to the biological structuring of a system as an actual mechanism that operates within the plant and animal interactions on a farm. Various researchers have raised and emphasised efficient biological structuring in strategies using rotations (Hardy, 2010; Francis & Clegg, 1990), mostly because such strategies are useful for incorporating diversity into cropping systems, providing nutrients and managing pests in the field.

Furthermore, efficient biological structuring addresses the need for the efficient transfer of energy and growth factors among crops and livestock within a system in order to maintain sustained yields, which could have been achieved through high and continuous applications of inputs based on fossil fuels (for example, fertilizers and pesticides). The efficiency of the biological structuring is influenced by, among others, the complexity of interactions of the components in the cropping sequence, and interdependencies among crops and their biotic factors (Babcock et al., 2010).

The complexity of interactions of the components in a cropping sequence helps sustain cropping systems that are greatly dependent on internal, renewable resources. An example of a more efficient and intimate biological structuring occurs when crops overlap, or are present in the field at the same time. Figure 2.8 illustrates what Francis and Clegg (1990) refer to as the progressive biological sequencing in the field. This figure summarises the totality of the linear and cyclical changes that occur in the field environment due to cropping activities, and the soil modifications that occur because of the crops and their management (Francis & Clegg, 1990).

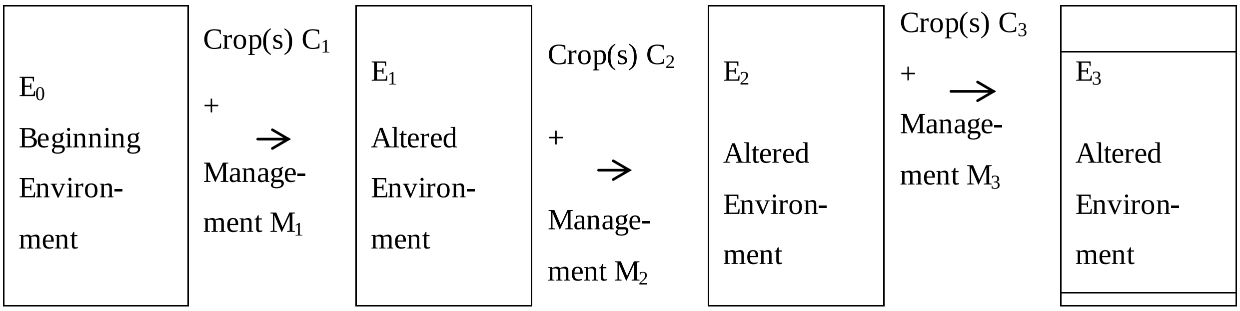

Figure 2.8: Conceptual pattern of dynamic cyclical and linear changes in one field crop environment due to successive crops and management decisions

Source: Francis et al., 1986 cited in Francis and Clegg, 1990

It is important for each producer to plan the crop sequences for each field, based on the planning of the whole production system, the suitability of the soils and the agronomic requirements for the crop (Hardy, 2010), as no individual enterprises or field functions in isolation from other farm activities. Furthermore, it is also significant to conceptualise how these primary interactions function across fields or pastures, when structuring a cropping system.

Proper structuring will lead to a rational distribution of resources, a sustainable food supply and income for the farm household, as well as an environmentally sound set of practices that can help build, rather than destroy, soil productivity. According to Hardy (2010), there are no specific recipes for how crop rotations should be structured; however, there are two main systems that are generally followed:

- **Long rotations:** where land is planted under perennial pastures (for example, lucerne) for five to seven years followed by a cropping phase of five to seven years before pasture is established again.
- **Short rotations:** where land is either continuously planted using different crops in sequences from one year to the next, or is planted under annual pasture (for example, medics/clover) in annual or biannual rotation with wheat or other cereal crops.

2.6. Empirical evidence of crop rotation system benefits: from the Langgewens Research Farm trial

Four continuous cropping and four crop/pasture systems are included in the trial, each in a four-year cycle; namely, as listed above, WWWW, WWWC, WCWL, WWLC, WMWM, WMCM, WMcWMc-1 and WMcWMc-2. All phases of each rotation are present in each year to accommodate the effect of inter annual climatic and commodity price fluctuations on crop yields

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and prices. Treatments are randomly allocated to 48 plots in the 50 ha experimental site. Plot size varies from 0.5 to 2.0 ha, which allows for the use of normal farm machinery in managing and harvesting crops, and provides sufficient area to accommodate the sheep numbers required for sheep production data from the pasture component. A conservation farming approach is applied to managing all treatments, and includes minimum- and no-till land preparation and planting, and retaining crop residue following harvesting (although crop residues are available to the sheep during the dry summer months in those systems that include a pasture phase).

The study uses data from the 2008 to 2012 seasons in gross margin analysis. For each year, all directly and indirectly allocable variable input costs per hectare, and gross income per hectare (minus marketing cost) for each crop and for the sheep component of each rotation system being tested in the trial were recorded. An Excel version of MicroCombud, designed specifically to accommodate the experimental design, was used to record trial data. Excel files, including all the data for each of the 48 plots from 2008 to 2012, were obtained from the Department of Agriculture. Data was received in terms of calculated enterprise budget per year.

Data was then summarised for each crop in each of the 48 plots in terms of gross income (minus marketing costs), allocable variable costs, and margin above directly allocable costs, indirectly allocable costs, gross margin above all allocable costs, and yields. These were then used to calculate average gross production value, average directly allocable costs, average gross margin, and average yield per crop for each of the five years. To incorporate this in the study, calculated averages were then expressed in terms of systems, while yield was expressed in terms of crop sequence.

The results of the study conducted by Hoffmann (Hoffmann & Laubscher, 2002) indicated that including medics and medics/clover pastures and alternative cash crops, such as canola and lupins, in the cropping system provides an improved return on capital investment in the Swartland region, when compared with wheat monoculture. The analysed results from the Langgewens trial, below, clearly illustrate the benefits of including annual legume pastures (with sheep production) in rain-fed farming systems practised in the Middle Swartland.

2.6.1. Yield improvements

Figure 2.9 shows the increase in wheat yield as a result of the crop sequence over the 2008–2012 periods. Average wheat yield (t/ha) is consistently lower for wheat after wheat than for wheat after alternative crops.

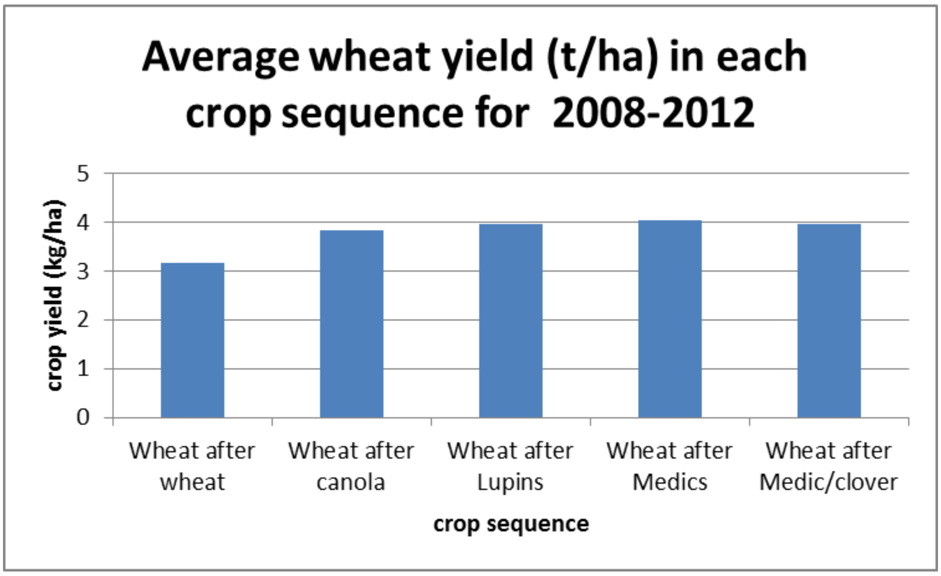

Figure 2.9: Average wheat yield (t/ha) in each crop sequence

Table 2.8 shows the total average farm wheat yield per system. This is also expressed in terms of the percentage of farm hectares under wheat in a particular system. The WMWM and WWWC systems have acceptable average wheat yields, though wheat is also cultivated in 50 and 20 per cent of the total farm land, respectively. Regardless of the high input costs, influenced by input prices, such as those of fertilizers and seeds and including sheep, these systems perform well when compared with the WWWW system.

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Table 2.8: Total average farm wheat yield per system

System	Average wheat yield kg/ha	Farm ha under wheat	Average wheat total ton/farm	Ranking
WWWW	2 854	100	2 283	1
WWWC	3 158	75	1 895	2
WLWC	3 794	50	1 518	5
WLCW	3 664	50	1 466	6
WMCW	4 072	25	814	7
WMWM	3 942	50	1 577	3
McWMcW	3 843	50	1 537	4

Source: Strauss et al, 2014

Figure 2.10 illustrates the average yield per hectare for different systems (expressed as a percentage) compared with monoculture, from 2002 to 2012. The straight red line indicates the difference in percentage yield, with the monoculture system at 100 per cent and the WMWM system at 141 per cent yield improvement.

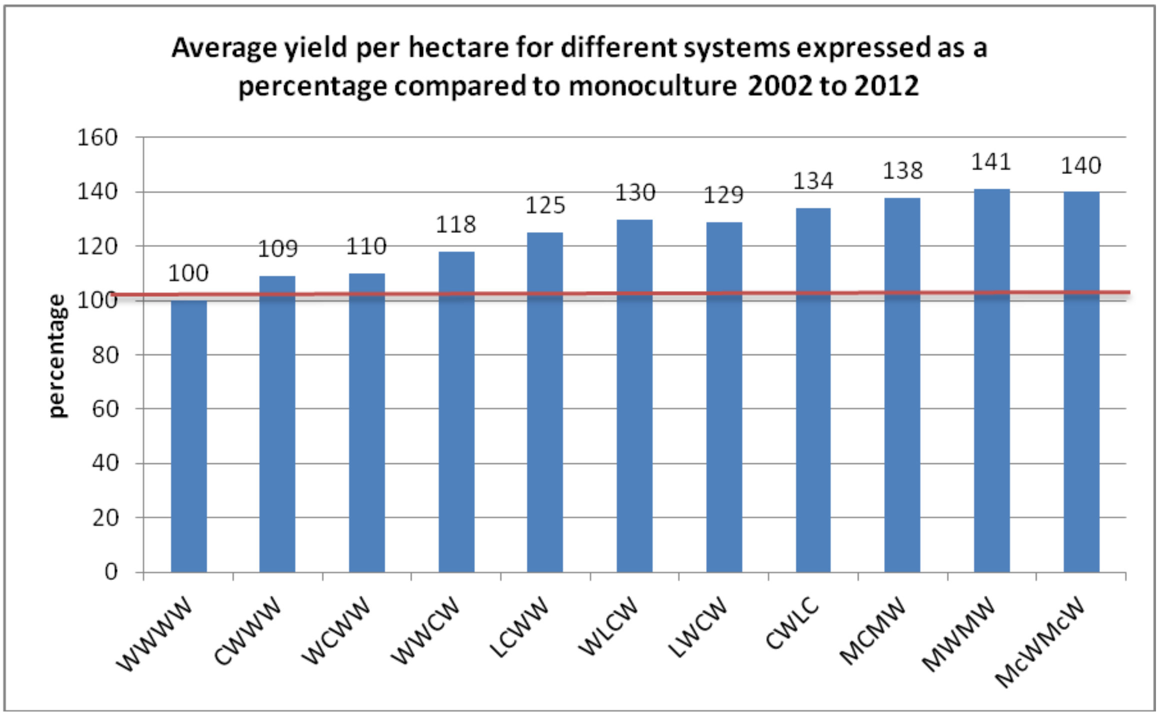

Figure 2.10: Average yield per hectare for different systems, expressed as a percentage compared with monoculture, 2002 to 2012

Source: Strauss et al, 2014

2.6.2. Directly allocated variable cost

Production value (PV) is the value of products sold from the enterprise; in this case, it is equal yield multiplied by price/ton, and the price is corrected for quality. Enterprise gross margin (GM) is the enterprise output less the variable costs of the enterprise.

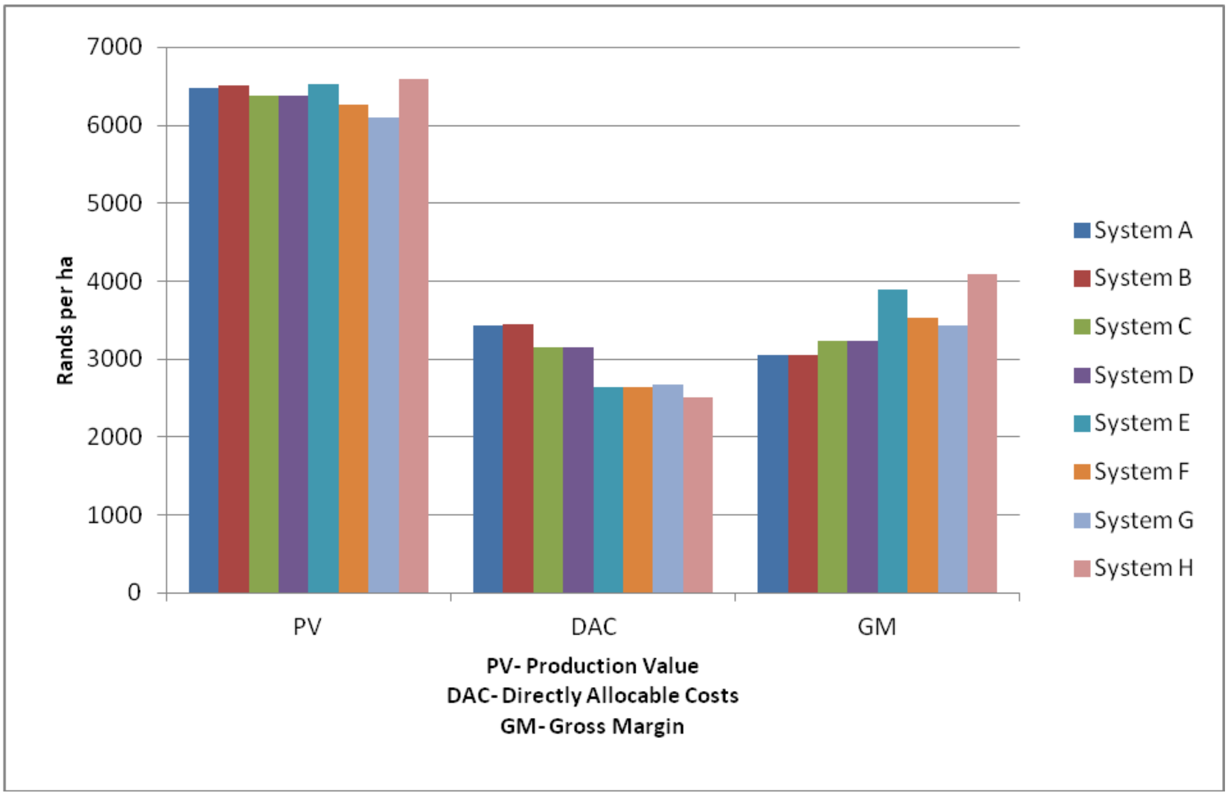

Figure 2.11: Mean annual (2008–2012) gross margin, gross value of production, and directly allocable costs for all rotation systems in the trial

Figure 2.11 illustrates the impact of crop sequences on gross margins, production levels and allocable cost for the past five years (2008–2012). Figure 2.12 specifically concentrates on the directly allocable costs. Higher gross margins are associated with rotation systems that include pastures than with the continuous crop rotation systems. In almost all years, the lowest gross margin recorded was for system A, while the highest gross margins were recorded for the pasture-based systems.

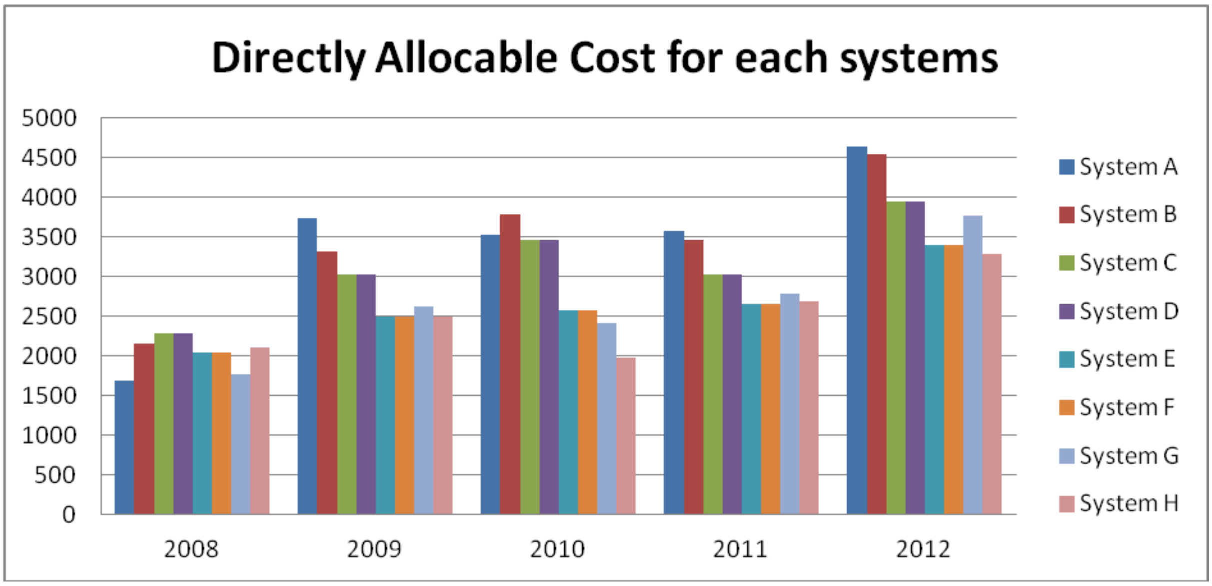

Figure 2.12: Directly allocable cost for each of the systems

The total directly allocable variable costs of the rotation systems that included sheep production from pastures were considerably lower than of continuous cropping systems. According to Hardy et al. (2012), this is mostly due to the fertilizer cost, as it accounted for approximately 35–50 per cent of the total input costs associated with the continuous cropping systems.

2.6.3. Gross Margin

The increase in crop diversification has resulted in a great improvement in farmers' finances in the past years. Including crops such as canola, lupin, and/or medics/clover pastures for sheep production has a positive impact on gross margin relative to those systems with approximately 75 per cent of the area allocated to wheat production. Figure 2.13 illustrates the impact of crop sequencing on whole-farm gross margin.

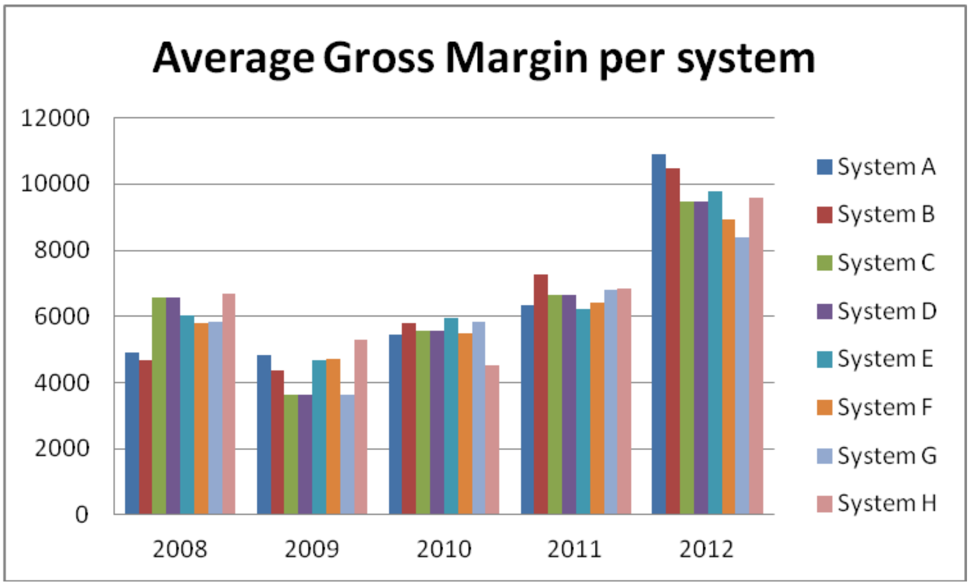

Figure 2.13: Average gross margin per system

Table 2.9 gives farm gross income per system practised in the Middle Swartland. In ranking, the McWMcW system is ranked one, followed by the WLWC system, with R2 721 600 and R2 440 800, respectively.

Table 2.9: Average gross margin and total gross margin per system

System	Average Gross Margin /ha	Total Gross Margin/800 ha farm under wheat	Ranking
WWWW	2022	1 617 600	7
WWWC	2684	2 145 600	5
WLWC	3051	2 440 800	2
WLCW	2495	1 996 000	6
WMCW	2985	2 388 000	3
WMWM	2972	2 377 600	4
McWMcW	3402	2 721 600	1

The McWMcW system also shows an average gross margin per hectare of R3 402 higher than that of wheat monoculture.

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A comparison between farm yield and gross income per system is shown in this section. Table 2.10 gives the difference between monoculture and rotation systems in terms of gross margin and percentage improvements. In comparison, the WWWC system and the WMWM system have higher average yield of wheat per system and high gross margin per system. In addition, McWMcW and WLWC have higher gross margin per system and lower average wheat yield per system.

Table 2.10: Farm yield vs gross income

System	Difference between monoculture and rotation systems	Percentage Improvements
WWWW	-	
WWWC	528 115	33.6
WLWC	823 401	50.9
WLCW	378 112	23.4
WMCW	770 553	47.6
WMWM	760 216	47
McWMcW	1 103 959	68.2

Source: Strauss et al, 2014

According to Hardy et al. (2012), systems with 50 per cent or less planted under wheat could be considered more stable than those with a higher proportion planted under wheat, provided that financial stability is defined as *" by the probability to achieve ... a gross margin in excess of R2 500 per ha in three years out of four*".

2.7. The impact of crop rotation on farm risk

The emergence of agriculture was a response to the risk of depending on hunting and gathering of food for survival. However, since then, agriculture has been characterised by risk and uncertainty. Both farmers and ranchers are faced with a significant amount of uncertainty; they operate and make decisions in an environment characterised by business risk (Gabriel & Baker, 1980; Lishman & Nieuwoudt, 2003). To worsen things, the abolition of the marketing boards in the 1996s left South African farmers even more vulnerable to business risks, such as variable product prices and

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more nominal interest rates. Consequently, agricultural sectors, including the grain industry, face high-income variability, even to date (Lishman & Nieuwoudt, 2003).

In search of better risk modification strategies, most grain-producing farmers have resorted to crop rotation practices, instead of monoculture, as a business-risk management strategy (Helmers et al., 2001; Babcock et al., 2010). However, the literature on risk balancing suggests that business-risk management strategies may, through risk balancing, lead farmers to take more financial risk than they would otherwise take, which, in turn, affects their balance sheet, through increasing the risk of equity loss (Anton & Kimura, 2009).

The risk-balancing hypothesis contends that exogenous shocks that affect a farm's business risk may induce the farm to make offsetting adjustments in its financial leverage position, leading to decreased (increased) financial risk in response to a rise (fall) in business risk (Gabriel & Baker, 1980). In short, the risk-balancing hypothesis assumes an inverse relationship between business and financial risk (Anton & Kimura, 2009). Business and financial risks are considered to be trade-offs in the decisions of the farmers. Thus, a decline in business risk would lead to the acceptance of greater financial risk, reducing the effects of the diminished business risk on total risk (Gabriel & Baker, 1980). This section aims to examine theoretically the impact of crop rotation on the financial riskiness of the farm as a whole.

2.7.1. Definition, types and sources of risk in farm management

Risk can be defined as the possibility of adverse outcomes due to uncertain and imperfect knowledge in decision-making. Risks are classified into two broad categories, based on their outcomes; namely, business and financial risks (Nicol et al., 2007). However, the two categories are trade-offs in the decisions of the farmers. Thus, a decline in business risk would lead to the acceptance of greater financial risk, reducing the effects of the diminished business risk on total risk (Gabriel & Baker, 1980).

Business risk is commonly defined as "… *the risk inherent in the firm, independently of the way it was financed*" (Boehlje & Eidman, 1984; Gabriel & Baker, 1980; Hardaker et al., 2004). Hardaker et al. (2004) explain it as the "… *aggregate effect of all the uncertainty influencing the profitability of the firm*". It is the effect of production, market, institutional and personal risk (Hardaker et al., 2004). However, business risk may also be influenced by internal factors such as management skills and investment decisions (Gabriel & Baker, 1980). In short, business risk (BR) is the inherent risk a farm faces due to biophysical influences and the market environment (for example, production, price, institutional risk and policy risk) (de Mey et al., 2013).

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It can be noticed mostly in the variability of the net operating income or net cash flows. That is, a high coefficient of variation of net cash flows reflects high business risk, and vice versa. The degree of business risk can be assessed based on the probability distribution of the net cash flow over a period of time (Boehlje & Eidman, 1984). Business risk has a crucial impact on both net cash flow and net farm income.

Types of business risk include: (i) production and yield risks; (ii) market and price risks; (iii) losses from severe casualties and disasters; (iv) Social and legal risks from changes in tax laws, government programmes, trade agreements, among others; (v) human risk in the performance of labour, contracts and management; (vi) risks of technological change and obsolescence (Barry & Ellinger, 2012).

Business risk is independent of financial risk (FR), which is defined as "*... the added variability of net returns to owner's equity that results from the financial obligation associated with debt financing*" (Gabriel & Baker, 1980; Hardaker et al., 2004; Nicol et al., 2007; de Mey et al., 2013). Financial risk is an additional risk that arises out of the method of financing the farm, the usage of debt financing (and/or cash leasing), and encompasses the risk of cash insolvency (De Mey et al., 2014). Gabriel and Baker (1980) further expand this notion to include the risk brought by the inability to meet the prior claims with the farm income. The existence and level of financial risk are influenced by the need to finance business operations and maintain cash flow levels adequate to repay debts and meet other financial obligations.

Using borrowed funds means that a share of the farm's total return has to be allocated to the repayment of the debt; that is, the greater the financial leverage, the more difficult it is to meet financial obligations to lenders, lease providers, and equity holders with available revenue streams (Barry & Ellinger, 2012). It is not only borrowed funds that expose farmers to more financial risks; even when a farm is 100 per cent financed by own capital, the farmers' capital is still exposed to the possibility of losing equity or net worth (Harwood et al., 1999).

Financial risk is also dependent on the level of BR, through the leverage effect. This effect is influenced by the unanticipated variations in interest rates, credit availability and other changes in loan terms, and access to sources of financial capital (Barry & Ellinger, 2012). The success of an agricultural enterprise, as with any other business, depends on considering the impact of financial risk when making farming decisions about any other risk categories. The importance of risk-balancing behaviour lies in the fact that business risk reducing strategies might unintentionally miss their target of lowering the total risk on a farm by inducing increased leveraging.

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2.7.2. The interaction between crop rotation and risk balancing

The study of farm-level evidence of risk balancing in the European Union (De Mey et al., 2014) encouraged an interest in research on the interaction between risk balancing and other risk management strategies. This followed an interaction that had already been studied and reported on by other researchers (De Mey et al., 2014; Harwood et al., 1999). The Gabriel and Baker (1980) hypothesis of risk balancing assumes an inverse relationship between business and financial risk.

It states that when exogenous shocks affect the level of farms' business risk, farmers are likely to make the offsetting financial adjustments, leading to decreased (or increased) financial risk in response to a rise (or fall) in business risk. Therefore, risk balancing refers to offsetting adjustments between business and financial risk (Anton & Kimura, 2009). The risk-balancing hypothesis is a theory that links the operating, financing and investment decisions that a farmer makes. It therefore often refers to a farmer aiming for an optimal level of total farm risk, by balancing its constituents' business risk and financial risks (de Mey et al., 2014).

As mentioned earlier in the chapter, business risk contributes to financial risk, relating directly to cash flows and the ability to secure and repay loans necessary for operation (Drollette, 2009); that is, the greater the probability that cash flow will be reduced by a particular business risk, the greater the financial risk. In fact, the production level and commodity prices produce the revenue with which farmers can meet financial obligations.

Generally, the use of crop rotation has been thought to minimise risk compared with monoculture. One of the advantages of crop rotation practices is that they involve various enterprises in which the returns do not move up and down in locked steps, so that when one activity has low returns, other activities would likely have higher returns (Harwood et al., 1999). Helmers et al. (2001) identified three distinct influences of crop rotation in minimising business risk. Firstly, rotation cropping is thought to reduce yield variability compared with monoculture practices. Secondly, crop rotation involves diversification, with the advantage that low returns in a specific year for one crop is combined with relatively high returns for a different crop. Lastly, rotations, in contrast with monoculture, may result in higher overall crop yields, as well as reduced production costs.

However, as with any other risk-management strategy, crop rotation is not intended to minimise risk altogether. In its attempt to minimise risk, crop rotation may give rise to other agricultural risks. These could result from the variability in returns across time and year-to-year changes in yields, crop prices and input costs (Helmers et al., 2001; Botha et al., 1999). Figure 2.14 illustrates the paradox of risk balancing for two different scenarios of the main decisions faced by farmers (de

Mey et al., 2013; Cheng & Gloy, 2008). Risk balancing for a farmer whose goal is profit maximisation is characterised by lower business risk and higher financial risk, while that of a farmer aiming to sustain a farm business is characterised by higher business risk and lower financial risk. Crop rotation may be an effective strategy in both the scenarios, as illustrated in Figure 2.14.

