The Financial and Management Implications of Integrating Beef Cattle into Crop Rotation Systems in the Middle Swartland.

by

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Declaration

By submitting this thesis electronically, I declare that the entirety of the work contained therein is my own, original work, that I am the sole author thereof (except when explicitly stated otherwise), that reproduction and publication thereof by Stellenbosch University will not infringe any third-party rights and that I have not previously in its entirety or in part submitted it for obtaining any qualification.

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Abstract

South Africa produced roughly R37 billion worth of beef in 2018. The Western Cape; however, contributed only five percent of this total with various factors playing a role to this effect. The environment and natural grazing opportunities of the northern summer rainfall areas lend itself towards beef production, with the largest consumer market, Gauteng, also being part of this geographical area. The Fynbos and Karoo veld types of the Western Cape are not quite suitable for the natural grazing of cattle.

Traditionally sheep has been the predominant livestock component used in farm systems in the Western Cape's Swartland. This area is mainly categorised as a wheat producing area. Since the 1990's the implementation of Conservation agriculture (CA) and crop rotation has been relatively high. It leads to an increase in crop diversity as it is one of the managing strategies to achieve enhanced productivity and sustainability. Cover crops can be used to serve a variety of key functions simultaneously with the collective goal being to achieve sustainability in farming systems. The inclusion of cover crops in rotation systems creates grazing opportunities, leading to the evaluation of further livestock integration.

Integrating livestock into a cereal production system is complex and multi-faceted. Soil health, disease build-up, weed management, marketing systems, labour requirements, mechanisation, and infrastructure need to be taken into consideration. These physical characteristics and relationships need to be balanced through knowledge, capital, diversification, sustainability, and profitability. Underlying factors should be considered when integrating livestock, which would in turn influence whole-farm aspects in CA production systems. A beef cattle component will likely differ from a sheep component in the same farm system. Specific crop rotation systems have the potential to financially benefit beef cattle rather than sheep. A combination of sheep and cattle as an option of integration is also likely.

Unfortunately, a lack of knowledge exists regarding the financial viability and management developments of integrating a beef cattle component in CA systems in the Swartland. A whole-farm multi-period budget model was constructed for a typical farm in the Middle Swartland. The financial model incorporated numerous assumptions and parameters that were validated by experts and producers. Multidisciplinary group discussions were a critical part of this study. Incorporating members' knowledge assured that the budget models were constructed with credible assumptions and parameters to simulate whole-farm systems that projects practical financial guidelines.

According to the financial analysis the wheat - medic rotation system, with a sheep livestock component, is the most lucrative over a 20-year period. Among systems that include cover crops (and therefore cattle integration), the rotation of cover crop - medic - wheat, with a mixed livestock integration, financially performed the best. Beef cattle integration is the least profitable livestock integration strategy according to this study, whilst a mixed livestock integration of sheep and beef cattle showed the best financial performance.

Opsomming

Suid-Afrika het ongeveer R37 biljoen se beesvleis in 2018 geproduseer. Die Wes-Kaap provinsie het slegs vyf persent van hierdie totaal bygedra. Verskeie faktore speel ‘n rol in hierdie situasie. Die natuurlike weiding van die noordelike somerreënvalgebiede is meer gepas vir beesvleisproduksie en die grootste verbruikersmark, Gauteng, lê in die geografiese gebied. Die Wes-Kaap beskik oor Fynbos en Karoo veldtipes wat nie gepas is as natuurlike beesweiding nie.

Skaap is tradisioneel die gekose veekomponent vir boerderysisteme in die Swartland. Hierdie gebied word hoofsaaklik as koringproduserende gebied gekategoriseer, maar die implimentering van bewaringslandboubeginsels, spesifiek wisselbou stelsels, is redelik gewild vanaf die 1990’s. Verhoogde gewas diversiteit is een van die bestuurstrategieë om verbeterde produktiwiteit en volhoubaarheid te bereik. Dekgewasse kan gebruik word om tegelykertyd 'n verskeidenheid sleutelfunksies te dien, waarvan die kollektiewe doelwit is om volhoubaarheid in boerderystelsels te bereik. Die insluit van dekgewasse in wisselboustelsels skep weidingsgeleenthede wat ‘n verdere evaluasie van vee-integrasie tot gevolg het.

Die integrasie van vee in 'n graanproduksiestelsel is kompleks en veelsydig. Aspekete soos grondgesondheid, siekte-opbou, onkruidbestuur, bemarkingstelsels, arbeidsvereistes, meganisasie en infrastruktuur moet in gedagte gehou word. Al hierdie fisiese eienskappe en verhoudings moet gebalanseer word met kennis, kapitaal, diversifikasie, doelwitte vir volhoubaarheid en winsgewendheid. Daar is onderliggende faktore wat in ag geneem moet word wanneer vee geïntegreer word. Die integrasie sal bewaringslandboustelsels en boerdery as geheel beïnvloed. 'n Vleisbeeskomponent sal waarskynlik redelik verskil van 'n skaapkomponent in dieselfde boerderysisteem en wisselboustelslels. Sekere boerderysisteme en wisselboustelsels het die potensiaal om voordelig te wees vir vleisbeesintegrasies. ’n Kombinasie van bees en skaap as ’n gemengde integragrasie is waarskynlik ook ’n waardevolle opsie.

Gebrekkige kennis bestaan rondom die finansiële implikasies en bestuursontwikkeling wat die integrasie van 'n vleisbeeskomponent in wisselboustelsels van die Middel Swartland inhou. ’n Geheelplaas multi-periodebegrotingsmodel is vir 'n tipiese Middel Swartland plaas opgestel. Dié finansiële model bevat talle parameters en aannames wat met kundiges en produsente getoets is. Multidissiplinêre groepbesprekings was 'n kritiese deel van hierdie studie, aangesien dit verseker dat die begrotingsmodelle met kredietwaardige aannames en ‘n volledige stel parameters saamgestel is om geheelplaasstelsels te simuleer wat praktiese finansiële riglyne projekteer.

Volgens finansiële ontledings, is tot die gevolgtrek gekom dat die koring - medic rotasiestelsel, met 'n skaapvee-komponent, die mees winsgewende oor 'n tydperk van 20 jaar is. Van die stelsels wat dekgewasse (en dus bees-integrasies) insluit, het die rotasie van dekgewas - medic - koring, met 'n gemengde vee-integrasie, finansiëel die beste gevaar. Vleisbees-integrasies toon die laagste winsgewendheid van die vee-integrasie strategiëe wat in hierdie studie geëvalueer is, terwyl 'n gemengde vee-integrasie van skape en beeste die beste finansiële prestasie getoon het.

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Table of Contents

List of Figures

List of Tables

Chapter 1: Introduction

1.1 Background

South Africa produced roughly R37 billion worth of beef in 2018. The Western Cape, however, only contributed five percent of to this total (DAFF, 2019). Various factors contribute to this situation. The natural savanna and bushveld of the northern summer rainfall areas lend itself towards beef production, with the largest consumer market, Gauteng, situated within the geographical vicinity. The predominant Fynbos and Karoo veld types of the Western Cape are not quite suitable as natural grazing for cattle. Areas with the potential for irrigation are usually characterised by high land prices and this leads to high-value crop production in the area. This leaves only rotation pastures with cereal and cereal residues available to be utilised for livestock enterprises. The Western Cape's cereal producing areas include the Swartland along the West Coast and the Overberg towards the Southern Cape. Rainfall in the Swartland occurs mostly during the winter, with hot and dry summers. In the Overberg rainfall is more evenly spread between summer and winter, allowing perennial pastures to be included in farming systems with cereal crops. Sheep has traditionally been the predominant livestock component for farm systems in the Swartland. Livestock theft, management preferences, and extended grazing possibilities due to the inclusion of cover crops, are some of the considerations that motivate the prospect of including beef cattle.

The Swartland area in the Western Cape is mainly a wheat producing area. Since the 1990's with the deregulation of agricultural marketing in 1996, conservation agriculture (CA) and crop rotation have been widely implemented in the area, in pursuit of sustainability (Hoffmann, 2001). CA is a holistic farming approach based on three principals:

- firstly, the retention of crop residues for maximum soil cover,
- secondly, minimum soil disturbance and
- thirdly, crop diversification through crop rotation systems.

South Africa is systematically adopting conservation agriculture, particularly in the Western Cape with its mediterranean climate (Basson, 2017).

Increased crop diversity is one of the managing strategies for achieving enhanced productivity and sustainability (MacLaren *et al.*, 2019). Crop rotation exists as an integrated part of CA principles (Smit *et al.*, 2021), whilst cover crops have the potential to diversify crop rotation systems further and are integrated for purposes other than harvesting (MacLaren *et al.*, 2019).

Cover crops can be used to serve a variety of key functions simultaneously. These functions share the collective goal to achieve sustainability in farming systems (Blanco-Canqui *et al.*, 2015). The development of wheat production systems in the Swartland, more specifically the utilisation of crop rotation and cover crops, presents more grazing opportunities.

Summers in South Africa's mediterranean climate region are hot and dry. These conditions are detrimental to both cash and cover crops. Thus, should cover crops be included in these rainfed crop rotation systems, it has to compete directly with the income potential of cash crops. The initial integration of annual legume pastures increases the potential to accommodate livestock and generate income. A livestock component is directly dependent on the crop rotation system and the type of crops used in this system. To determine the viability of integrating livestock in crop rotation systems, the ability to feed and accommodate livestock throughout seasonal changes should be considered thoroughly.

The basis for this study is technical data from the Langgewens experimental farm. The data is generated from trial plots, dedicated to CA, from 2002 to 2020. The trials consist of eight different crop rotation systems of which four include a rotation of wheat and medics (crop-pasture rotation systems) and, therefore, livestock. Basson (2017), financially analysed sheep management approaches within crop rotation systems in the Middle Swartland, using Langgewens data from 2002 to 2015. The purpose of this study is to assess the financial implications of expanding livestock integration options, by integrating beef cattle. This integration will generate financial, management, and whole-farm implications and so the aim is to accurately evaluate these implications.

1.2 Problem statement and research question

Livestock has been a part of CA and cropping systems across the globe for some time now. The success or impact seems inconsistent though. However, it is established that financial benefits are achieved in some cases and farm systems.

Integrating livestock into a cereal production system is complex and multi-faceted. Soil health, disease build-up, weed management, marketing systems, labour requirements and mechanisation, all need to be taken into account. These physical characteristics and relationships need to be balanced through knowledge, capital, diversification, sustainability goals, and profitability. Further underlying factors should be considered when also integrating livestock. The integration will influence whole-farm aspects in CA production systems. A beef cattle component will likely differ from a sheep component in the same farm system. Specific crop rotation systems will possibly benefit beef cattle, making it financially preferable to sheep. A combination of sheep and cattle as an option is also likely.

A lack of knowledge exists on the financial viability and management development of integrating beef cattle as a component in CA systems in the Swartland. Many producers adopt CA for its ecological and economic value, but the inclusion of beef cattle as component for farm profitability is still somewhat doubtful. Beef cattle may not be financially viable given the short and relatively unpredictable rainy season of the Swartland. Farmers in the Middle Swartland also consider the affordability of investing in a livestock component, as well as the type of livestock system that should be implemented.

Livestock theft, management relief, and the possibility to successfully integrate the seasonal production system of beef cattle into that of rotational crops, are the main driving forces of this study. The main research question for this project thus is: “What are the financial and management implications of integrating beef cattle into crop rotation systems in the Middle Swartland?”

1.3 Aim and objective of the study

The main objective of the study is to determine the financial and management implications of integrating beef cattle into the crop rotation systems of the Middle Swartland, following a CA approach. It is equally important to explain and assess management adjustments to producers.

The research goals of this study are as follows:

- To explore the role of and considerations for integrating livestock in crop rotation systems in terms of ecological and financial sustainability.
- To assess the different strategies to financially integrate beef cattle into a mixed crop-livestock system.
- To determine the financial implications of integrating beef cattle on the whole farm.
- Lastly to evaluate the sensitivity of key factors and considerations for various livestock managing systems on the whole-farm level and over the longer term.

1.4 Overview of methods applied in the study

To achieve the goals of the study a literature overview will be conducted. The Swartland area as well as wheat production will be revised in the overview. The sustainability of conservation agriculture and different crop rotation systems will be assessed and highlighted, and livestock integration thoroughly analysed. The literature overview will serve to identify current crop-livestock integrations, while debating the viability of beef cattle integration. This can affect numerous aspects such as cash flow, management, soil health, and the whole-farm system. The aim is to determine if the integration is a sustainable option for wheat producers in the Middle Swartland.

Farming with various though limited rotational cash and pasture crops, integrated with livestock requiring a large capital investment, within an area with a relatively unpredictable rainfall, is a complex and multifaceted enterprise. The simultaneous integration of various physical/biological and socio/economic factors requires a method that allows accommodating such complexity. The systems approach allows for exactly that integration and the acknowledgement of the individuality of the various components and interrelationships. It can further accommodate the integration of diverse knowledge that impacts on the same farm system. To address the complex decision-making environment, a multidisciplinary team of experts from the Middle Swartland was consulted. Experts from various fields such as producers, agricultural economics, agricultural mechanisation, and soil, plant- and animal science were involved. These discussions were used to determine typical farms, crop rotation systems, and livestock integrations.

A whole-farm model based on standard accounting principles was simulated to explore the financial implications of integrating beef cattle in typical crop rotation systems in the Middle Swartland. After consulting with experts and hosting group discussions, a whole-farm budget model will be constructed representing a typical farm. Results from models are site specific and since Langgewens data is utilised it should only act as a decision-making guideline in the Middle Swartland region. When producers use different management practices, results will differ.

A systems approach is used to integrate technological and natural processes, developing a productive system. Systems are producer, farm, and site specific, with sustainability depending on the nature of whole-farm systems (Ikerd, 1993). Integrating cattle needs to be considered as a whole and not by its individual components.

1.5 Outline of the study

Chapter 2: consists of two parts. In the first section the principles, benefits, and constraints of conservation agriculture is explained. The biological and ecological benefits from the improved soil fertility, decreased erosion, and moisture retention were identified as the driving forces to adopt CA. One of the principles of CA is the rotation of crops, including cover crops that have the potential to improve the yield of subsequent crops whilst reducing input costs. The need to integrate livestock is evident as it poses the opportunity to mitigate risk and to generate income. Integrating beef cattle into crop rotation systems will generate complex financial and management implications. The general profitability of sheep and beef cattle as livestock components were assessed. As the production cycles of cattle and sheep differ, it poses various management considerations. The literature overview identifies the potential benefits of mixed livestock integration. This strategy increases the diversity of crop rotations and can be a lucrative option.

The second part of Chapter 2: explains the methods utilised to accurately achieve the objectives of the study. Through the systems approach interaction within agricultural systems can be conceptualised and the long-term consequences of decisions and actions can be anticipated. Multidisciplinary group discussions as a research method facilitates the systems approach. The exploratory nature of this study motivates the utilisation of multidisciplinary group discussions, since the objective is to improve whole-farm systems and some of the required information does not exist at present. Systems thinking and multidisciplinary group discussions will enable the construction of an accurate whole-farm multi-period budget model. Such models can incorporate complex farm systems and are convenient to use when different integration strategies are being simulated.

The Langgewens crop rotation trials provide valuable information for various agricultural role players. The trials are discussed and evaluated in Chapter 3:. The average gross margin for crop-pasture rotation systems and continuous cash cropping systems are compared. From this the sustainability through effective CA practices, more specifically crop rotations, are evident. Langgewens trials pose as the foundation of this study and the construction of the typical farm budget models.