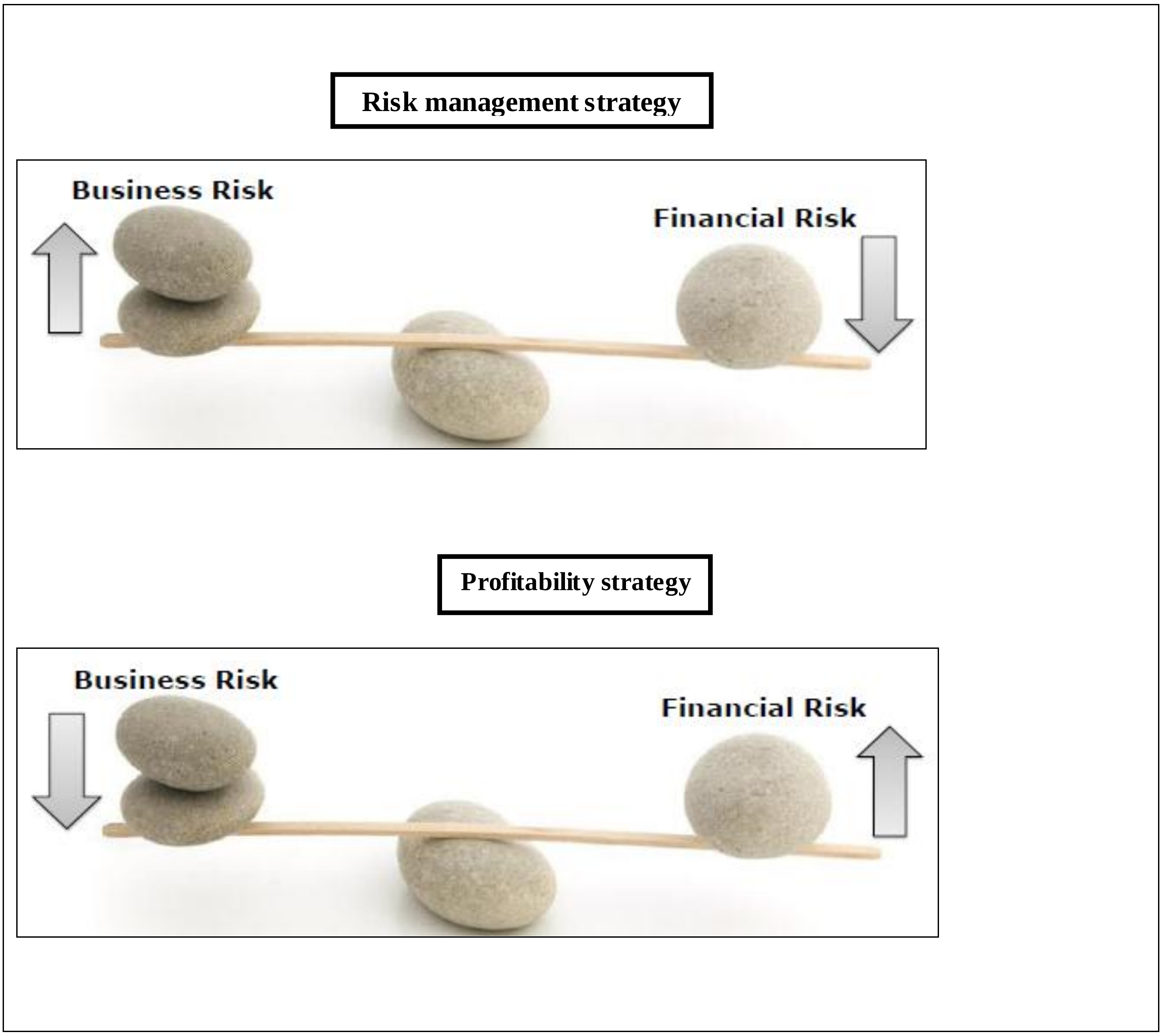

Figure 2.14: Risk balancing paradox in crop rotation systems

Source: Adapted from de Mey et al., 2013

2.8. Finance in the winter grain industry

The conversion from production practice of wheat monoculture to a crop rotation system may have potentially negative financial implications for farmers. Therefore, farmers may require some form of financial assistance to overcome the implications brought about by a switch in production

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systems. Subsequent to the abolition of marketing boards came the reduction of government financial support to commercial farmers. As a result, farmers seemed to be less inclined to stay in the industry, as farm profitability was becoming increasingly difficult to maintain (Marus, 2008). With the aim of minimising business risk, according to Middelberg (2013), wheat famers around South Africa have adopted crop rotation systems. However, adopting such systems exposes farmers to more financial risks, due to high sunk costs and a decrease in cash flow during the transition period (in the short-term).

Agricultural finance has different, if not unique, characteristics, a result of a lengthy production cycle and being capital intensive. This has specific implications for the acquisition of capital. Although financial statements of farm businesses usually illustrate a solvent state, the grain industry is often characterised by liquidity problems as well as cash flow pressures (Middelberg, 2013). These attributes influence the agricultural sector’s debt-servicing capacity and creditworthiness which makes it more vulnerable to fluctuating commodity prices and land values and increases the credit risk incurred by agricultural finance providers (Barry & Robison, 2001 cited in Middelberg, 2013).

According to Lee et al. (1980), the appropriate amount and combination of production inputs such as land, machinery, livestock, labour and managerial talents determine the total farm income. On the other hand, the level of farm income is determined by the amount of resources a farmer control, the terms and conditions under which they are obtained, and the way they are used. In the South African grain industry, as in any other business, the same principles are keys to a satisfactory income.

2.8.1. Agricultural finance providers

Agricultural finance in South Africa has gone through changes following the withdrawal of the government from direct participation in financing producers. Such changes included the amendment of the Land and Agricultural Development Bank of South Africa (Land Bank) Act in 2002 and the abolition of the Agricultural Credit Board (Middelberg, 2013; Van Zyl et al., 2013; Van Zyl, 2006). Subsequently, private financial institutions increasingly entered the agricultural finance market with a wide range of financial products and services. Financial institutions currently lending to and investing in agriculture include Land Bank, Commercial banks, Agricultural companies or cooperatives, other privately owned institutions Developmental finance institutions (DFIs) and the national government Department of Agriculture, Forestry and Fisheries (DAFF).

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Figure 2.15 illustrates the growth in farm debt for the three main providers of agricultural finance and corporate funding in South Africa, for the period 2003 to 2012. Commercial banks in South Africa, as a group, have started to dominate the previously difficult field of agricultural financing (Van Zyl, 2006). Development finance institutions (DFIs) are mainly concerned with providing finance to support the development of agriculture (Middelberg, 2013). The increase in the number of institutions providing finance in agriculture is influenced by the increase in demand for finance, indicating the significance of finance to producers.

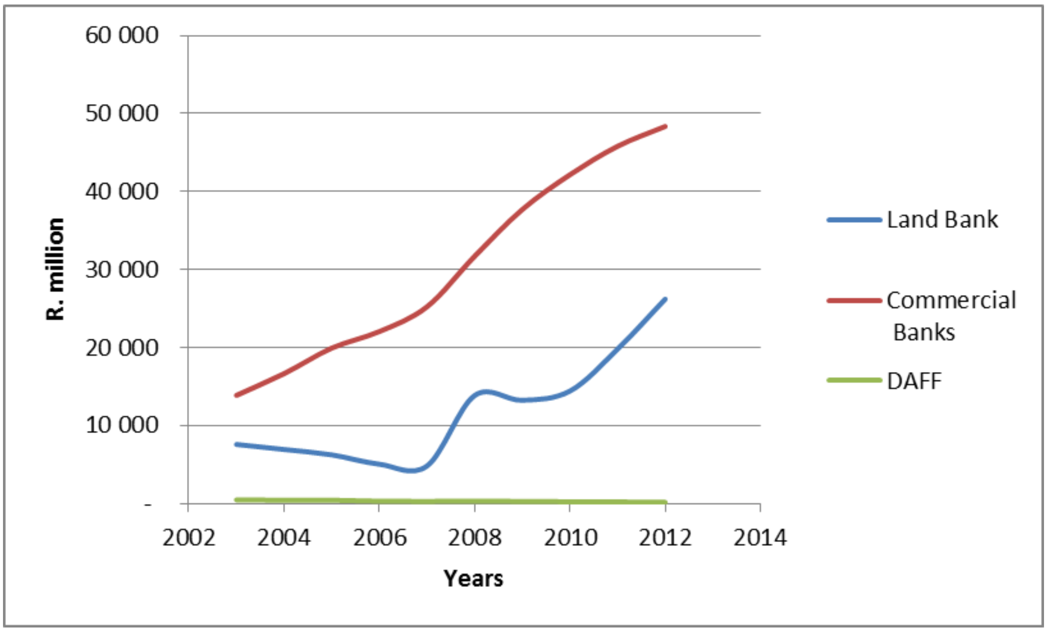

Figure 2.15: Farm debt growth in South Africa for the past 10 years

Source: Daff, Abstract, 2013

2.8.2. Agricultural financing methods overview

Agriculture production and the grain industry can be financed through a wide range of options, depending on producers' preference and availability of resources. Typically, investment is done with the use of own capital (own equity), obtaining loans or credit from a financial institution (external financing), and/or selling shares in the farm business. Within the external financing options, there are a number of alternatives in South Africa which Middelberg (2013) broadly classifies as traditional financing and alternative financing. Traditional financing encompasses balance sheet lending, and alternative financing encompasses grain contracts.

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2.8.2.1. Balance Sheet lending approach (traditional financing)

Balance sheet lending is the most common approach in financial assistance to grain producers in South Africa. The limiting factor attached to this approach is the need for collateral by financing institutions. It is mostly favoured by agricultural finance providers because it addresses the conservative risk profile (Rossouw, 2014). Application requirements for this approach include a balance sheet and cash flow forecast. Following submitting all required documents, the credit department within the financing institution reviews the application, determines the size of the required loan, rates the creditworthiness of the applicant, and determines the extent of the collateral required.

This approach acknowledges land as collateral; however, producers may also provide company shares (in an agricultural company), current assets (excluding land), or crop insurance as collateral. Land is the collateral preferred by agricultural finance providers (Middelberg, 2013; Rossouw, 2014). The application process is summarised in the steps below, which are taken to minimise the credit risk exposure for the financer:

1) **Review of application**

This is done by the credit department within the financing institution, and the process entails valuing all assets listed in the balance sheet, verifying balance sheet liabilities and confirming outstanding balances, constructing an updated balance sheet, and evaluating debt ratio and cash flow (Rossouw, 2014). The following assumptions, made by farmers, are scrutinised and verified: selling price of grain, input costs, and long-term average returns. The main purpose of this step is to determine if the applicant will be in a positive cash flow position to settle all the obligations and deliver a successful harvest of a quality product (Middelberg, 2013; Rossouw, 2014). Figure 2.16 illustrates the flow of the review process.

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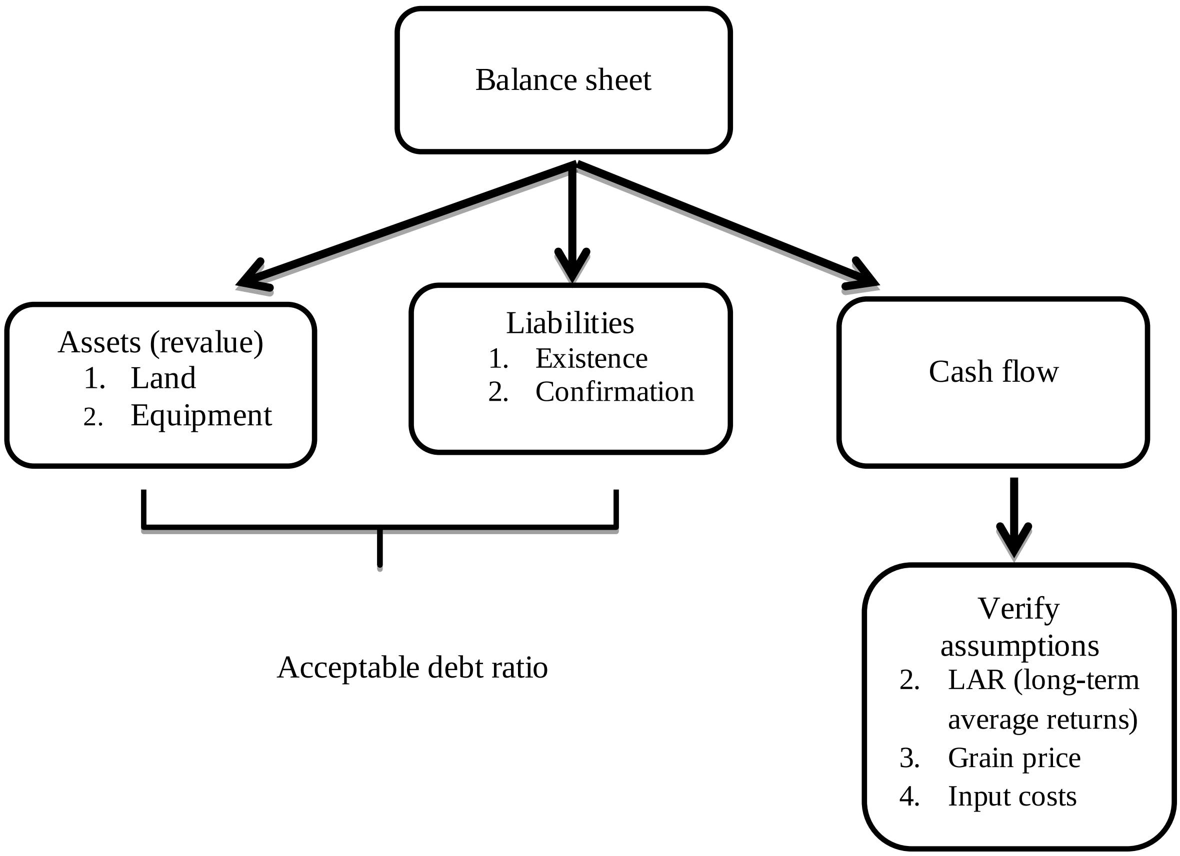

Figure 2.16: Flow diagram for "review process" of balance sheet lending approach

Source: Adapted from Middelberg, 2013

2) Determine the size of the required production loan facility

The aim of this step is to ensure that the loan facility is large enough to cover the producer's direct input expenses, and is done by an agricultural economist and measured against industry norms.

3) Evaluation of the applicant's creditworthiness

The applicant's creditworthiness is rated mostly according to a credit score. Based on the applicant's credit ratio, the extent of the collateral is determined.

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4) Loan application approval or rejection

The creditworthy applicant is granted the loan facility whereas the uncreditworthy applicant is rejected. Agribusinesses, as lending institutions, provide the option to purchase all the material required either directly from the finance provider or from an independent supplier. Agribusiness production loans often include delivery of the inputs directly to the producer (Goosen, 2014).

2.8.2.2. Alternative financing methods in the grain industry

Alternative methods are designed for producers who do not qualify for the traditional lending approach, mostly due to a lack of collateral. These include grain contract financing, with or without additional collateral (Middelberg, 2013; Goosen, 2014). According to Middelberg (2013), the two financing approaches were developed and utilised as a result of changes in the agricultural environment, such as unacceptable increases of production input costs, and land redistribution factors.

The grain contract financing is offered, since the deregulation of the grain market in the 1990s, by commercial banks as well as agricultural companies. This approach is regarded as a preproduction loan, and uses the expected harvest and crop insurance as collateral (Middelberg, 2013; Rossouw, 2014). Figure 2.17 summarises the application process, as well as the application requirements, whereas a detailed overview of the grain contract finance approach is given below. These are pointers used by commercial banks to differentiate between a number of products provided in terms of this approach (Goosen, 2014; Middelberg, 2013; Rossouw, 2014):

Apportionment and timing of the repayment of the loan: Terms and conditions of loan repayments differ among financing products. However, all finance providers use staggered payments; for instance, 60 per cent is payable before planting, 30 per cent once a plant and emergence report is submitted, and 10 per cent once a crop estimate report is submitted.

Determining the loan facility: This is done by multiplying a price per ton of the particular grain the for which the producer seeks finance; such prices are based on the SAFEX prices less transport differential.

Determining percentage financing of LAR: As an attachment to the application form, producers are requested to submit three to eleven years' yield from the relevant land. This is used by the finance provider to determine the LAR. Subsequently, the LAR is multiplied by the percentage financing that is to be granted to the producer.

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Determining the insured value and insurance premium:

Hedging and fixing the grain price:

Physical delivery of harvest:

Force majeure:

Crop insurance:

Precision farming:

Producers decide on the appropriate financial product for which to apply, based on their unique requirements and the different options. The application process is illustrated in Figure 2.17.

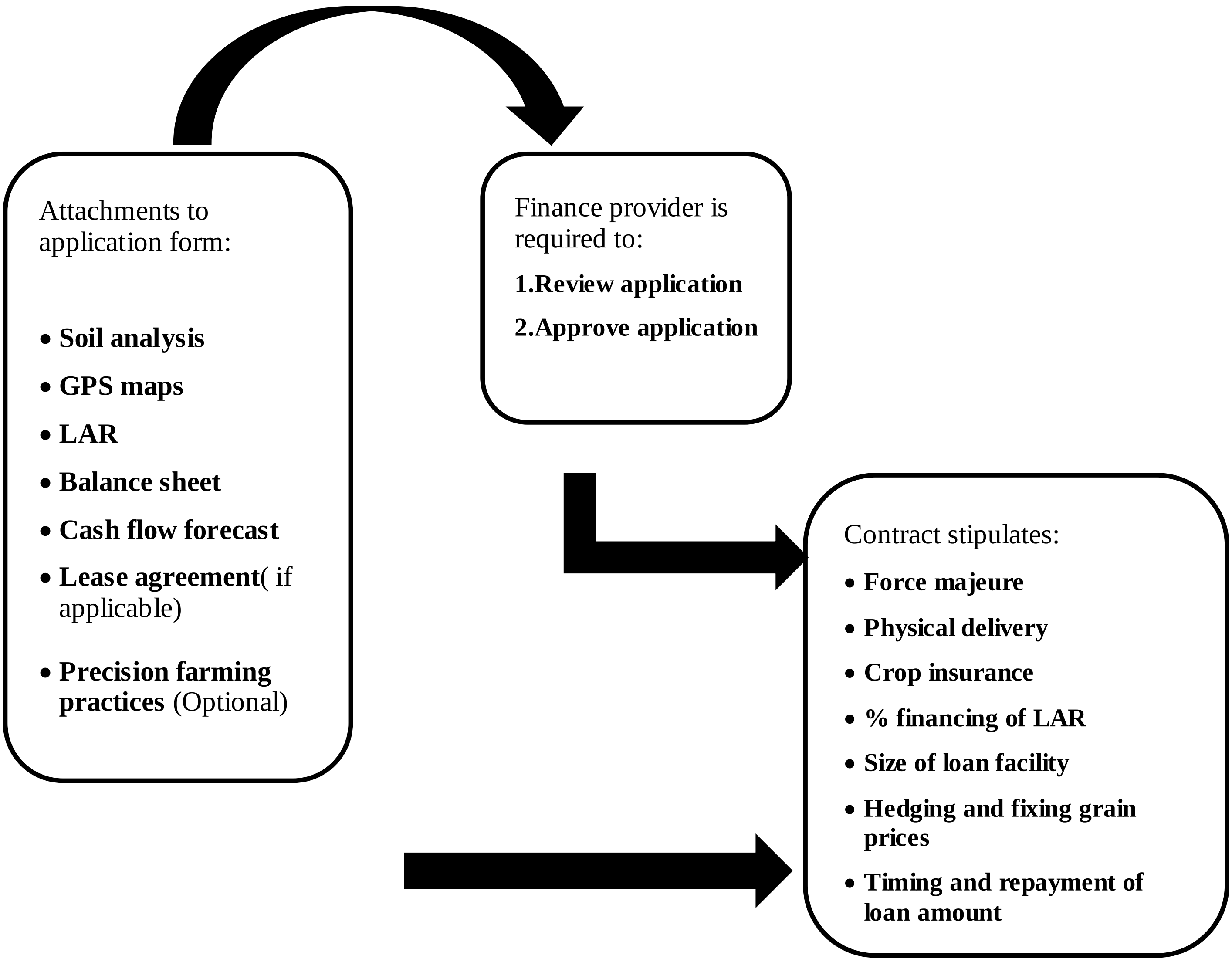

Figure 2.17: Flow diagram of grain contract financing application process

Source: Adapted from Middelberg, 2013

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2.8.3. Alternative agricultural lending solutions and products overview

There are various financing products and tools used in agricultural finance. Commercial banks, for example, organise finance instruments as follows: product financing, receivables financing, physical collateralisation, risk mitigation, and structured enhancement. This section describes the most common products and solutions within these instruments. It must be noted that the use of terms may vary between institutions and across agricultural sectors (Coetzee, 2014; Goosen, 2014; Rossouw, 2014). Table 2.11 gives an overview of the agricultural lending solutions provided by major commercial banks in South Africa.

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Table 2.11: Overview of agricultural lending solutions

PRODUCT/SOLUTION	DESCRIPTION
Seasonal overdrafts and short-term agricultural loans	A current account with seasonal overdraft facilities or a short-term loan caters for cash flow fluctuations, which are highly prevalent in the agricultural market.
Agri instalment sale agreement	Finances all types of agricultural equipment and machinery (for example, tractors and farming implements) with flexible repayment options, such as annual payments and extended repayment periods of up to 10 years, depending on all life expectancy and depreciation.
Agri medium-term loan (AMTL)	Finances productive assets (for example, breeding herds of cattle) or enhancing existing assets, and includes an option to withdraw surplus funds arising from excess payments.
Agri production loan (APL)	Finances production inputs such as maize, soya and wheat. It takes into account seasonality, the need to hedge prices, as well as the necessity for crop insurance.
Agri bond	Finances fixed property and capital improvements to fixed property. It is flexible finance to buy or enhance fixed property, incorporating interest-only periods and repayment options up to 15 years.
Agri debtor finance	Helps maintain a constant cash flow, keep administration costs down, and reduce the risks associated with the debtor book.
Agri trade finance	It includes post-import and pre-export financing, and discounting of bills.
Specialised finance and BEE	Provides debt structuring for acquisitions, management buyouts and leveraged buy-ins, and offers loan financing to black-owned businesses in the agricultural market.

Source: Rossouw, 2014; Goosen, 2014 and Burger, 2014

2.9. Conclusion

This chapter presents an overview of the South African grain industry, with an emphasis on the Western Cape. In terms of production and consumption, the Western Cape produces surplus wheat

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in the local market. Before deregulation the situation was even more favourable towards wheat production. Different wheat-producing systems were implemented following the abolition of the Wheat Marketing Board. A number of alternative crops became part of a typical production system, including canola, lupins, oats and medics pasture.

Of the two major Western Cape wheat-producing areas, the Southern Cape region, to a greater extent, has diversified its wheat production. Approximately 17 per cent of its total cultivated land is allocated to wheat production whereas the Swartland region has almost 33 per cent of its total cultivated land under wheat monoculture. The wheat monoculture system has a negative impact on the long-term farm profitability. Alternative to wheat monoculture is crop rotation with either a grain and/or pasture system, which offers an opportunity for higher whole-farm profitability over the long term. However, for farmers to switch from wheat monoculture to a crop rotation with pasture system, they must invest in pasture establishment, purchase livestock and forfeit income from grain production. As a result, they will experience a period of lower cash flow and have to realise some sunk cost.

This chapter also reviews the literature on crop rotation systems and their impact on farm profitability, sustainability and total risk. The benefits and challenges associated with adopting crop rotation systems and cropping sequencing for sustainable production systems have significant influence on farmers' management decision-making. The impact of crop rotation on risk is also significant, specifically the interaction between crop rotation as a risk mitigation strategy and risk balancing. Mainly, this is done by illustrating the relationship between business risk and financial risk in a typical farm that has adopted a crop rotation system as either a risk mitigation or profit maximisation strategy.

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Chapter 3 : Approach and Methods

3.1. Introduction

Agricultural production systems are complex in nature and often associated with high levels of uncertainty despite available information that assist farmers decision-making. According to Checkland (1993), a system is considered complex if it comprises interrelated parts. In agricultural production, enterprise, regional and international systems are interwoven and their relationships increase the complexity of the decision-making environment (Banson et al., 2014). The diversity of crops and livestock, implementation and adoption of new technologies, as well as the variability in products and input prices also play a major role in the increasingly complex nature of farming systems (Hoffmann, 2010).

Consequently, farmers are faced constantly with the prospect of having to anticipate consequences, without comprehensive information on the systems used in their management activities. This has influenced economists to search for enhanced approaches and methods to analyse and explain agricultural systems. The systems approach, or methodology, and methods of constructing models and developing simulation techniques has been adopted and further developed to be used in an agricultural context. Taking a whole-farm systems approach enhances the understanding of the farm management decision-making environment.

This chapter provides an overview of the literature on systems thinking, as well as the use of a typical farm in modelling whole farm systems. The first section of the chapter reviews the literature on general systems thinking, and its advantages and limitations in farm management studies. The second part gives an overview of concepts and the use of a typical farm in farm management research.

3.2. Systems thinking

The development of agriculture over the past century has been marred by negative trade-offs; hence, the introduction of systems theory aimed at providing concepts and tools to understand better the complex development of agriculture (Schiere et al., 2004). The term *systems thinking* refers to an activity that is as old as humankind is; however, this school of thinking was developed in the 1950s and 1960s (Bosch et al., 2007).

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The systems thinking school of thought developed a concept whereby the organisation is seen as a collection of interacting parts that must be viewed as a whole. It also played a vital role in developing agricultural research, by forcing the sub-disciplines within agricultural science (soil, animal, and plant) to come together and to be viewed as aspects of the whole-farm business (Shadbolt & Bywater, 2005).

Systems thinking views a farm system from an interdisciplinary and holistic perspective, rather than breaking it down into parts for further analysis. In mixed farming systems, both old and new concepts within systems thinking can be used to understand clearly the variation and inconsistencies in forms, processes and functions of the mixed crop-livestock systems (Van Keulen & Schiere, 2004; Banson et al., 2014). Systems approaches in agriculture developed from a number of different traditions, which may not inform one another. This school of thought is more diverse than is often realised (Figure 3.1) (Ison et al., 1997). Systems thinking developed from a "hard" systems approach to a "soft" systems approach. In agricultural management, systems' thinking involves exploring the complexity of interactions within both the "hard" systems and the "soft" systems.

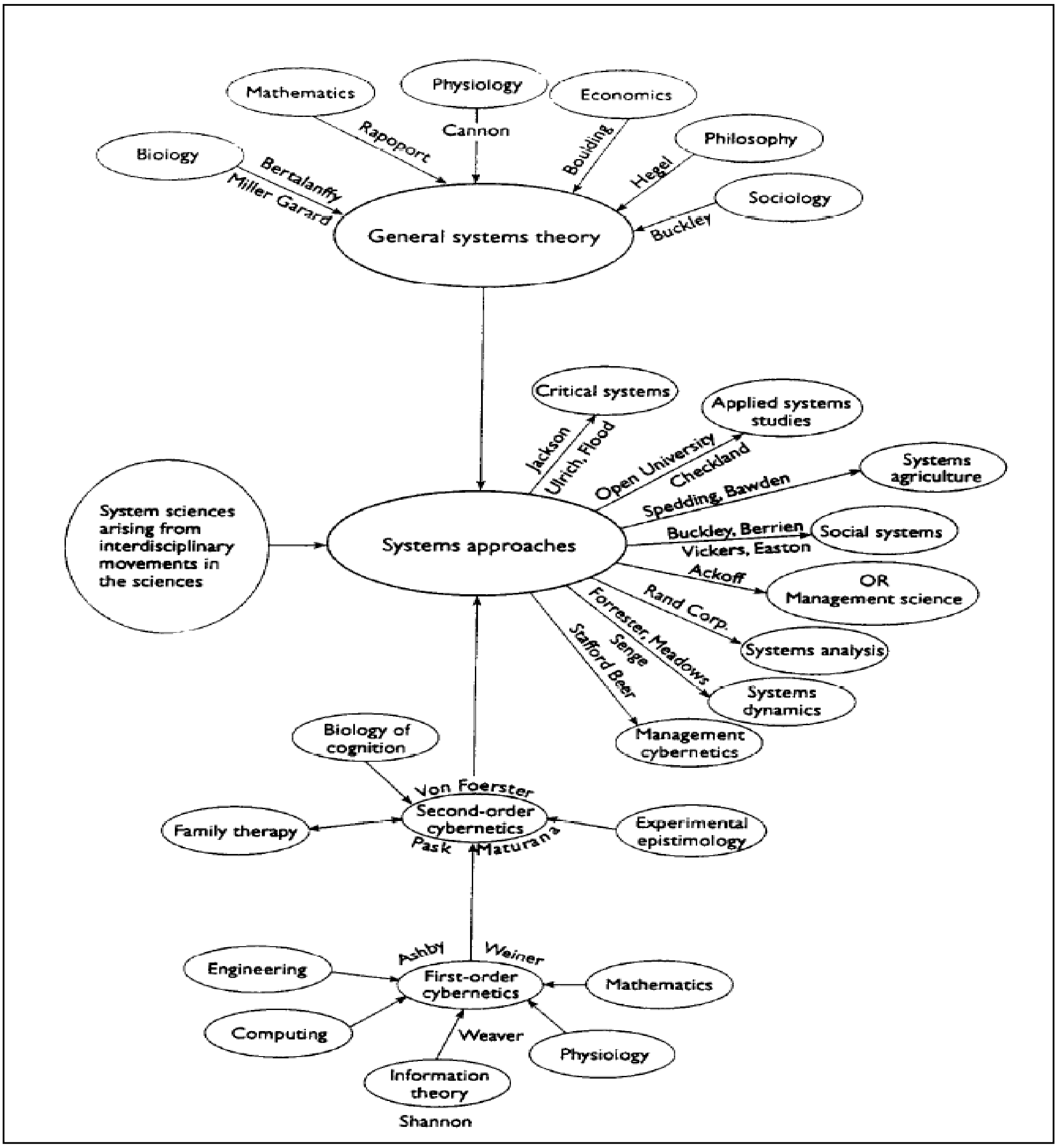

Figure 3.1: An influence diagram illustrating the different strands of the systems thinking school, and naming some key researchers

Source: Adapted from Ison et al., 1997

Hawkins (2009) described the "soft" systems approach as a learning process designed to determine what needs to be done in an ill-defined problem situation, while "hard" systems approaches are used to determine how to make improvements to a better-defined problem.

- **The "Hard" system and "Soft" system approaches**

Hard systems are predominant among more technically oriented disciplines. Apart from focusing on the so-called "hard facts" they also tend to focus on describing how things are, rather than on how they evolve (Van Keulen & Schiere, 2004). Characteristics of the hard systems approach are that it concentrates on observations, rather than reasoning for scenarios; focuses on parts, and not on wholes. The tools used in hard systems include multiple goal programming and crop growth modelling.

The emphasis of the "soft" systems approach is on mind-sets; it continues from where the "hard" systems approach left off. System in this sense is defined as "*a construct with arbitrary boundaries for discourse about complex phenomena to emphasise wholeness, interrelationships and emergent properties"* (Roling, 1994 cited in Van Keulen & Schiere, 2004). In short, the hard systems approach takes the world as being systemic. Thus, to hard systems thinkers, a system exists and has a clear purpose and well-defined boundaries. However, soft systems thinkers do not take the world as systematic, but they acknowledge the importance of dealing with it as if it were systematic. That is, a soft systems thinker sees phenomena as chaotic. Table 3.1 summarises the differences between the two types of thinking (Hawkins, 2009).

Following the study's main objective, as described in Chapter 1, the "hard" systems Langgewens Farm trial data has to be transposed and used to analyse and explain "soft" systems scenarios. The trial data concentrates on the hard facts and more on how things are, for instance, in terms of the yield and gross margin in the crop rotation systems, while the study's objectives include assessing various considerations that wheat producers need to take before switching to or adopting any of the crop production systems presented in the Langgewens trial data. That is, the study incorporates factors such as real interest rates, producers' opinions, prices and machinery life expectancy, with the hard facts given in the data to analyse its objectives.

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Table 3.1: Comparison between soft and hard systems methodology

	Soft systems methodology (SSM)	**Hard systems methodology (HSM)**
Philosophical approach	Constructive Oriented to learning	Positivists Oriented to goal-seeking
Ontological	Reality perceived in numerous ways Systems do exist; however, only to the extent that people agree on the goals, the boundaries and their components	Acknowledges the existence of reality Systems exist and have clear purposes, as well as defined boundaries
Epistemological	Neutral observations are impossible	Observations are not coloured by subjective aspects of the scientist or his or her instruments
How phenomena are viewed	Biophysical and social phenomena are viewed as dynamic, chaotic, changing and unpredictable	Biophysical and social phenomena are viewed as constant, regular, reoccurring and predictable
Research design	Emphasis on the use of qualitative methods and how to achieve a desired scenario	Emphasis on the use of quantitative methods, as well as on improving current problems
Purpose	Socially constructed knowledge to increase our understanding for more effective action Particularities or generalisations for one particular context Innovations	Objective knowledge Generalisation Maximising efficiency
Advantages	Available to both problem owners and professional	Permits the use of powerful techniques

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	practitioners: focus on human content of the problem situation	
Disadvantages	Accepts and acknowledges that inquiry is never-ending; hence, does not give answers	Requires professional practitioners Disruption from aspects beyond the logic of the problem situation

Source: Checkland, 1985 and Hawkins, 2009

3.3. Whole-farm systems approach

Managing a farm is inherently difficult and complex. Deciding on the best management strategy and enterprise mix is an important task for management (Pannell, 1996). An approach is therefore required that looks at a farm in a holistic manner. The approach can assist farmers in making more informed decisions on ways to manage their scarce resources, such as, financial, physical and human resources. The systems approach can also enable them to adopt the required behaviour to achieve their goals and objectives (Kelly & Bywater, 2005).

An understanding of the components of the farming system and their interactions can be achieved by applying a holistic approach; namely, a whole-farm system approach. Traditional approaches are powerful and useful, but they are less able to address questions relating to the ecological interactions of whole-farm systems, as well as their long-term environmental and economic sustainability (Luna et al., 1994).

3.3.1. Concepts in whole-farm systems approach

Systems have boundaries, which are described based on the reasons for defining a system. The first significant step to whole-farm systems management is to describe and define the "whole" that is being managed. There are many definitions of a system. Taking elements from various definitions, a system can be described as "*a set or group of components that interact to perform a function*" (Shadbolt & Bywater, 2005). Kelly & Bywater (2005) described a system as "*a grouping of elements contained within a boundary such that the elements within the boundary have strong functional relationships with each other, but limited, weak or non-existent relationships with elements or groupings outside the boundary*".

Taking into account the above definitions, to define systems in the farming context depends on the interrelationships, the characteristics and the purpose of the system. The whole systems will therefore include, among others, people, resources, and money. People includes labourers and those people who can either influence or be influenced by management decisions (clients, advisers, customers); resources includes land and other physical resources (machinery, equipment and buildings); money refers to the sources of finances available to the management of the systems, and includes cash on hand, potential for borrowing, and potential earnings generated from the resources (Kelly & Bywater, 2005).

According to Van Keulen and Schiere (2004), the term "system" in mixed farming systems implies "*a unit, with well-defined boundaries and goals, consisting of different parts that convert inputs into outputs and that work together towards a common goal*". Thus, the mixed farming systems consist of elements such as:

- Inputs and outputs;
- An external environment;
- Boundaries;
- The process of transforming inputs into outputs;
- Feedback;
- Hierarchies.

3.3.2. Whole-farm systems models

Kelly and Bywater (2005) defined a model as a simplification of reality, an abstraction, which is designed for a specific purpose, based on assumptions and data. Designing a model involves making assumptions about the objective of the study and collecting certain data. Generally, models may be manipulated to achieve certain objectives. Models, therefore, represent reality for a particular purpose, in a simplified, abstract form (Kelly & Bywater, 2005).

Modelling of farming systems at the whole-farm level started in the 1950s with the advent of powerful mainframe computers, which allowed more complex interactions to be studied (Doyle, 1990; Schilizzi & Boulier, 1997). Since its early development stage, systems theory has been bound up with mathematical models (Doyle, 1990). According to Wright (1971), this is for three reasons: firstly, the impracticality of studying the real system; secondly, the feasibility factor due to time and cost; thirdly, the act of measurement may disturb the real system to such as extent that the observation might relate to something that is artificial.

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Initially, whole-farm modelling was applied mainly to identifying the most profitable farm plan, given scarce resources. Since then researchers have also applied whole-farm modelling to analyse and understand complex whole-farm issues. This is one of the methods with which non-farmers can assess the whole-farm implication of any change to the farming system (Pannell, 1996). According to Kelly and Bywater (2005), models can be used in systems research in several ways, but basic distinctions in farm management can be drawn between descriptive or prescriptive, static and dynamic, and, linear and non-linear.

When a model is applied for descriptive purposes, it acts as a framework for identifying systems components, as well as relationships and determining satisfactory functional forms for these relationships. The purpose of a descriptive model is that of systems analysis where the objective is to gain a better and clearer understanding of the system (Wright, 1971). In contrast to descriptive models, normative models are used as attempts to solve problems. The problem may be either deviations from decision rules that will assist a decision-maker in making an optimal decision or concern with both system control and design. Unlike the descriptive model, a normative model requires some objective function to evaluate different decision rules (Wright, 1971).

Farm-level modelling is also distinguishes between a positive (simulation) or normative (optimisation) approach. The simulation approach to whole-farm modelling is widely used and ranges from simple to complex models (Schilizzi & Boulier, 1997); for instance, simple whole-farm budget models and complex biophysical dynamic simulation models (Pannell, 1996). The other category of whole-farm models, optimisation, has been used for a long time, with little or no success.

Simulation (positive) approach

The term "to simulate" means *to duplicate the essence of a system or activity without actually attaining reality itself* (Wright, 1971). Simulation is commonly defined as a technique that includes setting up a model of a real situation (system) and performing experiments on the model. In short, simulation involves modelling and experiments (Naylor, 1966). Csáki (1985) described simulation as "*an experiment of which the objective is to represent or reproduce the relationships between objects or persons in a real world and to predict the likely behaviour or response of these objects or persons in the specific system*".

Simulation neither requires nor typically involves an objective function to be optimised. However, it is an empirical technique employed to evaluate, assess, or predict the consequences of different courses of action or policies (Agrawal & Heady, 1972). Simulation embraces two distinct

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operations: the first is developing a model that adequately represents the system under study; the second is examining the behaviour of the model in reaction to changes (Dent & Anderson, 1971).

Figure 3.2 gives a general summary of the process of simulation. The simulation process is characterised by feedback. An opinion brought about by Wright (1971) on simulation methodology was that simulation is not a practical technique for farm studies and, therefore, should not be used unless the problem cannot be solved by simpler techniques. In agricultural systems, the methodology of simulation has difficulties and is not well developed. One of the main elements of agricultural management systems is the role of humans and, therefore, it is important to include human behaviour or decision-making in simulating agricultural systems. However, measuring and stimulating human behaviour or decision-making is challenging (Strauss, 2005; Strauss et al, 2008).

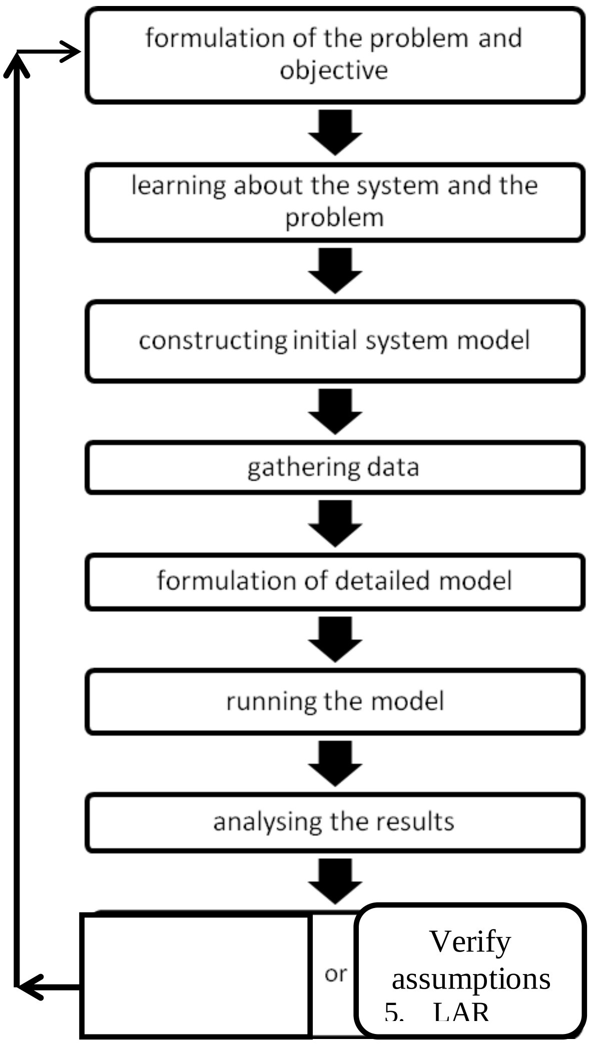

Figure 3.2: Diagrammatic illustration of the methodology of simulation

Source: Adapted from Csáki , 1985 and Wright, 1971

There are a number of methods that have been used under the positive approach. These methods include:

- Budget model
- Simulation of farm model
- Enterprise simulation model
- Production-oriented model

Optimisation (normative) approach

The normative approach to farm-level modelling optimises a goal function; that is, it shows what "should" happen to a certain system. Five main methods are used under the normative approach, namely:

- Mathematical statistics
- Production functions
- Input-output analysis
- Mathematical programming
- Network analysis

The main difference between simulation and optimisation is that optimisation specifies the behavioural assumption, whereas simulation does not. Nonetheless, both the approaches are systems of equations and/or inequalities created to imitate the farm-level activities linked to production, marketing and finance. The types of models utilised in farm management range from conventional budgeting methods to a range of decision models, which are based on statistical and mathematical equations aimed at optimising resource allocation to reach a predetermined goal. The most commonly used quantitative models are budgeting models, estimation models, simulation models and linear models (Hoffmann, 2010).

3.4. Whole-farm budget modelling

Hoffmann (2010) described budgeting as a non-optimising method that evaluates plans in physical and financial terms. Because they are simple to use, budget models are often widely used as a financial planning technique. Budget models are also used as comparable quantitative techniques

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and play a significant role in benchmarking. Budget models were classified as a simulation-type model after the development and introduction of computers. Since then, budget models have been used as dynamic planning and decision-making tools, based on accounting principles and methods, rather than on pure mathematics.

The introduction and application of budget models dates back as far as the inception of agricultural economics and extension. Since the early years, budget models have been based on standard accounting principles to generate comparable information for analyses and serve as benchmarking information. However, in academic studies, budgeting was considered straightforward and practical, and did not justify much attention in the academic literature. Nonetheless, it has been used in research continuously since the introduction of more sophisticated quantitative methods.

An important feature of budget models is that they are simulation models, mostly developed using spreadsheet programs. Within spreadsheet programs, complex and sophisticated calculations and relationships can be expressed by the amount of interrelationships that can be connected. The complexity and sophistication of budget models is enhanced by their ability to accommodate details, adaptability, as well as user-friendly factors. Whole-farm budgets are constructed to illustrate anticipated consequences in terms of parameters, proposed farm plans and other criteria.

Whole-farm budgets include both financial and physical parameters, and often generate profitability criteria such as net farm income and cash flow. Furthermore, whole-farm budgeting quantifies and subtracts fixed costs to produce a net farm income value. The calculated net farm income is suitable with compare the financial performance of various farm units (Hoffmann, 2010). By including some adaptation factors, these models may also be extended, over time, to calculate returns on capital invested and to calculate profitability indicators such as the internal rate of return on capital investment (IRR) or the net present value (NPV) (Hoffmann, 2010).

3.5. Typical farm technique in systems thinking methodology

The use of the typical farm approach has a long history in evaluating profitability at the farm level with initial studies applying the linear programming method and later substituted by budgeting to add additional flexibility and scope to studies field (Elliott, 1928). The typical farm technique proved to be a useful research technique in terms of providing guidance to farmers for making decisions. As in the study conducted in the Swartland region by Dr Hoffmann (Hoffmann, 2010). The application of typical farm models encouraged the shift from a traditional production-cost approach to a whole-farm systems approach wherein farming systems are viewed as units comprising the totality of production and consumption decisions (Hoffmann, 2010).

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Farmer-households are inherently different: they have different resources and face different challenges. They are likely to face distinctive decision-making problems, with unique solutions. Furthermore, the variety of factors of managerial ability, financial and economic circumstances, soil and physical characteristics, and farm resources imposing on the farmer's net income are numerous. No farms are the same in terms of factors determining net income. This encouraged the development of a typical farm approach to whole-farm systems research (Carter, 1963; Köbrich et al., 2003).

A typical farm is a "*model farm in a frequency distribution of farms from the same universe*" (Carter, 1968). The typical farm approach helps eliminate the so-called "blanket recommendations" in farming systems research segregating farms into homogenous groups with farm attributes determined by quantitative procedures that allows for recommendations for specific groups (Carter, 1963; Feuz & Skold, 1992; Köbrich et al., 2003).

Initially, studies based on typical farms applied a linear programming method. This was substituted by budgeting in past decades. The shift from linear programming to budgeting has been found to bring additional flexibility and scope to studies conducted in the agricultural economics field (Elliott, 1928).

3.6. Research methodology justification

A study done by Schultz (1939) emphasised the need for farm management research to provide a basis for guiding entrepreneurial decision-making when economic changes confront farmers. Schultz (1939) indicated that farms are complex in nature, and research should incorporate some theory of risk and uncertainty to provide more realistic guidance to farmers. In farm management research, the typical farm approach applies a budgeting technique using timeous programming capable of incorporating large numbers of variables to model variations in product prices, costs, resources availability and production coefficients (Carter, 1963).

The typical farm approach has its own critics, just like any other research methodology. It have been criticised for being static in nature whilst farms operate in a dynamic environment, and hence provide limited guidance to farmers (Carter, 1963).

3.7. Conclusion

The first section of this chapter focuses on general systems thinking and farm systems modelling. The introduction of the systems thinking approach is done to provide the concepts and tools to

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understand better the complexity of agriculture. The systems thinking school of thought developed a concept whereby the organisation is seen as a collection of interacting parts that must be viewed as a whole. It views the farm system from an interdisciplinary and holistic perspective, rather than breaking it down into parts for further analysis.

The soft systems approach is a learning process designed to determine what is to be done in an ill-defined problem situation, while the hard systems approach is used to determine how to make improvements to a better-defined problem. The distinction between the two approaches was influenced by the nature of the data used in the study. The study used the data from the Langgewens Research Farm trial that was captured to make improvements to crop yields and gross margins. This data was used to determine what needs to be done to construct scenarios for farmers' decision options when considering adopting crop production systems in order to improve their farm profitability.

Two approaches to systems modelling are discussed, namely, the normative approach and the positive approach. A model is a simplification of reality, an abstraction, which is designed for a specific purpose, based on assumptions and data. Farm-level modelling can be either positive or normative. Simulation involves setting up a model of a real situation and performing experiments on the model. The normative approach shows what should happen to a certain system.

Whole-farm budget modelling, as a technique to be applied in the following chapters of this study, is reviewed. Budgeting is a non-optimising method that evaluates plans in physical and financial terms. Budget models are used as a comparable quantitative technique, and they play a significant role in benchmarking. They are classified as simulation-type models and were developed using spreadsheet programs. Whole-farm budgets include both financial and physical parameters, and often generate profitability criteria such as net farm income and cash flow. Budgeting, in spreadsheet programs, allows for the capturing of the complex interrelationships inherent in farm systems and for relating such relationships, through a sequence of equations, to profitability criteria.

The last section of this chapter considers the typical farm approach as a guide to decision-making in the whole-farm approach. The typical farm technique is a useful research technique in providing guidance to farmers for making decisions. Application of the typical farm model has encouraged a shift from a traditional production-cost approach to a whole-farm approach. A typical farm is a "*model farm in frequency distribution of farms from the same universe*". It eliminates the so-called "blanket recommendation" in farming systems research.

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Chapter 4 : Implementation framework of the whole-farm systems approach and typical farm modelling

4.1. Introduction

Following the overview of wheat production in Chapter 2 and Chapter 3's description of approach and method, Chapter 4 describes the data collection used in whole farm multi-period budget model.. Establishing the financial benefits of the various systems is important in directing which systems should be adopted. Crop rotation data is available for the Langgewens Research Farm crop rotation trial, as discussed in Chapter 2. To understand the implications of the crop rotation system at the whole-farm level, and the implications of altering the crop rotation system, the trial data needed to be captured into a whole-farm budget model.

The first part of Chapter 4 outlines the study area and procedures followed to construct a typical farm model suitable for grain producers in the Middle Swartland area. The second part applies conceptual systems thinking techniques in analysing financial implications and considerations of switching from wheat monoculture to alternative crop production systems.

4.2. Description of the study area

The Western Cape province is divided into five administrative areas; that is, West Coast, Boland, Cape Metropole, Overberg and the Little Karoo. Wheat is only produced in three of these regions: the Little Karoo, Overberg and the West Coast. However, the major wheat-producing areas of the Western Cape are situated in the Swartland and Southern Cape regions.

The Swartland region, shown in Figure 4.1, is one of the two major wheat-producing areas in the Western Cape; when compared with the Southern Cape region, it has more cultivated land allocated to wheat (Coetzee, 2014). The Swartland region has unique challenges for wheat producers, the most important being that of the dry summers. A typical farm within the Swartland region was used as basis for comparing the systems. The typical farm parameters were adopted from a recent study done by Hoffmann (2010) in the Swartland.

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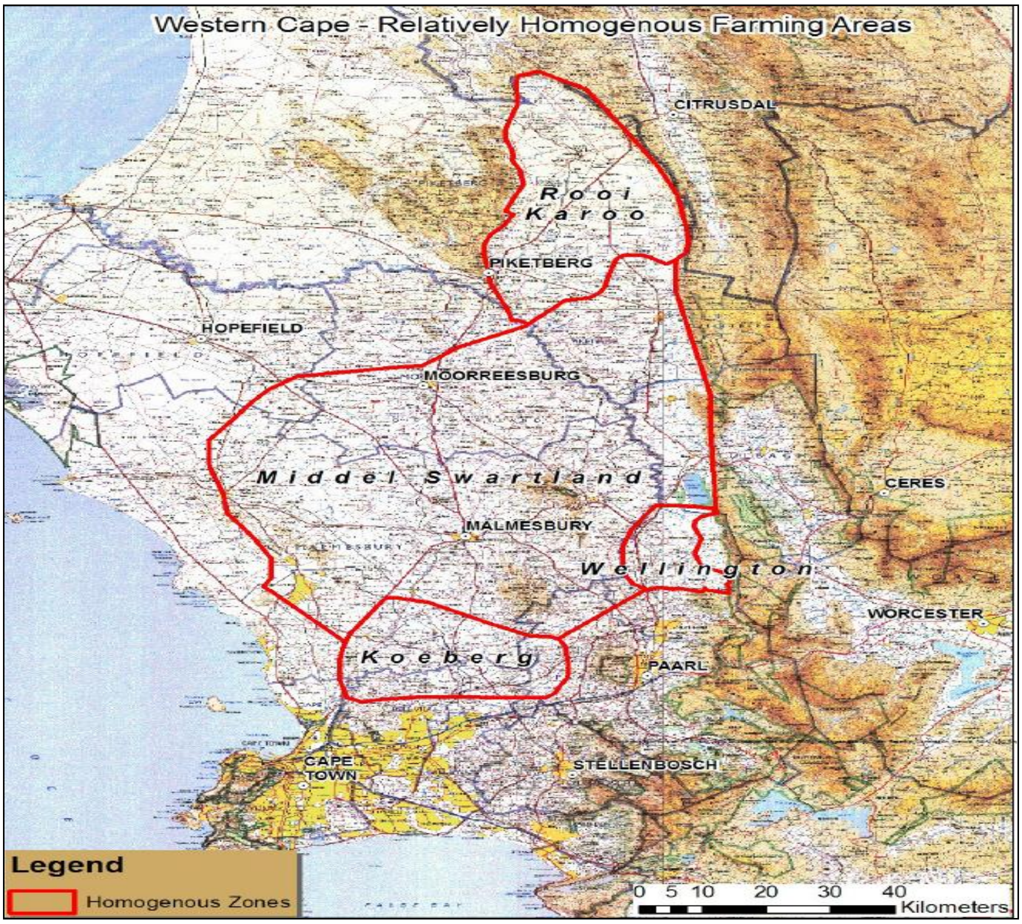

Figure 4.1: Swartland region Map

Source: Adapted from Hoffmann, 2010

4.2.1. Typical farm description

Carter (1963) argued that a typical farm, or representative farm, should be defined meaningfully, relating to the objective of the study. He argued also that the advantages and limitations of this approach should be viewed in context with the manner in which the technique is applied and the availability of alternative methods. In this study, the typical farm is used to represent a farm with physical parameters to which producers in the Middle Swartland can relate.

4.3. Data collection

The study used data recorded from the trial conducted at the Langgewens Research Farm over the past 17 years. A detailed description of trial and agronomic results are provided by Hardy et al. (2011). For each year, all direct and indirect variable input costs per hectare and gross income per hectare (less marketing costs) for each crop, and for the sheep component of each rotation system being tested in the trial were recorded (Hardy et al., 2011).

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Production and economic/financial performance data was sourced from the Western Cape government's Department of Agriculture through personal communication with agronomists and animal scientists working with the on the Langgewens Research Farm. Data on the financing instruments and products used to finance grain was obtained from representatives of commercial banks using a semi-structured interview. Prices for running a typical grain and pasture farm were obtained from experts working with grain farmers. However, prices for new machinery items were obtained from the *Guide to Machinery Cost for Western Cape Grain Producers* (2014). The Grain SA website (2014) and the South African Reserve Bank website (2014) were also used to extract data on current overall annual costs of running a typical grain farm, and the current inflation and interest rates.

A convenience sampling technique was used to select the participants in the data collection process, for both the semi-structured interviews and telecommunication discussions. The process of selecting appropriate participants was guided by the field of expertise required for this study. Participants in semi-structured interviews included experts from the field of agricultural finance, agricultural economics and agronomy. Representatives of commercial banks offering agricultural finance were selected by identifying the heads of the agribusiness division within the respective institutions. The agronomists consulted were those working closely with grains and crop rotation trials in various institutions, such as the Western Cape Department of Agriculture, KAAP Agri, and Grain SA. Experts consulted are included in Annexure 5.

4.3.1. Semi-structured interviews

This is a qualitative research technique used for data collection. It revolves around a few central questions. A semi-structured interview gives a researcher and participant much more flexibility: the interviewer is able to follow up particularly interesting avenues that arise in the interview, and the interviewee is able to give a broader picture. In this study, semi-structured interviews were used in order to gain a detailed picture of the financing of grain farmers by commercial banks and their perception of grain production, particularly wheat. Predetermined questions were set on an interview schedule. However, the interviews were rather guided, and not dictated by the schedule.

4.4. Technique used for whole-farm financial analysis

The complexity of the farm system requires that a tool used to describe the farm in financial terms be capable of incorporating accurately the wide variety of factors and relationships of the whole

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system. A whole-farm multi-period model as developed for a typical farm by Hoffman's (2010) was used in this study to measure whole-farm profitability of selected scenarios.

The motivation for using budget models in this study was based on their ability to incorporate three issues that are of significance to farm modelling. The first issue is the model's ability to incorporate issues at the farm level. The second issue is the financial conditions, the economic consequences, as well as the interdependencies involved in the marketing of goods produced. The third issue is the capturing of the technological-biological interrelationships of the production activities. Another advantage of the whole-farm budget model that motivated its usefulness in this study is its adaptability to extension over time to calculate the profitability of certain enterprises and the return on capital investment (Hoffmann & Kleynhans, 2014).

Various factors directly or indirectly influence the financial performance of a farm. Prices and quantities of outputs and inputs impact directly on the profitability of the farm as a whole. This study needed to establish the potential effect of such factors on the profitability of the typical farm over the long run. The model was applied for two purposes: firstly, to determine the current financial position of the typical farm, and, secondly, to calculate the financial impact of switching between cropping systems on the whole-farm operation. The second goal is measured in affordability or cash flow analysis.

The first task of the modelling process was to establish the initial profitability that would serve as the basis for comparison. The complexity of the farm needed to be captured. Factors and interrelationships that influence and determine profitability were focused on. These factors are parameters that allow for the possibility of manipulation and that could quickly illustrate the financial impact on the entire farm. The model was designed to be able to accommodate all the factors and functions illustrated in Figure 4.2.

The model consists of various sets of data and calculations that are interconnected and are based on standard accounting principles (Hoffmann & Kleynhans, 2014). The basic structure of the model can be summarised in three components; that is, the input component, the calculation component and the output component. The spreadsheet budget model can accommodate alterations in terms of prices, replacement of machinery, input cost items, farm size, crop rotation, and own-to-borrowed capital ratios (Hoffmann & Kleynhans, 2014).

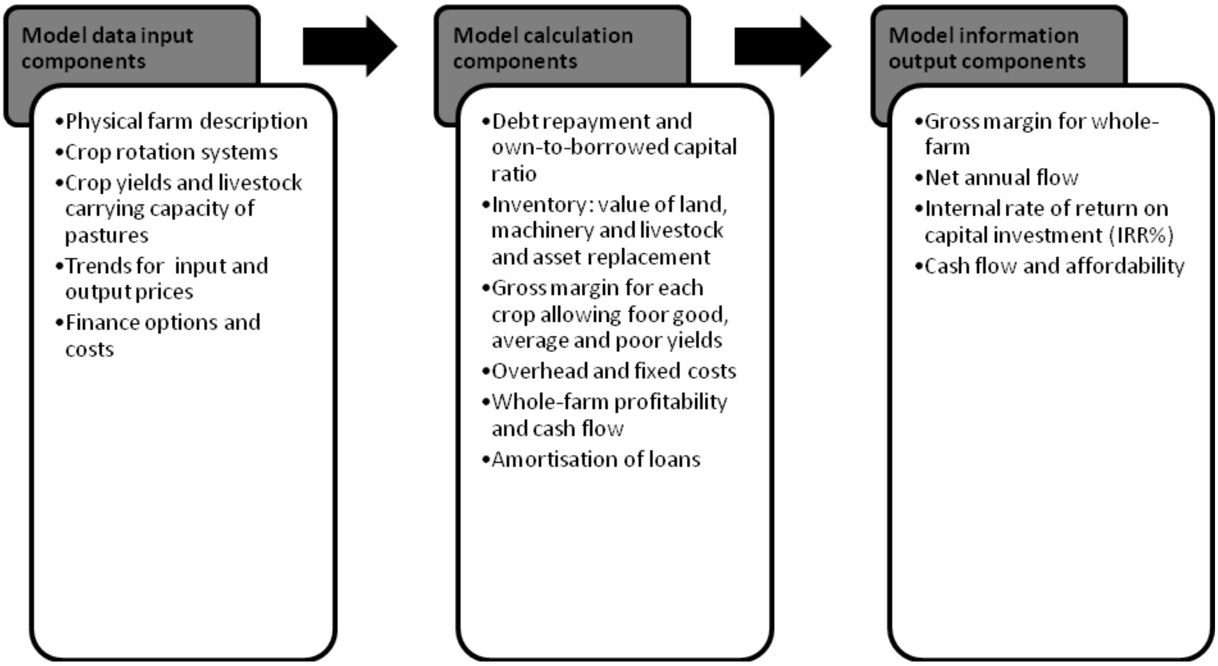

Figure 4.2: Components of whole-farm multi-period budget model

Source: Adapted from Hoffmann & Kleynhans, 2014

4.5. The whole-farm multi period budget model

The budget model components include input data, calculation and output components as described in Table below. The evaluation criteria used in assessing the profitability of each cropping system and the affordability of switching between cropping systems at the whole-farm level are highlighted. Calculations and assumptions made for each of the components are clarified, and the model validation processes are briefly explained.

4.5.1. Input data component

The input component of the whole-farm multi-budget model comprises the following: physical farm description, crop rotation system, crop yields and livestock carrying capacity of pastures, trends for input and output prices, and finance options and costs. Adapting all these factors impacts on the output component, through a sequence of calculations, which are based on the interrelationship between the components.

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4.5.1.1. Farm's physical description

Farm size forms the basis of the budget model determining numerous other factors and is considered by Hoffmann & Kleynhans (2014) as an important first assumption in the typical farm model. Factors that rely on, and or change with farm size alteration include land utilisation, cultivated area under each crop, mechanisation requirements, investment in fixed improvements, and investment in land, number of permanent labourers required and various other fixed costs. This study adopted the typical grain farm representative of the Swartland region developed by Hoffmann & Kleynhans (2014) and Hoffmann (2010). The following adaptations were made to the farm description to align it with the central part of Middle Swartland:

- Machinery requirements and usage
- Running/production costs
- Inventory registry calculation
- Managerial aspects

This decision was made based on the origin of the trial data used; that is, from the Langgewens Research Farm, as a smaller area of study was deemed more homogenous, and producers might switch systems more easily as they can relate to the Langgewens trial (Strauss, 2013; Coetzee, 2014).

The financial and physical extent of the typical farm was established in three phases. The first phase entailed describing the farm in physical terms based on data obtained from the producers study group. The second phase involved the expert groups' validating the proposed homogenous areas. The expert group was composed of agronomists, soil scientists, entomologists, agricultural economists, representatives from agribusinesses and local producers (Hoffmann, 2010). Thirdly, the relatively homogenous production areas were used to characterise the geographical areas and attributes such as included farming practices, typical crop rotation systems, typical machine replacement policies and affiliations to agribusinesses (Hoffmann & Kleynhans, 2014).

The financial performance of a typical farm may also be influenced by land usage, land usability as well as land ownership. Total land comprises both rented and own land, with rented land influencing the factor cost component of the model.

Own land and the assumed own-to-borrowed capital ratio determine the loan repayment requirements, which then impact on the expected cash flow. A general assumption of 20 percent

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borrowed capital was implemented, according to study group information from the Middle Swartland area (Coetzee, 2014). This is an important part of this study, as not only are alterations to crop production systems important, but also the rate of change.

Land usage illustrates the number of hectares in which each crop is cultivated and, therefore, depends on the crop rotation system, as well as the total cultivated area. Within the model, the crop rotation system can be manipulated to incorporate other crops or other sequences of crops. The model automatically adjusts the number of hectares under each crop with changes to crop rotation systems, using a series of "DSUM" formulas.

4.5.1.2. Input and output prices data

The budget model accommodates a list of prices for all production inputs, such as machinery costs and directly allocated inputs like seeds, fertilizers, chemicals and fuel. The list of prices is arranged into data tables that comprise price columns and quantity columns for the calculation of the enterprise's budget and inventory. The same was done for fixed and overhead costs. The data tables are incorporated into the model so that prices for alternative products or items can be selected quickly. The tables include units in which products are sold, the unit prices, typical or recommended application level and calculated value per hectare.

Seed costs are influenced by seed prices and the seeding densities for each crop. Seeding densities vary significantly from area to area and on the same farm, due to soil quality, cultivation methods, expected yield and technology. Variations in both seed cost and seed densities are adapted within the model. Thirty per cent of own seed was taken into account in determining the cost of seed. This percentage was used to substantiate the grain harvest that producers keep as seed for planting material for the next crop.

Prices, as well as the quantities of three main components of fertilizer were included; namely, N (nitrogen), P (phosphorus) and K (potassium). Chemicals were included in the model based on the cost per hectare, as their variety was too large to model. These prices, or costs, were kept constant for good, average and poor years. The running costs of machinery were incorporated directly in the activity costs calculating sheet, and inputted directly in the inventory calculating sheet. Differentiations were made between machinery requirements incurred for a typical pasture farm and a typical cash crop farm.

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4.5.1.3. Farm's financial description

The financial description of the farm is expressed in the form of an inventory; that is, it expresses the physical extent of the farm in financial terms. The inventory calculates the sum of the investment requirements for all assets. Items such as land, fixed improvements, machinery, equipment and livestock, as well as livestock handling facilities are included in the inventory. Since all these factors are dependent on the farm size, the inventory calculation sheet accommodates the alteration in farm size by automatically adjusting other factors. The livestock carrying capacities of pasture, as well as the field capacities of machines were used as bases for the assumptions determining moveable assets.

4.5.2. Calculation component

The calculation component of the budget model comprises the different calculations and interconnections that relate and link the various input parts to generate valid affordability and profitability outcomes. The model's calculation component was constructed using standard accounting principles; for example, factors such as total area that needs to be cultivated, time available for the activity, as well as the capacity of the machine and implements that are used to calculate the mechanisation requirements.

4.5.2.1. Inventory calculating sheet

The function of the inventory sheet is to calculate the expected capital requirement of the whole farm. Capital items comprise land and fixed improvements (included with the land price), livestock handling facilities, machinery, tools and equipment, and livestock (for a typical pasture farm). A three-year land price average was used to calculate the total investment requirements for land. Prices for new machinery items were obtained from the Guide to Machinery Cost for Western Cape Grain Producers (2014).