Chapter 4: focusses on the development and construction of a multi-period whole-farm budget model. The model is built in a spreadsheet program where numerous equations are used to evaluate a typical farm's performance. The data, assumptions, and parameters of the model are validated by heterogeneous experts through group discussions and meetings. It is specifically important to establish accurate cattle integration data as the Langgewens crop rotation trials only accommodate sheep. The discussions further focus on how this integration would change whole-farm systems and the farm's long-term financial position. The input component of the budget model is validated to ensure that the implications of integrating cattle are captured effectively. The model simulates the physical and biological farm system and expresses the farm's financial state in standardised profitability criteria. The accuracy of the input components and the effectiveness of the calculations are highlighted as it will determine how realistically the financial implications of integrating beef cattle are explored.

The budget models in Chapter 5: are used to project the financial performance of the traditional crop rotation of System E (wheat - medic rotation, with sheep utilising the medic pastures). System E's financial performance is then compared to other crop rotations that include cover crops. When cover crops are included in crop rotation systems, grazing opportunities will increase. Integration strategies for both sheep and beef cattle individually and a mixed-livestock integration of both species are financially evaluated.

Chapter 6: comprises of the conclusions, summary, and recommendations for this study.

Chapter 2: Literature review

2.1 Introduction

The integration of beef cattle into CA based farming systems was discussed in Chapter 1. The financial and management implications of different integration strategies were identified as the main objective of this study. Different CA farming systems in the Swartland were introduced. Systems with the possibility to accommodate beef cattle will be addressed in detail in Chapter 2:.

To sustain the growing world population by 2050, global food production requires an increase of 70 percent. Evidently natural resources are under ever-increasing pressure (Friedrich *el* al., 2009). The Swartland is one of the main wheat producing areas in South Africa. Winter cereal producers play a significant role in ensuring food security and contribute considerably to the local and national economy (Du Toit, 2018).

Knott (2015) concluded that practicing conservation agriculture (CA) improves food security, whilst sustaining the environment for the benefit of future generations of both producers and consumers. Basson (2017) explored the financial aspects of integrating livestock into different crop rotation systems in the Middle Swartland, focusing on sheep as the livestock component. The purpose of this exploratory study is to expand the option of integrating beef cattle into these systems. This option affects numerous aspects such as cash flows, management, soil health, and the whole-farm system. The aim is to accurately evaluate different cattle integration strategies (Lemaire *et al.*, 2014).

2.2 Literature review

2.2.1 The Swartland

The Swartland lies within the winter rainfall region of the Western Cape. This region with its typical mediterranean climate is known for wet and cold winters, with dry and hot summers. The area was named Swartland (black land), because of the indigenous Renosterbos (rhinoceros bush) that turns black after the rainy season. Other wheat producing areas such as the Southern Cape receive up to 50 percent of its annual rainfall in the summer. More than 80 percent of the Swartland's annual rainfall is concentrated between April and September (Strauss, 2021). Dryland producers in the Swartland are faced with uncertainty as they can only rely on an unpredictable winter rainfall (Hoffmann, 2001) and farm on shallow soils with poor moisture retention ability.

The main meteorological characteristics of summers in the Swartland, which cause formidable challenges for livestock farming, are illustrated in **Figure 2.1**. Livestock integration is limited to an extent, due to the inability to produce feed and grazing opportunities during the dry summer.

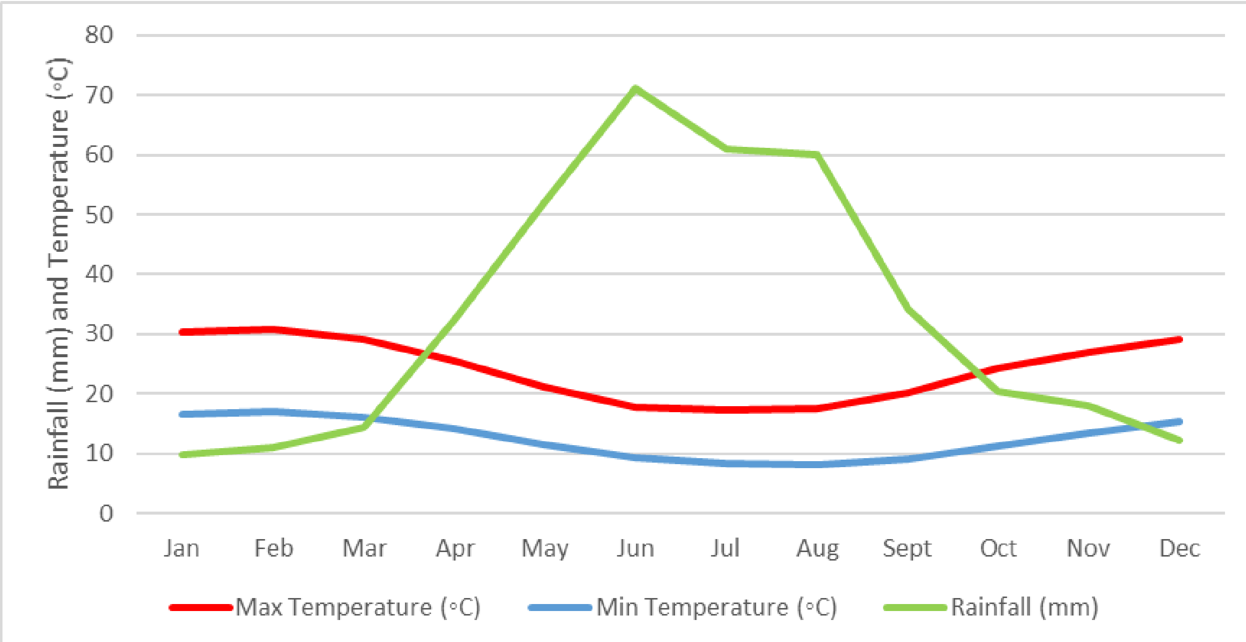

Figure 2.1: Average monthly precipitation and temperatures at Langgewens (1964-2019).

Source: Langgewens experimental farm.

Initially producers in the Swartland mainly produced wheat in a monoculture system. Producers who had a livestock component used fallow fields for grazing during the time when oats pastures were still being established and thus unfit for livestock grazing (Smit, 2019). Prior to 1996 the wheat price was fixed as the Wheat Marketing Control Board controlled the producer price (Hoffmann, 2010). The cost-plus fixed price system enabled producers to avoid price risk and maximise profit. This motivated the cultivation of wheat on all available and often increasingly marginal land (Swanepoel, *et al.*, 2016). The protective circumstances for wheat producers changed in 1996 when agriculture was deregulated and the Wheat Marketing Control Board terminated. Previously production decisions were based on price support rather than soil and climate suitability. Factors such as decreased soil potential, competitive world market prices, uncertain production due to unpredictable rainfall, and increasing input costs have since reduced the sustainability of wheat mono-cropping systems (Strauss, *et al.,* 2010). This increased the need to change production systems in the Swartland to be more sustainable, both environmentally and economically.

The Swartland's physical and biological characteristics provide excellent growing conditions, though limited by the soil quality, especially soil depth, and the climate. Although alternative crops such as oilseed and legumes can be cultivated it is often risky. This can have negative effects on the economic attractiveness of these crops, even though they present benefits for cereal production (Giller *et al.*, 2009; Knott, 2015; Nell, 2019 and Thierfelder *et al.,* 2015). Due to the marginal climate and/or soil conditions of the Middle Swartland, the variety of crops that can be grown successfully becomes limited. The crops that producers can include in their production basket and the drive for rotational cropping are therefore restricted (Strauss *et al.*, 2021).

2.2.2 Conservation agriculture

Due to the USA's Mid-West dust Bowl of the 1930's, which initiated no-tillage and conservation tillage, CA originated. After that, conservation tillage extended to other regions of the world as the degradation of natural resources became more apparent. Conservation agriculture (CA) is a holistic farming approach based on the following three principals:

- Advanced crop rotations for controlling pests, weeds, and diseases and for natural fertilisation (Hobbs *et al.,* 2008; Kassam *et al.,* 2019),
- Minimum soil disturbance for improved soil structure, infiltration, and water-holding capacity,
- Permanent organic soil cover to conserve soil moisture and moderate soil surface temperatures (Strauss *et al.*, 2021).

This set of principles is meant as a guide to sustainable, reliable, and climate-smart farming practices (Jat *et al.*, 2013; Lal, 2020).

Two interconnected features exist that encourages the adoption of CA. The first is the biological and ecological benefits from improved soil fertility, decreased erosion, and moisture retention. Conventional tillage can be replaced with live crop cover or dead mulch which provides food for soil biota and acts as biological tillage (Knowler & Bradshaw, 2007). In the long term producers achieve sustainability as these benefits show an annual accumulating effect. Secondly financial benefits present itself in the form of reduced input costs and less exposure to production risk. The requirement for certain, and often expensive inputs such as fertiliser, decline as the soil structure improves due to less soil disturbance and fertility increases due to rotational cropping. The risk associated with climate change is mitigated as the soil's moisture retention ability improves. A diversified cropping system spreads the price risk over various enterprises (Knott, 2015).

Thus, successful CA practices enhance sustainability by optimising profit margins and efficiency, while offering environmental benefits to producers and the society. It is important to emphasise that CA is a knowledge-intensive practice and long-term commitment is necessary.

The challenges Swartland wheat producers are faced with are discussed in the previous section. CA provides the opportunity to minimise exposure to financial risk and to maximise production efficiency and sustainability. Therefore, South Africa, particularly the Western Cape, is systematically implementing conservation agriculture (Basson, 2017).

2.2.2.1 The concept of conservation agriculture

As previously noted, the famous dust bowl of the US Great Plains in the 1930s, was caused by excessive tillage which led to the soil being exposed to wind erosion. Evidently, awareness arose of the negative impact that unnecessary tillage could have on soil management. Deep unrestrained tillage highlighted the ability to manage soil in an unsustainable manner and cause degradation and erosion.

Conservation agriculture aims to improve land use in a sustainable fashion. However, it is not based on a single technology. Conceptually, technology consists of three facets. The first is the artefact or physical instrument, genetic material, or method. The second is the skill set required to properly use the artefact. The third is the supporting or organisational environment. In the case of GPS technology for example, it entails the network of global positioning satellites. Conservation farming requires the integration of several technologies geared towards achieving a common goal. Conservation agriculture is an approach to stimulate the resilience of natural systems rather than to manipulate it. The concept emerged from the practice of no-till and conservation tillage. Although these concepts are still practiced, systems have developed to allow for a more holistic approach through the inclusion of crop rotations and emphasis on permanent soil cover. No-till and conservation tillage can be defined as follows:

- No-tillage:

No-till is defined as the sowing of seeds into soil that has not been previously tilled in any way to form a “seedbed” (Baker *et al.*, 2007; Knott, 2015).

- Conservation tillage

Conservation tillage is the umbrella term given to no-till, direct-drilling, minimum-tillage, and/or ridge-tillage to indicate that each practice has a conservation goal of some nature (Baker *et al.*, 2007). Conservation tillage essentially focuses on three tillage practices; no-tillage, ridge-tillage, and mulch-tillage that contribute to soil fertility (Knott, 2015). Alternatively, conservation tillage can be referred to as a tillage practice that requires reduced tillage when compared to conventional mouldboard ploughing (Reicosky, 2015).

Derpsch *et al.,* (2013) highlighted the confusion surrounding different tillage practices, in that inconsistent academic results on CA are generated. Mulch tillage, reduced tillage, and minimum tillage are sometimes incorporated into CA experiments and often leads to inaccurate results (Derpsch *et al.*, 2013).

Friedrich *et al*., (2012) described CA as an "*approach to maintaining Agri-ecosystems for improved and sustained productivity, increased profits and food security, while preserving and enhancing the resource base and the environment*". In brief, CA is a holistic approach based on three interactive principles namely; the retention of crop residues for maximum soil cover, minimum soil disturbance, and crop diversification through crop rotation systems (Derpsch, 2001).

2.2.2.2 The benefits and constraints of conservation agriculture

Knott (2015) identified seven environmental and economic benefits of CA. These are:

(1) reduced erosion and environmental degradation,

(2) improved soil structure and biology,

(3) improved soil moisture retention,

(4) higher soil carbon levels,

(5) increased yields,

(6) reduced input costs, and

(7) reduced CO2 emissions.

Both evidence and ample studies prove that CA (if practised effectively) can ensure a more sustainable future in the Swartland and the rest of the world (Baker *et al.*, 2007; Derpsch & Friedrich, 2010; Friedrich *et al.*, 2009; Hobbs *et al.*, 2008; Hoffmann & Laubscher, 2002; Knott, 2015 and Smit *et al.*, 2021).

It is equally important to understand the constraints and challenges of conservation agriculture. For producers to adopt CA, requires a realignment in their approach to farming, as traditional practices, accumulated knowledge, and current assets may be less relevant. To adopt an unknown concept and switching agricultural practices can be costly and intimidating. It can be expensive to adopt CA as the initial capital expenditure is high and financial benefits take several years to be seen (Knott, 2015). Therefore, it is vital to highlight the need for assistance in calculating the expected financial impact and thus adopt CA successfully.

Furthermore, CA is not a generic "one-size-fits-all" practice (Basson, 2017). The process to convert to CA is knowledge intensive and requires a site specific approach. The need for continuous progression through interaction between producers, support groups, and stakeholders is crucial in the process of converting to CA (Modiselle *et al.*, 2015).

Although the benefits and constraints of CA are an important building block for this study, the focus is on the financial and management implications of integrating beef cattle in already successful CA systems in the Swartland.

2.2.3 Livestock integration

In a crop-pasture rotation system, livestock feed on crop residue from the cash crops and biomass produced by the annual legumes, resulting in reduced levels of soil cover. Practicing CA is further challenged as livestock trampling can cause soil compaction which may require tillage to alleviate (Basson, 2017). Care needs to be taken during wetter periods as to guard against soil compaction. Integrating livestock and practicing CA successfully, poses various challenges to the Swartland producers and challenges also being site specific.

The predominant livestock choice for wheat producers in the Swartland is sheep. The implications for replacing sheep with beef cattle on a whole-farm system need to be assessed and captured accurately and thoroughly. Infrastructure, cash flows, management, and marketing changes amongst others, will be determining factors when measuring financial viability.

Producers are considered risk averse which makes integrating livestock into their cropping systems an appealing consideration to diversify and mitigate production and financial risk (Bell & Moore, 2012). Crookes *et al.,* (2017) modelled the effects of drought on the economics of these cropping systems. He concluded that systems that integrated livestock performed significantly better under these challenging conditions. Diverse crop-livestock systems have a positive effect on soil biology, or the soil food web, restoring key soil properties to critical threshold levels (Lal, 2015). This results in the restoring of essential soil services and functions such as soil nutrient cycling, soil carbon sequestration, ground diversity, the water infiltration rate, water runoff and erosion, weed management, and reducing of soil borne diseases (Strauss *et al.*, 2021).

If livestock is managed in such a manner that it complements CA principles, the combination may lead to decreased input costs (Basson, 2017). The potential constructive synergy between livestock and production systems is encouraging. Establishing annual legume pastures in crop rotation systems play a fundamental role in achieving the benefits of crop-livestock integration. Including crops to achieve objectives other than harvesting, for instance to generate positive soil benefits, may lead to the loss of short-term income. Livestock has the potential to subsidise these losses if integrated efficiently.

2.2.3.1 Cover crops in crop rotation systems and the role of livestock

Crop diversification through crop rotation systems is a crucial principle of CA, especially when assessing livestock integration. Strauss *et al.,* (2010) concluded that soil organic matter increased with the inclusion of medics and clovers, while also providing between 40kg and 100kg of nitrogen per ha. In some cases, the nitrogen supplied by the legumes is retrieved more effectively by wheat than fertiliser applied on the surface (Strauss, 2021). At the same time annual legume pastures have the potential to assist in weed control efforts, therefore, reducing costs and increasing the yield of the subsequent grain crop (Strauss *et al.*, 2010). Equally important, the inclusion of an annual legume pasture decreases mechanical soil disturbance and may increase the soil carbon content (Strauss *et al.,* 2010). Annual legume pastures can be beneficial with regards to subsequent cash crop production and can also pose a lower financial risk by obtaining higher or similar gross margins with lower input costs (Strauss, 2021).