The replacement period, as suggested in the *Guide to Machinery Cost* (2013), for machinery items is 12 years. However, in practice, most of the farmers replace their machinery items after approximately 15 years, due to their financial position, as well as its underusage in terms of annual working hours, compared with the standards used in the guide. The *Guide to Machinery Costs* is based on an annual usage of 1000 hours while the practice in the Western Cape and the Swartland is closer to 350–500 hours annually (Hoffmann, 2010).

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Investment in livestock was determined by herd size and herd composition, while the herd size was calculated using the area allocated to pasture and grazing capacity. Assumptions with regard to the ewe replacement policy and ram-to-ewe ratio were made to calculate the herd composition.

4.5.2.2. Gross production value and gross margin calculating sheets

Three separate budgets were compiled for each of the crops, one each for good, average and poor yield. The yields were based on total annual rainfall and rainfall dispersion during the season. Each year was then indicated in the multi-period budget as good, average or poor. Thereafter, the model selected the gross margin for the whole-farm budget, based on the type of the year, multiplied by the number of hectares planted under a specific crop. The calculated enterprise budgets comprise production value, directly allocated variables costs, and non-directly allocated variable costs, on a per hectare basis. The model was run according to various alternative sequences for good, average and poor yield years. The budget period was a randomly selected cycle of 20 years in the farm's existence.

4.5.2.3. Overhead and fixed costs calculating sheets

The overhead and fixed costs consist of permanent labour, licences, insurances, water scheme levies, fuel and maintenance on general farm vehicles, maintenance on fixed improvements, banking costs, electricity, communications costs, administration costs, as well as provision for diverse costs. Furthermore, the owner's salary is incorporated in the model as a fixed cost. The items included and the amounts of each were calculated based on farmers study group data for the Middle Swartland.

4.5.3. Model's profitability and affordability evaluation criteria

The budget model was based on a 20-year calculation period to capture the nature of the crop rotation systems, to capture the impact of changing to an alternative system, and to allow for the replacement of machinery and equipment. This long 20-year period reflects only a random period in the life of a typical farm to allow for comparable evaluation. The main objective of the model was to determine the current financial positions of the typical farms and to determine the relative impacts of switching between cropping systems on whole-farm profitability and cash flow. All calculations were based on constant prices, with inflation captured in the use of real interest rates for all cash flow and financial profitability calculations.

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The gross margins for each crop are calculated by looking up the gross margins according to good, average or poor yields per hectare and multiplying them by the amount of hectare under each crop, as dictated by the crop rotation system. The total area under each crop is calculated by a series of selective summing formulas. The total gross margin of each typical whole farm is the sum of the gross margins for all crops for each specific year deemed as good, average or poor. The annual fixed and overhead costs are kept constant throughout the calculation period. The capital expenditure is calculated on the inventory sheet, and the replacement of machinery and equipment is based on the life and age at the beginning of the calculating period and their expected life. The salvage value of a machinery item is subtracted from the price of the new item in the calculation.

The capital-flow budget calculates the net flow of funds, that is, gross margin minus overhead and fixed costs, minus capital expenditure. The annual net flow of funds over the calculating period is then used to calculate profitability. The following measures are used as decision criteria: (i) internal rate of return (IRR), (ii) net present value (NPV), and (iii) cash flow. IRR and NPV are calculated to express the profitability of the whole farm, and a cash flow analysis measures the affordability of the borrowed capital amount in terms of the effect of borrowed capital and interest. For this study, the cash flow analysis is important because it determines the affordability of a typical farm in adopting a switch to an alternative system, and this is the study's objective.

4.5.3.1. Internal rate of return (IRR)

IRR is the discount rate that makes the net present value of the incremental net benefit stream or incremental cash flow equal to zero (Gittinger, 1982). It is the maximum interest that a project could pay for the resources used if the project is to recover its investment and operating costs and still break even. It is that rate of return on the capital outstanding per period while it is invested in the project (Merrett and Sykes 1963 cited in Gittinger, 1982). IRR is a very useful measure of project worth, as the project with the highest IRR is preferred by farmers/investors. However, direct comparison of internal rates of return in mutually exclusive projects can lead to erroneous investment decisions; hence, the recommended use of the net present value criterion. The internal rate of return is the discount rate at which (Perkins, 1994):

$$NPV = \sum_{t=0}^{n} \frac{(B_t - C_t)}{(1+r)^t} = 0$$

Where

$\mathbf{B}_t$ is the project income in period t

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$\mathbf{C}_t$ is the project cost in period t

$\boldsymbol{r}$ is the appropriate discount rate

$\boldsymbol{n}$ is the number of years over which the income and cost of the project are taken into account

4.5.3.2. Net present value (NPV)

The net present value of a project is obtained by discounting the stream of net incomes produced by the project over its lifetime. In short, the NPV of a project is the present value of its net benefit stream; its formula is (Perkins, 1994):

$$NPV = \sum_{t=0}^{n} \frac{(B_t - C_t)}{(1+r)^t}$$

Where

B_t are project benefits in period t

C_t are project costs in period t

r is the appropriate financial discount rate

n is the number of years for which the project will operate

4.5.3.3. Cash flow analysis

The cash flow measures the affordability of the borrowed capital amount in terms of cash flow. This is done to establish the effect of borrowed capital and interest, and incorporates only cash items. To establish the impact of interest payments on the farm's bank balance, the three-year average nominal interest rate is converted to a real interest rate. The calculation for converting the nominal rate to the real rate is done using the following formula:

$$Real\ interest\ rate = \left\{\left[\frac{(1+N_i)}{(1+I_i)}\right] - 1\right\}\%$$

Where

N_i is the nominal rate

I_i is the inflation rate

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As a consequence of their ability to calculate breakeven years or illustrate periods of positive and negative cash flow, cash flow budgets are used to establish the affordability of borrowed capital, as well as the replacement of mechanisation items. Affordability is measured in the breakeven time after a shift, and the indication of times and levels of cash shortages.

4.6. Conclusion

This chapter outlines the methodology followed in this study, as well as the data collection strategies employed. A typical farm within the Middle Swartland was constructed and used as the basis for the comparison between systems. The typical farm parameters are adopted from a recent study conducted in the Swartland region. Some adaptations were made for the farm description to align it more closely with the study area.

Empirical data from the Langgewens Research Farm trial is used. It includes other parameters such as current prices, interest rates and machinery usage descriptions, to allow the simulating of scenarios. Semi-structured interviews were used to identify the financing options available and accessible to grain farmers in the Western Cape. Options identified were from the commercial banks, agribusinesses and the Land Bank. The study included agricultural economists, animal scientists, agronomists and producers to establish the typical farm. Representatives of the commercial banks offering agricultural finance were selected by identifying the heads of the agribusiness division within the respective institutions.

To describe the farm in financial terms required a tool that was capable of incorporating accurately the wide variety of factors and relationships of the whole-farm system. Hence, the study developed and adopted the whole-farm multi-period budget model. The model has the ability to incorporate issues at the farm level, the financial conditions, the financial consequences, as well as the interdependencies involved in the marketing of goods produced, and the capacity of the technological interrelationships of the production activities.

The model has three main components: the input data component, the calculation component and the output component. The budget model is based on a 20-year calculation period, to capture the nature of the crop rotation systems, to allow for the replacement of machinery and equipment, and to capture the impact of switching to alternative crop production systems. The main purpose of the model was to determine the relative impacts of switching between cropping systems on whole-farm profitability and cash flow.

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The last section of the chapter describes the evaluation criteria used in assessing the profitability of each cropping system, and the affordability of switching to alternative crop production systems. Three evaluation criteria are used, the NPV, IRR and cash flow analysis. The NPV and IRR are calculated to express the profitability of the whole farm, and a cash flow analysis is done to measure the affordability of the borrowed capital amount in terms of the effect of borrowed capital and interest.

Chapter 5 : Financial impact of switching to alternative crop production systems

5.1. Introduction

Chapter 4 discusses the structure of the typical whole-farm multi-period budget model used in this study. The model is designed to determine the likely effect of adopting, or switching to alternative crop production systems on a typical grain farm’s financial position. The model is designed to analyse the farm-level adjustments that would take place due to changes to crop production systems; it also evaluates the strategies to adopt such changes. These are the possible factors that need to be considered when adopting the switch, in order to sustain the farm and realise profit.

The current financial position of a wheat monoculture production system on the typical farm is assumed as the point of departure for all the comparisons. This chapter provides the financial description of the typical farm, as well as the profitability resulting from various crop rotation systems. Proper care was taken in capturing various prices into the model, and basic accounting principles were adhered to. To substantiate the advantages and benefits of crop rotation systems given in Chapter 2, this chapter gives the results of the typical grain farm model on the financial implication scenarios. Various scenarios are simulated to assess the impact of switching from a wheat monoculture system to the alternative crop production systems. The systems evaluated are based on promising expected financial outcomes and their relatively easy adoption from a practical point of view.

5.2. Typical farm investment requirements

An inventory for each of the crop rotation systems was compiled and used to assess the investment requirements of a typical grain farm in the Swartland region. An inventory, or assets register, is a statement of all the physical assets of the farm business. An inventory records the size, quantity and currency value of assets such as land, fixed improvements, machinery and stocks. The following are included in the inventories of typical cash crop and pasture farms:

- Size of the farm and valuation of the production unit
- Description and valuation of fixed improvements
- Investments in vehicles, machinery and equipment, as well as their numbers and types
- Numbers and types of investments in livestock

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The inventory is used to calculate the expected capital requirements for the whole typical farm, for a cash crop system, and for a pasture system. An inventory determines, in financial quantities, the sum of all assets required to farm sustainably and profitably. These provide the total capital requirement and, thus, the basis for calculating the expected return on investment, in this instance the IRR and NPV.

The prices for all machinery items were obtained from the Guide to Machinery Cost for Western Cape Grain Producers (2014) and Guide to Machinery Cost (2013). The choice of guide was influenced by the variation in average usage of machinery in the Western Cape compared with other parts of the country. For instance, the Guide to Machinery Cost bases annual average usage on 1000 hours per annum whereas, according to Rautenbach (2007 cited in Hoffmann, 2010), average annual machinery usage in the Western Cape varies from 300 to 350 hours per annum.

Prior to inventory calculations, assumptions on the operating area, operating time, as well as the machinery capacity were used to determine machinery requirements. Inventory for all typical grain farms was based on similar assumptions whereas changes in machinery assumptions were made for grain and pasture typical farms. Farm prices for dryland grain production in the Middle Swartland over the past three years was R24 000/ha. The typical farm size and the price of land contribute to the investment requirements. The carrying capacity of pastures and herd camps determine the required investment in livestock.

Table 5.1 shows the capital requirements for a typical grain farm, which is, for a 1000 ha farm, R33 041 299. Compared with a typical grain farm, the capital requirement for a typical grain and pasture system is R37 322 568, as shown in Table 5.2. The expected lifetimes of all machinery are based on the Guide to Machinery Cost for Western Cape Grain Producers (2014) and Finance and farm management (Van Zyl et al., 2013).

Table 5.1: Inventory for system A – wheat monoculture

Item			Amount (ha)	R/item	Value R
Land including fixed improvements			1000	24000	25060000
Mechanisation					
Item	**Price/new R**	**Current Age (years)**	**Expected Lifetime**	**Depreciation R**	**Value R**
Combine harvester					
1 x 240kW	3440000	5	13	1433333	2006667
Swather					
1 x 7m	698500	3	13	174625	523875
Tractors					
230kW	2556500	5	20	1065208	1491292
120 kW	1130500	9	20	847875	282625
120 Kw	1130500	8	20	753667	376833
70 kW	543000	10	20	452500	90500
70 kW	543000	11	20	497750	45250
Planter					
1 x 9m (no till)	1324250	4	10	441417	882833
sprayers					
18m 1500 litres	216500	4	10	72167	144333
2 X 18 m 1500 litres	216500	5	10	90208	126292
Fertilizer spreader					
2 x 1500 litres	105750	4	10	35250	70500
2 x 1500 litres	105750	5	10	44063	61688
Tine implements					
1 x Chisel plough 11 tine	111750	5	10	46563	65188
1 x harrow 1.83 m	97500	4	10	32500	65000
Trailers					
3 x 8 ton	89200	5	20	37167	52033
3 x 8 ton	89200	4	20	29733	59467
3 x 8 ton	89200	3	20	22300	66900
Water cart					
1000 litres	43500	5	100	18125	25375
Front loader					
X1	87000	3	40	21750	65250
Grain cart					
7.5t x1	596750	3	100	149188	447563
Lorry 10 ton	824500	5	20	343542	480958
LDV					
1 x 2.5 Diesel LWB	171463	2	8	28577	142886
1 x 3 litres LWB	251883	4	8	83961	167922
Tools and equipment					240000
Total mechanisation					7533666
Total Assets					**33041229**

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Table 5.2: Inventory for system E – wheat and medics rotation

Item			Amount (ha)	R/item	Value R
Land including fixed improvements			1000	24000	**26110000**
Mechanisation					
Item	**Price/new R**	**Current Age (years)**	**Expected Lifetime**	**Depreciation R**	**Value R**
Combine harvester					
1x 170kW	2675000	5	12	1114583	1560417
Swather					
Tractors					
1 x 200 kW	2223000	4	20	741000	1482000
1 x 120 kW	1130500	5	20	471042	659458
1 X 70 kW	543000	5	20	226250	316750
Planter					
1 x 7m (no till)	1088750	5	10	453646	635104
Sprayers					
1 x 18 m (1500 litres)	605000	5	10	252083	352917
Fertilizer spreader					
1 X 1500 litres	154000	5	10	64167	89833
Tine implements					
1 X Chisel plough	111750	3	10	27938	83813
Trailers					
2 x 8 ton	101000	6	20	50500	50500
2 x 8 ton	101000	3	20	25250	75750
Water cart					
1000 litres	43500	3	100	10875	32625
Front loader					
X1	87000	3	40	21750	65250
Grain cart					
21m^3	596750	3	100	149188	447563
Lorry 10 ton	824500	5	20	343542	480958
LDV					
1 x 2.5 Diesel LWB	171463	2	8	28577	142886
1 x 3 litres LWB	251883	5	8	104951	146932
Tools and equipment					240000
Total mechanisation					**6862755**
Livestock			**Amount**	**R/unit**	**Value**
Rams			26	6500	169813
Ewes			1045	3500	3657500
Replacement ewes			261	2000	522500
Total Assets					**37322568**

5.3 Comparison of the financial performance of crop rotation systems

This section compares directly allocatable variable costs, gross margin, overhead and fixed costs, capital expenditure, internal rate of return and accumulated cash flow for three categories of season described as good, average and poor for the following twelve (12) crop sequences:

- Wheat after Wheat
- Wheat after Medics
- Wheat after Canola

- Wheat after Lupin
- Canola after Medics
- Wheat after medics/clover
- Wheat second year after canola
- Wheat third year after canola
- Canola
- Lupin
- Medics
- Medics/clover

5.3.1 Directly allocable variable costs

A three-year average of the directly allocable variable costs for each crop sequence included in the crop rotation system was calculated using data from the Langgewens trial as shown in Figure 5.1.

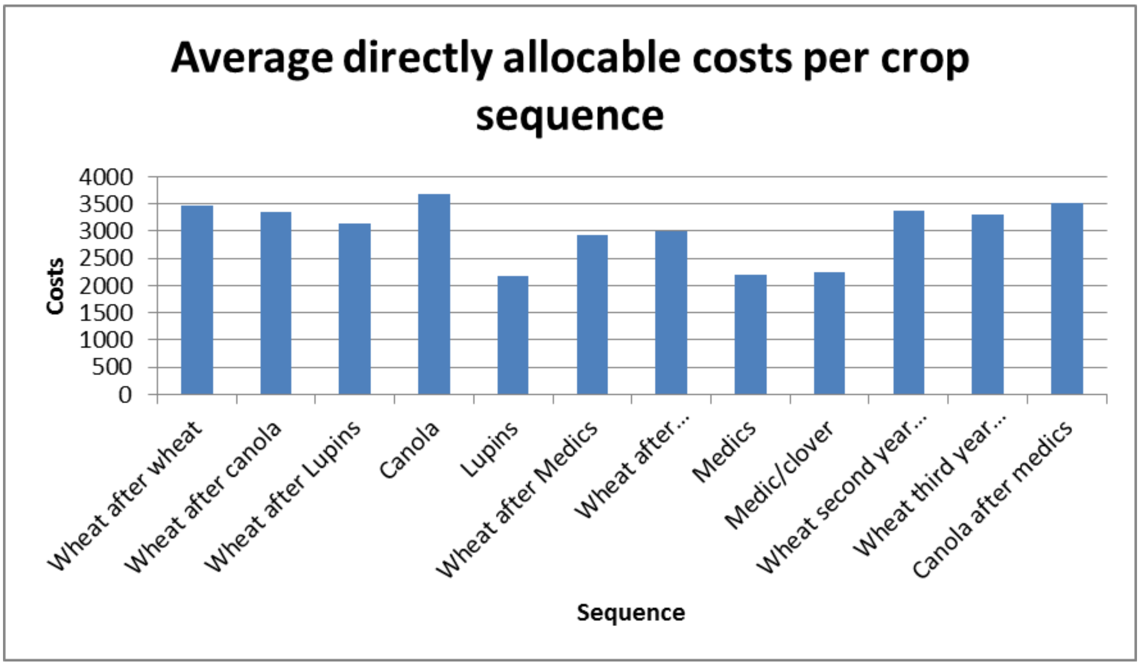

Figure 5.1: Directly allocatable variable costs

There is a marked difference in variable costs for the same crop in alternative crop sequences; for instance, the difference between variable costs for wheat cultivated after canola, wheat in the second year after canola, and wheat cultivated in the third year after canola. Wheat directly after wheat has the second highest variable cost of R3 481, following canola after medics at R3 512.

5.3.2 Gross margin

The gross margin is calculated by subtracting the gross production value (average yield multiplied by crop price) from variable directly allocable costs. This is done for each good, average and poor year of each crop included in the crop rotation system. The good, average and poor years were determined by rainfall distribution (Hoffmann, 2010). The typical yields for good, average and poor years are based on the trial data, but the prevalence and sequence of crop rotation system was determined in semi-structured interviews. The prevalence and associated yields are presented in Table 5.3. The gross margin for the whole farm is the sum of the gross margins for all individual enterprises with each system. Table 5.4 shows the gross margin per hectare, as well as for the whole farm. Wheat coming after medics or medics/clover has the highest gross margins for good, average and poor years (Coetzee, 2014; Heunis, 2014; Strauss, 2013).

Table 5.3: Prevalence of good, average and poor years, with associated yields

Summary of returns		
Wheat / Wheat	**ton/ha**	**Frequency(out of ten)**
Good year	3	2
Average year	2.4	7
Poor year	1.8	1
Canola		
Good Year	1.5	2
Average year	1.1	6
Poor year	0.5	2
Lupins		
Good Year	1.2	3
Average year	1	3
Poor year	0.5	4
Percentage increase		
Wheat after canola: Yield increase	22%	1.22
Wheat after medics: yield increase	30%	1.30
Wheat after lupin	25%	1.25
Wheat two years after canola	14%	1.14
Wheat three years after medics	8%	1.08

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Table 5.4: Gross margin for crop rotation sequence

Crop rotation sequence	Years		
	Good (R)	Average (R)	Poor (R)
Wheat after wheat	5714	3875	2036
Wheat after canola	7876	5633	3389
Wheat after lupin	8366	6067	3768
Wheat after medics	9017	6626	4235
Wheat after medics / clover	8961	6570	4180
Wheat, second year after canola	7101	-11768	2987
Wheat, third year after canola	6628	4642	2656
Canola	3133	1313	-1417
Canola after medics	4269	2194	-918
Lupins	1180	620	-780
Medics	2876	2586	2549
Medics / clover	2350	2244	2100

5.3.4 Overhead and fixed costs

Items included in the overhead and fixed costs are not dependent on the production scale and, therefore, are similar for a typical grain farm, regardless of the systems adopted. Items included in the fixed costs are water scheme fees, levies, electricity, administration costs, permanent labour, and maintenance on fixed improvements, auditing fees, and owner's remuneration. The fixed and overhead costs differ from farm to farm; however, the fixed costs of a typical grain farm in the Western Cape are approximately R1 095 (Burger, 2014). The overhead and fixed costs of a typical grain farm for each crop rotation system are shown in Annexure 1 and amount to R1 434 490.

5.3.5 Capital expenditure

The capital outlay for a cash crop system differs from that of a cash crop that includes a pasture and livestock system. Including a pasture in a typical cash crop system entails an alteration in mechanisation outlay. The capital outlay for a wheat monoculture system calculates land and fixed improvements and intermediate capital components. The capital outlay comprises combine harvesters, a swather, tractors, a planter, sprayers, a fertilizer spreader, tine implements, trailers, a water cart, a front loader, a grain cart, lorries and LDVs. Including pastures and livestock entails

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altering the capacity size and number of machines required and including livestock purchasing costs.

Capital outlay calculations are done following the inventory setup and calculations. Land and fixed improvements are calculated by adding the price of land and total fixed improvements, as calculated in the inventory sheet. The value is also incurred in each year of the entire 20-years simulated period. Intermediate capital calculations are done by extracting all the relevant machinery descriptions in terms of name, number, and age, as well as purchasing price/value from the inventory. The purchasing value is then inputted in the first year, as well as the replacement year, as guided by the life expectancy inputted in the inventory sheet. This is done for all the required machinery, and then total intermediate capital value is calculated by adding all the costs inputted in the columns representing a certain year. For a pasture system, the cost of purchasing livestock is then added. The total land and fixed improvement value plus the total intermediate value, plus the livestock purchasing value gives the total capital expenditure for a typical grain farm.

5.3.6 Profitability analysis

The profitability analysis is done over a 20-year period. A whole-farm multi-period budget model is used for calculating the NPV and IRR for each crop rotation system as shown in. Table 5.5 illustrates the expected NPV and IRR for each system within a typical farm. These are calculated on the net flow of funds for each system, for a period of 20 years.

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Table 5.5: Net present value (NPV) and internal rate of return on capital investment (IRR) for each cropping system

Crop Rotation	Net present value (NPV) R	Internal rate of return (IRR) %
system A	20 272 348	5.28%
system B	25 068 466	6.35%
system C	11 489 361	3.52%
system D	6 948 040	2.60%
system E	31 956 897	7.01%
system F	28 603 437	6.37%
system G	12 736 231	3.48%
system H	28 603 437	6.37%

Despite the high land price and consequently higher investment requirement, system E shows the highest projected profitability, with an IRR of 7.01 per cent, shown in Figure 5.2. System D is projected to have the lowest profitability, with a 4 per cent IRR. The typical capital budgets for each of systems A, B and E is presented in Annexure 2.

Table 5.5 illustrates the NPV, as well as the corresponding IRR for each of the eight crop rotation systems. In terms of NPV and IRR, system B and system E, H and F are the most profitable compared with all the other systems.

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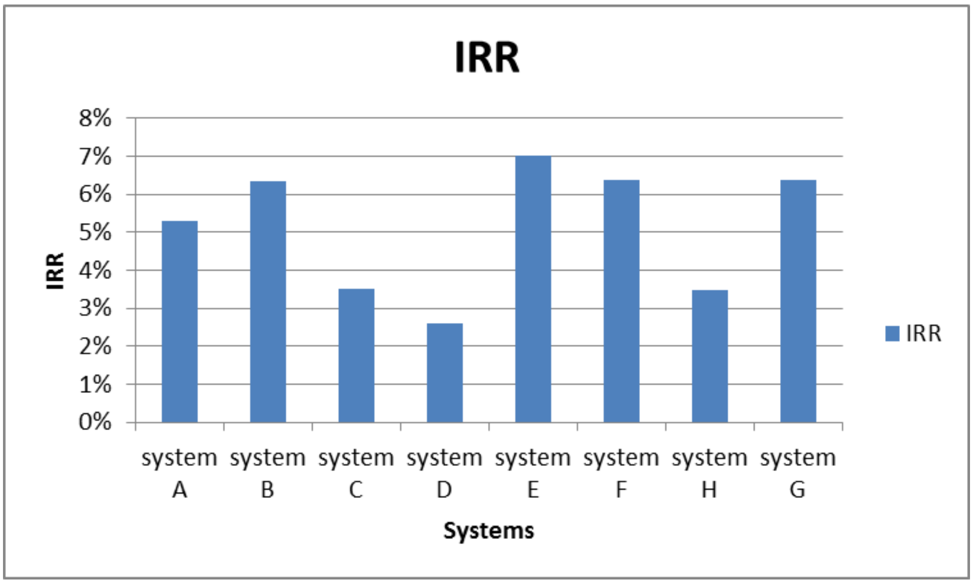

Figure 5.2: Internal rate of return for all eight systems

5.3.7 Affordability analysis of each cropping system

The projected accumulated cash flow of each of the crop rotation systems in a typical grain farm is measured over a 20-year period. This is done to evaluate the affordability of a typical grain farm to adopt crop rotation system. Accumulated cash flow calculations include only capital items, and calculations are done with the assumption that all the capital items in the inventory were financed with 60 per cent own capital and 40 per cent borrowed capital. The cash flow budget takes into account the annual cash in- and outflows that would typically reflect the farm's bank balance.

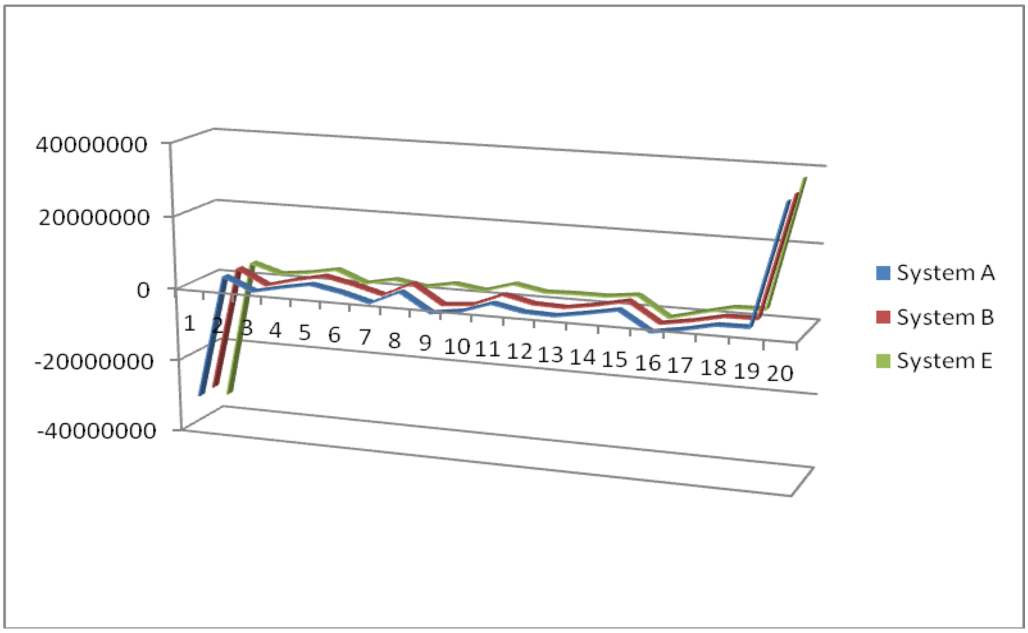

Figure 5.3: Projected accumulated cash flow for systems A, B and E

Figure 5.3 shows the projected cash flow of systems A, B and E. Systems B and E, when compared with system A, have less cash flow in the first three years. However, in the long run, their positive cash flow is higher than that of system A, with system E being the highest. System A cash flow increases at a lower rate, in the long run, as compared to the rest of the systems. This makes it a less preferable system if the farmer's objective is to make a profit over the long run.

5.4 Financial implications of switching between alternative crop rotation systems on a typical grain farm

To substantiate the benefits and advantages of crop rotation given in Chapter 2, this section simulates four scenarios to evaluate the financial implications of switching from the baseline scenario, wheat monoculture (A) to the proposed four alternative scenarios. The analysis is done on the accumulated cash flow of a typical farm. The model evaluates the affordability of farm's accumulated cash flow in making a switch between cropping systems. The section above analysed the impact of each crop rotation system on the financial position of a typical grain farm. Based on their IRR and NPV, system B and System E are the more profitable systems compared with the wheat monoculture system. It is therefore considered financially viable for a typical grain farm in the Middle Swartland to switch from wheat monoculture to either system B or system E.

As described in Chapter 2, system A involves wheat monoculture, system B is wheat rotated with canola every four years, while system E is wheat rotated with medics pasture, and includes a livestock component. The livestock component is a Dohne Merino sheep enterprise, farming for

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wool and mutton. The scenarios evaluating the whole-farm affordability of adopting or switching between cropping systems are simulated and analysed using the whole-farm multi-period budget model.

System A's scenario is used as the baseline with which the rest of the scenarios are compared. Scenario one simulates a switch from system A to system B over a two-year period. Scenario two entails a switch from system A to system E over a two-year period using own capital. Scenario three evaluates a switch from system A to system E over a ten-year period. Scenario four simulates a switch from system A to system E over a two-year period**,** using foreign capital. However, in practice, producers could implement alternative scenarios. The scenarios presented here represent practical, broad options.

5.4.1. Status quo scenario: system A

The main objective of the modelling and simulation activity is to represent a typical grain farm as realistically as possible, and secondly, to assess the financial implications of, and considerations for switching or adopting various crop production systems. In order to clearly understand and study the implications, a baseline has to be generated, against which the other scenarios can be compared. For this purpose it is assumed that a typical grain farm in the Middle Swartland practises wheat monoculture. This typical farm scenario will subsequently be used as a basis of comparison.

The purpose of the research is also to determine the possible adoption strategies, considering the possible factors that might be of relevance to the producers in support of the switch and the whole farms' affordability. All scenarios are simulated on a positive approach: that is, the study does not attempt to describe what should happen to the farm, but rather what is likely to happen given the current combination of the farm's activities, management practices and financial position.

Baseline calculations were done on a 1 000 ha typical grain farm, with 950 ha allocated to wheat monoculture. The gross margin of wheat after wheat, for good, average and poor years is multiplied by the total number of hectares, to give a total gross margin for system A.

To obtain the margin of fixed and overall costs, the annual overall cost of a typical 1 000 ha grain farm is subtracted from the total gross margin, and then deducted from the external factor cost to get the margin-to-foreign factor cost. Using the typical capital outlay of a cash crop system, the total capital outlay was calculated and subtracted from the margin-to-foreign-factor cost to obtain the total annual net flow. This is then used to calculate the IRR and NPV for system A over a 20-year

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period. Calculated over a 20-year period, system A shows an IRR and NPV of 5.23 per cent and R20 272 348, respectively.

5.4.2. Scenario one: switching from system A to system B

As discussed earlier, system A is wheat monoculture and System B is a four-year cycle rotation system, where three years' wheat is rotated with one year of canola. The cycle sequence for system B, is thus canola: wheat: wheat: wheat. The results of the profitability analysis of each system show that system B, over a period of 20 years, has an IRR of 6 per cent and an NPV of R25 068 46. Based on this result, it is considered financially viable to switch from system A to system B. The financial affordability of such a switch is yet to be evaluated.

Scenario one evaluates the financial implications of switching from system A to system B, over a period of two years, with the assumption that the producer has the means to use own capital to finance the transition. Annexure 3 presents a capital budget outlay for scenario one. A whole-farm multi-period budget model is run over a 20-year period, where in year one a farmer is assumed to be practising wheat monoculture, and the transition period starts in year two, and stretches over a four-year period. The scenario adopted the percentage increases in wheat yield following canola; that is, a 22 per cent increase in wheat after canola, a 14 per cent increase in wheat yield two years after canola, and an 8 per cent increase in wheat yield three years after canola.