Crop rotation exists as an integrated part of the principles of CA (Smit *et al.,* 2021). Increasing the diversity of crops is one of the managing strategies to achieve productivity and sustainability (MacLaren *et al.*, 2019). Cover crops have the potential to further diversify crop rotation systems. They are grown primarily to cover and protect the soil from erosion and nutrient loss due to leaching and draining (Unger & Vigil, 1998). Furthermore, cover crops can be used to serve a variety of key functions simultaneously. These functions share the collective goal of impacting the farming system positively (Blanco-Canqui *et al.*, 2015).

Cover crops have been proved to deliver numerous environmental and agronomic services within agroecosystems. These include enhanced soil organic matter, reduced soil erosion, increased biological diversity, increased nutrient cycling and biological N2 fixation, improved weed control, and increased crop yield (Adetunji *et al.*, 2020; Alvarez *et al.*, 2017; Mitchell *et al.*, 2017; Mubvumba *et al.*, 2021; Wang, 2020; Wang *et al.*, 2017; Wortman *et al.*, 2012 and Wulanningtyas *et al.*, 2021). These services and benefits form part of the complex, but valid, argument that cover crops play a valuable role in crop rotation systems.

The objectives of cover crops vary significantly from one crop rotation system to the other. Different plant species in multiple combinations may be used as cover crops. Different combinations are used to achieve certain goals within agroecosystems (Ramírez-García *et al.*, 2015). Boyd *et al.,* (2009) evaluated the different grid patterns and seeding rates of cover crops while Garcia *et al.,* (2019) assessed the complementary nature of different species of cover crops. In turn Colbach *et al.,* (2021) concluded that the implementation of cover crops depends on the production situation and cropping systems. It is important to understand the role cover crops play in crop rotation systems and to ensure that it is integrated successfully.

Increased rainfall variety and rising fertiliser prices make an already challenging environment more difficult. Cover crops have the potential to mitigate these risks and achieve sustainability in the long run (Basche *et al.*, 2016 and Schipanski *et al.*, 2014). Swartland wheat producers make increasingly more use of cover crops in their crop rotation systems, albeit slowly. If a producer in the Middle Swartland encounters challenges that can be addressed by cover crop production, the utilisation of these cover crops can improve the productivity of the system (Smit, 2019).

Smit (2019) explained that the utilisation of cover crops can replace single species pasture crops rather than replacing cash crops with cover crops. A gradual shift towards the inclusion of cover crops and the utilisation thereof, with the goal of increasing diversity, is taking place. The three main principles of CA should be adhered to when production systems in the Middle Swartland include and utilise cover crops. This implies that soil should still be sufficiently covered with plant material after grazing.

2.2.3.2 The need for livestock integration

The success that annual legume pastures and cover crops can have in the production systems of wheat producers in the Swartland is apparent. The success of these crop rotation systems serves as the foundation of this explanatory study for livestock integration.

Residues from both cash and cover crops in crop rotation systems, have the potential to act as livestock feed either by grazing or by feeding (Hoffmann, 2001). From a financial point of view the integration of livestock has the prospect to ensure numerous benefits. Producers constantly strive to diversify and mitigate risk. It can be achieved by integrating livestock (Bell & Moore, 2012). The opportunity to subsidise short term loss of income associated with cover crops not being harvested, is financially appealing. When livestock is managed in such a manner that it complements the CA farming system it may lead to a decrease in input costs (Basson, 2017).

Grazing animals directly on pastures or cover crops can be seen as a catalyst, as it reshapes and accelerates the flow of nutrients (Basson, 2017). For instance, 70 to 95 percent of the biomass ingested by grazing animals is returned to the soil in the form of urine or manure (Martins *et al.*, 2014). Cruse *et al.,* (2012) explained that the continuous rise in fossil energy prices could be subsidised by using more diverse cropping systems and manure. Defoliation through grazing can accomplish increased root exudation which affects the rhizosphere community and increases plant nitrogen availability (Basson, 2017 and Mills & Adl, 2011). Other studies have shown that grazing intensity can affect both carbon and nitrogen's allocation to roots, as well as influence the dynamics of nematode communities (Hokka *et al.*, 2004; Ilmarinen *et al.*, 2005 and Mikola *et al.*, 2001).

Anibal *et al.,* (2014) determined that integrated crop livestock systems resulted in greater environmental gains with less vulnerability and more financial benefits compared to non-integrated livestock farming. Hunt *et al.,* (2016) argued that livestock within modern conservation cropping systems can benefit production and business risk without compromising crop performance. Further studies also proved that livestock integration can improve sustainability through production efficiency, reduced environmental degradation, and profitability (Lemaire *et al.*, 2014; Liebig *et al.*, 2020 and Salton *et al.*, 2014).

The potential of a constructive synergy between livestock and CA production systems is encouraging, as the benefits are numerous, both in the short and long term. The possible whole-farm benefits of livestock integration are evident.

2.2.4 Integrating beef cattle

As stated earlier, sheep is the traditional livestock component used by wheat producers in the Middle Swartland. The same challenges emerged when producers had to make a mind shift from conventional practices to that of CA. To evaluate the integration of beef cattle into crop rotation systems in the Middle Swartland, it is crucial to understand that the farmers remain predominantly wheat producers. Almost every aspect of their whole-farming systems is designed to promote successful and sustainable wheat production. In short, the income generated by livestock and specifically beef cattle, is little compared to that of wheat. Nevertheless, when integration can ensure multiple benefits for the producers, it is a viable option.

When exploring the financial and management implications of integrating beef cattle, it is important to identify the differences between beef cattle and sheep. In agriculture it is difficult to accurately compare commodities with one another as there are numerous variables to be considered. At the same time and for the purpose of this study, it is important to identify the differences between sheep, the traditional livestock component in the Swartland, and beef cattle.

2.2.4.1 Financial implications

Considering the financial differences in income generated by both sheep and beef cattle, the obvious difference would be size and, therefore, weight. Depending on the quality of feed, ruminants (like cattle and sheep) need a particular amount per day to function sufficiently (Freer *et al.*, 1997). This amount can change as animals reach certain stages in their lifetime and it correlates to their bodyweight. Depending on the farm's crop rotation system a certain amount of feed is available for livestock grazing throughout different stages of the year. The intensive nature of the different livestock management approaches also influences stocking rates (Barnes *et al.*, 2008). This means a homogeneous farm would be able to accommodate a specific number of sheep and a specific (but fewer) number of beef cattle. This number would depend on various variables like the type of breed, quality of the animals, external challenges, and so forth.

In some livestock systems ewes are managed in such a way that they lamb in intervals shorter than twelve months. The climate and rotation systems in the Middle Swartland can only accommodate ewes to lamb once a year. It is possible to manage ewes intensively as to ensure more frequently lambing (Abdoli *et al.*, 2019), but then sheep would be more of a commodity on its own and less of an integration into crop rotation systems. Both lambing and calving takes place annually; however, the rate of multiple lambs is much higher than that of calves and this can affect the income generated by sheep considerably. On the other hand, sufficient management of ewes during pregnancy and lactation requires financial investment such as a lambing shed and educated supervision (Fthenakis *et al.*, 2012).

When integrating cattle into a farming system that only accommodated sheep, infrastructure changes would probably have to be done. Depending on the existing livestock management characteristics and infrastructure, financial investment will be needed to assure that fences, transportation methods, handling pens, and livestock equipment are in place to accommodate the relevant livestock. Though various technological options are available on the market (Herlin *et al.*, 2021), a change from sheep to beef cattle, or the integration of both, requires financial expenses.

In most commercial beef cattle production systems, selling weaner calves and other cattle is the sole source of income, whereas sheep breeds in the Swartland provide the opportunity to generate further income through selling wool. This may have a positive effect on cash flow for wheat producers as they generate more regular income (Farrell *et al.*, 2020). This further contributes to diversification as the meat price (lamb and mutton) is unrelated to wool prices on the market side. Wool prices are much more influenced by the international price trends while meat is more directly affected by domestic trends.

Regardless of the livestock production system implemented, the market price at the time of sale can have a substantial impact on the income generated. Understanding the annual price cycle for red meat and in particular weaner calves and lambs, can help producers being more profitable (Maré, 2019). Beef may have a geographical market advantage since producing lamb and mutton is preferred in the Swartland. On the other hand buying breeding material may be a challenge because of the limited availability of cattle compared to sheep.

Figure 2.2 and **Figure 2.3** illustrates the annual price cycle for A2 beef and weaner calves, and A2 lambs and weaner lambs, respectively. The cycle is calculated using the average monthly price in South Africa (2012-2018) and then calculating each month's price as a percentage of the average price over that period. The varying market price of sheep, compared to that of cattle, is an important observation when reviewing the figures. The sheep market is more volatile, making the timing of the producer's marketing more important.

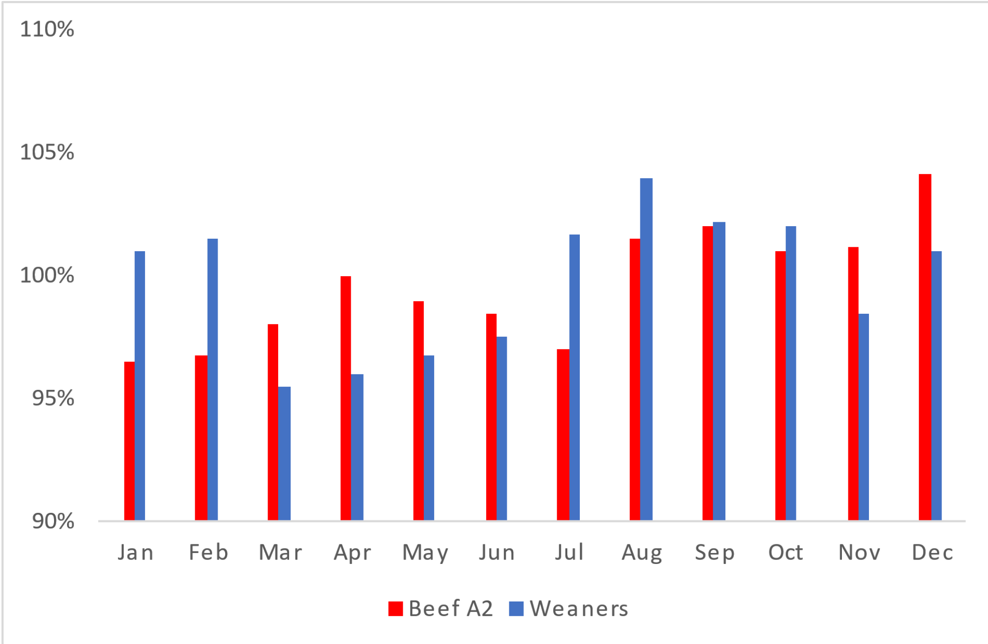

Figure 2.2: Annual average price cycle of weaner calves and A2 beef carcasses (2012 to 2018). Source: Maré (2019).

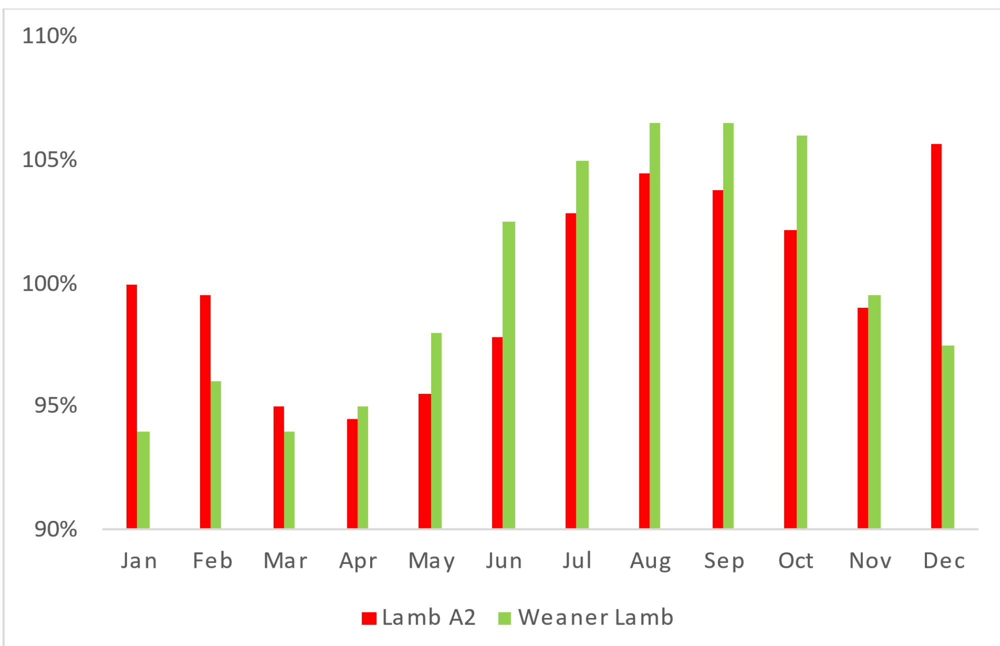

Figure 2.3: Annual average price cycle of weaner lambs and A2 lamb carcasses (2012 to 2018). Source: Maré (2019).

The complexity of accurately comparing beef cattle and sheep financially, without site-specific data from numerous years, is challenging. In the case of this exploratory study, it is important to note that a typical farm, with determined values and systems, will be assessed. The utilization of systems thinking, and the panel of experts will enable the building of realistic financial budget models, to accurately predict the financial implications of different beef cattle integrations.

2.2.4.2 Management of females in production

Managing livestock in the Middle Swartland depends on the wheat production system practised by the producer. However, important considerations need to be addressed when integrating beef cattle.

During production, female animals require different management strategies depending on their production phase. The reproduction efficiency of beef cows and ewes is dependent on management and the soundness thereof (Dziuk & Bellows, 1983). Pregnancy lasts about five months for ewes (Fthenakis *et al.*, 2012), whereas cows are pregnant around nine months (Amundson *et al.*, 2006). This means the time of pregnancy would make up for roughly 40 and 75 percent respectively of the annual production cycle. In practice this period would be even longer for the entire herd depending on the breeding period practiced by producers (Fthenakis *et al.*, 2012). Production objectives and management characteristics will determine the age of weaning and the lactation period of cows and ewes. Calves are generally weaned between the ages of six and seven months (Moriel & Arthington, 2013 and Tao *et al.*, 2018), whereas lambs vary between three and four months (Campbell *et al.*, 2021). By comparison, ewes will normally have a dry period of three to four months prior to breeding and cows will be mated when their calves are roughly three months old.

The production cycle of beef cows varies significantly from that of ewes. There are four important stages to take into account when considering the management of these production cycles:

(1) The breeding period,

(2) pregnant period,

(3) lactating period, and

(4) the weaning period.

The physical condition and health of sheep and cows during the breeding period are crucial as it will affect pregnancy rates and thus production (Behrendt *et al.*, 2019 and Diskin & Kenny, 2016). Pregnant females also require relevant management to limit abortions and to ensure that healthy calves and lambs are born (Fogarty *et al.*, 1992 and Reese *et al.*, 2020). To achieve optimal milk quality and quantity, lactating females require an augmenting environment (Sevi *et al.*, 2004). To maintain this advantageous environment, supplements and management are recommended in certain lactating periods and/or circumstances (Funston *et al.*, 2012). These circumstances include droughts, multiple lambs or calves, insufficient nutrients, and more. Finally, in the weaning phase the weight of lambs and calves will determine the income generated. It is important to ensure conditions that motivate the growth of weaners, whilst maintaining the long-term health and wellbeing of females in production (Galvani *et al.*, 2014 and Moriel & Arthington, 2013).

To conclude, effective management is needed in different stages of the annual cycle of females in livestock production. The management for beef cows will differ from that of sheep, due to the duration of different stages in the cycle, but also due to variations in the species. When examining these differences, it is important to note that the goal is to achieve a satisfying rhythm between the integration of livestock and crop rotation systems.

2.2.4.3 Managing replacement females

After evaluating management options for females in production, the focus shifts to managing the entire livestock herds and all its components. Sustaining a particular herd size demands careful planning and management to accomplish continuity. Again, the specific management requirements depend on the livestock production system of the producers, but sufficient replacement females and breeding males are necessary. Ranching involves complex systems and management decisions which play an integral role in financial profits and herd dynamics (Turner *et al.*, 2013).

Reproducing cows and ewes reach a certain age where their reproduction ability declines, thus new females are needed to sustain herd productivity. Injuries, health, fatalities, infertility, and other factors may also cause the need for females to be replaced. These replacement females can be bought into a producer's herd, or they can be bred by the producer. Decisions regarding replacement flocks are complex and depend on a multitude of variables, but mostly on the livestock management system and the quality of livestock in the herd (Scarnecchia, 1990). Nevertheless, introducing efficient replacement females is crucial in having a successful livestock component.

Worldwide multiple studies considering different strategies to replace females in sheep and beef cattle herds exist (Cushman *et al.*, 2013; Maher, Good & More, 2008; Pettigrew *et al.*, 2019; Scarnecchia, 1990; Turner *et al.*, 2013 and Wall *et al.*, 2018). It is common for livestock farmers to follow a fixed replacement percentage strategy (e.g., 25 percent of females annually), although others prefer to evaluate the herd annually and replace females according to the evaluation. Both strategies depend on the production efficiency and maturity of the females in the existing herd. Longevity of producing females is a popular research topic, but it is site specific and can be influenced by numerous variables (Kenyon *et al.*, 2011 and McLaren *et al.*, 2020). It can be argued that beef cows have a longer production lifetime than ewes (McGregor, 2011 and Waldner *et al.*, 2009), but site-specific data is required to prove this argument.

When producers follow the strategy of breeding replacement females, the females are selected from the weaner crop. There is a great deal to consider regarding the selection, preparation, and mating of these females. Various studies identify strategies to prepare and mate females to achieve optimal efficiency (Day & Nogueira, 2013; Douhard *et al.*, 2016; Kenyon *et al.*, 2011; Núñez-Dominguez *et al.*, 1991; Pettigrew *et al.*, 2019 and Wathes *et al.*, 2014). Most wheat producers in the Swartland follow a conservative livestock management approach since ewes will lamb at the age of two for the first time. When managed correctly, it is possible for ewes to lamb as early as twelve months. Producers in the beef industry usually aim to breed replacement heifers at 15 months and to calve at 24 months but achieving this goal has been found unrealistic in some cases (Wathes *et al.*, 2014). It is thus possible that Swartland wheat producers would prefer heifers to calve at 3 years of age, avoiding intensive management.

The age at which females will calf or lamb for the first time, depends on the management preferences and integration goals of the specific producer. It is preferable for replacement females to remain in the same annual cycle as the rest of the herd, as this cycle aims to integrate with that of the wheat production cycle. In other words, ewe lambs selected as replacement females ought to lamb at one or two years of age and the selected heifers at two or three years of age. In the same way, when replacement females are bought in from other farms, they should be appropriately integrated into the existing wheat and livestock production cycles. The shorter production cycle of ewes poses more possibilities to mate replacement ewes separate from the rest of the herd and manipulate the annual cycle.

When replacement females come from weaner groups on the farm they require additional management. The preparation strategies are determined by the herd management objectives and subsequently the target age and condition of females when they start producing. Generally, this preparation phase entails managing the females on separate pastures, providing additional nutrition, and administrating an environment that stimulates their initial production (Mousel *et al.*, 2014). Considering popular sheep management strategies followed by Swartland wheat producers, weaner ewe lambs selected as replacement females will be managed to lamb at two years of age, successfully wean their lamb/s, and finally enter the main producing female herd. However, the intensive management and resources associated with the preparation of heifers effectively calving at two years of age may seem unattractive to producers. It is therefore plausible that Swartland wheat producers would prefer the option of heifers calving at the more mature age of three years. In this case the replacement heifers would take considerably longer than ewes to generate income. The farm would also have to accommodate an additional replacement heifer group, which means the limited resources on the farm would be utilised by fewer females in production (Gates, 2013).

Thus, there are two options to acquire replacement females for both sheep and cattle herds. Firstly, when weaners are sold and selected replacement females are bought in from other farms. Secondly, replacement females are bred and come from the weaner group. The first option may cause challenges regarding the price, quality, and transport when purchasing replacement cows due to the limited amount of beef cattle breeders in the Swartland area. Whereas the second option entails that less weaners are sold, more preparation investment is required, and a possible prolonged time before the females generate income. Evidently producers will determine their strategy according to their integration objectives as both options involve a certain amount of risk and management.

2.2.4.4 Management considerations in general

The intensity of livestock management can, to some extent, be determined by wheat producers and their objectives. Sheep, even in an extensive management environment, is likely to require more management resources than cattle in a comparable management environment. Lambing season is going to require that some, or all ewes be kept in lamb pens, sheds, or another form of paddock at some stage (Stafford & Gregory, 2011 and Zhang *et al.*, 2016). These lambs, depending on their sex and the livestock production system, are likely to undergo castration or tail docking (Lomax *et al.*, 2010 and Molony *et al.*, 1993). Sheering season demands further unavoidable management (Cloete *et al.*, 2000).

The loss of livestock is inevitable, although fatalities due to sickness and injury can be limited by efficient health management (Sargison, 2020). More specific, Nattrass & Conradie (2018) and Nattrass *et al.,* (2017) have researched the loss of livestock due to predation to some extent. The predominant predators responsible for livestock loss in South Africa are black-backed jackal (65 percent) and caracal (30 percent); however, cases of baboons, leopards, and vagrant dogs have been reported (Van Niekerk, 2010). Turpie and Babatopie (2018) estimated that 6.2 percent of small livestock loss in the Western Cape is due to predators. Mortalities due to predators in South Africa are estimated at 8.2 percent for small livestock and only 0.3175 percent for large livestock (Badenhorst, 2014; Van Niekerk, 2010; Thorn *et al.*, 2013 and Turpie & Babatopie, 2018). Predators can be a difficult challenge for livestock farmers, but the risk is significantly higher for small livestock like sheep compared to that of larger livestock like cattle.

Livestock producers across South Africa are victims of stock theft and statistics show that numbers are ever rising (Lombard & Bahta, 2019). This is an intricate matter, as statistics do not always give the full picture and the number of occurrences is area related and unpredictable (Scholtz & Bester, 2010). Nonetheless, livestock theft can have a negative impact on producer's income. Annually, the occurrences and numbers of sheep stolen are higher than that of cattle, although the value of cattle stolen is greater (Clack, 2013). Evidently, it is quite difficult to predict if livestock theft can be limited when Swartland producers integrate cattle rather than sheep. It can be argued that sheep are more at risk than cattle, because of the lesser effort needed to handle them, but this statement lacks site specific proof.

The quality of animals in livestock herds will have an overriding impact on the profitability and efficiency of livestock production systems (Chudleigh *et al.*, 2019 and Herd *et al.*, 2003). Selecting and managing animals to achieve production objectives is an art that needs to be developed continuously (Ash *et al.*, 2015; Rowe, 2010). Traditional Swartland wheat producers have acquired years of skills and knowledge managing sheep as livestock component on their farms. Although many of these skills are relevant to all livestock types, running an optimal cattle production system will require producers to expand their abilities (Getachew *et al.*, 2010; Ramsey *et al.*, 2005). A Swartland wheat producer should be prepared and willing to commit to integrating beef cattle when considering it.

2.2.5 Integrated livestock component

The financial and management implications of integrating beef cattle into crop rotation systems have been discussed. In this section the possibility of integrating sheep and beef cattle together, as an integrated livestock component, will be explored. Previous studies have shown that mixed or sequential grazing can lead to improved performance of one or more of the species and a higher total output per unit area (Fraser *et al.*, 2007).

Smit *et al.,* (2021) concluded that when cover crops are grazed in the Western Cape's mediterranean climate, soil quality and nitrogen content improves. Although the selection of plant species incorporated in cover crop mixtures requires site specific consideration, combining appropriate species increases the number of ecosystem services provided (Muhammad *et al.*, 2019 and Schappert *et al.*, 2019). Therefore, cover crop mixtures have the potential to pose further benefits for mixed grazing by cattle and sheep (Walker, 1997). These benefits are the result of the different dietary habits of the animals, since both species have complementary feeding preferences (Putfarken *et al.*, 2008). Differences in dietary habits are associated with the physical ability to select and the physiological ability to detoxify forage phytochemicals. Compared to cattle, sheep have the superior ability to select from a fine-scale mixture, have more variety in their diet, and can graze lower in the forage canopy. Dietary overlap between sheep and cattle tends to decline when available forage decreases, since cattle shifts to lesser quality but more accessible forage, whereas sheep continue to select their preferred diet (Walker, 1997).

Frazer *et al.,* (2007) evaluated various sheep and cattle grazing strategies and concluded that carrying capacity, growth rates, and live weight gain per unit were superior for integrated grazing strategies. The improved performance of cattle and sheep is a result of a combination of factors, rather than a response to a particular parameter (Fraser *et al.*, 2007). An integrated livestock component has also been proven to yield economic and ecological advantages, whilst stimulating the sustainability of livestock production (Anderson *et al.*, 2012; Martin *et al.*, 2020).

Thus, cover crops form part of Swartland wheat producer's crop rotation systems to achieve numerous objectives and advantages. These crops are selected and implemented to promote sustainable wheat production while posing various opportunities for livestock integration. Cover crop mixtures and/or livestock integration can be organised into a synergy optimal for producers. The integration of both sheep and cattle generates possibilities to stimulate the effective use of available resources. Multi-specie integration also provides producers with the option to gradually integrate beef cattle rather than a radical change from the traditional sheep livestock component.

2.3 Method

In the previous section the relevant literature was assessed to evaluate the integration of beef cattle into crop rotation systems in the Middle Swartland. Various financial and management implications were considered and possible integration strategies were discussed. The inclusion of cover crops generates progressive livestock integration possibilities.

The purpose of this study is to evaluate the financial and management implications, the integration of beef cattle into crop rotation systems, may have on wheat producers in the Middle Swartland. The appropriate assessment requires the identification of strategies that increases profitability and assessing the wider consequences within the whole-farming system.

For instance, adjusting crop rotations slightly can have substantial ripple effects on the rest of the farm in terms of machinery requirements or livestock management (Hoffmann, 2010).

The focus will be on the methods used to obtain and analyse available data and information, and to accurately evaluate the integration of beef cattle.

2.3.1 Systems thinking

Like most agricultural aspects, evaluating the integration of cattle is complex. The reason for this being the numerous variables and components, interrelated in such a way that tiny alterations or adjustments are expected to impact the outcome of the entire holistic system (Basson, 2017).

Reductionist science has contributed immensely to agricultural productivity and growth in the 1900's. However, during the Green Revolution in the 1960's and 1970's, scientists experienced an increased sense of unease regarding the degradation of biophysical environments, distortions of socio-economic environments, and even the dislocation of cultural environments (Bawden, 1991). Varying results from experimental trails and unexpected trade-offs within agricultural systems, were generated (Knott, 2015). A reductionist approach fails to compare holistic systems with each other as an isolated component is the focus of these studies. The different components in agricultural systems are interrelated which leads to the utilisation of a systems approach in agriculture.

The fundamental concept of a systems approach is the principle of the irreducibility of the whole (Hoffmann, 2010). The systems approach is able to better conceptualise the interaction between the components within agricultural systems (Smith, 2010) and to anticipate the long-term consequences of decisions and actions (Banson et al., 2015). Ikerd (1993) explains that whole-farm systems have properties, qualities, and characteristics that are absent in their elementary components. The accurate evaluation of agricultural systems thus necessitates a systems approach (Basson, 2017). The components of systems provide the structure of the system and the interrelationships gives it function.

When evaluating the integration of beef cattle into crop rotation systems, the interrelatedness of the various components should be thoroughly considered. Wheat producing farms in the Middle Swartland will experience numerous knock-on effects due to this integration. It is important to capture these effects accurately, otherwise the results presented to producers may be incomplete and impractical. The interrelated components that create such a complex decision-making environment are amongst others, the ecological region, links between crops and livestock, marketing systems, livestock handling facilities and related infrastructure, product prices, input costs, wheat producer's preferences, and the management structure (Basson, 2017 and Knott, 2015). Therefore, to encourage effective decision making, the whole system should be considered.

Producers are often faced with challenges that require strategic decision-making. For instance, farming systems are usually intertwined within various parts of value chains across different disciplines, therefore, a range of stakeholders and role players with diverse knowledge and backgrounds are required to stimulate efficient decision-making. A systems-thinking approach accommodates such a decision-making environment and thus relevant to this study, the evaluation of different beef cattle integration considerations. Multidisciplinary group discussions as a research method facilitate the systems approach (Hoffmann, 2010).

2.3.2 Multidisciplinary group discussions as research method

Multidisciplinary group discussions as research method or technique to generate information, originated in the military during World War II (Calheiros *et al.*, 2000; Colin & Crawford, 2000; Hoffmann, 2010, 2001 and Linstone *et al.*, 1975). Since then it has developed into a popular method used in farm management assessment.

Specialised or disciplined-based research can fragment existing information and understandings. In these cases, multidisciplinary group discussions are especially valuable as disciplinary gaps can be bridged and knowledge can be utilised to better understand specific concepts (Hoffmann, 2010). Farm management research is categorised as multifaceted, therefore, the participation of specialists in miscellaneous fields is essential for an effective group discussion (Bullock *et al.*, 2007).

The exploratory nature of this study motivates the use of multidisciplinary group discussions since the objective is to improve whole-farm systems and some of the required information does not yet exist (Hoffmann, 2010). To generate applicable exploratory information on the implications of alternating livestock integration, logical and consistent inputs from experts are required. Hoffmann (2010) argued that multidisciplinary group discussions are an efficient and time saving method for generating information.

In this study a multidisciplinary group discussion is used to validate assumptions and parameters to construct a typical farm budget model. The model will be used to assess different aspects that has to be considered regarding the integration of beef cattle and appropriate integration strategies will be identified. The multidisciplinary group discussion had four main objectives:

(1) to identify and invite experts that cover the necessary fields relevant to this study,

(2) to present and validate the existing knowledge and to encourage participation,

(3) to accumulate valuable inputs from the experts and to identify viable integration options,

(4) to have experts agree on assumptions, parameters, and strategies.

Group discussions can create an environment that stimulates creative thinking which enhances decision-making and efficient research output.

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

2.3.3.1 The typical farm budget model

The typical farm represents a normal farm within a homogeneous area (Knott, 2015). In the USA, during the 1930's, the focus shifted away from the production-cost approach towards a whole-farm approach. This led to the utilisation of the typical farm model. It can be used to evaluate farm profitability and capture the effect of variations in a range of variables for farm-level profitability. Typical farm models are often used to measure managerial considerations and implications and are a cost and time effective research method (Hoffmann, 2010). Feuz *et al.,* (2010) defined a typical farm as a farm that represents a group of farms in an essentially homogeneous area (Knott, 2015).

Farms and farming units are heterogeneous in different parts of the world, countries, and regions. Even small farms are complex and unique. The same factor will not affect profitability in the same way on different farms. This study focusses on certain production systems within a specific area and the integration of livestock into these production systems. When constructing the typical farm, the objective targets the mode rather than the average of the farms in this homogeneous area. This relates to the management standards, access to markets, cropping systems, cultivation practices, land size and profitability of farms in this area (Hoffmann, 2010; Knott, 2015). Furthermore, the effect of outliers should be reduced, in this case the exceptionally profitable or non-profitable farms.

Using a typical farm model enables the exploring of beef cattle integration and the implications on expected profitability of whole-farm systems in the Middle Swartland. The multi-period aspect of the whole-farm budget model is significant as such implications are generally demonstrative over the longer term. The results and findings generated from the model can be regarded as typical to the area and not directly applicable to a specific farm. The practicality and convenience that these models offer producers make it an ideal research tool (Basson, 2017 and Knott, 2015).