Table 5.6: Crop sequencing per camp for scenario one

	Year one	Year two	Year three	Year four	Year five
Camp one	Wheat	Canola	Wheat after canola	Wheat 2 years after canola	Wheat 3 year after canola
Camp two	Wheat	Wheat after wheat	Canola	Wheat after canola	Wheat 2 years after canola
Camp three	Wheat	Wheat after wheat	Wheat after wheat	Canola	Wheat after canola
Camp four	Wheat	Wheat after wheat	Wheat after wheat	Wheat after wheat	Canola

In year 2, 75 per cent of the 950 ha land is allocated to wheat and 25 per cent to canola, realising a 75 per cent of the wheat-after-wheat gross margin plus 25 per cent of canola gross margin. That is, the total gross margin for the entire typical farm is equal to the wheat-after-wheat gross margin

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multiplied by 0.75, plus 25 per cent of the canola gross margin. Table 5.6 shows the hectare division assumption that was made in this scenario. The 950 ha land was divided into four equal camps. Each crop was allocated 25 per cent of the total 950 ha land, and gross margins, as dictated by good, average or poor years, were calculated based on these assumptions.

The hectare percentage allocation is similar to that of year two throughout the simulated years; the difference lies in gross margin realised. The total gross margin for year 3 is equal to the wheat-after-wheat gross margin multiplied by 0.5 times the total area, plus 25 per cent of the 950 ha total area of canola's gross margin, plus 25 per cent of the wheat-after-canola gross margin. The total gross margin for year 4 is equal to the wheat-after-wheat gross margin multiplied by 0.25 plus 25 per cent of the canola gross margin, plus 25 per cent of the wheat-after-canola gross margin, plus 25 per cent of wheat second year after canola gross margin.

From year 5 onwards, the total gross margin equals 25 per cent of the total area (950 ha) times the gross margin/ha, as determined by the good, average or poor years of canola gross margin plus, 25 per cent of the wheat-after-canola gross margin, plus 25 per cent of wheat in the second year after the canola gross margin, plus 25 per cent of the wheat in the third year after canola gross margin. To obtain the margin of fixed and overall costs, annual overall cost of a typical 1 000 ha grain farm is subtracted from the total gross margin, then less the external factor cost to get the margin-to-foreign-factor cost. It is assumed that the capital outlay with be similar to that of system A for the 20-year simulated period, as both systems are cash crop systems (Annexure 3).

Therefore, using the typical capital outlay of a cash crop system, the total capital requirement was calculated and subtracted from the margin-to-foreign-factor cost, to obtain the total annual net flow. This was then used to calculate the IRR and NPV for system A, to switch to system B. Scenario one has an IRR of 5.6 per cent. System B, as used from year one, shows an IRR of 6 per cent, including the transition, and is thus still an improvement on system A, which shows an IRR of 5.28 per cent. This indicates that a shift should be considered. A canola crop not only improves gross margins and IRR, it gives farmers a longer window period for both planting and harvesting. Although farmers might have a longer window period, they are unlikely to change their mechanisation outlay, in practice, when switching from system A to system B.

To evaluate the affordability of a typical grain farm to adopt to, or switch from system A to B, projected accumulated cash flow is calculated over a 20-year period. It is assumed that 60 per cent of the total assets required are financed with own capital and 40 per cent with borrowed capital. These calculations are done using a calculated real interest rate of 4.07 per cent and a merit of 1.28

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per cent. The repayment on borrowed capital is calculated as a function of 40 per cent of the total assets over a 20-year repayment period.

The repayment amount is added to the total annual costs plus total external factor costs, to get the total outflow amount. The opening balance for year one is assumed as zero. The inflow balance is equal to the total farm gross margin. The cash flow balance before interest is equal to the opening balance plus inflow, less outflow. If the cash flow before interest balance is positive, then interest is earned, and if negative, interest is paid at the real rate. Therefore, the closing balance is a function of cash flow before interest plus the interest balance. The opening balance from year two onwards equals the closing balance from the previous year.

Figure 5.4 shows the results of scenario one, in comparison with the status quo scenario. In terms of profitability, the status quo scenario has an IRR of 5.2 per cent, and scenario one has an IRR of 5.6 per cent (Annexure 3). Over the long run, scenario one's accumulated cash flow is higher than that of wheat monoculture. That is, from year 10 of the transition period, scenario one's accumulated cash flow increases above that of wheat monoculture. The reason is that the transition is relatively easy and the added benefit of higher yields from wheat after canola starts relatively early.

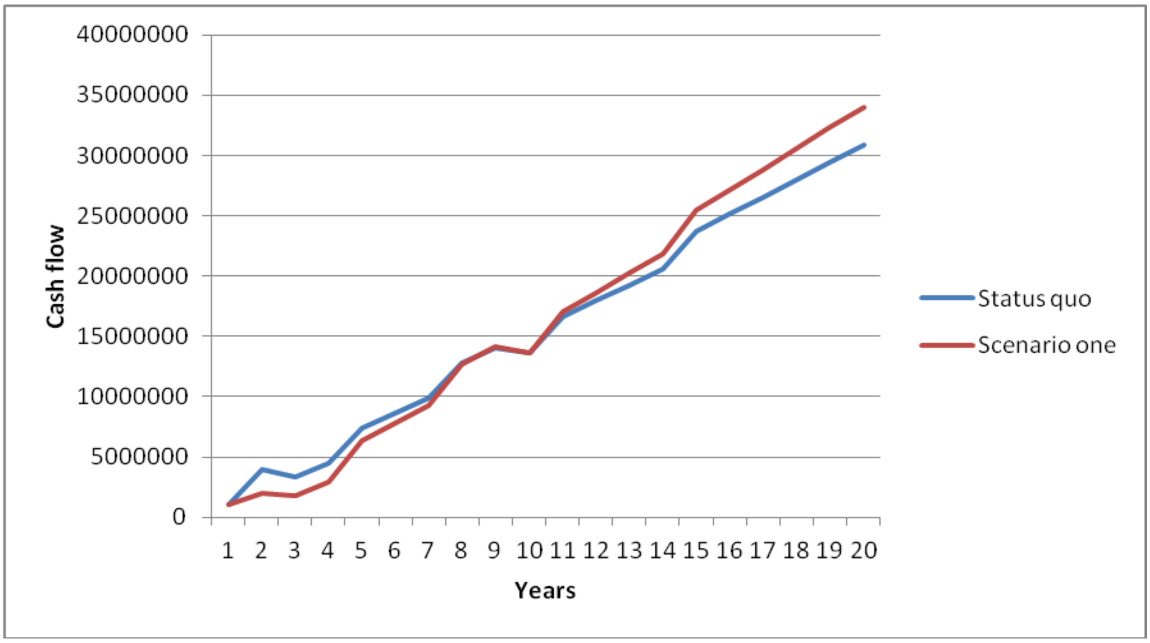

Figure 5.4: Projected accumulated cash flow for Scenario one and System A

5.4.3. Scenario two: switching from system A to system E over a two-year period, using own capital

As mentioned in Chapter 2, system E is a four-year-cycle rotation system, where wheat is rotated with medics/pasture, including a livestock component on the farm. The livestock component typically consists of a Dohne Merino sheep flock. The benefits of rotating medics/pasture with wheat were described in Chapter 2. To substantiate, the profitability analysis results in section 5.3.5, show system E to be the most profitable crop rotation system. Based on this, a switch from system A to system E seems to be a financially viable strategy. However, the main issue is the whole-farm affordability, in terms of accumulated cash flow, to adopt such a switch.

Scenario two evaluates the financial implications of switching from system A to system E over a two-year period, with the assumption that the farmer uses own capital to finance the transition. This is shown in Annexure 3. It is assumed that in year one, a total of 950 ha of land is allocated to wheat monoculture. Therefore, the total gross margin for year one is that of wheat after wheat multiplied by the total number of hectares. The transition period then starts in year two and stretches over two years. Of the total 950 ha land, 475 ha is allocated to medics/pasture in year two. It is assumed that in the year of establishment, only 30 per cent of the total medics gross margin will be realised (Brand, 2014). During the establishment year, pastures need time to establish well and livestock can only be put on to the pastures at a later stage. compared with established pastures. Therefore, the total gross margin of year two is equal to the wheat-after-wheat gross margin multiplied by 0.50 of

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the cultivated area, plus the total medics gross margin per 475 ha multiplied by 0.3, less the medics establishment cost multiplied by 0.5 of the area.

In year three, medics is established on the remaining 0.5 of the area. The total gross margin for year two is thus equal to the gross margin for wheat after medics plus 30 per cent of the medics gross margin per 475 ha, less the establishment cost for medics per 475 ha. From year four onwards, the total gross margin is calculated as wheat after medics on 475 ha, plus the medics gross margin on 475 ha. The cost of buying livestock is split in two and incurred in year 2 (30 per cent) and year 4 (70 per cent), while the cost of livestock handling facilities is incurred in year two (Brand, 2014 and Coetzee, 2014).

As shown in section 5.2, the capital requirement for a cash crop system differs from that of a cash crop/pasture system. Therefore, including a pasture in a typical cash crop system entails an alteration in mechanisation outlay. Farmers are, therefore, likely to change their mechanisation outlay. An assumption is made in this scenario about the capacity and size requirements of machinery, such as a combine harvester and number of tractors, and includes livestock and livestock handling facilities in the total capital outlay calculations during the transition period (Coetzee, 2014; Strauss 2013). The alterations can thus be made to the mechanisation outlay, but, for practical considerations, producers will mostly convert when the life of the current machines expires.

Due to various factors, such as the availability of auction markets and the structuring of the industry, the alteration does not necessarily entail selling machines. These alterations were incorporated in the net annual cash flows calculation. Starting with the wheat monoculture mechanisation outlay sheet, in all the first-time replacement years, a new machine suitable for a pasture system was incorporated. This was done manually, in the exact replacement year: the purchasing value of the new machine less the salvage value of the replaced machine. Other machinery was manually taken out by inputting zero in the replacement year, as the number required in the cash crop system exceeds that of the pasture system. This was based on the experience of producers who do not scale down immediately and sell all excess capacity (Burger, 2014 and Coetzee, 2014).

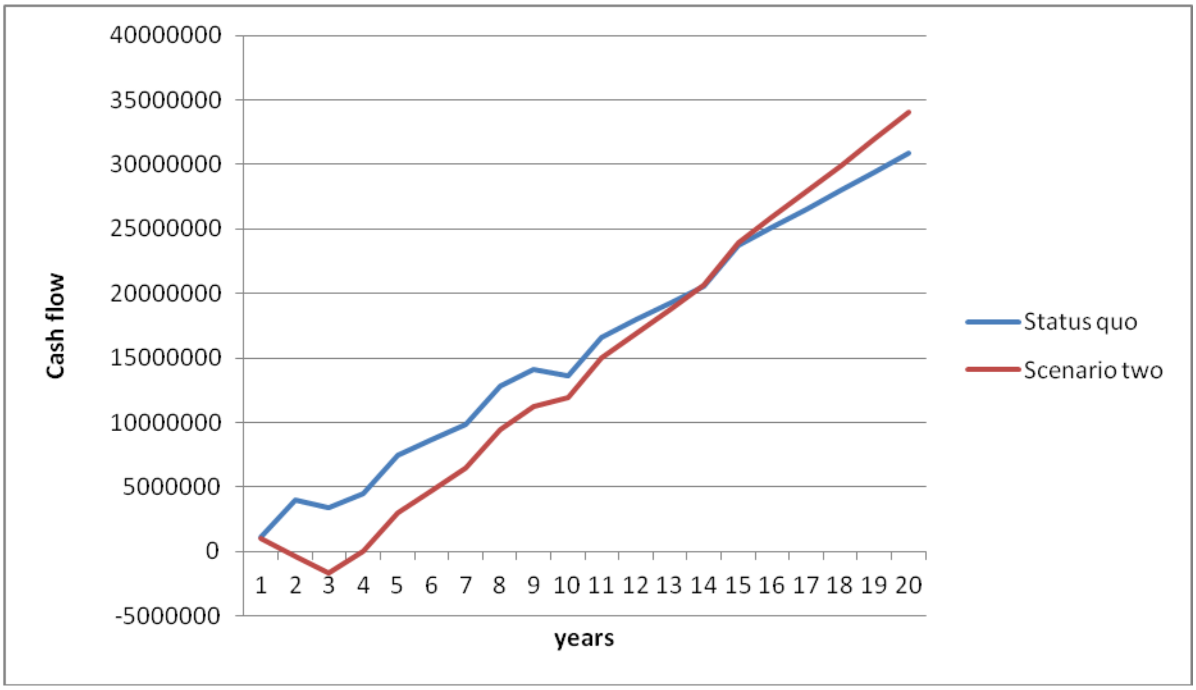

Figure 5.5: Project accumulated cash flow for scenario two and system A

Figure 5.5 gives the projected accumulated cash flow for system A and scenario two. During years two to year four of the transition period, the typical farm is likely to realise a less or negative accumulated cash flow. However, after a complete transition, farmers' accumulated cash flow increases and, over the long run, it increases even further above that of wheat monoculture. In terms of profitability, scenario two has a better IRR of 6.6 per cent compared with that of the status quo, which is 5.2 per cent (Annexure 3).

5.4.4. Scenario three: switching from system A to system E over ten year period

Scenario three is simulated to evaluate the financial implications of switching from wheat monoculture to system E over a period of 10 years, with the assumption that the farmer uses own capital/reserves to finance the transition period. Year 1 is assumed to be wheat monoculture. This scenario was suggested as an alternative for producers wanting to make the change, but not wanting to take the risk of changing quickly. The lack in experience in pasture and livestock production creates a risk situation (Coetzee, 2014 and Heunis, 2014).

Hence, 950 ha total land is allocated to wheat monoculture, and the gross margin realised in year 1 is that of wheat after wheat multiplied by the number of cultivated hectares. Medics/pasture is established, at 95 ha per year, from year 2 until year 11. It is assumed that on the 95 ha established plot, only 30 per cent gross margin is realised per year due to introducing livestock late in the

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establishment year (Brand, 2014). Every two years, 10 per cent wheat after wheat is thus replaced by wheat after medics.

The total gross margin for newly established medics during the transition period is equal to the medics/pasture gross margin per ha multiplied by 30 per cent, multiplied by 95 ha. The gross margin for fully established medics/pasture multiplied by corresponding hectares is only realised from years 4 to year 11 of the transition period. The transition from wheat monoculture over a ten-year period is illustrated in Annexure 3. The establishment of medics every year affects the hectares under wheat, but also, in time, the hectares under wheat after medics.

However, after the transition period, the total gross margin includes only wheat-after-medics gross margin per 475 ha, plus the medics gross margin per 475 ha. The cost of purchasing livestock is stretched for five years within the transition period. A farmer will buy the number of livestock corresponding to the capacity size of the 95 ha of newly established pasture in the first three years, and then the remaining numbers will be purchased corresponding to the total number of hectares of a fully established medics pasture.

The other assumption made in this scenario is for the capacity requirement of machinery, such as for the combine harvester and number of tractors. Due to including livestock and livestock handling facilities during the transition period in terms of the capital outlay, the fixed improvement cost is similar to that of scenario two. The projected accumulated cash flow for system A and scenario three are shown in Figure 5.6. The graph shows that in terms of affordability, a switch from system A to system E over a 10-year period using own capital to finance the transition period is not relatively feasible. Though the accumulated cash flow for scenario three increases after a negative accumulated cash flow period in the first years of the transition period, it is still below that of wheat monoculture. In terms of profitability, the wheat monoculture scenario is much better, with an IRR of 5.2 per cent compared with the 4.8 per cent of scenario three (Annexure 3).

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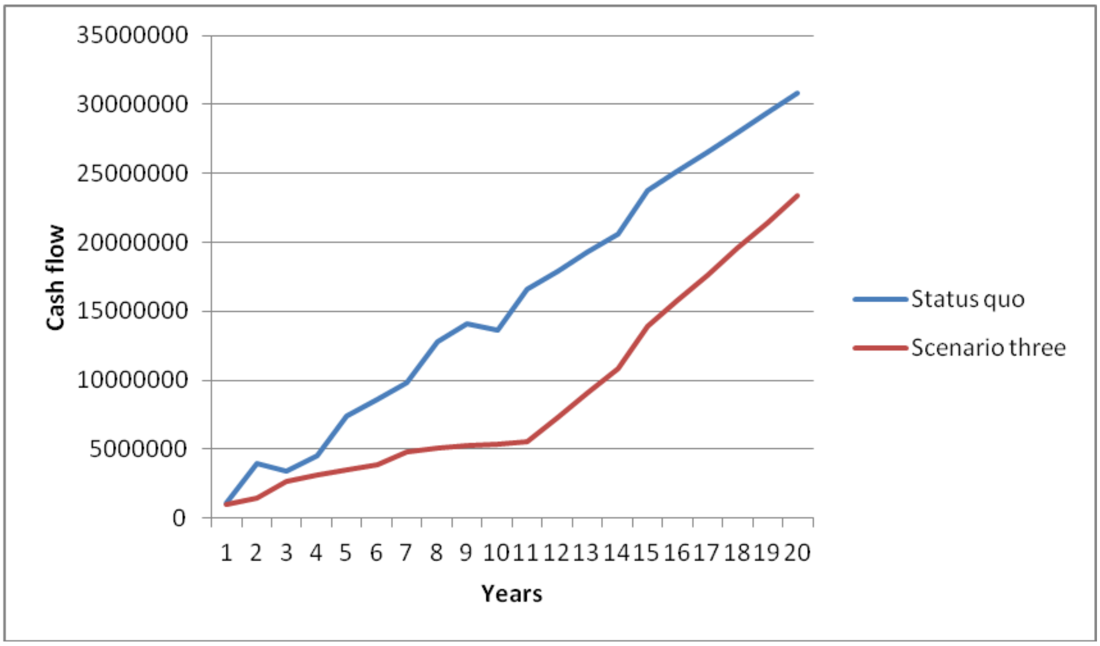

Figure 5.6: Projected accumulated cash flow for system A and scenario three

5.4.5. Scenario four: switching from system A to system E over a two-year period, using foreign capital

Scenario four evaluates the financial implications of switching from system A to system E under the assumption that foreign capital is used to finance the transition period. It is assumed that a typical grain farm operating in the Middle Swartland has a capital ratio of 60 per cent own to 40 per cent borrowed capital. In this scenario, further financial assistance is required for the transition period. The loan amount is equivalent to the capital required for purchasing livestock and establishing pastures. The framework of agri finance, discussed in Chapter 2, has no one specific financing product that is suitable for this scenario.

Various agricultural finance institutions proposed that there are two financial products available to finance such a switch (Rossouw, 2014; Coetzee, 2014; Goosen, 2014). First, to finance acquiring livestock, a farmer may use a medium-term loan at a 9.25 per cent interest rate per year with a repayment period of five years (Goosen, 2014). Secondly, to finance establishing a medics/pasture, a farmer may use a production loan, a finance solution designed upon request, with an extension of one year added to the repayment period. Normally, a production loan is short-term-orientated over one production season or cycle. Further descriptions of each of the financial products are given in Chapter 2. Calculations and assumptions for this scenario are similar to that of scenario two; the only difference is that it incorporates financing.

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In year two of the transition period, 30 per cent of the total capital required is borrowed to purchase livestock. The repayment is calculated as 30 per cent multiplied by the livestock value, and paid over five years with 9.25 per cent interest. Seventy per cent of the required capital for livestock is borrowed in year four of the transition period, with a similar repayment period and interest rate.

For establishing medics, a production loan is assumed that acquires production inputs instead of cash. Repayments are in cash over a period of three years, with an interest rate of between 9.25 per cent and 10 per cent. In year two, a farmer gets 50 per cent of the total establishment cost and repays it at a 9.25 per cent interest rate over three years. The total borrowed amount for medics established, in year 2 is 475 ha multiplied by 50 per cent, multiplied by R1 800/ha. The same applies in year 3 of the transition period.

Figure 5.7 shows the projected accumulated cash flow for system A compared with scenario four. It is financially feasible, in terms of affordability, for a typical farm in the Middle Swartland with a borrowed capital ratio of 40 per cent or less to take on this strategy. Though borrowing more funds entails higher monthly instalments, the scenario four accumulated cash flow increases are higher than those of system A in the long run. Scenario four has an IRR of 6.6 per cent, which is more profitable compared with the status quo scenario of 5.2 per cent (Annexure 3).

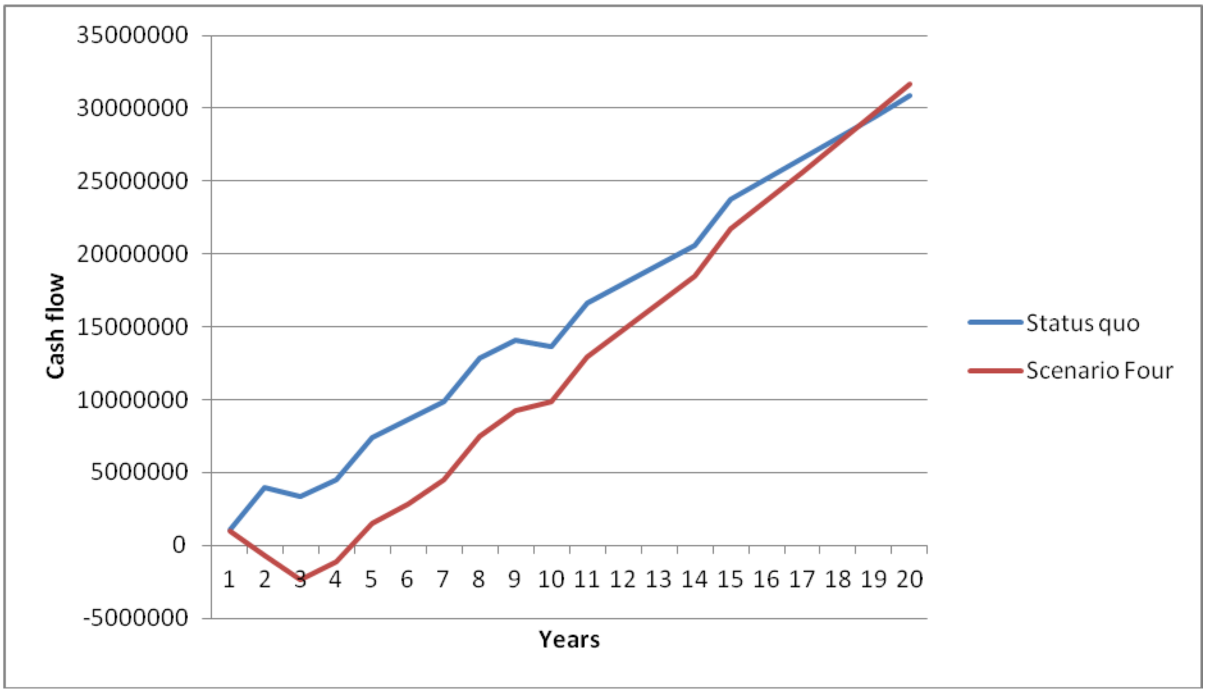

Figure 5.7: Projected accumulated cash flow for system A and scenario four

5.5. Comparison of all scenarios with system A

This section compares all four scenarios with the baseline scenario. This is done to conclude which of the four alternatives is more financially viable and affordable to a typical grain farm in the Middle Swartland, after considering all the relevant factors, such as financing options and length of transition periods.

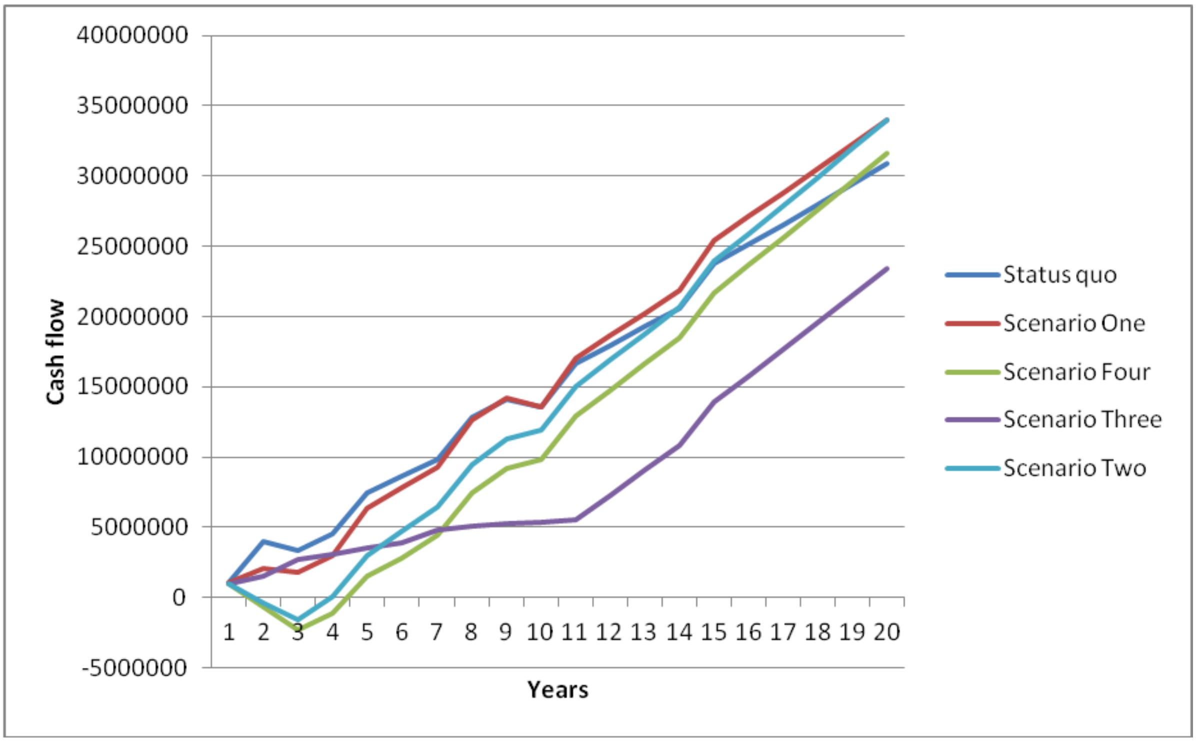

Figure 5.8: Projected accumulated cash flow for all scenarios

Figure 5.8 gives a comparison of all the simulated scenarios, in terms of a 20-year projected accumulated cash flow. Following the profitability analysis conducted on all eight crop rotation systems and the four scenarios; in comparison to wheat monoculture, all four scenarios were found to be more profitable with IRRs equal to or above that of the status quo scenario. However, in terms of affordability, scenario one, two and four are more affordable for a typical grain farm in the Middle Swartland, in the long run, after considering all the necessary financial implications associated with the switch or adoption. Although scenario three is profitable, it is, however, not affordable for a typical grain farm in the Middle Swartland to adopt it. It is, therefore, not financial feasible for typical grain farmers to gradually switch from wheat monoculture to system E using own capital, in the Middle Swartland. According to Figure 5.8, a typical grain farm in the Middle Swartland can either switch from wheat monoculture to system B over a four-year period or switch from wheat monoculture to system E over two years, either with foreign or own capital.

5.6. Conclusion

Various strategies of adopting alternative crop production systems are described in this chapter. The models are used to measure the profitability and affordability of switching to alternative crop production systems. An inventory for each of the crop rotation systems is compiled and used to assess the investment requirement of a typical grain farm in the Middle Swartland production region. This provides the total capital requirement, and is thus the basis for calculating the expected profitability, in this instance the IRR and NPV. Comparisons of the financial performance of cropping systems at a whole-farm level are done in terms of profitability and affordability analysis. The profitability and affordability analyses are done over a 20-year period, using the whole-farm multi-period budget model. Using the crop rotation trial results, it is evident that various crop rotation systems are more profitable, over the longer term, than wheat monoculture.

The main aim of this study is to establish the affordability of switching to crop rotation systems. Four like strategies of making the switch were identified with the input of experts from the Middle Swartland. The strategies are presented in the form of scenarios. The system A, wheat monoculture, scenario is simulated and serves as the baseline to which the other scenarios are compared. Adhering to standard accounting principles and structuring the multi-period whole-farm budget model on a typical farm of 1 000ha, the model was used to calculate the IRR and NPV for the systems over a 20-year period. Calculated over a 20-year period, system A showed an IRR and NPV of 5.23 per cent and R20 272 348, respectively.

Scenario one was simulated to evaluate the switching strategy from system A to system B over a period of two years, with the assumption that the producer has the means to use own capital to finance the transition. The assumption is made because the production structure does not change, and one cash crop is replaced by another on part of the production area. The transition period starts in year two and stretches over a four-year period. In the long run, scenario one’s accumulated cash flow is better than that of wheat monoculture. Even in years of negative accumulated cash flow, scenario one’s condition is better than that of wheat monoculture. The reason is that the transition is relatively easy, and the added benefit of higher yields from wheat after canola starts relatively early.

Scenario two evaluates the financial implication of switching from system A to system E over a two-year period, assuming that the farmer uses own capital to finance the transition. It is assumed

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that, in year one, a total of 950 ha land is allocated to wheat monoculture, and the transition period starts in year two and stretches over two years. Medics pastures are established in the first 457 ha portion of the land in year two, and the remaining portion in year three of the transition period. The results of the scenario compared with the baseline show that the accumulated cash flow of scenario two increases or improves more than that of system A.

Scenario three evaluates the financial implication of switching from wheat monoculture to system E, but over a period of 10 years, with the assumption that the producer uses own capital or reserves to finance the transition period. Year one is assumed to be wheat monoculture, and medics pastures are established from year two until year eleven. Establishing medics is done in 95 ha blocks and, in the first year only 30 per cent gross margin is realised due to the late introduction of livestock. Every two years, 10 per cent wheat after wheat is thus replaced by wheat after medics during the transition. The projected accumulated cash flow for system A and scenario three shows that, in terms of affordability, a switch from system A to system E over a 10-year period using own capital to finance the transition period should be affordable.

Scenario four evaluates the financial implication of switching from system A to system E, under the assumption that borrowed capital is used to finance the transition period. It is assumed that a typical grain farm operating in the Middle Swartland has a capital ratio of 60 per cent own to 40 per cent borrowed capital. In this scenario, further financial assistance is required for the transition period. The loan amount is equivalent to the capital required for purchasing livestock and establishing pastures. Calculations and assumptions for this scenario are similar to those of scenario two; the only difference is that it incorporates financing. In year two of the transition period, 30 per cent of the total capital required is borrowed to purchase livestock.

The scenario results show that it seems to be financially feasible for a typical farm in the Middle Swartland either to switch from wheat monoculture to system B over a four-year period or to switch from wheat monoculture to system E, with either foreign or own capital. Though borrowing more funds entails higher monthly instalments, in the long run, scenario four’s accumulated cash flow increases above that of system A.

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Chapter 6 :
Conclusion, summary and recommendations

6.1. Conclusion

The Western Cape Province produces about 42 per cent of the South African wheat crop of 1.9 million tons per annum. The Southern Cape and the Swartland regions contribute 85 per cent of the wheat produced in the Western Cape. Wheat production has decreased since the abolition of the Wheat Marketing Board, with crops such as canola, oats and barley gaining relative importance in the industry. An increase in the variety of products and greater exposure to volatile markets has contributed to an increase in the complexity of crop production systems and an expansion of the farm-level decision-making environment in the Western Cape.

Consequently, Western Cape wheat producers are caught in a precarious position, and the profitability of the wheat sector is frequently questioned. This is partly influenced by the structural oversupply issue that is currently affecting the wheat producers in the province. That is, the Western Cape grain farmers produce more wheat than is consumed in the province, and, therefore, have to deal with the high cost of transporting wheat to the interior parts of the country. In response to the external shocks facing the Western Cape wheat sector, a long-term crop and crop/pasture rotation trial was established at the Langgewens Research Farm in 1996. The trial was conducted with the aims of increasing diversification of the farm for greater financial stability, increasing crop yield, improving margins in the production systems, increasing protein and oilseed production, and reducing input costs.