A whole-farm, multi-period budget model has three key components:

- The first is the input component that consists of the specifications of the typical farm, land usage, crop rotations, yield assumptions, input prices, and output prices (Hoffmann, 2010). All these inflow and outflow variables can be altered which would have an immediate impact on the output component.
- The second is the calculation component that calculates the interconnections connecting numerous input parts to generate effective financial outputs. Within this component gross production value and gross margin analysis are done, overhead and fixed costs are calculated, and the inventory and asset replacement are determined.
- The third component is the output of the models which includes the calculation of whole-farm profitability. The profitability is expressed as an internal rate of return on capital investment (IRR) and a net present value (NPV).

Figure 2.4 illustrates the three components of a typical whole-farm multi-period budget model. These models incorporate various sets of data and calculations that are interconnected and based on standard accounting principles and methods.

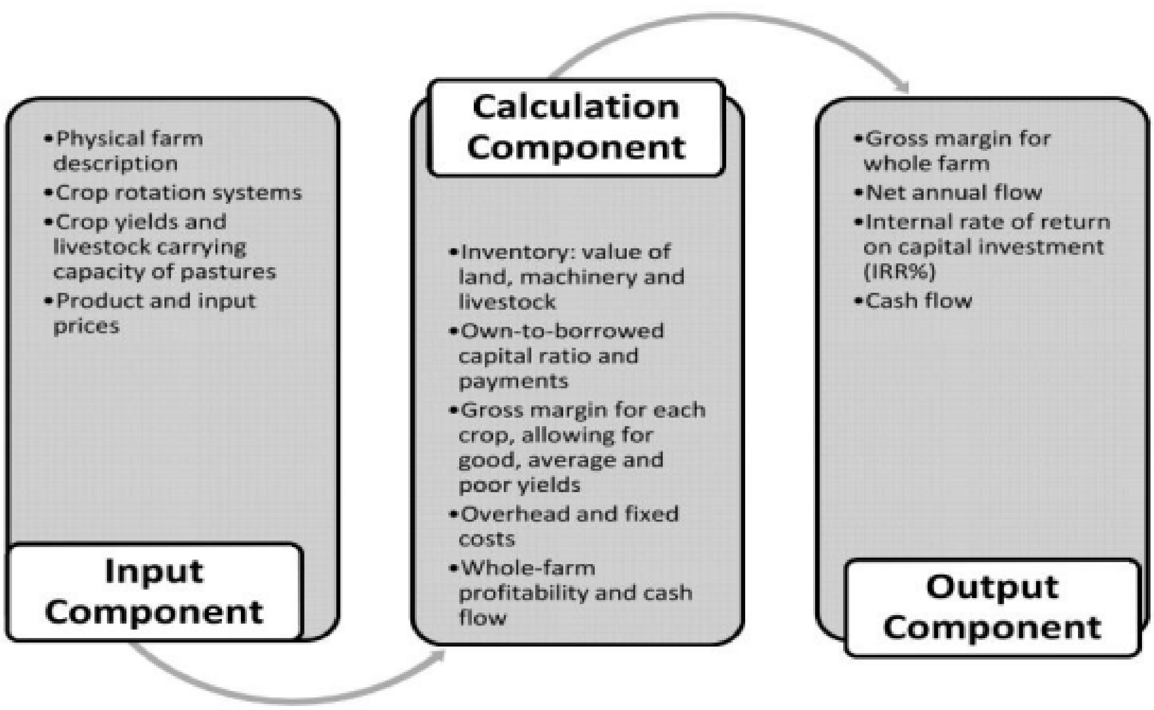

Figure 2.4: A graphic representation of the components of the whole-farm, multi-period budget model.

Source: Hoffmann (2010).

The scientific knowledge basis for this study was formed through research data from trials conducted at Langgewens. In this study, the accurate and efficient construction, validation and utilisation of whole-farm multi-period budget models will generate valuable decision-making information. Scott *et al.,* (2013) concluded that these models are effective tools for considering the profitability of different livestock integrations, particularly where sustainability is amongst the main objectives.

2.3.3.2 Type of model

Modelling can be defined as creating a representation of a real-world system, or the conceptualisation of an abstract system of relationships into something more familiar and useful (Breimyer, 1991; Hoffmann, 2010 and Strauss, 2005). In other words it's a tool to visualise something that cannot necessarily be observed directly or instantly. A model should be developed to accommodate and incorporate the maximum available and relevant information, whilst avoiding over complication and clumsiness (Hoffmann, 2001).

Numerous approaches exist for modelling farm systems. The approach used should be based on the research problem and research questions (Hoffmann, 2010). Thus, the questions the model should answer, or the objectives of the model, will determine the approach. A normative approach is prescriptive in nature and describes what is believed or 'ought to be'. Hoffmann (2010) stated that a normative approach lacks the ability to compare alternative predicted consequences to the current or referenced situation. Malcolm (1990) explained that a further disadvantage of the normative approach is its narrow focus on a specific problem, which sometimes results in a failed opportunity to consider other alternatives. A positive approach is concerned with 'what is', 'what was', and/or 'what will be'. Positive models are not concerned with desirability but are descriptive in nature. They are used to measure the 'probable' outcome of specific variables (Hoffmann, 2010; Kerselaers *et al.*, 2007 and Strauss, 2005). Evidently, a positive approach suites the constructing of models for the exploration of beef cattle integrations.

Models utilised to simulate farms can be categorised in terms of the objective of the model and/or the type of system being modelled (Strauss, 2005). Two identifiable types of models are deterministic and stochastic models. Deterministic models are used to simulate specific outcomes based on a specific set of inputs, but unlike stochastic models risks are not incorporated (Hoffmann, 2010). For this study a systematic approach is being followed and most of the input variables are known, therefore, a deterministic model is most suitable. A sense of risk will be determined by incorporating different scenarios. Typical objectives for modelling are prediction, explanation, or exploration. Exploration models aim to identify viable alternative strategies such as the integration of beef cattle. These models focus on the sensitivity of the model to a specific variable or a certain combination of variables and are interested in conditions and how the outcome is impacted (Hengsdijk *et al.*, 1998 and Hoffmann, 2010).

For this study it is important to identify appropriate criteria when constructing a whole-farm budget model as different crop rotation systems and integrated crop-livestock systems should be compared. Margin analysis will enable the profitability of these systems to be compared. There are numerous variables such as product prices, yields, and stocking rates that can have substantial financial implications. Therefore, it is important that the model allows for sensitivity analysis that measures the profitability alterations that are caused by changes in these variables.

2.3.4 Conclusion

The biological and ecological benefits from improved soil fertility, decreased erosion, and moisture retention were identified as the driving forces for adopting CA. One of the principles of CA is the rotation of crops. Including cover crops in crop rotation systems has the potential to improve the yield of subsequent crops, whilst reducing input costs. The inclusion of cover crops creates grazing opportunities; therefore, other livestock integrations are explored. Integrating beef cattle into crop rotation systems will generate complex financial and management implications. The literature overview further identified the potential benefits of a mixed livestock integration. This strategy increases the diversity of crop rotations and can be a lucrative option.

With the systems approach, interaction within agricultural systems can be conseptualised and long-term consequences of decisions and actions can be anticipated. Multidisciplinary group discussions as a research method facilitates the systems approach. The exploratory nature of this study motivates the utilisation of multidisciplinary group discussions as the objective is to improve whole-farm systems and some of the required information does not exist yet. Systems thinking and multidisciplinary group discussions will enable the construction of an accurate whole-farm multi-period budget model. Such models can incorporate the complexity of farm systems and are convenient when different integration strategies are being simulated.

Chapter 3: Method application

3.1 Introduction

Conservation agriculture and the inclusion of cover crops in crop rotation systems of the Middle Swartland were addressed in Chapter 2:. Different management considerations regarding livestock integration strategies were discussed and the possible synergy in mixed crop-livestock systems was established. The integration of beef cattle was explored in depth.

The gradual shift towards the inclusion and utilisation of cover crops amongst producers in the Middle Swartland creates more grazing opportunities that need to be explored. Cover crops are implemented to achieve objectives other than being harvested as a cash crop. The efficient utilisation of these crops can add economic value to farming systems. The literature overview further identified that an integrated livestock component (sheep together with beef cattle), poses greater opportunities. This integrated livestock component has the potential to improve profitability, as farming units can be utilised more effectively. The inclusion of cover crops and livestock, particularly an integrated livestock component, increases diversity. This can add substantial value and sustainability to whole-farm systems.

The Langgewens crop rotation trials provide data regarding crop rotation and livestock integration in the Middle Swartland. This provided the basis for the development of the livestock integration strategies and considerations that is incorporated into the whole-farm budget models of this study. This chapter introduces and explains the crop rotation trials of Langgewens Experimental Farm and discusses the financial analysis of different crop rotation systems included in the trial. The data utilised in this study is presented and livestock integration validated.

Sheep is currently the livestock component integrated into crop rotation systems on Langgewens. This integration poses as the foundation of this study. Crop rotation systems in the Middle Swartland are evolving. The financial and management implications of integrating beef cattle into these evolving crop rotation systems are a viable and necessary study.

3.2 Langgewens trial data

3.2.1 Background

The long term CA trials are conducted by the Western Cape Department of Agriculture. It was established in 1996 on the Langgewens Research farm, approximately 100 km north of Cape Town. The farm is situated in the Middle Swartland and is considered typical in nature to farms in this area. Between 1996 and 2001, minimum tillage was used in all systems and since 2002 full

CA production practices were implemented for all the crops included in the experiment. All the operations and actions on the experimental farm are completed using normal-size farm implements. Most crops are planted from the end of April, after the first rain has fallen, to the end of May. The crops are generally harvested between mid-October to the end of November (Basson 2017 and Botha, 2013). Annexure A: Map indicating the location of the Langgewens experimental farm in the Middle Swartland shows a map indicating the location of the Langgewens experimental farm in the Middle Swartland.

The nature of the Langgewens crop rotation trials necessitates experts across many disciplines, including plant and soil sciences, weed management, and economics, to be involved. These role players were used to establish guidelines for the trials and are constantly involved in decision-making processes. Apart from the contribution the Langgewens information has in this study, the experimental farm has also been a catalyst for other research fields including cultivar studies, plant pathology, soil nitrogen studies, and no-till experiments (Strauss, 2021).

The data selected for this study is generated from two research trial data sets, conducted on Langgewens. By integrating data from the trials it is possible to accurately simulate practical farming systems in the Middle Swartland. The gross margins of different livestock integration strategies into crop rotation systems can then be incorporated in a typical farm multi-period budget model.

The first trial compares respective crop and crop/annual legume pasture rotation systems to determine the potential implications of CA practices in systems with and without livestock. The trial is conducted by Dr Strauss of the Western Cape Department of Agriculture and is titled "An investigation into the production dynamics of eight crop rotations systems, including wheat, canola, lupins and pasture species in the Swartland, Western Cape".

All crops in each of the eight rotation systems were present on the field every year to allow for comparisons between various systems. Wheat *(Triticum aestivum)*, canola *(Brassica napus)*, and lupin *(Lupinus angustifolius)* are the cash crops included in the trial. Annual medic *(Medicago truncatula and M. polymorpha)* and clover *(Trifolium repens)* are grazed by sheep at a stocking rate of four sheep per ha (Strauss, 2021). Sheep are moved onto forage crops in April and/or May when medic and clover pastures self-generate. In System H the sheep are kept off for an extended time of about six weeks until the annual medic/clover mix has reached at least 90 percent ground cover. During this time, they forage on saltbush *(Atriplex nummularia)* that is included additionally in System H. This allows for the medic/clover mix to better establish before the sheep are put in for grazing (Basson, 2017 and Strauss, 2021).

Table 3.1: Crop rotation systems included at the Langgewens crop rotation trials

System code	Rotation system	Letter sequence
A	Wheat–Wheat–Wheat–Wheat	WWWW
B	Wheat–Wheat–Wheat–Canola	WWWC
C	Wheat–Canola–Wheat–Lupin	WCWL
D	Wheat–Wheat–Lupin–Canola	WWLC
E	Wheat–Medic–Wheat–Medic	WM^GWM^G
F	Wheat–Medic + Clover–Wheat–Medic + Clover	WMc^GWMc^G
G	Wheat–Medic–Canola–Medic	WM^GCM^G
H	Wheat-Medic + Clover–Wheat–Medic + Clover	$WMc^{sG}WMc^{sG}$

Note ^{G}Crop phases grazed by sheep; ^{s}Saltbush pastures are included (medic+/clover pastures rests)

Fifty hectares of trial land were divided into 38 camps with the smallest and largest respectively being a half and two hectares. As illustrated in **Figure 3.1**, livestock was integrated in all crop-pasture Systems (E-H). Sheep also graze cash crop residue during the summer in Systems E-H.

All rotations are managed according to the best practices recommended locally and by industry. A maximum soil disturbance of 20 percent in the planting row is achieved through all systems being subjected to no-till practices. No-till continuous wheat serves as the control. Yield and system gross margin data from 2002 onwards are included in this study and discussed in the next section.

The second trial was initiated in 2016 and is titled "Improving existing grain cropping systems in the Swartland by developing agro-ecological production methods". Conducted by Dr Strauss of the Western Cape Department of Agriculture, the trial's main objective is to evaluate alternative cropping systems for the Swartland, concentrating on the inclusion of cover crops and the reduction of synthetic inputs to improve soil health. Healthier soil will generate healthier crops, higher yields, and mitigate the challenges of climate change.

This 16-ha trial is located next to the long-term crop rotation trials on Langgewens and is managed by the same team. The five crop rotation treatments in the trial are replicated four times in a randomised block design. Each treatment is fully represented each year. There are three diversity systems included in the trials:

- System A – low diversity system – 50 percent cereal (single cereal type), 30 percent oilseed (single type), 20 percent cover crop (2 mixes)
  - Sequence: cereal-broadleaf-cereal-cover crop mix (predominantly legumes)-cereal-cereal-cover crop mix (predominantly grasses)-broadleaf-cereal-broadleaf
- System B – more diverse system – 50 percent cereal (single type), 10 percent oilseed (single type), 20 percent legume (2 types), 20 percent cover crop (2 mixes)
  - Sequence: cereal-broadleaf-cereal-cover crop mix (predominantly legumes)-cereal-cereal-cover crop mix (predominantly grasses)-broadleaf-cereal-broadleaf
- System C – most diverse system – 50 percent cereal (3 types), 20 percent oilseed (2 types), 20 percent cover crops (2 mixes)
  - Sequence: cereal-broadleaf-cereal-cover crop mix (predominantly legumes)-cereal-cereal-cover crop mix (predominantly grasses)-broadleaf-cereal-broadleaf

The plots in this trial are divided into these three sections and managed accordingly. Disc planters are used and zero till procedures are followed.

3.2.2 Analysis of the crop rotation trials

The gross margin per system depends on the different components included in the system. In Systems A-D the cash crops contribute to the gross income. Pasture/crop Systems E-H have a wheat and livestock (meat and wool) component, while canola is also included in System G. Gross margins were calculated by subtracting the direct allocable production costs from the gross income of each system. Annexure B: Example of gross margin calculations at Langgewens experimental farm illustrates an example of gross margin calculations at Langgewens experimental farm. The cash crops systems were left ungrazed until the end of the season. The legume pastures were grazed during the production season and thereafter residues of both wheat and pastures in these systems were grazed in the summer months. Grazing was managed to meet the minimum soil-cover target of 30 percent and at least half of the crop residues were conserved for the next planting season.

Figure 3.1 illustrates the average gross margin of the different crop rotation systems included in the trial. The data used to calculate these margins range from 2002 to 2015 after which rotation systems were alternated and so the economics may be deceptive.

The average gross margin of System H was the highest whereas System A (continuous wheat) was the lowest. Lupin's poor performance due to low yields and commodity price over various seasons resulted in a negative gross margin for this crop in Systems C and D which caused a lower gross margin. Two years of cereal followed by two broadleaf years, with crops that share similar diseases, meant that the formation of System D contributed to weaker wheat and canola yields and lower gross margins compared to Systems C and B (Strauss, 2021). Basson (2017) explained that the superior gross margin of System H can be attributed to the configuration of the system. The added saltbush planted on marginal land meant that the sheep could be kept from the legume pastures at the beginning of the growing season. This ultimately enabled a higher stocking rate and lambs being marketed earlier, which contributed to a higher gross income, compared to other pasture/crop systems.

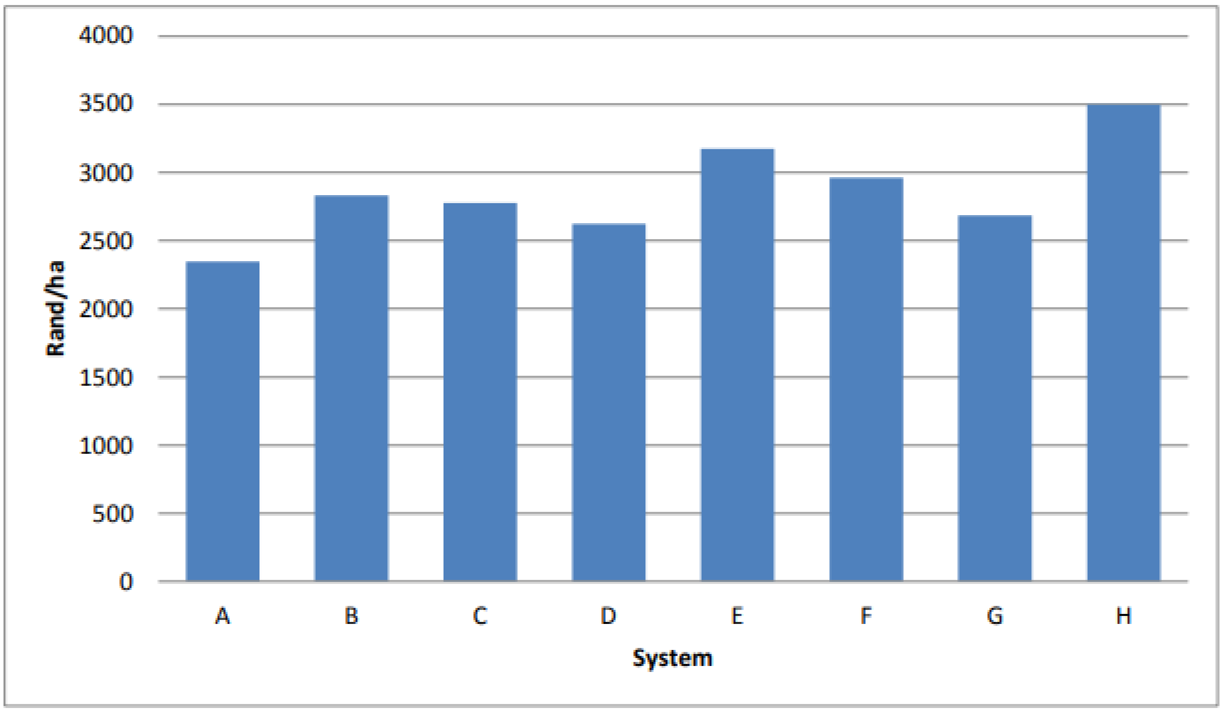

Figure 3.1: Average gross margin above all allocatable costs 2002-2015.

Strauss (2021) emphasised the importance of creating resilience. Since the start of the CA trials in 2002 there have been various challenges coupled with dry seasons. The progress CA has made through better soil structure, surface cover by crop residues, better infiltration, and greater water holding capacity creates resilience and sustainability. In 2003, one year after implementing CA the average wheat yield was 524 kg/ha, this was due to only 210 mm of rain during the April-September growing season. In that year only the rotation systems that included medic and medic/clover pastures managed to sustain the wheat until August and September when most of the season’s 210 mm fell. In 2017 an average wheat yield of 2 488 kg/ha was achieved with an even lower in-season rainfall of 175 mm (Strauss, 2021).

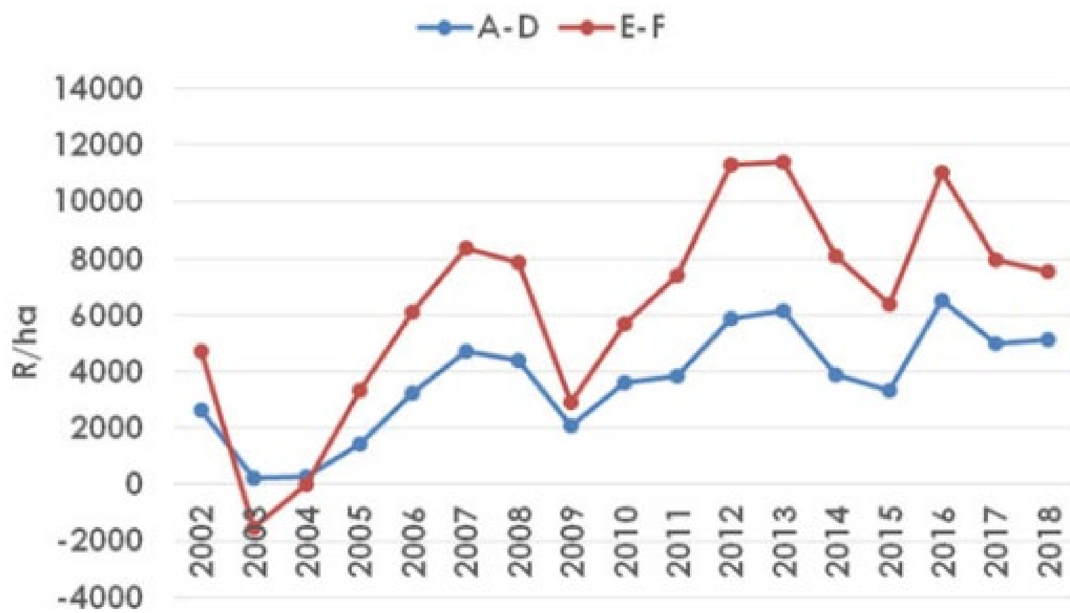

Figure 3.2: Average Gross margin over time, pure cash crop systems (A-D) vs crop/pasture systems (E-F)

To achieve average to good yields in the Middle Swartland, sufficient rain in September is critical (Basson, 2017). It is predicted that South Africa's climate will experience more heat waves, greater occurrence of draught and extreme rainfall events, and more rainfall unpredictability in the future (Shew *et al.*, 2020 and Ziervogel *et al.*, 2014). This volatility makes it difficult to manage input costs according to the season's climatic conditions. The efficient management of input costs is an important tool in limiting the negative effect lower yields may have on a gross margin, ultimately reducing risk and promoting sustainability.

The benefits of CA lie not only in improved yields, but also in reduced inputs. Input costs such as pest and disease control, diesel, and fertilisers are lower in the crop/pasture systems. The sustainability of Systems E - H becomes even clearer when we consider the lower carbon footprint and the ecological benefit of these diverse systems (MacLaren *et al.*, 2019). Ultimately, sustainable farming can have a positive impact on food security, now and in the future.

MacLaren *et al.,* (2019) established that a crop/livestock integrated approach promotes the sustainability of CA cropping systems. Seedbank data from the long-term trials on Langgewens indicates that integrating crops, livestock, and management diversity is key to effective weed control in CA systems (MacLaren *et al.*, 2019; Strauss, 2021). The economic and ecological benefits of an integrated crop/livestock CA approach are abundant. Integrating beef cattle has the potential to enhance diversity.

There exists sufficient evidence that livestock integration can facilitate weed suppression and maintain or inflate yields at lower levels of agrichemical inputs, offering both environmental and economic benefits that promote sustainability (Ghahramani & Moore, 2016; Lemaire *et al.*, 2014; MacLaren *et al.*, 2019 and De Moraes *et al.*, 2014). Basson (2017) analysed the Langgewens crop rotation trials and concluded that comparisons could be drawn between yields from diverse grazed and ungrazed systems and found that the reduced cost of inputs and increased diversity of marketable outputs in grazed systems generated higher long-term profitability.

3.3 Implementing the group discussion

3.3.1 The panel of experts

To lend credibility and enable the replication of the process, it is important to focus on the idea of experts as participants. The process of gathering the experts to partake in the group discussion is based on selected criteria. When considering the different disciplines that need to participate to achieve the objectives of the group discussion, it is important to consider the main objective of the study. As the objective of the study is to evaluate financial and management implications when integrating beef cattle, experts outside the grain industry are required. For instance, wheat producers who practice crop rotation in the Middle Swartland are important, but so are experts from livestock industries. The value of multidisciplinary group discussions is demonstrated when experts contribute alternative opinions based on expert knowledge and experience.

For this study, it was important that producers and researchers from the Middle Swartland were included in the group discussion. It was even more important to identify producers experienced in livestock integration, particularly cattle integration in the Swartland area. These producers provided guidance and a balanced perspective. They contributed significantly to the refinement of parameters, proposals, and assumptions. These producers highlighted the lack of practicality in some of the beef cattle integration assumptions that were considered before the group discussion. Some parameters and assumptions were adjusted and others were simply found as being unpractical. Technical experts gave insight on the latest technology and the costs thereof. The scientists contributed to various whole-farm system considerations, for example input and outputs, and the interrelatedness of livestock and crops. When it came to the transformation of physical-biological data into financial details, the agricultural economists were valuable. They also contributed a great deal when risk management, profitability, and trade-offs between the capital investment in livestock and other components in farming systems were discussed.

The following individuals participated in the group discussion:

Mr. Rens Smit - Manager of Langgewens research farm and agronomy specialist.

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

Dr Willem Hoffmann - Agricultural economist and lecturer at Stellenbosch University.

Dr Chris de Brouwer – Animal scientist at the Department of Agriculture: Western Cape.

Mr. JP Bester – Producer.

Mr. Cobus Bester – Producer.

Mr. Gideon Melck – Producer.

Mr. Sakkie Rust – Producer.

Mr. Hannes Eksteen – Producer.

3.3.2 The multidisciplinary group discussion

The group discussion took place on the 10th of September 2021 at the Langgewens experimental farm between Malmesbury and Moorreesburg. Each of the participants received a booklet, in advance, containing information on the study and an outline of the topics up for discussion. This information included parameters and data for the construction of the whole-farm budgeting model. The session ended with a visit to the trial sites followed by lunch to allow for further discussion.

At the beginning of the group discussion the study and objectives of the workshop was briefly explained. During the discussion all participants had the opportunity to make suggestions. All the suggestions and input were open for discussion until consensus had been reached. The main topics of the group discussion were:

- the parameters to construct a typical farm for the multi-period budget models
- the crop rotation systems in the Middle Swartland and the identification of systems that accommodates beef cattle integration
- the validation of different cattle integration strategies and the management considerations of these integrations.

With regards to the physical and financial extent of the typical farm, aspects that required detailed attention were the land size and price of a sustainable farm in the Middle Swartland.

The accurate simulation of the financial implications when integrating beef cattle received most of the attention. Before the group discussion, one of the goals was to predict the financial implications for integrating beef cattle into crop rotation systems that previously only accommodated sheep. The aim was to evaluate the profitability of a farm, incorporating alternative livestock options; one with beef cattle, the other with sheep as livestock component, and to explore an integrated livestock component. The crop rotation systems, physical extent and management preferences regarding these farms would then be alternated to measure and assess the expected financial viability of beef cattle integrations on different farms in the Middle Swartland. The aim was to financially compare beef cattle integration with the existing livestock component of sheep in different crop rotation systems and to generate valuable decision-making information for producers in the Middle Swartland. Concern regarding this financial comparison was raised.

The financial implications of different crop rotation systems in the Middle Swartland can be evaluated accurately as the site-specific data is available from trials on the Langgewens experimental farm. In contrast, the only livestock component integrated into the crop rotation systems on the Langgewens farm is sheep. Therefore, the expert group suggested that the expected financial implications of integrating beef cattle should be considered thoroughly. Numerous possible cattle integration strategies were discussed in depth. Parameters and variables regarding the stocking rate, herd composition, and management requirements were determined. The integration of beef cattle should only be considered when the benefits of CA are maximised and sustainability is encouraged.

The producer participants in the group discussion had a beef cattle component integrated into their cropping systems. The diversity and heterogeneity of their cattle integrations guaranteed valuable contributions. It was clear that the management preferences determined the integration strategies and that it was important to integrate cattle in a way that compliments the whole-farm system. The producers highlighted that cattle integration strategies differ, but that the integration of cattle adds value and sustainability to their whole-farm systems. It was established that the integration of beef cattle into crop rotation systems that did not include cover crops, were unpractical as these rotation systems only accommodate sheep.

The expert group contributed significantly to the process of considering and validating integration strategies and to constructing the typical farm. Further consultation with experts present at the workshop and others in the industry, was necessary to obtain and validate further information.

This included many of the management alterations of the integration strategies, prices and costs, and infrastructural changes regarding the integration of beef cattle.

3.4 Conclusion

The Langgewens crop rotation trials provide valuable information for various agricultural role players. Achieving sustainability through effective CA practices, more specifically crop rotations, are evident. The Langgewens trials pose as the foundation of this study and the construction of the typical farm budget. The next chapter aims to explain the different components of the budget model and how the financial implications of integrating beef cattle can be captured accurately.

Chapter 4: Financial analyses of integration strategies

4.1 Introduction

Chapter 3: introduced and elaborated on the crop rotation trials at Langgewens experimental farm. The resilience and sustainability achievable with effective crop rotation systems within a CA farming approach are evident. The Langgewens experimental farm provides valuable data and information for this study and role players across different backgrounds. In achieving long-term sustainability, the quest to feed the growing world population in escalating challenging environments, is accommodated.

In this chapter the preparation and utilisation of Langgewens research data is discussed for the financial exploration of beef cattle integrations. The process of constructing whole-farm multi-period budget models is introduced. The financial results of these models and the comparison of the results are explained. The interrelatedness of whole-farm systems and the ripple effect that tiny alterations may have on the financial position of farms were emphasised in previous chapters. Chapter 4: describes how data and assumptions are validated by multidisciplinary group discussions and the continuous involvement of experts. This will accurately capture the interrelatedness of farm systems and ultimately encourage the construction of models that simulate financial outcomes that portray the real world.

As explained in Chapter 2:, constructing whole-farm models consists of three components. These components are the input, calculation, and output, referred to in **Figure 2.4**. The components each play a part in the process of building a model that yields accurate and efficient results. This chapter will address each component and the respective variables within them.

4.2 Development and construction of a multi-period whole-farm budget model

The main objective of this study is to determine the financial and management implications of integrating beef cattle into crop rotation systems of the Middle Swartland. To address the financial implications, multiple whole-farm budget models for the Middle Swartland were constructed. The models were used to simulate a typical farm with crop rotations and different livestock integrations into these systems.

To consider the consequences of individual components on whole-farm budget models, the need for multidisciplinary group discussions arose. The models capture scientific knowledge by integrating research data and expert knowledge. The producers contributed practical knowledge, although lay knowledge gained through experience, it is still expert knowledge when models are utilised. The model determines the expected financial implications of different livestock integration strategies into various crop rotation systems.

A farm's financial condition is affected by various interconnected elements from both the internal and external environments. Input and commodity prices are some of the external forces that are beyond the control of the producer. The yield of crops and livestock is one of the main factors determining farm profitability but cannot be directly controlled. The complexity of farming systems can be captured within whole-farm budget models which accommodate physical/biological and socio/economic variables.