Based on the trial results and the relevant literature, rotating wheat with other grain crops or pasture presents an opportunity for higher productivity and profitability. In addition, including a livestock component into the rotation system presents numerous advantages in terms of risk diversification. However, the typical fixity of assets on the farm, as well as the risks involved in adopting or switching between crop rotation systems, puts farmers in the predicament of not being able to alter the farm systems, as this may cause severe damage to the farm's financial position. Though crop rotation systems minimise total farm business risk, this practice is likely to increase the farm's financial risk. The switch between crop production systems and/or including a livestock component presents a period of relatively lower accumulated cash flow and a resulting impact on the farm's financial leverage (position).

This study was intended, therefore, to determine the various strategies that farmers may use to lessen or overcome the financial implications of switching to or adopting cropping systems that include medics or medics/clove pasture with a livestock component, or alternative grains such as lupin and canola. The study's central question was to determine the financial implications of, and considerations for switching between alternative crop production systems in the Middle Swartland wheat-producing areas. The specific objectives were to determine the profitability of different typical crop production systems in the Middle Swartland, to identify and describe the financial performance of a typical grain farm in the Middle Swartland, and to identify and evaluate the affordability of supporting a switch in crop production systems.

Though studies are been conducted on the economic and environmental implications of switching between crop rotation systems, there is still only limited literature on the financial implications of including medics/clover pastures with a livestock component and/or other grains, such as lupin and canola, in the crop rotation systems. Therefore, questions around the financial implications of and consideration for adopting alternative crop production systems remain among the commercial grain producers. This is due to the uncertainty around farm diversification methods, such as crop rotation, and total-farm risk balancing. The literature reviewed shows the advantages and benefits of crop rotation, especially when including pastures and a livestock component. However, there are also challenges observed by various researchers in adopting such cropping systems. In addition, crop rotation practices were found to raise questions among grain producers concerning whole-farm risk balancing, and how they impact on business and financial risk at a farm-level.

Though the study did not run a statistics test to support this, the literature was reviewed on this aspect, which indicated the effectiveness of crop rotation as either risk mitigation or a profit maximisation strategy. That is, when applied as a profit maximisation strategy, crop rotation tends to minimise total-farm business risk and maximise financial risk. On the other hand, crop rotation, when practiced as a risk management strategy, maximises business risk and minimises financial risk.

Due to the nature of the data used, and the complexity of the whole-farm system, a systems thinking approach was embraced in this study. This school of thought allows using hard facts and including people's mind-sets to simulate likely scenarios. The study followed the positive whole-farm level modelling approach, and assumed what is likely to happen to a typical grain farm given all the necessary farm resources, management abilities and skills, and financing options. Primary data on the crop rotation systems and production activities of commercial wheat farmers in the Middle Swartland was obtained from the Langgewens Research Farm trial. This was used to construct a typical grain farm in the Middle Swartland based on production data (gross margins, direct allocable costs and production values), financial statements, whole-farm management and complete farm setups, as obtained from the farmers study group located in the Middle Swartland, and Langgewens Research Farm trial data.

The complexity of the farm system requires that a tool used to describe the farm in financial terms be capable of incorporating accurately the wide variety of factors and relationships of the whole system. The whole-farm multi-period models were developed and adapted for this study. The complete typical grain farm setup and collected data were used to develop a multi-period budget model for a typical grain farm in the Middle Swartland area, to evaluate profitability and affordability of a whole farm.

The whole-farm multi-period budget model was simulated over a 20-year period for various scenarios aimed at describing and understanding the typical grain farm in the Middle Swartland. Different scenarios were simulated to evaluate the financial implications of switching from a wheat monoculture system to alternative cropping systems. Assumptions made varied per scenario and included the length of the transition period, the financing options, the capital contribution ratio, as well as the mechanisation outlay.

The typical farm is described in both physical and financial terms. The financial aspects include the overall typical farm investment requirement for either a cash crop system or a pasture system. The current financial position of a typical grain farm is analysed for all the cropping systems, and the financial impact of each system is evaluated. The last analysis is on the scenarios simulated to evaluate the financial impact of switching from system A to system B or E. System A is used as the status quo or baseline scenario, to which all the other scenarios are compared.

Due to differentiation in mechanisation outlay and the costs of fixed improvements, the pasture system's investment requirement is higher than that of a cash crop system. The results prove that indeed the adoption of, or switch from a wheat monoculture system to an alternative crop production system has some financial implications, and there are various factors that a wheat producer needs to consider relating to the affordability of implementing such a switch. The results of the financial implications of each system on a typical grain farm showed an IRR of 5.23 per cent, 6 per cent, and 7.01 per cent for systems A, B and E, respectively. Furthermore, the results of the affordability analysis showed that a typical grain farm in the Middle Swartland could afford to switch from either wheat monoculture to system B or system E, either with foreign or own capital, compared with other scenarios. Therefore, with an appropriate adoption strategy, the financial implications of adopting a crop rotation system may be lessened. Furthermore, adopting a crop rotation system either as a risk mitigation strategy or as a profit maximisation strategy, depending

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on the farmer's objective, will either increase financial risk and decrease business risk, or vice versa.

The research questions are therefore found to be valid, and the study objectives were met. Given the lower input costs and higher gross margin, as well as the lower financial risk of monoculture practices, the study results illustrate the benefits of including annual legume pastures, with the possibility of a livestock component, in the rain-fed farming systems practised in the Middle Swartland region.

Furthermore, the study results elucidate the factors that grain producers need to consider when investigating a switch between cropping systems. These factors include the length of the transition period, and options available and accessible for financing a switch to crop rotation. In short, including medics and medics/clover pastures with a livestock component, and/or alternative grains, such as canola and lupin, in the cropping system provides an improved return on capital invested compared with wheat monoculture, taking into consideration the transition period and the financing options.

6.2. Summary

The aim of this study was to determine the financial implications and considerations of switching between crop production systems in the Middle Swartland wheat-producing area. Model results show that it promotes sustainable farming practices and improves whole-farm profitability. The crop rotation practices may increase farm's financial risk but does minimise business risk and increase farmers' abilities to resist external shocks to the wheat sector.

A typical farm model was developed to evaluate the abovementioned financial implications and considerations. This was done using data from the Langgewens Research Farm and the farm setup description done by the commercial wheat farmers study group. The first specific objective was to identify and describe the financial performance of a typical grain farm in the Middle Swartland. The budget model was used to analyse this objective. The financial performance was analysed in terms of inventory calculation, gross production value and gross margin calculation, and overhead and fixed costs. The second specific objective was to identify production strategies and evaluate the affordability of supporting a switch in crop production systems.

The whole-farm multi-period budget model is used to assess this objective, and includes an amortisation table to incorporate the capital contribution assumptions. This model is used because it accommodates the complexity of a farm system, and can also be used to simulate long-term scenarios. Four different scenarios are simulated to evaluate strategies that grain producers may follow to adopt a switch from wheat monoculture to alternative crop production systems. Decision criteria used as basis of comparison between the scenarios are the following parameters: IRR, NPV and cash flow.

The background to the South African grain industry was given in terms of the importance of the industry, domestic consumption and production, as well as regional production and consumption. The wheat-producing systems practised in the Western Cape were mainly influenced by protectionist policies and the non-availability of alternative crops. Further distinctions are given between wheat monoculture and crop rotation practices as the two main producing systems in the Western Cape. The emphasis is on crop rotation practices as the main subject of the study. Crop rotation supports the concept of sustainable and profitable production systems. Management decision-making in crop rotation systems is more complex, but crop rotation lowers farm risk.

Emphases on crop sequencing and management decisions about a sustainable production system are presented with reference to previous studies. The extent to which crop rotation systems contribute to total farm risk balancing is also presented, with illustrations of the effectiveness of crop rotation systems as either a risk mitigating strategy or a profit maximising strategy. Success stories of crop rotation systems are supported by empirical evidence of the financial performance of some systems currently evaluated in the crop rotation trial conducted at Langgewens Research Farm.

Chapter 3 gives a theoretical background to the systems thinking approach and typical farm modelling technique. Different types of systems thinking approach were discussed, as well as typical farm modelling as an exercise within the systems thinking approach. A distinction between hard and soft systems approaches is made to emphasise the direction of the study. The reasons for choosing a budget model, instead of other models, are given in this chapter. The budget model is considered useful in this study because of its simplicity and ability to simulate scenarios over a long period. A background on the application and development of budget models is given in the chapter. A brief overview of the introduction and applicability of typical farm techniques was also given in Chapter 3.

Chapter 3 further justifies the research techniques used in the study. This is done to show that the researcher is aware of the criticisms and significance of the techniques. Typical farm studies are criticised because of being static in nature, while the farm operates in a dynamic framework. This is considered a disadvantage, as results from studies conducted using a typical farm technique cannot

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effectively provide guidance to the individual producer, who differs widely in managerial ability, capital availability, tenure, age and goals.

Chapter 4 presents an implementation framework for the research methodology used in this study. This is based on the theoretical background given in Chapter 3. A clear description is given of how the techniques are applied in this study, as well as of all the relevant procedures followed. A description of the study area, its climatic conditions, geographic location, and its suitability as a study area are presented. Next the procedures followed to construct a typical farm suited for the described study area are also presented, as well as the parameters included in the typical farm.

Data used and procedures followed to construct a representative farm are also described, as well as procedures followed to collect data, and the sampling techniques. A typical whole-farm multi-period budget is developed to assess the financial implication of each cropping system, as well as the farm affordability in switching from one system to another. Detailed descriptions of the steps followed to construct the model are given, as well as the model components. The budget model has three components: input data, calculation and output. Assumptions on data inputted in the model, as well as the validation of the model are discussed. Data collection and sampling techniques used in the study are discussed, and justifications of choice of study area are given in this chapter. The model is developed to run over a 20-year period.

Chapter 5 presents the study results on the financial implications of, and considerations for switching between crop production systems. Analyses are done for each cropping system. The inventory, or assets register, is used to assess the initial capital investment required for sustainably operating a typical grain farm. This gave a picture of the variation between a typical grain farm and a pasture farm. The financial implications of each system were analysed in terms of directly allocable costs, gross margin, as well as overhead and fixed costs assessment. The IRR for each crop rotation system is measured and used to analyse the profitability of each system, and the cash flow analysis is conducted to measure the affordability of adopting each system for a typical grain farm.

The second part of Chapter 5 describes four different scenarios of strategies that farmers may use to switch between crop productions systems. They evaluate the financial implications in terms of affordability of, and considerations for such a switch. System A was used as the baseline scenario for comparison. The system A scenario entails that the entire 950 ha is cultivated with wheat; that is, it is a wheat monoculture scenario. Scenario one evaluates the financial implications and considerations of switching from system A to system B over a period of two years, with the

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assumption that the farmer has the means to use own capital to finance the transition. Scenario two evaluates the financial implications of switching from system A to system E over a two-year period, on the assumption that the farmer uses own capital to finance the transition.

Scenario three is simulated to evaluate the financial implication of, and considerations for switching from system A to system E over a ten-year period, assuming that the farmer uses own capital to finance the transition. This scenario is suggested as an alternative for farmers wanting to make the change but not wanting to take the risk of changing quickly. Scenario four evaluates the financial implications of switching from system A to system E, on the assumption that foreign capital is used to finance the transition.

The scenarios that involve shifting to system E entail adjustments to, or changes in outlay for typical grain farm machinery, including the costs of establishing pastures, purchasing livestock, including livestock-handling facilities costs, and land and total fixed improvements costs. Furthermore, depending on the length of the transition period, farmers will forfeit some of their farm income due to the switch. However, these scenarios have proven to be a very good calculated risk in the long run, as they show acceptable IRR over a period of 20 years, and a positive cash flow. Moreover, they promote sustainable farming practices.

The scenarios evaluated in this study also indicate the factors that producers who are supporting the switch need to consider. A conclusion of the entire study is given, and the comparisons between the baseline scenario and the alternative scenarios are presented. The conclusion presents validates and answers the central research question.

6.3. Recommendations

The results and conclusion of this study serve as a basis for making the following recommendations for crop production practices and further research:

- Grain producers in the rain-fed area of the Middle Swartland should consider a switch to crop-producing systems that include medics or medics-clover pasture with a livestock component or including alternative cash crops such as canola and lupin to improve the whole-farm return on capital investment.

- It is, however, significant that the grain producer considers aspects such as the length of the transition period and the financing options when supporting such a switch. Preferably,

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the switch should be implemented over a longer period such as two years or more and own capital should be used to finance the transition.

- Cropping systems proposed for grain farmers in the Middle Swartland incorporate two different enterprises of livestock and crop production. Financial institutions offering agricultural finance consider these enterprises separately and, therefore, have different financing products with terms and conditions suitable for each of the enterprises practiced separately, not incorporated into one system. The study therefore recommends that financial institutions consider designing products tailor-made for such a system.

- Further research should be done on the relevance of grain farmers' financing options in addressing the financial implications of adopting crop rotation systems

- Further research should also be done by commercial banks and other institutions providing agricultural finance on designing financing options tailor-made for the agricultural sector that meet the needs of the farmers, regardless of enterprises, whether they are specialising or diversifying.

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Annexures

Annexure 1: Annual overhead fixed cost for a typical grain farm

Overall annual costs	
Regular labour + Foreman	438900
Salary (Secretary)	34800
casual labour	4266
Water fees:	88000
electricity	60000
Municipal taxes:	40000
Insurance (overall):	87351
Bank charges:	30000
phone	48000
Administration	36000
Auditors & Consultation fees	40000
Supply: camps	42000
Supply: water distribution	30000
Farm owner remuneration	400000
Miscellaneous cost (4%)	55172.68
Total	**1434490**

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Annexure 2: Capital budget for system A, B and E

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Whole farm multi-period budget : System A year 1 to 10

Year in calculation period	1	2	3	4	5	6	7	8	9	10
Yield potential based on rainfall										
Type of year for wheat and barley*	2	1	3	2	1	2	2	1	2	3
Type of yeat for canola and lupin*	2	2	3	2	1	2	2	1	2	3
Gross margin										
Crop										
Wheat after wheat	3681695	5428745	1934645	3681695	5428745	3681695	3681695	5428745	3681695	1934645
Gross margin total farm:	**3681695**	**5428745**	**1934645**	**3681695**	**5428745**	**3681695**	**3681695**	**5428745**	**3681695**	**1934645**
Overhead and fixed costs:										
Regular workers	438900	438900	438900	438900	438900	438900	438900	438900	438900	438900
Salary (Secretary)	34800	34800	34800	34800	34800	34800	34800	34800	34800	34800
Casual labour	4266	4266	4266	4266	4266	4266	4266	4266	4266	4266
Water fees	88000	88000	88000	88000	88000	88000	88000	88000	88000	88000
Electricity	60000	60000	60000	60000	60000	60000	60000	60000	60000	60000
Municipal taxes	40000	40000	40000	40000	40000	40000	40000	40000	40000	40000
Insurance (overall)	87351	87351	87351	87351	87351	87351	87351	87351	87351	87351
Bank charges	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000
Phone	48000	48000	48000	48000	48000	48000	48000	48000	48000	48000
Administration	36000	36000	36000	36000	36000	36000	36000	36000	36000	36000
Auditors & Consultation fees	40000	40000	40000	40000	40000	40000	40000	40000	40000	40000
Supply: camps	42000	42000	42000	42000	42000	42000	42000	42000	42000	42000
Supply: water distribution	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000
Farm owner remuneration	400000	400000	400000	400000	400000	400000	400000	400000	400000	400000
Miscellaneous cost (4%)	55173	55173	55173	55173	55173	55173	55173	55173	55173	55173
Total overhead and fixed costs	**1434490**	**1434490**	**1434490**	**1434490**	**1434490**	**1434490**	**1434490**	**1434490**	**1434490**	**1434490**

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Margin above overhead and fixed costs:	**2247205**	**3994255**	**500155**	**2247205**	**3994255**	**2247205**	**2247205**	**3994255**	**2247205**	**500155**
External factor cost:										
Hired management	180000	180000	180000	180000	180000	180000	180000	180000	180000	180000
Total	180000	180000	180000	180000	180000	180000	180000	180000	180000	180000
Margin above foreign factors costs:	**2067205**	**3814255**	**320155**	**2067205**	**3814255**	**2067205**	**2067205**	**3814255**	**2067205**	**320155**
Capital outlay:										
Long-term capital:										
Land and fixed improvements	25060000	0	0	0	0	0	0	0	0	0
Intermediate Capital:										
Combine harvester 240kW	2006667	0	0	0	0	0	0	0	3440000	0
Swather 7m	523875	0	0	0	0	0	0	0	0	0
Tractor 230 kW	1491292	0	0	0	0	0	0	0	0	0
Tractor 120 kW	282625	0	0	0	0	0	0	0	0	0
Tractor 120 kW	376833	0	0	0	0	0	0	0	0	0
Tractor 70 kW	90500	0	0	0	0	0	0	0	0	0
Tractor 70 kW	45250	0	0	0	0	0	0	0	0	543000
Planter	882833	0	0	0	0	0	1324250	0	0	0
Sprayer	144333	0	0	0	0	0	216500	0	0	0
Sprayer	126292	0	0	0	0	0	216500	0	0	0
Fertilizer spreader	70500	0	0	0	0	0	105750	0	0	0
Fertilizer spreader	61688	0	0	0	0	0	105750	0	0	0
Tine implement	65188	0	0	0	0	0	0	111750	0	0
Tine implement	65000	0	0	0	0	0	0	97500	0	0
Trailer	52033	0	0	0	0	0	0	0	0	0
Trailer	59467	0	0	0	0	0	0	0	0	0
Trailer	66900	0	0	0	0	0	0	0	0	0
Water cart	25375	0	0	0	0	0	0	0	0	0

Front loader	65250	0	0	0	0	0	0	0	0	0
Grain cart	447563	0	0	0	0	0	0	0	0	0
Lorry	480958	0	0	0	0	0	0	0	0	0
LDV	142886	0	0	0	0	0	171463	0	0	0
LDV	167922	0	0	0	251883	0	0	0	0	0
Tools and equipment	240000									
Total Intermediate capital	**7981229**	**0**	**0**	**0**	**251883**	**0**	**2140213**	**209250**	**3440000**	**543000**
Total Capital outlay	**33041229**	**0**	**0**	**0**	**251883**	**0**	**2140213**	**209250**	**3440000**	**543000**
Net annual flows	**-30974023**	**3814255**	**320155**	**2067205**	**3562372**	**2067205**	**-73008**	**3605005**	**-1372795**	**-222845**
IRR	5.28%									

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

Cash flow:										
Opening	0	1102229	3986552	3369275	4512943	7439214	8632938	9841344	12833148	14093212
Inflow	3681695	5428745	1934645	3681695	5428745	3681695	3681695	5428745	3681695	1934645
Outflow	2592857	2592857	2592857	2592857	2592857	2592857	2592857	2592857	2592857	2592857
Flow before interest	1088838	3938117	3328340	4458113	7348831	8528052	9721776	12677231	13921986	13435000
Interest	13392	48435	40935	54830	90383	104886	119568	155917	171226	165237
Closing balance	1102229	3986552	3369275	4512943	7439214	8632938	9841344	12833148	14093212	13600236

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Whole farm multi-period budget : System A year 11 to 20

Year in calculation period	11	12	13	14	15	16	17	18	19	20
Yield potential based on rainfall										
Type of year for wheat and barley*	1	2	2	2	1	2	2	2	2	2
Type of yeat for canola and lupin*	1	2	2	2	1	2	2	2	2	2
Gross margin										
Crop										
Wheat after wheat	5428745	3681695	3681695	3681695	5428745	3681695	3681695	3681695	3681695	3681695
Gross margin total farm:	**5428745**	**3681695**	**3681695**	**3681695**	**5428745**	**3681695**	**3681695**	**3681695**	**3681695**	**3681695**
Overhead and fixed costs:										
Regular workers	438900	438900	438900	438900	438900	438900	438900	438900	438900	438900
Salary (Secretary)	34800	34800	34800	34800	34800	34800	34800	34800	34800	34800
Casual labour	4266	4266	4266	4266	4266	4266	4266	4266	4266	4266
Water fees	88000	88000	88000	88000	88000	88000	88000	88000	88000	88000
Electricity	60000	60000	60000	60000	60000	60000	60000	60000	60000	60000
Municipal taxes	40000	40000	40000	40000	40000	40000	40000	40000	40000	40000
Insurance (overall)	87351	87351	87351	87351	87351	87351	87351	87351	87351	87351
Bank charges	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000
Phone	48000	48000	48000	48000	48000	48000	48000	48000	48000	48000
Administration	36000	36000	36000	36000	36000	36000	36000	36000	36000	36000
Auditors & Consultation fees	40000	40000	40000	40000	40000	40000	40000	40000	40000	40000
Supply: camps	42000	42000	42000	42000	42000	42000	42000	42000	42000	42000
Supply: water distribution	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000
Farm owner remuneration	400000	400000	400000	400000	400000	400000	400000	400000	400000	400000
Miscellaneous cost (4%)	55173	55173	55173	55173	55173	55173	55173	55173	55173	55173
Total overhead and fixed costs	**1434490**	**1434490**	**1434490**	**1434490**	**1434490**	**1434490**	**1434490**	**1434490**	**1434490**	**1434490**

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Margin above overhead and fixed costs:	**3994255**	**2247205**	**2247205**	**2247205**	**3994255**	**2247205**	**2247205**	**2247205**	**2247205**	**2247205**
External factor cost:										
Hired management	180000	180000	180000	180000	180000	180000	180000	180000	180000	180000
Total	180000	180000	180000	180000	180000	180000	180000	180000	180000	180000
Margin to foreign factors costs:	**3814255**	**2067205**	**2067205**	**2067205**	**3814255**	**2067205**	**2067205**	**2067205**	**2067205**	**2067205**
Capital outlay:										
Long-term capital:										
Land and fixed improvements	0	0	0	0	0	0	0	0	0	0
Intermediate Capital:										
Combine harvester 240kW	0	0	0	0	0	0	0	0	0	0
Swather 7m	698500	0	0	0	0	0	0	0	0	0
Tractor 230 kW	0	0	0	0	0	2556500	0	0	0	0
Tractor 120 kW	0	1130500	0	0	0	0	0	0	0	0
Tractor 120 kW	0	0	1130500	0	0	0	0	0	0	0
Tractor 70 kW	543000	0	0	0	0	0	0	0	0	0
Tractor 70 kW	0	0	0	0	0	0	0	0	0	0
Planter	0	0	0	0	0	0	1324250	0	0	0
Sprayer	0	0	0	0	0	0	216500	0	0	0
Sprayer	0	0	0	0	0	0	216500	0	0	0
Fertilizer spreader	0	0	0	0	0	0	105750	0	0	0
Fertilizer spreader	0	0	0	0	0	0	105750	0	0	0
Tine implement	0	0	0	0	0	0	0	111750	0	0
Tine implement	0	0	0	0	0	0	0	97500	0	0
Trailer	0	0	0	0	0	89200	0	0	0	0
Trailer	0	0	0	0	0	0	89200	0	0	0
Trailer	0	0	0	0	0	0	0	0	89200	0
Water cart	0	0	0	0	0	0	0	0	0	0

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Front loader	0	0	0	0	0	0	0	0	0	0
Grain cart	0	0	0	0	0	0	0	0	0	0
Lorry	0	0	0	0	0	824500	0	0	0	0
LDV	0	0	0	0	171463	0	0	0	0	0
LDV	0	0	251883	0	0	0	0	0	0	0
Tools and equipment										
Total Intermediate capital	**1241500**	**1130500**	**1382383**	**0**	**171463**	**3470200**	**2057950**	**209250**	**89200**	**0**
Total Capital outlay	**1241500**	**1130500**	**1382383**	**0**	**171463**	**3470200**	**2057950**	**209250**	**89200**	**0**
Net annual flows	**2572755**	**936705**	**684822**	**2067205**	**3642792**	**-1402995**	**9255**	**1857955**	**1978005**	**35108434**

IRR 5.28%

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

Cash flow:										
Opening	13600236	16638272	17945134	19268070	20607277	23731491	25125593	26536842	27965447	29411622
Inflow	5428745	3681695	3681695	3681695	5428745	3681695	3681695	3681695	3681695	3681695
Outflow	2592857	2592857	2592857	2592857	2592857	2592857	2592857	2592857	2592857	2592857
Flow before interest	16436124	17727109	19033972	20356908	23443165	24820329	26214431	27625679	29054284	30500460
Interest	202147	218025	234098	250369	288327	305264	322410	339767	357337	375124
Closing balance	16638272	17945134	19268070	20607277	23731491	25125593	26536842	27965447	29411622	30875584

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Whole farm multi-period budget: System B year 1 to 10

Year in calculation period	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Type of year for wheat and barley*	2	1	3	2	1	2	2	1	2	3
Type of year for canola and lupin*	2	2	3	2	1	2	2	1	2	3
Gross margin										
Crop										
Wheat after wheat	0	0	0	0	0	0	0	0	0	0
Wheat after canola	1337758	1870608	804907	1337758	1870608	1337758	1337758	1870608	1337758	804907
Wheat, second year after canola	1188470	1686379	709391	1188470	1686379	1188470	1188470	1686379	1188470	709391
Wheat, third year after canola	1102477	1574181	630774	1102477	1574181	1102477	1102477	1574181	1102477	630774
Canola	311919	744169	-336456	311919	744169	311919	311919	744169	311919	-336456
Gross margin total farm:	**3940624**	**5875337**	**1808617**	**3940624**	**5875337**	**3940624**	**3940624**	**5875337**	**3940624**	**1808617**
Overhead and fixed costs:										
Regular workers	438900	438900	438900	438900	438900	438900	438900	438900	438900	438900
Salary(secretary)	34800	34800	34800	34800	34800	34800	34800	34800	34800	34800
Casual labour	4266	4266	4266	4266	4266	4266	4266	4266	4266	4266
Water fees	88000	88000	88000	88000	88000	88000	88000	88000	88000	88000
Electricity	60000	60000	60000	60000	60000	60000	60000	60000	60000	60000
Municipal taxes	40000	40000	40000	40000	40000	40000	40000	40000	40000	40000
Insurance (overall)	87351	87351	87351	87351	87351	87351	87351	87351	87351	87351
Bank charges	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000
Phone	48000	48000	48000	48000	48000	48000	48000	48000	48000	48000
Administration	36000	36000	36000	36000	36000	36000	36000	36000	36000	36000
Auditors & Consultation fees	40000	40000	40000	40000	40000	40000	40000	40000	40000	40000
Supply: camps	42000	42000	42000	42000	42000	42000	42000	42000	42000	42000
Supply: water distribution	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000
Farm owner remuneration	400000	400000	400000	400000	400000	400000	400000	400000	400000	400000
Miscellaneous cost (4%)	55173	55173	55173	55173	55173	55173	55173	55173	55173	55173
Total	**1434490**	**1434490**	**1434490**	**1434490**	**1434490**	**1434490**	**1434490**	**1434490**	**1434490**	**1434490**

Margin above fixed and overhead costs:	**2506135**	**4440848**	**374127**	**2506135**	**4440848**	**2506135**	**2506135**	**4440848**	**2506135**	**374127**
Hired management	180000	180000	180000	180000	180000	180000	180000	180000	180000	180000
Total	**180000**	**180000**	**180000**	**180000**	**180000**	**180000**	**180000**	**180000**	**180000**	**180000**
Margin above factors costs:	**2326135**	**4260848**	**194127**	**2326135**	**4260848**	**2326135**	**2326135**	**4260848**	**2326135**	**194127**
Capital outlay:										
Long-term:										
Land and fixed improvements	25060000	0	0	0	0	0	0	0	0	0
Intermediate Capital:										
Combine harvester 240 kW	2006667	0	0	0	0	0	0	0	3440000	0
Swather 7m	523875	0	0	0	0	0	0	0	0	0
Tractor 239 kW	1491292	0	0	0	0	0	0	0	0	0
Tractor 120 kW	282625	0	0	0	0	0	0	0	0	0
Tractor 120 kW	376833	0	0	0	0	0	0	0	0	0
Tractor 70 kW	90500	0	0	0	0	0	0	0	0	0
Tractor 70 kW	45250	0	0	0	0	0	0	0	0	543000
Planter	882833	0	0	0	0	0	1324250	0	0	0
Sprayer	144333	0	0	0	0	0	216500	0	0	0
Sprayer	126292	0	0	0	0	0	216500	0	0	0
Fertilizer spreader	70500	0	0	0	0	0	105750	0	0	0
Fertilizer spreader	61688	0	0	0	0	0	105750	0	0	0
Tine implement	65188	0	0	0	0	0	0	111750	0	0
Tine implement	65000	0	0	0	0	0	0	97500	0	0
Trailer	52033	0	0	0	0	0	0	0	0	0
Trailer	59467	0	0	0	0	0	0	0	0	0
Trailer	66900	0	0	0	0	0	0	0	0	0
Water cart	25375	0	0	0	0	0	0	0	0	0

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Front loader	65250	0	0	0	0	0	0	0	0	0
Grain cart	447563	0	0	0	0	0	0	0	0	0
Lorry	480958	0	0	0	0	0	0	0	0	0
LDV	142886	0	0	0	0	0	171463	0	0	0
LDV	167922	0	0	0	251883	0	0	0	0	0
Tools and equipment	240000									
Total Intermediate capital	**7533666**	**0**	**0**	**0**	**251883**	**0**	**2140213**	**209250**	**3440000**	**543000**
Total Capital outlay	**32593666**	**0**	**0**	**0**	**251883**	**0**	**2140213**	**209250**	**3440000**	**543000**
Net annual flows	**-30267531**	**4260848**	**194127**	**2326135**	**4008965**	**2326135**	**185922**	**4051598**	**-1113865**	**-348873**
IRR	6.35%									

* Type of year indicated by code: Good year = 1, average year = 2 and poor year = 3

Cash flow:										
Opening	0	1312768	4573212	3711930	4998283	8158440	9770334	11310129	14824148	16117136
Inflow	3940624	5875337	1808617	3940624	5875337	3940624	3940624	5875337	3940624	1808617
Outflow	2643806	2670455	2714998	2714998	2814302	2447435	2538243	2541425	2843451	2859045
Flow before interest	1296818	4517650	3666831	4937556	8059319	9651629	11172716	14644041	15921321	15066709
Interest	15950	55562	45098	60727	99121	118705	137413	180106	195816	185305
Closing balance	1312768	4573212	3711930	4998283	8158440	9770334	11310129	14824148	16117136	15252014

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Whole farm multi-period budget: System B year 11 to 20

Year in calculation period	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	
Type of year for wheat and barley*	1	2	2	2	1	2	2	2	2	
Type of year for canola and lupin*	1	2	2	2	1	2	2	2	2	
Gross margin										
Crop										
Wheat after wheat	0	0	0	0	0	0	0	0	0	
Wheat after canola	1870608	1337758	1337758	1337758	1870608	1337758	1337758	1337758	1337758	133
Wheat, second year after canola	1686379	1188470	1188470	1188470	1686379	1188470	1188470	1188470	1188470	118
Wheat, third year after canola	1574181	1102477	1102477	1102477	1574181	1102477	1102477	1102477	1102477	110
Canola	744169	311919	311919	311919	744169	311919	311919	311919	311919	31
Gross margin total farm:	**5875337**	**3940624**	**3940624**	**3940624**	**5875337**	**3940624**	**3940624**	**3940624**	**3940624**	**394**
Overhead and fixed costs:										
Regular workers	438900	438900	438900	438900	438900	438900	438900	438900	438900	43
Salary(secretary)	34800	34800	34800	34800	34800	34800	34800	34800	34800	3
Casual labour	4266	4266	4266	4266	4266	4266	4266	4266	4266	
Water fees	88000	88000	88000	88000	88000	88000	88000	88000	88000	8
Electricity	60000	60000	60000	60000	60000	60000	60000	60000	60000	6
Municipal taxes	40000	40000	40000	40000	40000	40000	40000	40000	40000	4
Insurance (overall)	87351	87351	87351	87351	87351	87351	87351	87351	87351	8
Bank charges	30000	30000	30000	30000	30000	30000	30000	30000	30000	3
Phone	48000	48000	48000	48000	48000	48000	48000	48000	48000	4
Administration	36000	36000	36000	36000	36000	36000	36000	36000	36000	3
Auditors & Consultation fees	40000	40000	40000	40000	40000	40000	40000	40000	40000	4
Supply: camps	42000	42000	42000	42000	42000	42000	42000	42000	42000	4
Supply: water distribution	30000	30000	30000	30000	30000	30000	30000	30000	30000	3
Farm owner remuneration	400000	400000	400000	400000	400000	400000	400000	400000	400000	40
Miscellaneous cost (4%)	55173	55173	55173	55173	55173	55173	55173	55173	55173	5