Data validation is an important aspect of accurate modelling and simulation. Trials and experiments are often conducted in environments that are not applicable to farm level. Heterogenic experts participating are required to validate the information and data obtained from the Langgewens trials to ensure alignment with practice-based principles. Some conditions that lead to alternative results generated by trials may be impractical, such as farmer management preferences and risk appetite, soil structure, and farm size.

When exploring the financial implications of integrating beef cattle into complex crop rotation systems, the interrelatedness of various factors affected by this integration should be captured accurately. Inaccurate data and/or assumptions could result in unreliable results that diminish trustworthiness. A thorough understanding of whole-farm systems, crop rotation and livestock production systems is a prerequisite to simulation modelling. When assumptions regarding livestock integrations are validated, thorough systems thinking is needed, as different integrations will change the balance of production systems. The model in this instance was constructed with the guidance and input from producers and scientists, experts in their various fields relevant to this study. Producers with experience in beef cattle farming within the Middle Swartland and cereal production systems were crucial. The group discussions focused on the validation of beef cattle integrations and the financial implications it will have.

A multi-period budget model was constructed to explore the effects beef cattle integrations will have on the profitability of a typical farm. Once the current financial position of a typical farm in the Middle Swartland was established in the model, the financial implications of these integration strategies could be compared. Standard accounting principle was followed and provided a format to calculate financial margins and flows. Numerous spreadsheets with integrated data sets were incorporated into a simulation model that accommodates various adjustments to the whole-farm financial performance. Adjustments can be made to countless variables, as the model's interrelatedness aims to mimic that of real-world farm systems. Some of these variables are farm size, input costs, stocking rates, livestock prices, inventory requirements, and interest rates.

4.3 Input component

The input component includes the physical description, land utilisation, and financial dimensions of a typical farm. The crop rotation systems and livestock integration options within these systems, as well as the input and output prices are all included in the input component. These variables can be altered, which instantly results in the recalculation of the financial position of the farm. During the group discussions various input variables were changed to illustrate the financial effect on the farm's gross margins and profitability. The instant calculations and ability to compare options stimulated the accurate validation of variables and assumptions by the experts involved.

4.3.1 Physical description of a typical farm

The typical farm is representative of a farm within a homogeneous area (Knott, 2015). This farm represents farming systems in the Middle Swartland and creates a point of departure for producers to explore changes in farming systems. The physical parameters of a typical farm in the Middle Swartland were described by Hoffmann (2010), but these parameters were outdated and needed validation as farms evolve over time. The numerous variables of the typical farm required the validation of experts from the group discussion. These variables included the farm size, which influences many other factors such as labour and mechanisation requirements, livestock numbers, livestock replacement strategies, and infrastructure which evidently affects the farm's profitability.

4.3.2 Land utilisation

When the physical description of a typical farm is established, the utilisation of the farm should be determined. The proportion of land left unutilised is categorised as fall-out land. This part of the typical farm is not used for cultivation due to unfit soil, or it may be used for roads, livestock camps, buildings and infrastructure. It is important to correctly identify the percentage of fall-out land on a typical farm as the rest is categorised as arable land and will be utilised in the crop rotation systems. The fall-out land is part of the initial capital investment of a typical farm, but does not contribute financially.

The total arable land will determine the number of hectares available for each crop in the crop rotation systems. This will directly affect the number of livestock that can be integrated as certain crops do not accommodate livestock and others are more prone to livestock integration.

4.3.3 Financial extent of a typical farm

An asset register financially expresses the physical dimensions of a typical farm. The total value of the asset register indicates the funds required for the assets of a typical farm. Included in the inventory of the typical farm model is the value of the land and all the fixed improvements, the mechanisation and equipment, and the livestock required for a typical farm. These variables are altered as different integration strategies in various rotation systems are explored.

The group discussions validated the asset requirements for different crop rotation systems and thereafter established how different livestock integrations will change these requirements. For instance, in an intensive livestock management approach the change from sheep to that of cattle may require less fixed improvements, as a lambing shed would not be needed anymore. The percentage of arable land utilised by cash crops and the combination of crops in rotation systems determines the amount and type of machinery required.

4.3.4 Integrating the risk factor

Many factors influence crop yields to vary from one year to another. Seasonal weather fluctuations directly affect crop yields and cannot be managed by producers. The risk associated with inconsistent yields is incorporated into the financial models by establishing the yields of poor, average, and good years. The multidisciplinary group and experts from various agricultural backgrounds used weather data to incorporate the effect weather has on yields and the profitability of farms. These occurrences of differently categorised seasons also influenced the stocking rates and/or the required feed supplements for different integrations. When exploring the integration of beef cattle, a dry year not producing enough fodder for cows in production will have financial implications.

The quantity and dispersion of rainfall within a season is the distinguishing factor between a good, average, or poor year. Hoffmann (2010) explained that using these seasonal variations can be an effective way to incorporate risk, as the prevalence of these categorised years are likely to follow the same trend. Poor years are associated with droughts and the irregular dispersion of rain, conditions disadvantageous to crops, resulting in low yields. The average year portrays a "normal" but not perfect production season in the Middle Swartland. This can mean that the quantity of rainfall was sufficient, but the dispersion wasn't ideal and crop development was limited in certain stages. A good year is when advantageous circumstances occur throughout the crop's development and growing season. For this to take place the quantity and dispersion of rain must be on point.

The experts in the group discussions established the frequency of the different categories as the data from the Langgewens crop rotation trials were presented to them. For each of the years yields were confirmed and the effect of these fluctuations was built into the typical farm models.

4.3.5 Crop rotation systems used

The multidisciplinary group identified crop rotation systems that accommodate livestock integration. In this study all the crop rotation systems include pastures in the form of medic or cover crops, as the systems that only rotate cash crops are unfit for livestock integrations. A popular crop rotation in the Middle Swartland is that of wheat and medics (System E in the long-term crop rotation trials of Langgewens research farm). This crop rotation system has an integrated sheep component, but it was concluded in the group discussion that the integration of cattle into these systems is unpractical and risky as grazing is limited. This system is included in the study as it acts as control system and beef cattle integration within evolved crop rotation systems could be compared with one of the successful “traditional” crop rotation systems in the Swartland.

It was important to incorporate systems that included cover crops, as these crop rotation systems motivated the exploration of beef cattle integration. A further two rotations were included, a wheat - cover crop rotation (System 1) and a wheat - cover crop - medics rotation (System 2). Through the group discussions these rotations were evaluated as the two systems most appropriate to explore cattle integrations.

Chapter 3: discussed the importance of long-term sustainability in challenging environments. The selected rotations aim to stimulate soil health and resilience, whilst reducing inputs and enhancing diversity. In System E the medics are grazed by livestock, whereas in System 2 the medics are baled and sold. The cover crops in both System 1 and 2 are utilised by livestock.

4.3.6 Livestock integration strategies

Once the typical farm and its crop rotation systems have been established, the livestock integration strategies were validated. The three main benefits of livestock integration are the mitigation of risk, the added diversity into rotation systems, and the income generated when crops previously not harvested are utilised.

To explore the integration of beef cattle, accurate financial comparisons between beef and sheep (the livestock component in most crop rotation systems of the Middle Swartland) integration were done. Both sheep and cattle were integrated as the sole livestock component into rotation Systems 1 and 2. This generated financial results that provided the opportunity to compare livestock gross margins and whole-farm profitability within the same rotation systems. These results can also be compared to that of the traditional rotation System E that does not include cover crops. The possible benefits of integrating livestock (sheep and beef cattle together) have been highlighted throughout the study. This was again confirmed in the group discussions. A mixed livestock integration of sheep and beef cattle was also built into the farm models for Systems 1 and 2, enabling the evaluation of the financial implications.

These rotation systems and their respective livestock integrations provide producers with guidelines for strategies that can be considered when integrating livestock. The identification of systems that are declared invalid for some integration options is just as important as the viable ones, as they present ineffective strategies and financial losses.

Further integration options, such as speculation, stud breeding, and grass-fed beef production were discussed and classified as having potential. The scarcity of cattle integration in the Middle Swartland and the relative uncertainty regarding cover crop inclusion in this area meant that the cattle integration explored in this study should not be overcomplicated. The viability of extensive cattle farming in these systems is an important steppingstone for other strategies, as more cattle in the area provides more opportunities for speculation and stud breeding. The discussion group further mentioned that when intensive speculation is evaluated, it is more of a farm commodity on its own and less of an integration.

4.3.7 Input and output prices

Product prices and input costs are merged into data tables in the budget model. The information then serves as the basis for calculating enterprise budgets. Gross margins for livestock integration strategies and the crop rotation systems they are integrated in, are calculated by subtracting data from these tables. The per hectare production costs are calculated using the input prices and application rates for each system and integration. It is important that the prices included into these data sheets are accurate, as different systems and integrations each apply unique quantities and products to generate specific outputs.

Recent averages derived from Langgewens trial data were used as a foundation for the discussion and validation of input costs and earnings in rotation systems and livestock integrations. The estimates for beef cattle input costs and output prices were derived from cattle integration data from other areas, from producers with cattle in the Middle Swartland, and from various experts and agri-businesses. Information like weaner price averages, the amount and type of supplement feed, and dosing programs had to be validated specifically for the Middle Swartland.

Overberg Agri, Kaap Agri, and SSK developed a model (2020) that accurately reflects the machinery costs in cereal production systems in the Western Cape. This model was compared to the National Department of Agriculture's "*Guide to machinery cost*" (2020). An effective, updated tool to calculate the machinery cost for each activity per hectare was then built into the farm-budget models. Annexure C: Guide used to determine machinery and activity cost illustrates the guide used to determine machinery and activity cost. The cost of activities is calculated regarding the power source and type of implement that is used. This is based on the engine size of the tractors or machinery, the size of the implement, and the activities performed. Gross margin calculations then incorporate the operating costs for the activities completed for each rotation system and non-directly allocated variable costs are assigned to each crop and/or livestock integration.

4.4 Calculation component

The calculation component is constituted by a series of interconnected calculations. The typical farm attributes assumptions and parameters for the various strategies, and rotation systems are all incorporated into the calculations. This component generates the information into standardised financial criteria by strict adhering to standard accounting principles.

4.4.1 Farm inventory

A farm inventory encompasses the capital requirements that a farm requires to function in a sustainable manner. It includes the land, fixed improvements, moveable assets, and livestock. These components are interconnected and depend on the typical farm system that is being simulated. Land prices in the Swartland are relatively high; therefore, it requires the most capital.

Farm systems require different moveable assets as they differ from each other in various ways. These differences in capital requirements affect a farm's profitability. A crop rotation system that is solely made up of cash crops will most likely require more planting and harvesting equipment as the time pressure in these stages of production will be high. A crop - pasture rotation system will probably require livestock equipment and less or different machinery. Crop rotation systems that utilise ⅔ of the arable land for pasture crops will generate less income, but these systems require less or cheaper moveable assets which influence the farm's profitability.

The validation of farm inventories for different rotations and integrations was important. Initially in the group discussions, the inventory of system E (wheat - medic - wheat - medic) was established for a typical farm. Other crop rotation systems and integration strategies were then discussed to identify how the required capital and farm inventories would change if these alterations were made. The "*Guide to machinery costs"* (2020) (see Annexure C: Guide used to determine machinery and activity cost) was used to determine the price of agricultural machinery utilised in the various systems.

Assumptions regarding livestock investments received detailed attention during the group discussions. The rotation systems determined stocking rates for the different livestock integrations. Once the quantity of production female animals on the typical farm was established the female to male ratios for sheep and cattle were determined. Livestock prices from recent auctions in the area were presented and further validated to ensure an accurate valuation of livestock investment. The required investment was also dependent on the management strategies for livestock for example female replacement strategies will determine the land utilisation and herd composition.

The moveable assets for different livestock integration strategies were also different. Sheep and cattle require separate handling equipment, transport, and feeding- and water systems. Many of these assets require the same financial inputs, but the integration of a mixed livestock component means that both animal types need to be accommodated on the farm.

Inventories of the crop rotation systems and livestock integration strategies included in this study are presented in more detail in Annexure D: Farm inventories according to crop rotations and livestock integrations.

4.4.2 Overhead and fixed costs

Fixed costs are a part of total costs that are fixed over a short period. It is the costs that can only be allocated to specific industries on condition that thorough recordkeeping is done. Items that fall under this cost category include licences and insurance on vehicles, fuel for the vehicles, maintenance costs of equipment and fixed improvements, labour costs, and insurance on fixed improvements (Hoffmann, 2001). Systems that require more moveable assets, such as tractors and harvesters, typically have higher overhead costs.

An initial model containing overhead and fixed costs were derived from different agricultural role-players in the area. This model was presented to experts for discussions to validate, ensuring an accurate collection of overhead and fixed costs to build into the model.

4.4.3 Gross margins

The validated yields, prices, and costs built into the budget models are used to calculate the gross margins for a typical farm. When System E is taken as example, halve of the arable land is utilised for wheat production and the other for medic pastures that are grazed by sheep. The poor, average or good year category then determines the yield for wheat for a specific season. The production value for wheat will then be the yield per ha multiplied by the hectares used for wheat production, multiplied by the price per ton for the wheat.

The input costs for crops are also determined by the crop that is being used, as one of the CA benefits are reduced input costs. The difference between gross production value and the directly allocated costs for each crop in the rotation is the gross margin for that crop. The sum of the gross margins of different crops in the rotation will be the gross margin of the farm.

All the rotation systems in this study have an integrated livestock component. The gross margins when medic or cover crops are being grazed, are directly influenced by the input costs and income generated by the livestock. The input costs for these crops are calculated the same way as cash crops, but the cost regarding livestock production is also added. In most cases (except when medics are baled and sold), the integrated livestock component generates the sole income for these crops. The viability and significance of livestock integration were established when these gross margins were calculated. These calculated gross margins form part of the output component.

4.5 Output component

The output component of the model is where whole-farm profitability and cash flows are generated. Multi-period cash flows are included so that the sensitivity of cash flows in rotation systems and the affordability of borrowed capital can be evaluated. The whole-farm profitability of a typical farm is demonstrated as the net present value (NPV) and internal rate of return on invested capital (IRR).

4.5.1 Profitability and affordability

A calculation period of 20 years was applied in the budget models. The reason for this extended period was to accurately capture the sustainability of different livestock integrations in rotation systems. Another reason was to effectively incorporate the replacement of machinery and equipment in the budget models. Validated three-year average prices (2018, 2019 and 2020), for inputs and products were used for calculations in the models.

The main objectives of the models in this study are to establish the current financial position of a typical farm in the Middle Swartland and to examine the financial impact of livestock integration on profitability. Inflation is captured by using real interest rates in calculating cash flows and profitability.

The affordability of required investment is measured using multi-period cash flows. The cash flow demonstrates the effect of different ratios of borrowed to owned capital. Cash-flow budgets contain only cash items, therefore, the impact of interest payments on the farm's cash flow and "bank balance" can be assessed. The utilisation of constant prices in the budget models meant that the three-year average nominal interest rate needed to be converted into a real interest rate. This rate is then used to calculate the amount of interest paid or received, depending on the bank balance. The real interest rate is calculated using the following formula: Real interest rate = {[(1+nominal interest rate) / (1+inflation rate)]-1} %. A "breakeven-year" is calculated in the cash-flow budgets to establish the affordability of borrowed capital and to capture the effect of replacing equipment and machinery. Multi-period budgets for each of the crop rotations and livestock integrations are presented in Annexure F: multi-period capital budgets for the rotation systems and integration strategies utilised.

The calculation of gross margins for the crop rotations and livestock integrations used in this study is discussed In Section 4.4.3. The capital-flow budget calculates the net flow of funds by subtracting the overhead and fixed costs and the capital expenditure from these calculated gross margins. The annual net flow over the 20-year budget is then used to calculate profitability. The profitability, measured in NPV and IRR, of livestock integrations can then be evaluated and compared.