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Total	**1434490**	**1434490**	**1434490**	**1434490**	**1434490**	**1434490**	**1434490**	**1434490**	**1434490**	**143**
Margin above fixed and overhead costs:	**4440848**	**2506135**	**2506135**	**2506135**	**4440848**	**2506135**	**2506135**	**2506135**	**2506135**	**250**
Hired management	180000	180000	180000	180000	180000	180000	180000	180000	180000	18
Total	**180000**	**180000**	**180000**	**180000**	**180000**	**180000**	**180000**	**180000**	**180000**	**18**
Margin above factors costs:	**4260848**	**2326135**	**2326135**	**2326135**	**4260848**	**2326135**	**2326135**	**2326135**	**2326135**	**232**
Capital outlay:										
Long-term:										
Land and fixed improvements	0	0	0	0	0	0	0	0	0	
Intermediate Capital:										
Combine harvester 240 kW	0	0	0	0	0	0	0	0	0	
Swather 7m	698500	0	0	0	0	0	0	0	0	
Tractor 239 kW	0	0	0	0	0	2556500	0	0	0	
Tractor 120 kW	0	1130500	0	0	0	0	0	0	0	
Tractor 120 kW	0	0	1130500	0	0	0	0	0	0	
Tractor 70 kW	543000	0	0	0	0	0	0	0	0	
Tractor 70 kW	0	0	0	0	0	0	0	0	0	
Planter	0	0	0	0	0	0	1324250	0	0	
Sprayer	0	0	0	0	0	0	216500	0	0	
Sprayer	0	0	0	0	0	0	216500	0	0	
Fertilizer spreader	0	0	0	0	0	0	105750	0	0	
Fertilizer spreader	0	0	0	0	0	0	105750	0	0	
Tine implement	0	0	0	0	0	0	0	111750	0	
Tine implement	0	0	0	0	0	0	0	97500	0	
Trailer	0	0	0	0	0	89200	0	0	0	
Trailer	0	0	0	0	0	0	89200	0	0	
Trailer	0	0	0	0	0	0	0	0	89200	
Water cart	0	0	0	0	0	0	0	0	0	

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Front loader	0	0	0	0	0	0	0	0	0	
Grain cart	0	0	0	0	0	0	0	0	0	
Lorry	0	0	0	0	0	824500	0	0	0	
LDV	0	0	0	0	171463	0	0	0	0	
LDV	0	0	251883	0	0	0	0	0	0	
Tools and equipment										
Total Intermediate capital	**1241500**	**1130500**	**1382383**	**0**	**171463**	**3470200**	**2057950**	**209250**	**89200**	
Total Capital outlay	**1241500**	**1130500**	**1382383**	**0**	**171463**	**3470200**	**2057950**	**209250**	**89200**	
Net annual flows	**3019348**	**1195635**	**943752**	**2326135**	**4089385**	**-1144065**	**268185**	**2116885**	**2236935**	**3491**

IRR 6.35%

* Type of year indicated by code: Good year = 1, average year = 2 and poor year = 3

Cash flow:										
Opening	15252014	17926897	18526014	19180812	20122426	23105350	24755011	26593492	28432118	3020
Inflow	5875337	3940624	3940624	3940624	5875337	3940624	3940624	3940624	3940624	394
Outflow	3418258	3566589	3518865	3243488	3173133	2591726	2425241	2447435	2538243	254
Flow before interest	17709093	18300932	18947774	19877948	22824631	24454249	26270394	28086682	29834500	3160
Interest	217803	225082	233038	244478	280719	300762	323099	345437	366933	38
Closing balance	17926897	18526014	19180812	20122426	23105350	24755011	26593492	28432118	30201434	3198

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Whole farm multi-period budget for system E: year 1 to 10

Year in calculation period	1	2	3	4	5	6	7	8	9	10
Type of year for wheat and barley*	2	1	3	2	1	2	2	1	2	3
Type of year for canola and lupin*	2	2	3	2	1	2	2	1	2	3
Gross margin										
Crop										
Wheat after Medicsmedics	3147428	4283011	2011846	3147428	4283011	3147428	3147428	4283011	3147428	2011846
Medics	1228283	1366033	1210708	1228283	1366033	1228283	1228283	1366033	1228283	1210708
Gross margin total farm:	**4375711**	**5649044**	**3222554**	**4375711**	**5649044**	**4375711**	**4375711**	**5649044**	**4375711**	**3222554**
Overhead and fixed costs										
Regular workers	438900	438900	438900	438900	438900	438900	438900	438900	438900	438900
Salary (Secretary)	34800	34800	34800	34800	34800	34800	34800	34800	34800	34800
Casual labour	4266	4266	4266	4266	4266	4266	4266	4266	4266	4266
Water fees	88000	88000	88000	88000	88000	88000	88000	88000	88000	88000
Electricity	60000	60000	60000	60000	60000	60000	60000	60000	60000	60000
Municipal taxes	40000	40000	40000	40000	40000	40000	40000	40000	40000	40000
Insurance (overall)	87351	87351	87351	87351	87351	87351	87351	87351	87351	87351
Bank charges	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000
Phone	48000	48000	48000	48000	48000	48000	48000	48000	48000	48000
Administration	36000	36000	36000	36000	36000	36000	36000	36000	36000	36000
Auditors & Consultation fees	40000	40000	40000	40000	40000	40000	40000	40000	40000	40000
Supply: camps	42000	42000	42000	42000	42000	42000	42000	42000	42000	42000
Supply: water distribution	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000
Farm owner remuneration	400000	400000	400000	400000	400000	400000	400000	400000	400000	400000
Miscellaneous cost (4%)	55173	55173	55173	55173	55173	55173	55173	55173	55173	55173
Total	**1434490**	**1434490**	**1434490**	**1434490**	**1434490**	**1434490**	**1434490**	**1434490**	**1434490**	**1434490**
Margin above fixed and overhead	**2941222**	**4214554**	**1788064**	**2941222**	**4214554**	**2941222**	**2941222**	**4214554**	**2941222**	**1788064**

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costs:										
Hired management	180000	180000	180000	180000	180000	180000	180000	180000	180000	180000
Total	**180000**	**180000**	**180000**	**180000**	**180000**	**180000**	**180000**	**180000**	**180000**	**180000**
Margin above factor costs:	**2761222**	**4034554**	**1608064**	**2761222**	**4034554**	**2761222**	**2761222**	**4034554**	**2761222**	**1608064**
Capital outlay:										
Long-term:										
Land and fixed improvements	26110000	0	0	0	0	0	0	0	0	0
Intermediate Capital:										
Combine harvester 170 kW	1560417	0	0	0	0	0	0	2675000	0	0
Tractor 200 kW	1482000	0	0	0	0	0	0	0	0	0
Tractor 120 kW	659458	0	0	0	0	0	0	0	0	0
Tractor 70 kW	316750	0	0	0	0	0	0	0	0	0
Planter	635104	0	0	0	0	1088750	0	0	0	0
Sprayer	352917	0	0	0	0	605000	0	0	0	0
Fertilizer spreader	89833	0	0	0	0	154000	0	0	0	0
Tine implement	83813	0	0	0	0	0	0	111750	0	0
Trailer	50500	0	0	0	0	0	0	0	0	0
Trailer	75750	0	0	0	0	0	0	0	0	0
Water cart	32625	0	0	0	0	0	0	0	0	0
Front loader	65250	0	0	0	0	0	0	0	0	0
Grain cart	447563	0	0	0	0	0	0	0	0	0
Lorry	480958	0	0	0	0	0	0	0	0	0
LDV	142886	0	0	0	0	0	171463	0	0	0
LDV	146932	0	0	251883	0	0	0	0	0	0
Tool and equipment	**240000**									
Total Intermediate capital	**6862755**	**0**	**0**	**251883**	**0**	**1847750**	**171463**	**2786750**	**0**	**0**
Livestock	4349813									
Total Capital outlay	**37322568**	**0**	**0**	**251883**	**0**	**1847750**	**171463**	**2786750**	**0**	**0**

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Net annual flow:	**-34561346**	**4034554**	**1608064**	**2509339**	**4034554**	**913472**	**2589759**	**1247804**	**2761222**	**1608064**

IRR 7.01%

* Type of year indicated by code: Good year = 1, average year = 2 and poor year = 3

Cash flow analysis:

Opening	0	1753206	5438121	6666933	9078198	12707587	15464000	18162389	22179737	24651760
Inflow	4375711	5649044	3222554	4375711	5649044	4375711	4375711	5649044	4375711	3222554
Outflow	2643806	2030200	2074742	2074742	2174046	1807179	1897987	1901169	2203195	2218789
Flow before interest	1731905	5372050	6585933	8967902	12553196	15276119	17941724	21910263	24352253	25655525
Interest	21301	66071	81000	110296	154391	187880	220665	269473	299507	315536
Closing balance	1753206	5438121	6666933	9078198	12707587	15464000	18162389	22179737	24651760	25971062

Whole farm multi-period budget for system E: year 11 to 20

Year in calculation period	11	12	13	14	15	16	17	18	19	
Type of year for wheat and barley*	1	2	2	2	1	2	2	2	2	
Type of year for canola and lupin*	1	2	2	2	1	2	2	2	2	
Gross margin										
Crop										
Wheat after Medicsmedics	4283011	3147428	3147428	3147428	4283011	3147428	3147428	3147428	3147428	3147
Medics	1366033	1228283	1228283	1228283	1366033	1228283	1228283	1228283	1228283	1228
Gross margin total farm:	**5649044**	**4375711**	**4375711**	**4375711**	**5649044**	**4375711**	**4375711**	**4375711**	**4375711**	**4375**
Overhead and fixed costs										
Regular workers	438900	438900	438900	438900	438900	438900	438900	438900	438900	438
Salary (Secretary)	34800	34800	34800	34800	34800	34800	34800	34800	34800	34
Casual labour	4266	4266	4266	4266	4266	4266	4266	4266	4266	4
Water fees	88000	88000	88000	88000	88000	88000	88000	88000	88000	88
Electricity	60000	60000	60000	60000	60000	60000	60000	60000	60000	60
Municipal taxes	40000	40000	40000	40000	40000	40000	40000	40000	40000	40
Insurance (overall)	87351	87351	87351	87351	87351	87351	87351	87351	87351	87
Bank charges	30000	30000	30000	30000	30000	30000	30000	30000	30000	30
Phone	48000	48000	48000	48000	48000	48000	48000	48000	48000	48
Administration	36000	36000	36000	36000	36000	36000	36000	36000	36000	36
Auditors & Consultation fees	40000	40000	40000	40000	40000	40000	40000	40000	40000	40
Supply: camps	42000	42000	42000	42000	42000	42000	42000	42000	42000	42
Supply: water distribution	30000	30000	30000	30000	30000	30000	30000	30000	30000	30
Farm owner remuneration	400000	400000	400000	400000	400000	400000	400000	400000	400000	400
Miscellaneous cost (4%)	55173	55173	55173	55173	55173	55173	55173	55173	55173	55
Total	**1434490**	**1434490**	**1434490**	**1434490**	**1434490**	**1434490**	**1434490**	**1434490**	**1434490**	**1434**

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Margin above fixed and overhead costs:	**4214554**	**2941222**	**2941222**	**2941222**	**4214554**	**2941222**	**2941222**	**2941222**	**2941222**	**2941**
Hired management	180000	180000	180000	180000	180000	180000	180000	180000	180000	180
Total	**180000**	**180000**	**180000**	**180000**	**180000**	**180000**	**180000**	**180000**	**180000**	**180**
Margin above factors costs:	**4034554**	**2761222**	**2761222**	**2761222**	**4034554**	**2761222**	**2761222**	**2761222**	**2761222**	**2761**
Capital outlay:										
Long-term:										
Land and fixed improvements	0	0	0	0	0	0	0	0	0	
Intermediate Capital:										
Combine harvester 170 kW	0	0	0	0	0	0	0	0	0	2675
Tractor 200 kW	0	0	0	0	0	0	2223000	0	0	
Tractor 120 kW	0	0	0	0	0	1130500	0	0	0	
Tractor 70 kW	0	0	0	0	0	543000	0	0	0	
Planter	0	0	0	0	0	1088750	0	0	0	
Sprayer	0	0	0	0	0	605000	0	0	0	
Fertilizer spreader	0	0	0	0	0	154000	0	0	0	
Tine implement	0	0	0	0	0	0	0	111750	0	
Trailer	0	0	0	0	101000	0	0	0	0	
Trailer	0	0	0	0	0	0	0	101000	0	
Water cart	0	0	0	0	0	0	0	0	0	
Front loader	0	0	0	0	0	0	0	0	0	
Grain cart	0	0	0	0	0	0	0	0	0	
Lorry	0	0	0	0	0	824500	0	0	0	
LDV	0	0	0	0	171463	0	0	0	0	
LDV	0	251883	0	0	0	0	0	0	0	
Tool and equipment										
Total Intermediate capital	**0**	**251883**	**0**	**0**	**272463**	**4345750**	**2223000**	**212750**	**0**	**2675**
Livestock										

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Total Capital outlay	**0**	**251883**	**0**	**0**	**272463**	**4345750**	**2223000**	**212750**	**0**	**2675**
Net annual flow:	**4034554**	**2509339**	**2761222**	**2761222**	**3762091**	**-1584528**	**538222**	**2548472**	**2761222**	**37408**

IRR 7.01%

* Type of year indicated by code: Good year = 1, average year = 2 and poor year = 3

Cash flow analysis:

Opening	25971062	29196831	31023126	32920193	35119356	38705780	41635878	44770545	47921299	51018
Inflow	5649044	4375711	4375711	4375711	5649044	4375711	4375711	4375711	4375711	4375
Outflow	2778002	2926334	2878609	2603232	2532877	1951470	1784985	1807179	1897987	1901
Flow before interest	28842103	30646209	32520228	34692672	38235523	41130021	44226604	47339077	50399023	53493
Interest	354728	376916	399965	426684	470257	505856	543941	582221	619856	657
Closing balance	29196831	31023126	32920193	35119356	38705780	41635878	44770545	47921299	51018879	54151

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Annexure 3: Capital budget for scenario one, two, three and four

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Whole farm multi-period budget for Scenario one: year 1 to 10

Year in calculation period	1	2	3	4	5	6	7	8	9	1
Yields based on (good,average, and poor years)	2	1	3	2	1	2	2	1	2	
Gross margin										
Crop										
Wheat after wheat	3681695	2761271	1840847	920424	0	0	0	0	0	
Wheat after canola	0	0	804907	1337758	1870608	1337758	1337758	1870608	1337758	80490
Wheat, second year after canola	0	0	0	1188470	1686379	1188470	1188470	1686379	1188470	70939
Wheat, third year after canola	0	0	0	0	1574181	1102477	1102477	1574181	1102477	63077
Canola	0	744169	-336456	311919	744169	311919	311919	744169	311919	-33645
Gross margin total farm:	**3681695**	**3505441**	**2309299**	**3758571**	**5875337**	**3940624**	**3940624**	**5875337**	**3940624**	**180861**
Overhead and fixed costs:										
Regular work:	438900	438900	438900	438900	438900	438900	438900	438900	438900	43890
Salary (secretary)	34800	34800	34800	34800	34800	34800	34800	34800	34800	3480
Casual labour	4266	4266	4266	4266	4266	4266	4266	4266	4266	426
Water fees:	88000	88000	88000	88000	88000	88000	88000	88000	88000	8800
Electricity	60000	60000	60000	60000	60000	60000	60000	60000	60000	6000
Municipal taxes:	40000	40000	40000	40000	40000	40000	40000	40000	40000	4000
Insurance (overall):	87351	87351	87351	87351	87351	87351	87351	87351	87351	8735
Bank charges:	30000	30000	30000	30000	30000	30000	30000	30000	30000	3000
Phone	48000	48000	48000	48000	48000	48000	48000	48000	48000	4800
Administration	36000	36000	36000	36000	36000	36000	36000	36000	36000	3600
Auditors & Consultation fees	40000	40000	40000	40000	40000	40000	40000	40000	40000	4000
Supply: camps	42000	42000	42000	42000	42000	42000	42000	42000	42000	4200
Supply: water distribution	30000	30000	30000	30000	30000	30000	30000	30000	30000	3000
Farm owner remuneration	400000	400000	400000	400000	400000	400000	400000	400000	400000	40000
Miscellaneous cost (4%)	55173	55173	55173	55173	55173	55173	55173	55173	55173	5517

Total	**1434489.7**	**1434490**	**1434490**	**1434490**	**1434490**	**1434490**	**1434489.7**	**1434490**	**1434489.7**	**1434489.6**
Margin above fixed and overhead costs:	**2247205**	**2070951**	**874810**	**2324081**	**4440848**	**2506135**	**2506135**	**4440848**	**2506135**	**37412**
Hired management	180000	180000	180000	180000	180000	180000	180000	180000	180000	18000
Total	**180000**	**180000**	**180000**	**180000**	**180000**	**180000**	**180000**	**180000**	**180000**	**18000**
Margin above factor costs:	**2067205**	**1890951**	**694810**	**2144081**	**4260848**	**2326135**	**2326135**	**4260848**	**2326135**	**19412**
Capital outlay:										
Long-term:										
Land and fixed improvements	25060000	0	0	0	0	0	0	0	0	
Intermediate Capital:										
Combine harvester 240 Kw	2006666.7	0	0	0	0	0	0	0	3440000	
Swather 7m	523875	0	0	0	0	0	0	0	0	
Tractor 230 kW	1491291.7	0	0	0	0	0	0	0	0	
Tractor 120 kW	282625	0	0	0	0	0	0	0	0	
Tractor 120 kW	376833	0	0	0	0	0	0	0	0	
Tractor 70 kW	90500	0	0	0	0	0	0	0	0	
Tractor 70 kW	45250	0	0	0	0	0	0	0	0	54300
Planter	882833	0	0	0	0	0	1324250	0	0	
Sprayer	144333	0	0	0	0	0	216500	0	0	
Sprayer	126292	0	0	0	0	0	216500	0	0	
Fertilizer spreader	70500	0	0	0	0	0	105750	0	0	
Fertilizer spreader	61688	0	0	0	0	0	105750	0	0	
Tine implement	65188	0	0	0	0	0	0	111750	0	
Tine implement	65000	0	0	0	0	0	0	97500	0	
Trailer	52033	0	0	0	0	0	0	0	0	
Trailer	59467	0	0	0	0	0	0	0	0	

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Trailer	66900	0	0	0	0	0	0	0	0	
Water cart	25375	0	0	0	0	0	0	0	0	
Front loader	65250	0	0	0	0	0	0	0	0	
Grain cart	447563	0	0	0	0	0	0	0	0	
Lorry	480958	0	0	0	0	0	0	0	0	
LDV	142886	0	0	0	0	0	171463	0	0	
LDV	167922	0	0	0	251883	0	0	0	0	
Tools and equipment	240000									
Total Intermediate capital	**7981228.7**	**0**	**0**	**0**	**251883**	**0**	**2140213**	**209250**	**3440000**	**54300**
Total Capital outlay	**33041229**	**0**	**0**	**0**	**251883**	**0**	**2140213**	**209250**	**3440000**	**54300**
Net annual flows	**- 30974023**	**1890951**	**694810**	**2144081**	**4008965**	**2326135**	**185922**	**4051598**	**-1113865**	**-34887**
IRR	5.6%									
Cash flow analysis:										
Opening	0	1102229	2039593	1777633	2979546	6339043	7781350	9241396	12677907	1419817
Inflow	3681695	3505441	2309299	3758571	5875337	3940624	3940624	5875337	3940624	180861
Outflow	2592857	2592857	2592857	2592857	2592857	2592857	2592857	2592857	2592857	259285
Flow before interest	1088838	2014813	1756035	2943346	6262027	7686810	9129117	12523876	14025674	1341393
Interest	13392	24780	21597	36200	77016	94540	112279	154031	172501	16497
Closing balance	1102229	2039593	1777633	2979546	6339043	7781350	9241396	12677907	14198176	1357891

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Whole farm multi-period budget for Scenario one: year 11 to 20

Year in calculation period	11	12	13	14	15	16	17	18
Yields based on (good, average, and poor years)	1	2	2	2	1	2	2	2
Gross margin								
Crop								
Wheat after wheat	0	0	0	0	0	0	0	0
Wheat after canola	1870608	1337758	1337758	1337758	1870608	1337758	1337758	1337758
Wheat, second year after canola	1686379	1188470	1188470	1188470	1686379	1188470	1188470	1188470
Wheat, third year after canola	1574181	1102477	1102477	1102477	1574181	1102477	1102477	1102477
Canola	744169	311919	311919	311919	744169	311919	311919	311919
Gross margin total farm:	**5875337**	**3940624**	**3940624**	**3940624**	**5875337**	**3940624**	**3940624**	**3940624**
Overhead and fixed costs:								
Regular work:	438900	438900	438900	438900	438900	438900	438900	438900
Salary (secretary)	34800	34800	34800	34800	34800	34800	34800	34800
Casual labour	4266	4266	4266	4266	4266	4266	4266	4266
Water fees:	88000	88000	88000	88000	88000	88000	88000	88000
Electricity	60000	60000	60000	60000	60000	60000	60000	60000
Municipal taxes:	40000	40000	40000	40000	40000	40000	40000	40000
Insurance (overall):	87351	87351	87351	87351	87351	87351	87351	87351
Bank charges:	30000	30000	30000	30000	30000	30000	30000	30000
Phone	48000	48000	48000	48000	48000	48000	48000	48000
Administration	36000	36000	36000	36000	36000	36000	36000	36000
Auditors & Consultation fees	40000	40000	40000	40000	40000	40000	40000	40000
Supply: camps	42000	42000	42000	42000	42000	42000	42000	42000
Supply: water distribution	30000	30000	30000	30000	30000	30000	30000	30000

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Farm owner remuneration	400000	400000	400000	400000	400000	400000	400000	400000
Miscellaneous cost (4%)	55173	55173	55173	55173	55173	55173	55173	55173
Total	**1434489.68**	**1434489.68**	**1434489.68**	**1434489.68**	**1434489.68**	**1434489.68**	**1434489.68**	**1434489.68**
Margin above fixed and overhead costs:	**4440848**	**2506135**	**2506135**	**2506135**	**4440848**	**2506135**	**2506135**	**2506135**
Hired management	180000	180000	180000	180000	180000	180000	180000	180000
Total	**180000**	**180000**	**180000**	**180000**	**180000**	**180000**	**180000**	**180000**
Margin above factor costs:	**4260848**	**2326135**	**2326135**	**2326135**	**4260848**	**2326135**	**2326135**	**2326135**
Capital outlay:								
Long-term:								
Land and fixed improvements	0	0	0	0	0	0	0	0
Intermediate Capital:								
Combine harvester 240 Kw	0	0	0	0	0	0	0	0
Swather 7m	698500	0	0	0	0	0	0	0
Tractor 230 kW	0	0	0	0	0	2556500	0	0
Tractor 120 kW	0	1130500	0	0	0	0	0	0
Tractor 120 kW	0	0	1130500	0	0	0	0	0
Tractor 70 kW	543000	0	0	0	0	0	0	0
Tractor 70 kW	0	0	0	0	0	0	0	0
Planter	0	0	0	0	0	0	1324250	0
Sprayer	0	0	0	0	0	0	216500	0
Sprayer	0	0	0	0	0	0	216500	0
Fertilizer spreader	0	0	0	0	0	0	105750	0
Fertilizer spreader	0	0	0	0	0	0	105750	0
Tine implement	0	0	0	0	0	0	0	111750
Tine implement	0	0	0	0	0	0	0	97500
Trailer	0	0	0	0	0	89200	0	0

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Trailer	0	0	0	0	0	0	89200	0
Trailer	0	0	0	0	0	0	0	0
Water cart	0	0	0	0	0	0	0	0
Front loader	0	0	0	0	0	0	0	0
Grain cart	0	0	0	0	0	0	0	0
Lorry	0	0	0	0	0	824500	0	0
LDV	0	0	0	0	171463	0	0	0
LDV	0	0	251883	0	0	0	0	0
Tools and equipment								
Total Intermediate capital	**1241500**	**1130500**	**1382383**	**0**	**171463**	**3470200**	**2057950**	**209250**
Total Capital outlay	**1241500**	**1130500**	**1382383**	**0**	**171463**	**3470200**	**2057950**	**209250**
Net annual flows	**3019348**	**1195635**	**943752**	**2326135**	**4089385**	**-1144065**	**268185**	**2116885**
IRR	5.6%							
Cash flow analysis:								
Opening	13578913	17068771	18643042	20236676	21849909	25441492	27118739	28816615
Inflow	5875337	3940624	3940624	3940624	5875337	3940624	3940624	3940624
Outflow	2592857	2592857	2592857	2592857	2592857	2592857	2592857	2592857
Flow before interest	16861393	18416538	19990810	21584443	25132390	26789259	28466506	30164382
Interest	207378	226504	245866	265466	309102	329480	350108	370991
Closing balance	17068771	18643042	20236676	21849909	25441492	27118739	28816615	30535373

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Whole farm multi-period budget for scenario two: year 1 to 10

Year in calculation period	1	2	3	4	5	6	7	8	9	10
Gross margin										
Crop										
Wheat after wheat	3681695	1840847	0	0	0	0	0	0	0	0
Wheat to Medicsmedics	0	0	2011846	3147428	4283011	3147428	3147428	4283011	3147428	2011846
medics	0	409810	363212	1228283	1366033	1228283	1228283	1366033	1228283	1210708
Establishment cost for medics pastures		855000	855000							
Gross margin: total farm	**3681695**	**1395657**	**1520058**	**4375711**	**5649044**	**4375711**	**4375711**	**5649044**	**4375711**	**3222554**
Overhead and fixed costs										
Regular work:	438900	438900	438900	438900	438900	438900	438900	438900	438900	438900
Salary (secretary)	34800	34800	34800	34800	34800	34800	34800	34800	34800	34800
Casual labour	4266	4266	4266	4266	4266	4266	4266	4266	4266	4266
Water fees:	88000	88000	88000	88000	88000	88000	88000	88000	88000	88000
Electricity	60000	60000	60000	60000	60000	60000	60000	60000	60000	60000
Municipal taxes:	40000	40000	40000	40000	40000	40000	40000	40000	40000	40000
Insurance (overall):	87351	87351	87351	87351	87351	87351	87351	87351	87351	87351
Bank charges:	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000
Phone	48000	48000	48000	48000	48000	48000	48000	48000	48000	48000
Administration	36000	36000	36000	36000	36000	36000	36000	36000	36000	36000
Auditors & Consultation fees	40000	40000	40000	40000	40000	40000	40000	40000	40000	40000
Supply: camps	42000	42000	42000	42000	42000	42000	42000	42000	42000	42000
Supply: water distribution	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000
Farm owner remuneration	400000	400000	400000	400000	400000	400000	400000	400000	400000	400000
Miscellaneous cost (4%)	55173	55173	55173	55173	55173	55173	55173	55173	55173	55173
Total	**1434490**	**1434490**	**1434490**	**1434490**	**1434490**	**1434490**	**1434490**	**1434490**	**1434490**	**1434490**

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Margin above fixed and overhead costs:	**2247205**	**-38832**	**85569**	**2941222**	**4214554**	**2941222**	**2941222**	**4214554**	**2941222**	**1788064**
Hired management	180000	180000	180000	180000	180000	180000	180000	180000	180000	180000
Total	180000	180000	180000	180000	180000	180000	180000	180000	180000	180000
Margin above foreign factors costs:	2067205	-218832	-94431	2761222	4034554	2761222	2761222	4034554	2761222	1608064
Capital outlay:										
Long-term:										
Land and fixed improvements	25060000	200000	0	0	0	0	0	0	0	0
Intermediate Capital:										
Combine harvester 240 kW	2006667	0	0	0	0	0	0	0	1359750	0
Swather 7m	523875	0	0	0	0	0	0	0	0	0
Tractor 230 kW	1491292	0	0	0	0	0	0	0	0	0
Tractor 120 kW	282625	0	0	0	0	0	0	0	0	0
Tractor 120 kW	376833	0	0	0	0	0	0	0	0	0
Tractor 70 kW	90500	0	0	0	0	0	0	0	0	0
Tractor 70 kW	45250	0	0	0	0	0	0	0	0	0
Planter	882833	0	0	0	0	0	546821	0	0	0
Sprayer	144333	0	0	0	0	0	338483	0	0	0
Sprayer	126292	0	0	0	0	0	0	0	0	0
Fertilizer spreader	70500	0	0	0	0	0	82783	0	0	0
Fertilizer spreader	61688	0	0	0	0	0	0	0	0	0
Tine implement	65188	0	0	0	0	0	77294	0	0	0
Tine implement	65000	0	0	0	0	0	0	0	0	0
Trailer	52033	0	0	0	0	0	0	0	0	0
Trailer	59467	0	0	0	0	0	0	0	0	0
Trailer	66900	0	0	0	0	0	0	0	0	0
Water cart	25375	0	0	0	0	0	0	0	0	0
Front loader	65250	0	0	0	0	0	0	0	0	0

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Grain cart	447563	0	0	0	0	0	0	0	0	0
Lorry	480958	0	0	0	0	0	0	0	0	0
LDV	142886	0	0	171463	0	0	0	0	0	0
LDV	167922	0	0	0	0	0	0	0	251883	0
Tools and equipment	240000									
Total Intermediate capital	**7981229**	**0**	**0**	**171463**	**0**	**0**	**1045381**	**0**	**1611633**	**0**
Livestock:	0	1304944		3044869						
Total Capital outlay	**33041229**	**1504944**	**0**	**171463**	**0**	**0**	**1045381**	**0**	**1611633**	**0**
Net annual flows	**-30974023**	**-1723776**	**-94431**	**2589759**	**4034554**	**2761222**	**1715840**	**4034554**	**1149589**	**1608064**
IRR	6.6%									
Cash flow analysis:										
Opening	0	973898	-364316	-1627508	28925	2994723	4708005	6442358	9487035	11280166
Inflow	3681695	1395657	1520058	4375711	5649044	4375711	4375711	5649044	4375711	3222554
Outflow	2719630	2719630	2719630	2719630	2719630	2719630	2719630	2719630	2719630	2719630
Flow before interest	962065	-350075	-1563888	28573	2958339	4650805	6364087	9371772	11143117	11783090
Interest	11832	-14241	-63621	351	36384	57200	78272	115263	137049	144920
Closing balance	973898	-364316	-1627508	28925	2994723	4708005	6442358	9487035	11280166	11928010

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Whole farm multi-period budget for scenario two: year 11 to 20

Year in calculation period	11	12	13	14	15	16	17	18	19
Gross margin									
Crop									
Wheat after wheat	0	0	0	0	0	0	0	0	0
Wheat to Medicsmedics	4283011	3147428	3147428	3147428	4283011	3147428	3147428	3147428	3147428
medics	1366033	1228283	1228283	1228283	1366033	1228283	1228283	1228283	1228283
Establishment cost for medics pastures									
Gross margin: total farm	**5649044**	**4375711**	**4375711**	**4375711**	**5649044**	**4375711**	**4375711**	**4375711**	**4375711**
Overhead and fixed costs									
Regular work:	438900	438900	438900	438900	438900	438900	438900	438900	438900
Salary (secretary)	34800	34800	34800	34800	34800	34800	34800	34800	34800
Casual labour	4266	4266	4266	4266	4266	4266	4266	4266	4266
Water fees:	88000	88000	88000	88000	88000	88000	88000	88000	88000
Electricity	60000	60000	60000	60000	60000	60000	60000	60000	60000
Municipal taxes:	40000	40000	40000	40000	40000	40000	40000	40000	40000
Insurance (overall):	87351	87351	87351	87351	87351	87351	87351	87351	87351
Bank charges:	30000	30000	30000	30000	30000	30000	30000	30000	30000
Phone	48000	48000	48000	48000	48000	48000	48000	48000	48000
Administration	36000	36000	36000	36000	36000	36000	36000	36000	36000
Auditors & Consultation fees	40000	40000	40000	40000	40000	40000	40000	40000	40000
Supply: camps	42000	42000	42000	42000	42000	42000	42000	42000	42000
Supply: water distribution	30000	30000	30000	30000	30000	30000	30000	30000	30000
Farm owner remuneration	400000	400000	400000	400000	400000	400000	400000	400000	400000
Miscellaneous cost (4%)	55173	55173	55173	55173	55173	55173	55173	55173	55173

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Total	**1434490**	**1434490**	**1434490**	**1434490**	**1434490**	**1434490**	**1434490**	**1434490**	**1434490**
Margin above fixed and overhead costs:	**4214554**	**2941222**	**2941222**	**2941222**	**4214554**	**2941222**	**2941222**	**2941222**	**2941222**
Hired management	180000	180000	180000	180000	180000	180000	180000	180000	180000
Total	180000	180000	180000	180000	180000	180000	180000	180000	180000
Margin above foreign factors costs:	4034554	2761222	2761222	2761222	4034554	2761222	2761222	2761222	2761222
Capital outlay:									
Long-term:									
Land and fixed improvements	0	0	0	0	0	0	0	0	0
Intermediate Capital:									
Combine harvester 240 kW	0	0	0	0	0	0	0	0	0
Swather 7m	0	0	0	0	0	0	0	0	0
Tractor 230 kW	0	0	0	0	0	1332871	0	0	0
Tractor 120 kW	0	0	0	0	0	0	0	0	0
Tractor 120 kW	0	0	621775	0	0	0	0	0	0
Tractor 70 kW	307700		0	0	0	0	0	0	
Tractor 70 kW	0	0	0	0	0	0	0	0	
Planter	0	0	0	0	0	1088750	0	0	0
Sprayer	0	0	0	0	0	0	216500	0	0
Sprayer	0	0	0	0	0	0	0	0	
Fertilizer spreader	0	0	0	0	0	0	154000	0	0
Fertilizer spreader		0	0	0	0	0	0	0	
Tine implement	0	0	0	0	0	0	111750	0	0
Tine implement	0	0	0	0	0	0	0	0	
Trailer	0	0	0	0	0	0	0	45297	0
Trailer	0	0	0	0	0	0	0	0	0
Trailer	0	0	0	0	0	69060	0	0	
Water cart	0	0	0	0	0	0	0	0	0

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Front loader	0	0	0	0	0	0	0	0	0
Grain cart	0	0	0	0	0	0	0	0	0
Lorry	0	0	0	0	0	0	0	824500	0
LDV	0	171463	0	0	0	0	0	0	0
LDV	0	0	0	0	0	0	251883	0	0
Tools and equipment									
Total Intermediate capital	**307700**	**171463**	**621775**	**0**	**0**	**2490681**	**734133**	**869797**	**0**
Livestock:									
Total Capital outlay	**307700**	**171463**	**621775**	**0**	**0**	**2490681**	**734133**	**869797**	**0**
Net annual flows	**3726854**	**2589759**	**2139447**	**2761222**	**4034554**	**270541**	**2027089**	**1891425**	**2761222**
IRR	6.6%								
Cash flow analysis:									
Opening	11928010	15040155	16901583	18785904	20693401	23913351	25883910	27878705	29898034
Inflow	5649044	4375711	4375711	4375711	5649044	4375711	4375711	4375711	4375711
Outflow	2719630	2719630	2719630	2719630	2719630	2719630	2719630	2719630	2719630
Flow before interest	14857424	16696236	18557664	20441986	23622815	25569433	27539992	29534786	31554115
Interest	182731	205346	228240	251415	290536	314477	338713	363247	388083
Closing balance	15040155	16901583	18785904	20693401	23913351	25883910	27878705	29898034	31942198

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Whole farm multi-period budget for scenario three: year 1 to 10

Year in calculation period	1	2	3	4	5	6	7	8	9	10
Gross margin										
Crop										
Wheat after wheat	3681695	3313525	3313525	2945356	2945356	2577186	2577186	2209017	2209017	1840847
Wheat to Medicsmedics	0	0	0	0	0	0	0	0	0	0
Medics	0	0	0	245657	273207	491313	491313	819620	736970	968566
Medics establisment year	0	81962	726425	73697	81962	81886	736970	81962	73697	72642
Establishment cost for medics pastures		171000	171000	171000	171000	171000	171000	171000	171000	171000
Gross margin: total farm	**3681695**	**3224487**	**3868950**	**3093710**	**3129525**	**2979385**	**3634469**	**2939599**	**2848684**	**2711056**
Overhead and fixed costs:										
Regular work:	438900	438900	438900	438900	438900	438900	438900	438900	438900	438900
Salary (secretary)	34800	34800	34800	34800	34800	34800	34800	34800	34800	34800
Casual labour	4266	4266	4266	4266	4266	4266	4266	4266	4266	4266
Water fees:	88000	88000	88000	88000	88000	88000	88000	88000	88000	88000
Electricity	60000	60000	60000	60000	60000	60000	60000	60000	60000	60000
Municipal taxes:	40000	40000	40000	40000	40000	40000	40000	40000	40000	40000
Insurance (overall):	87351	87351	87351	87351	87351	87351	87351	87351	87351	87351
Bank charges:	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000
Phone	48000	48000	48000	48000	48000	48000	48000	48000	48000	48000
Administration	36000	36000	36000	36000	36000	36000	36000	36000	36000	36000
Auditors & Consultation fees	40000	40000	40000	40000	40000	40000	40000	40000	40000	40000
Supply: camps	42000	42000	42000	42000	42000	42000	42000	42000	42000	42000
Supply: water distribution	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000

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Farm owner remuneration	400000	400000	400000	400000	400000	400000	400000	400000	400000	400000
Miscellaneous cost (4%)	55173	55173	55173	55173	55173	55173	55173	55173	55173	55173
Total	**1434490**	**1434490**	**1434490**	**1434490**	**1434490**	**1434490**	**1434490**	**1434490**	**1434490**	**1434490**
Margin above fixed and overhead costs:	**2247205**	**1789998**	**2434461**	**1659220**	**1695035**	**1544896**	**2199980**	**1505109**	**1414194**	**1276567**
Hired management	180000	180000	180000	180000	180000	180000	180000	180000	180000	180000
Total	180000	180000	180000	180000	180000	180000	180000	180000	180000	180000
Margin above factor costs:	2067205	1609998	2254461	1479220	1515035	1364896	2019980	1325109	1234194	1096567
Capital outlay:										
Long-term:										
Land and fixed improvements	25060000	200000	0	0	0	0	0	0	0	0
Intermediate capital:										
Combine harvester	2006667	0	0	0	0	0	0	0	1359750	0
Swather	523875	0	0	0	0	0	0	0	0	0
Tractor 230 kW	1491292	0	0	0	0	0	0	0	0	0
Tractor 120 kW	282625	0	0	0	0	0	0	0	0	0
Tractor 120 kW	376833	0	0	0	0	0	0	0	0	0
Tractor 70 kW	90500	0	0	0	0	0	0	0	0	0
Tractor 70 kW	45250	0	0	0	0	0	0	0	0	0
Planter	882833	0	0	0	0	0	546821	0	0	0
Sprayer	144333	0	0	0	0	0	338483	0	0	0
Sprayers	126292	0	0	0	0	0	0	0	0	0
Fertilizer spreader	70500	0	0	0	0	0	82783	0	0	0
Fertilizer spreader	61688	0	0	0	0	0	0	0	0	0
Tine implement	65188	0	0	0	0	0	77293.75	0	0	0
Tine implement	65000	0	0	0	0	0	0	0	0	0

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Trailer	52033	0	0	0	0	0	0	0	0	0
Trailer	59467	0	0	0	0	0	0	0	0	0
Trailer	66900	0	0	0	0	0	0	0	0	0
water cart	25375	0	0	0	0	0	0	0	0	0
front loader	65250	0	0	0	0	0	0	0	0	0
Grain cart	447563	0	0	0	0	0	0	0	0	0
Lorry	480958	0	0	0	0	0	0	0	0	0
LDV	142886	0	0	171463	0	0	0	0	0	0
LDV	167922	0	0	0	0	0	0	0	251883	0
Tools and equipment	240000									
Total Intermediate capital	**7981229**	**0**	**0**	**171463**	**0**	**0**	**1045381.3**	**0**	**1611633**	**0**
Livestock	0	260989	0	608974	0	869963	0	869963	0	1739925
Total Capital outlay	**33041229**	**460989**	**0**	**171463**	**0**	**869963**	**1045381**	**869963**	**1611633**	**1739925**
Net annual flows	**-30974023**	**1149009**	**2254461**	**1307757**	**1515035**	**494933**	**974599**	**455147**	**-377439**	**-643358**
IRR	4.8%									
Cash flow analysis:										
Opening	0	973898	1496943	2678809	3090437	3543382	3849912	4823353	5105350	5298782
Inflow	3681695	3224487	3868950	3093710	3129525	2979385	3634469	2939599	2848684	2711056
Outflow	2719629.7	2719630	2719630	2719630	2719630	2719630	2719630	2719630	2719630	2719630
Flow before interest	962065	1478755	2646263	3052889	3500331	3803137	4764752	5043322	5234404	5290208
Interest	11832	18187	32546	37547	43050	46775	58601	62028	64378	65064
Closing balance	973898	1496943	2678809	3090437	3543382	3849912	4823353	5105350	5298782	5355272

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Whole farm multi-period budget for scenario three: year 11 to 20

Year in calculation period	11	12	13	14	15	16	17	18	19	2
Gross margin										
Crop										
Wheat after wheat	1840847	0	0	0	0	0	0	0	0	
Wheat to Medicsmedics	0	3147428	3147428	3147428	4283011	3147428	3147428	3147428	3147428	314742
Medics	1092826	1228283	1228283	1228283	1366033	1228283	1228283	1228283	1228283	122828
Medics establishment year	81962	0	0	0	0	0	0	0	0	
Establishment cost for medics pastures	171000									
Gross margin: total farm	**2844636**	**4375711**	**4375711**	**4375711**	**5649044**	**4375711**	**4375711**	**4375711**	**4375711**	**437571**
Overhead and fixed costs:										
Regular work:	438900	438900	438900	438900	438900	438900	438900	438900	438900	43890
Salary (secretary)	34800	34800	34800	34800	34800	34800	34800	34800	34800	3480
Casual labour	4266	4266	4266	4266	4266	4266	4266	4266	4266	426
Water fees:	88000	88000	88000	88000	88000	88000	88000	88000	88000	8800
Electricity	60000	60000	60000	60000	60000	60000	60000	60000	60000	6000
Municipal taxes:	40000	40000	40000	40000	40000	40000	40000	40000	40000	4000
Insurance (overall):	87351	87351	87351	87351	87351	87351	87351	87351	87351	8735
Bank charges:	30000	30000	30000	30000	30000	30000	30000	30000	30000	3000
Phone	48000	48000	48000	48000	48000	48000	48000	48000	48000	4800
Administration	36000	36000	36000	36000	36000	36000	36000	36000	36000	3600
Auditors & Consultation fees	40000	40000	40000	40000	40000	40000	40000	40000	40000	4000
Supply: camps	42000	42000	42000	42000	42000	42000	42000	42000	42000	4200

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Supply: water distribution	30000	30000	30000	30000	30000	30000	30000	30000	30000	3000
Farm owner remuneration	400000	400000	400000	400000	400000	400000	400000	400000	400000	40000
Miscellaneous cost (4%)	55173	55173	55173	55173	55173	55173	55173	55173	55173	5517
Total	**1434490**	**1434490**	**1434490**	**1434490**	**1434490**	**1434490**	**1434490**	**1434490**	**1434490**	**143449**
Margin above fixed and overhead costs:	**1410146**	**2941222**	**2941222**	**2941222**	**4214554**	**2941222**	**2941222**	**2941222**	**2941222**	**294122**
Hired management	180000	180000	180000	180000	180000	180000	180000	180000	180000	18000
Total	180000	180000	180000	180000	180000	180000	180000	180000	180000	18000
Margin above factor costs:	1230146	2761222	2761222	2761222	4034554	2761222	2761222	2761222	2761222	276122
Capital outlay:										
Long-term:										
Land and fixed improvements	0	0	0	0	0	0	0	0	0	
Intermediate capital:										
Combine harvester	0	0	0	0	0	0	0	0	0	
Swather	0	0	0	0	0	0	0	0	0	
Tractor 230 kW	0	0	0	0	0	1332871	0	0	0	
Tractor 120 kW	0	0	0	0	0	0	0	0	0	
Tractor 120 kW	0	0	621775	0	0	0	0	0	0	
Tractor 70 kW	307700		0	0	0	0	0	0		
Tractor 70 kW	0	0	0	0	0	0	0	0		
Planter	0	0	0	0	0	1088750	0	0	0	
Sprayer	0	0	0	0	0	0	216500	0	0	
Sprayers	0	0	0	0	0	0	0	0		
Fertilizer spreader	0	0	0	0	0	0	154000	0	0	
Fertilizer spreader		0	0	0	0	0	0	0		
Tine implement	0	0	0	0	0	0	111750	0	0	
Tine implement	0	0	0	0	0	0	0	0		

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Trailer	0	0	0	0	0	0	0	45297	0	
Trailer	0	0	0	0	0	0	0	0	0	
Trailer	0	0	0	0	0	69060	0	0		
water cart	0	0	0	0	0	0	0	0	0	
front loader	0	0	0	0	0	0	0	0	0	
Grain cart	0	0	0	0	0	0	0	0	0	
Lorry	0	0	0	0	0	0	0	824500	0	
LDV	0	171463	0	0	0	0	0	0	0	
LDV	0	0	0	0	0	0	251883	0	0	
Tools and equipment										
Total Intermediate capital	**307700**	**171463**	**621775**	**0**	**0**	**2490681**	**734133**	**869797**	**0**	
Livestock	0	0								
Total Capital outlay	**307700**	**171463**	**621775**	**0**	**0**	**2490681**	**734133**	**869797**	**0**	
Net annual flows	**922446**	**2589759**	**2139447**	**2761222**	**4034554**	**270541**	**2027089**	**1891425**	**2761222**	**3580245**
IRR	4.8%									
Cash flow analysis:										
Opening	5355272	5547680	7292360	9058499	10846358	13945200	15793161	17663850	19557547	2147453
Inflow	2844636	4375711	4375711	4375711	5649044	4375711	4375711	4375711	4375711	437571
Outflow	2719630	2719630	2719630	2719630	2719630	2719630	2719630	2719630	2719630	271963
Flow before interest	5480278	7203762	8948442	10714580	13775773	15601282	17449243	19319932	21213629	2313061
Interest	67402	88599	110057	131778	169428	191880	214608	237615	260906	28448
Closing balance	5547680	7292360	9058499	10846358	13945200	15793161	17663850	19557547	21474534	2341509

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Whole farm multi-period budget for scenario four: year 1 to 10

Year in calculation period	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**1**
Gross margin										
Crop										
Wheat after wheat	3681695	1840847	0	0	0	0	0	0	0	
Wheat after Medicsmedics	0	0	2011846	3147428	4283011	3147428	3147428	4283011	3147428	201184
Medics	0	409810	363212	1228283	1366033	1228283	1228283	1366033	1228283	121070
Establishment cost for medics pastures		855000	855000							
Gross margin: total farm	**3681695**	**1395657**	**1520058**	**4375711**	**5649044**	**4375711**	**4375711**	**5649044**	**4375711**	**322255**
Overhead and fixed costs:										
Regular workers	438900	438900	438900	438900	438900	438900	438900	438900	438900	43890
Salary (secretary)	34800	34800	34800	34800	34800	34800	34800	34800	34800	3480
Casual labour	4266	4266	4266	4266	4266	4266	4266	4266	4266	426
Water fees	88000	88000	88000	88000	88000	88000	88000	88000	88000	880
Electricity	60000	60000	60000	60000	60000	60000	60000	60000	60000	600
Municipal taxes	40000	40000	40000	40000	40000	40000	40000	40000	40000	400
Insurance (overall):	87351	87351	87351	87351	87351	87351	87351	87351	87351	873
Bank charges	30000	30000	30000	30000	30000	30000	30000	30000	30000	300
Phone	48000	48000	48000	48000	48000	48000	48000	48000	48000	480
Administration	36000	36000	36000	36000	36000	36000	36000	36000	36000	360
Auditors & Consultation fees	40000	40000	40000	40000	40000	40000	40000	40000	40000	400
Supply: camps	42000	42000	42000	42000	42000	42000	42000	42000	42000	420

Supply: water distribution	30000	30000	30000	30000	30000	30000	30000	30000	30000	3000
Farm owner remuneration	400000	400000	400000	400000	400000	400000	400000	400000	400000	4000
Miscellaneous cost (4%)	55173	55173	55173	55173	55173	55173	55173	55173	55173	551
Total	**1434490**	**1434490**	**1434490**	**1434490**	**1434490**	**1434490**	**1434490**	**1434490**	**1434490**	**14344**
Margin above fixed and overhead costs:	**2247205**	**-38832**	**85569**	**2941222**	**4214554**	**2941222**	**2941222**	**4214554**	**2941222**	**17880**
Hired management	180000	180000	180000	180000	180000	180000	180000	180000	180000	1800
Total	**180000**	**180000**	**180000**	**180000**	**180000**	**180000**	**180000**	**180000**	**180000**	**1800**
Margin above foreign factors costs:	2067205	-218832	-94431	2761222	4034554	2761222	2761222	4034554	2761222	16080
Capital outlay:										
Long-term:										
Land and fixed improvements	25060000	200000	0	0	0	0	0	0	0	
Intermediate capital:										
Combine harvester										
Swather	523875	0	0	0	0	0	0	0	0	
Tractor 230 kW	1491292	0	0	0	0	0	0	0	0	
Tractor 120 kW	282625	0	0	0	0	0	0	0	0	
Tractor 120 kW	376833	0	0	0	0	0	0	0	0	
Tractor 70 kW	90500	0	0	0	0	0	0	0	0	
Tractor 70 kW	45250	0	0	0	0	0	0	0	0	
Planter	882833	0	0	0	0	0	546821	0	0	
Sprayers	144333	0	0	0	0	0	338483	0	0	
Sprayers	126292	0	0	0	0	0	0	0	0	
Fertilizer spreader	70500	0	0	0	0	0	82783	0	0	
Fertilizer spreader	61688	0	0	0	0	0	0	0	0	
Tine implements	65188	0	0	0	0	0	77294	0	0	
Tine implements	65000	0	0	0	0	0	0	0	0	

Trailers	52033	0	0	0	0	0	0	0	0	
Trailers	59467	0	0	0	0	0	0	0	0	
Trailers	66900	0	0	0	0	0	0	0	0	
water cart	25375	0	0	0	0	0	0	0	0	
front loader	65250	0	0	0	0	0	0	0	0	
Grain cart	447563	0	0	0	0	0	0	0	0	
Lorry	480958	0	0	0	0	0	0	0	0	
LDV	142886	0	0	171463	0	0	0	0	0	
LDV	167922	0	0	0	0	0	0	0	251883	
tools and equipment	240000									
Total Intermediate capital	**7981229**	**0**	**0**	**171463**	**0**	**0**	**1045381**	**0**	**1611633**	
livestock:	0	1304944		3044869						
Total Capital outlay	**33041229**	**1504944**	**0**	**171463**	**0**	**0**	**1045381**	**0**	**1611633**	
Net annual flows	**-30974023**	**-1723776**	**-94431**	**2589759**	**4034554**	**2761222**	**1715840**	**4034554**	**1149589**	**16080**
IRR	6.6%									
Cash flow analysis:										
Opening	0	973898	-712127	-2337280	-1096349	1478738	2796502	4233788	6977744	81426
Inflow	3681695	1395657	1520058	4375711	5649044	4375711	4375711	5649044	4375711	32225
Outflow	2719630	3053845	3053845	3091922.97	3091923	3091923	2989864.2	2989864.2	3309694.4	3309694
Flow before interest	962065	-684290	-2245914	-1053492	1460772	2762526	4182349	6892967	8043761	80555
Interest	11832	-27838	-91366	-42857	17966	33976	51439	84776	98930	990
Closing balance	2731462	3026007	2962478	3049066	3109889	3125899	3041303	3074641	3408624	34087

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Whole farm multi-period budget for scenario four: year 11 to 20

Year in calculation period	11	12	13	14	15	16	17	18	19	
Gross margin										
Crop										
Wheat after wheat	0	0	0	0	0	0	0	0	0	
Wheat after Medicsmedics	4283011	3147428	3147428	3147428	4283011	3147428	3147428	3147428	3147428	31474
Medics	1366033	1228283	1228283	1228283	1366033	1228283	1228283	1228283	1228283	12282
Establishment cost for medics pastures										
Gross margin: total farm	**5649044**	**4375711**	**4375711**	**4375711**	**5649044**	**4375711**	**4375711**	**4375711**	**4375711**	**43757**
Overhead and fixed costs:										
Regular workers	438900	438900	438900	438900	438900	438900	438900	438900	438900	4389
Salary (secretary)	34800	34800	34800	34800	34800	34800	34800	34800	34800	348
Casual labour	4266	4266	4266	4266	4266	4266	4266	4266	4266	42
Water fees	88000	88000	88000	88000	88000	88000	88000	88000	88000	880
Electricity	60000	60000	60000	60000	60000	60000	60000	60000	60000	600
Municipal taxes	40000	40000	40000	40000	40000	40000	40000	40000	40000	400
Insurance (overall):	87351	87351	87351	87351	87351	87351	87351	87351	87351	873

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Bank charges	30000	30000	30000	30000	30000	30000	30000	30000	30000	300
Phone	48000	48000	48000	48000	48000	48000	48000	48000	48000	480
Administration	36000	36000	36000	36000	36000	36000	36000	36000	36000	360
Auditors & Consultation fees	40000	40000	40000	40000	40000	40000	40000	40000	40000	400
Supply: camps	42000	42000	42000	42000	42000	42000	42000	42000	42000	420
Supply: water distribution	30000	30000	30000	30000	30000	30000	30000	30000	30000	300
Farm owner remuneration	400000	400000	400000	400000	400000	400000	400000	400000	400000	4000
Miscellaneous cost (4%)	55173	55173	55173	55173	55173	55173	55173	55173	55173	551
Total	**1434490**	**1434490**	**1434490**	**1434490**	**1434490**	**1434490**	**1434490**	**1434490**	**1434490**	**14344**
Margin above fixed and overhead costs:	**4214554**	**2941222**	**2941222**	**2941222**	**4214554**	**2941222**	**2941222**	**2941222**	**2941222**	**29412**
Hired management	180000	180000	180000	180000	180000	180000	180000	180000	180000	1800
Total	**180000**	**180000**	**180000**	**180000**	**180000**	**180000**	**180000**	**180000**	**180000**	**1800**
Margin above foreign factors costs:	4034554	2761222	2761222	2761222	4034554	2761222	2761222	2761222	2761222	27612
Capital outlay:										
Long-term:										
Land and fixed improvements	0	0	0	0	0	0	0	0	0	
Intermediate capital:										
Combine harvester										
Swather	0	0	0	0	0	0	0	0	0	
Tractor 230 kW	0	0	0	0	0	1332871	0	0	0	
Tractor 120 kW	0	0	0	0	0	0	0	0	0	
Tractor 120 kW	0	0	621775	0	0	0	0	0	0	
Tractor 70 kW	307700		0	0	0	0	0	0		
Tractor 70 kW	0	0	0	0	0	0	0	0		
Planter	0	0	0	0	0	1088750	0	0	0	
Sprayers	0	0	0	0	0	0	216500	0	0	

Sprayers	0	0	0	0	0	0	0	0		
Fertilizer spreader	0	0	0	0	0	0	154000	0	0	
Fertilizer spreader		0	0	0	0	0	0	0		
Tine implements	0	0	0	0	0	0	111750	0	0	
Tine implements	0	0	0	0	0	0	0	0		
Trailers	0	0	0	0	0	0	0	45297	0	
Trailers	0	0	0	0	0	0	0	0	0	
Trailers	0	0	0	0	0	69060	0	0		
water cart	0	0	0	0	0	0	0	0	0	
front loader	0	0	0	0	0	0	0	0	0	
Grain cart	0	0	0	0	0	0	0	0	0	
Lorry	0	0	0	0	0	0	0	824500	0	
LDV	0	171463	0	0	0	0	0	0	0	
LDV	0	0	0	0	0	0	251883	0	0	
tools and equipment										
Total Intermediate capital	**307700**	**171463**	**621775**	**0**	**0**	**2490680.8**	**734133**	**869796.7**	**0**	
livestock:										
Total Capital outlay	**307700**	**171463**	**621775**	**0**	**0**	**2490681**	**734133**	**869797**	**0**	
Net annual flows	**3726854**	**2589759**	**2139447**	**2761222**	**4034554**	**270541**	**2027089**	**1891425**	**2761222**	**358024**
IRR	6.6%									
Cash flow analysis:										
Opening	8154625	10553865	11890086	13102960	14693061	17591712	18746265	19788525	20787846	217994
Inflow	5649044	4375711	4375711	4375711	5649044	4375711	4375711	4375711	4375711	43757
Outflow	3378028	3183950	3322032	2964124	2964124	3448916	3573873	3628953	3628953	36289
Flow before interest	10425641	11745627	12943765	14514547	17377981	18518507	19548104	20535283	21534604	225462
Interest	128225	144459	159195	178514	213731	227758	240421	252563	264853	2772

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Closing balance	16074685	16121338	17319476	18890258	23027025	22894218	23923815	24910995	25910315	269219

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Annexure 4: Scenario Three area allocation and gross margin calculation

Scenario three description

Year 1

Hectares planted of wheat : 950ha

Gross margin realised : wheat after wheat GM/ha x 950ha

Year 2

Hectares planted of wheat : 855 ha

Medics newly established : 95ha

Wheat-after-wheat gross margin : GM[i]/ha x 855 ha

Medics gross margin : GM/ha x 30% x 95ha

Livestock required/ value : Total value required/ha x 95 ha x 30%

Year 3

Hectares planted of wheat : 855 ha

Medics newly established : 95 ha

Wheat-after-wheat gross margin : GM/ha x 855 ha

Medics gross margin : GM/ha x 30% x 95 ha

Year 4

Hectares planted of wheat : 760 ha

Medics newly established : 95 ha

Pasture medics : 95ha

Wheat-after-wheat gross margin : GM/ha x 760 ha

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Medics gross margin	: GM/ha x 30% x 95 ha
Pasture medics gross margin	: GM/ha x 95 ha
Livestock required/ value	: Total value required/ha x 95 ha x 70%
Year 5	
Hectares planted of wheat	: 760 ha
Medics newly established	: 95 ha
Pasture medics	: 95ha
Wheat-after-wheat gross margin	: GM/ha x 760 ha
Medics gross margin	: GM/ha x 30% x 95 ha
Pasture medics gross margin	: GM/ha x 95 ha
Year 6	
Hectares planted of wheat	: 665 ha
Medics newly established	: 95 ha
Pasture medics	: 190 ha
Wheat-after-wheat gross margin	: GM/ha x 665 ha
Medics gross margin	: GM/ha x 30% x 95 ha
Pasture medics gross margin	: GM/ha x 190 ha
Livestock required/ value	: Total value required/ha x 95 ha
Year 7	
Hectares planted of wheat	: 665 ha
Medics newly established	: 95 ha
Pasture medics	: 190 ha

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Wheat after wheat gross margin	: GM/ha x 665 ha
Medics gross margin	: GM/ha x 30% x 95 ha
Pasture medics gross margin	: GM/ha x 190 ha
Year 8	
Hectares planted of wheat	: 570 ha
Medics newly established	: 95 ha
Pasture medics	: 285 ha
Wheat after wheat gross margin	: GM/ha x 570 ha
Medics gross margin	: GM/ha x 30% x 95 ha
Pasture medics gross margin	: GM/ha x 285 ha
Livestock required/ value	: Total value required/ha x 95 ha
Year 9	
Hectares planted of wheat	: 570 ha
Medics newly established	: 95 ha
Pasture medics	: 285 ha
Wheat after wheat gross margin	: GM/ha x 570 ha
Medics gross margin	: GM/ha x 30% x 95 ha
Pasture medics gross margin	: GM/ha x 285 ha
Year 10	
Hectares planted of wheat	: 475 ha
Medics newly established	: 95 ha
Pasture medics	: 380 ha

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Wheat after wheat gross margin	: GM/ha x 475 ha
Medics gross margin	: GM/ha x 30% x 95 ha
Pasture medics gross margin	: GM/ha x 380 ha
Livestock required/ value	: Total value required/ha x 95 ha
Year 11	
Hectares planted of wheat	: 475 ha
Medics newly established	: 95 ha
Pasture medics	: 380 ha
Wheat after wheat gross margin	: GM/ha x 475 ha
Medics gross margin	: GM/ha x 30% x 95 ha
Pasture medics gross margin	: GM/ha x 380 ha

[i] GM : Gross Margin

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Annexure 5: List of experts consulted on the establishment of information relevant to farm description and crop rotation systems

Initial establishment of parameters of typical farm:
Discussion on farm level situation for the Middle Swartland and Rooi Karoo
Held on 13/06/2007 at JS Marais building: Stellenbosch
Members of the Small-grains Expert Group present
Prof Andre Agenbag (US: Department Agronomy)
Prof Theo Kleynhans (US: Department of Agricultural Economics)
Prof Johan Laubscher (US: Department of Agricultural Economics; retired)
Attie Haasbroek (Kaap Agri: Porterville)
Dr Mark Hardy (Department of Agriculture: Western-Cape)
Sakkie Slabbert (Department of Agriculture: Moorreesburg)
Johan Loubser (MKB – Moorreesburg)
Jim McDermott (DuPont agricultural Chemicals)
Lukas Rautenbach (Mechanisation expert and producer)
Dr Johan Labuschagne (Soil Scientists Department of Agriculture)
Prof Altus Viljoen (US: Department Plant Pathology)
Johan Kotzé (Producer)
WG Treurnicht (Producer)
Willem Hoffmann (US: Department of agricultural Economics)
JP Louw (US: Department of agricultural Economics)

Confirmation or changes consulted with:
Dr Johann Strauss (Agronomists, Department of Agriculture Western Cape)
Louis Coetzee (Extension officer for Kaap-Agri)
Kobus Bester (Farmer Middle Swartland)
Wynhand Heunis (Extension officer for Overberg Agri, Moorreesburg)
Frian Bester (Farmer Middle Swartland)
Hardus van Vuuren (Agriculturalist, Wenchem)