4.5.2 IRR and NPV

Hoffmann (2010) defines IRR as the rate, that when used as an interest rate, would return a zero NPV. The NPV determines the present value of future cash flow. The IRR and NPV are exemplary when options such as different livestock integrations need to be compared to each other. In this study, the objective of exploring the financial implications of integrating beef cattle into crop rotation systems can be established by the IRR and NPV. In short, these criteria indicate whether an investment would add value to the farm or not.

As the IRR is a measurement of growth it should be higher than inflation and interest rates as the lesser would mean that other investments would be financially preferable. If the IRR is lower than the discount rate the NPV would generate a negative value. The discount rate used in the NPV calculations is obtained as a three-year average repo rate, published by the South African Reserve Bank.

4.6 Conclusion

In this chapter the focus falls on the development and construction of a multi-period whole-farm budget model. The model was built in a spreadsheet program where numerous equations were used to evaluate a typical farm's performance. The data, assumptions, and parameters of the model were validated by different experts in group discussions and meetings. It was specifically important to establish accurate cattle integration data as the Langgewens crop rotation trials only accommodated sheep. It was important to simulate beef cattle integration into appropriate rotation systems. The group discussions further focussed on how this integration would change whole-farm systems and the farm's long-term financial position. The input component of the budget model was validated to assure that the implications of integrating cattle are captured effectively. The model simulates the physical and biological farm system and expresses the farm's financial state in standardised profitability criteria. The accuracy of the input components and the effectiveness of the calculations are highlighted, as this will determine how realistically the financial implications of integrating beef cattle are explored. These implications generated by the typical farm model are addressed in the next chapter.

Chapter 5: The financial implications of beef cattle integration in crop rotation systems in the Middle Swartland

5.1 Introduction

This chapter aims to explore the financial implications of integrating beef cattle. Three different crop rotation systems are utilised to determine how livestock integration changes would affect the financial performance of these rotations. **Table 5.1** illustrates the cop rotation systems used in this study.

Table 5.1: Crop rotation systems utilised in this study.

Rotation System	Year 1	Year 2	Year 3	Year 4
E	Wheat	Medic	Wheat	Medic
1	Wheat	Cover crop	Wheat	Cover crop
2	Cover crop	Medic	Wheat	*Cover crop*

Note: The fourth year of system 2 is the start of a new rotation cycle.

System E utilises half of the arable land for wheat and the other half for medics in any given year. System 1 does the same, with wheat and cover crops. System 2 is a three-year rotation system where the arable land is evenly split in three, for cover crop, medic, and wheat cultivation. It is noteworthy that these assumptions are made for comparative reasons. In practice producers will not always be capable to divide their land into precise segments.

System E is the traditional rotation system, part of the long-term crop rotation trials on the Langgewens research farm. The system has an integrated sheep component. Beef cattle and sheep will exclusively be integrated as a mixed livestock component in both System 1 and 2. The financial implications of these systems and integrations will then be compared and analysed.

This chapter regularly refers to Chapter 4:, as the financial implications are generated by the budget models described above. The efficiency of the models is highlighted in this chapter when various changes to the whole-farm system can be made and the financial implications of these changes can be explored with relative ease and accuracy.

5.2 Assumptions of the typical Middle Swartland farm

The input component of a whole-farm multi-period budget model is described in Chapter 4:. Assumptions of the typical farm are an important foundation when generating the financial implications of livestock integration changes in crop rotation systems. This typical farm also poses as a yardstick for experts and producers in the multidisciplinary group discussion to evaluate different integrations and alterations in farm systems of the Middle Swartland. The validated physical parameters of a typical farm in the Middle Swartland are shown in **Table 5.2**.

Table 5.2: Physical assumptions of the typical farm.

Attribute	Amount
Land size (ha)	850
Price per hectare	R 50 000
Arable land (%)	95
Total arable hectares	807.5

Through multidisciplinary group discussions it was agreed that a typical farm in the Middle Swartland is 850ha. The price for this typical farm is R 50 000 per hectare (R 42 500 000 for the farm), and 95 percent of the farm is classified as arable land. The 807.5 ha arable land is evenly split when the crop rotation systems are being simulated, allocating the same size of land to each crop.

This typical farm is established to represent a general and sustainable farm in the Middle Swartland. It is important to note that the financial implications and predictions generated by the budget model are for a typical farm, it should act as a guideline rather than a fixed financial prediction.

The risk associated with production systems in the Middle Swartland is incorporated by categorising yields as poor, average, and good years and the frequency of these years are then established. The proses of developing these categories and incorporating it into the models are explained in Section 4.3.4.

Crop yields and frequency for the systems utilised in the budget model, exploring the financial integration of beef cattle, are illustrated in

Table **5.3**, Table 5.4, and Table 5.5. Experts and producers from the Middle Swartland combined their practical experience and knowledge to validate these yields and their frequency.

Table 5.3: Validated frequencies and crop yields for System E

wheat - medic- wheat- medic		
Classification	Frequency	Wheat yield (ton/ha)
Poor year	1	3
Average year	7	4
Good year	2	4.5

Table 5.4: Validated frequencies and crop yields for System 1

wheat - cover crop - wheat- cover crop		
Classification	Frequency	Wheat yield (ton/ha)
Poor year	1	3
Average year	7	4
Good year	2	4.5

Table 5.5: Validated frequencies and crop yields for System 2

cover crop - medic – wheat				
Classification	Frequency	Medic yield (ton/ha)	Frequency	Wheat yield (ton/ha)
Poor year	4	1	1	3
Average year	4	2.5	7	4
Good year	2	5	2	4.5

These yields are achieved through the high nitrogen fixation, improved- soil moisture retention, and soil structure that is gained through the inclusion of legumes and cover crops. The benefits of effective CA practises stretch further than just improved yields. It is important to note that these validated yields are achieved with lower input costs, gained through crop rotations, minimum soil disturbance, and sufficient soil cover.

5.3 Livestock parameters

Livestock parameters and assumptions are a crucial part of this study, as they directly affect the profitability of different integrations. The validation process of these parameters necessitated various livestock experts to be involved. It was important that sheep and beef cattle farmers were involved, whilst constantly revisiting the CA principles. For the model to accurately capture the complexity of livestock integrations, the parameters had to be accurate.

Data and information on sheep were available from the Langgewens experimental farm as well as numerous producers from the region. Data for integrating beef cattle in the Middle Swartland were relatively scarce and inconsistent. This meant that accurate and unbiased parameters had to be generated as producers had different opinions. "Extreme"- breeds and management practises were discarded to achieve "normal", extensive, and balanced parameters. These parameters are interconnected, for example increasing the supplement feed can increase stocking rates or weaner weights. After careful consideration and input from various experts and producers gained, accurate parameters for beef cattle integration in various crop rotation systems of the Middle Swartland were established.

Table 5.6 illustrates the parameters for sheep when integrated as individual livestock component. These parameters were obtained from the Langgewens experimental farm and validated by the experts in the multidisciplinary group discussions.

Table 5.6: Validated sheep assumptions

			Ram	Ewe	Weaner
Ewes/ha	2	Wool per animal (kg)	6	4	1
Ewes/ram	20	Slaughter weight per animal (kg)	37.5	32.5	20
Replacement %	25				
Lambing %	140				
Wean %	120				

The established stocking rate for ewes utilising medic and cover crop pastures is two ewes per hectare. This was validated with the knowledge that wheat residue is available in the summer and that continued sufficient soil cover had to be achieved. The ewes per ram ratio, lamb and wean percentages are then derived from the stocking rate of ewes to determine the quantity of rams and lambs per hectare in certain stages of the production cycle.

Experts alternated and validated Langgewens data to determine wool yields of 6kg, 4kg, and 1 kg for rams, ewes, and lambs respectively. The slaughter weight of weaners was an important assumption as the income generated by weaner sales is the largest contributor to the gross income of livestock.

Producers and experts established that a fixed 25 percent ewe replacement system is an accurate and practical assumption for the Middle Swartland. This means that 25 percent of the ewes in the producing flock are slaughtered each year to make way for the replacement ewes. Langgewens research data was confirmed by producers when they assured that the slaughter income of mature (and therefor heavier) ewes can afford the cost of the younger (and therefore lighter) replacement ewes. The ram, veterinary, sheer, supplement feed, and transport costs will be discussed in Section 5.6.

In Table 5.7 the parameters for beef cattle integration are illustrated. As explained in Chapter 4: cattle are only integrated into cover crop pastures as integrating them into medic pasture rotations alone, may be too risky.

Table 5.7: Validated beef cattle assumptions

			Bull	Cow	Weaner
Cows/ha	0.4	Live weight per animal (kg)	800	450	250
Cows/bull	33.333	Slaughter weight per animal (kg)	464	261	-
Replacement %	20				
Calving %	98				
Wean %	95				

Initial literature and guidelines indicated that cattle should be integrated at a stocking rate of one sixth of that of sheep, which would translate to 0.333 cows per hectare. The experts at the multidisciplinary group discussions as well as numerous livestock experts across South Africa, established that 0.4 cows per hectare is a more realistic parameter when appropriate supplement feeds and licks are given in the dry summer months when forage is scarce. This stocking rate is for cattle utilising cover crop pastures and grazing on wheat residue in the summer months, while adhering to CA principles. Cattle can graze higher in the plant canopy and can therefore exploit the high growth of some of the crop species included in cover crop mixtures.

The multidisciplinary group established that three bulls per hundred cows would be a sufficient and realistic ratio when calculating the herd composition of cattle in the Middle Swartland. A fixed replacement strategy of 20 percent is followed. Cows calve at a rate of 98 percent whereas calves are weaned at a rate of 95 percent.

The average weight of weaner calves is assumed to be 250kg. The validated slaughter weights of cattle on the typical farm are shown in Table 5.7. This assumption is significant as the weights determine the income that is generated when cattle are slaughtered. The live weights were important in the feed intake and veterinary dosage calculation processes, as the multidisciplinary group validated veterinary packages and supplement feed programs that needed to be allocated per hectare variable costs. These costs are used in the gross margin calculations and discussed in Section 5.7.

The literature review concluded that a mixed livestock integration of both sheep and beef cattle has the potential to reap multiple benefits. The multidisciplinary group argued that most of the validated assumptions regarding sheep and beef cattle can be kept constant when a mixed livestock integration strategy is followed. Assumptions regarding stocking rates and farm inventory needed to be changed. Experts in the group discussions agreed that dividing the stocking rate of both sheep and beef cattle by two would not be an accurate assumption.

The complimentary feeding preferences of beef cattle and sheep were identified in Chapter 2:. This was established when the experts agreed on a 60 percent stocking rate for both sheep and beef cattle. This meant that 0.24 cows and 1.2 ewes could be stocked per hectare when a mixed livestock integration strategy is followed. The farm inventory changes are discussed in Section 5.4.

5.4 Farm inventory

Section 4.4.1 indicates how the land, permanent improvements, equipment, and livestock all form part of the farm inventory. Prices of land in the Middle Swartland can vary as yield potential and irrigation opportunities between farms fluctuate. It was critical to establish an accurate valuation of a typical rainfed (dry-land) cereal producing farm in the Middle Swartland as the land value is a substantial part of the capital requirements. Property evaluators, agents, and experts in the group discussion were consulted to establish and validate the value of R 50 000 per hectare.

The size, capacity, maintenance, and replacement of machinery are all determined by the size of the farm and the utilisation of the arable land. Adjustments to the inventory of a typical farm are due to crop rotation variations and livestock integration changes. Continuous cash crop systems are likely to require more farm machinery or machinery with larger engine sizes due to larger cultivation areas within the same planting and harvesting time window. Different livestock integrations require different handling equipment and fixed improvements.

The multidisciplinary group agreed that the same mechanisation and equipment for crop rotation Systems E and 1 were needed when livestock integration is kept constant. The crop rotation of System 2 meant that only 269.17 hectares of the arable land are used for wheat production, whereas System E and 1 produced wheat on 403.75 hectares. Experts and producers found that the two harvesters included in the inventories of Systems E and 1 are excessive in the crop rotation of System 2, as one harvester will be sufficient for the number of hectares under wheat production. The confirmed capital requirements for mechanisation and equipment in Systems E and 1 are R 15 577 832 and R 13 282 832 for System 2.

Adjustments to the inventory for the livestock integration change from sheep to beef cattle and vice versa are due to diverse requirements for handling equipment, machinery, and fixed improvements. These requirements include handling tools, feed and water containers, trailers and transport specifications, feed production machinery, lambing sheds, fences, and kraals. The multidisciplinary group argued that although the requirements for these integrations differ in specification, the capital requirement is similar. The investment costs required for shearing and lamb sheds are nullified by the more expensive handling equipment (loading structures, head clamps and bigger pens) required for cattle integration.

It is important to note that changing from a traditional livestock component of sheep to beef cattle will be expensive in practise. The model simulates a typical farm with the appropriate inventory requirements for a sustainable crop rotation system and cattle integration. When a producer changes the livestock component from sheep to beef cattle, numerous inventory changes need to take place. These changes are expensive and when considering this option, thorough financial planning is necessary, as profitability will be affected.

Establishing the inventories of crop rotation systems with mixed livestock integration required detailed consideration and input from the individuals in the group discussions. An appropriate inventory for cattle and sheep integration was exclusively established to require similar capital investment. The inventory and investments are designed to accommodate one or the other integration which meant extra investment was needed to enable mixed livestock integration. For instance, the fixed water supply systems of a typical farm would be able to accommodate both livestock types but the drinking points would require modifications. Expensive lambing and shearing sheds required for sheep integration, together with expensive handling equipment and kraals for cattle integration are necessary for effective mixed livestock integration.

Establishing an accurate and sufficient inventory for mixed livestock integration required various calculations and discussions with livestock experts specialising in infrastructure, livestock feeding, handling equipment, and breeding. The experts concluded that the livestock handling equipment needed to be multiplied by 1.6. The fixed improvements could be kept unchanged as the lower stocking rate of sheep, due to the mixed integration, would require smaller lambing and shearing sheds. The lower capital requirement will cover the costs associated with upgrading the kraals, loading stations, and fences. An additional livestock trailer was included in the inventories of mixed livestock integrations, a practical necessity to accommodate livestock transport for both livestock types.

The livestock quantities included in the inventories are derived from the stocking rates and other assumptions regarding herd compositions discussed in Section 5.3. Detailed farm inventories for the crop rotation systems and livestock integration strategies included in this study are illustrated in Annexure D: Farm inventories according to crop rotations and livestock integrations.

5.5 Gross production values

Gross production values are the quantity of output (yields or weaner weights) multiplied by the price received for the output (commodity). The whole-farm gross production value is the sum of the individual gross production values for all the enterprises on the farm. The three-year (2018 - 2020) average product prices were used in the whole-farm budget model, illustrated in **Table 5.8**. Silo costs, marketing costs, transport costs, and other variable costs are excluded from these average prices and will be discussed in Section 5.5.

Gross production value analysis were prepared for each seasonal classification, good, average, or poor for wheat in Systems E and 1, and wheat and medic in System 2. The gross production margins for medic and cover crop pastures utilised for grazing were determined by the income generated by weaner calves and/or lambs.

Table 5.9 illustrates the whole-farm gross output value for the crop rotation systems and the related livestock integration strategies in this study.

Table 5.8: Average commodity prices (2018 - 2020)

Product	Unit	Average R/unit
Wheat: BS	Ton	4 091
Wheat: B1	Ton	3 989
Wheat: B2	Ton	3 764
Wheat: B3	Ton	3 470
Medics	Ton	2 750
Meat (lambs)	Kg	66
Meat (calves)	Kg	37.08
Wool	Kg	133

Table 5.9: Whole farm and per hectare production values

	Good		Average		Poor	
	R/farm	R/ha	R/farm	R/ha	R/farm	R/ha
System E	9 199 522	10 823	7 581 933	8 920	5 266 135	6 195
System1 *S*	9 438 592	11 104	8 117 091	9 550	5 474 090	6 440
System 1 *BC*	9 112 923	10 721	7 791 422	9 166	5 148 421	6 057
System 1 *MX*	9 611 183	11 307	8 289 682	9 753	5 646 681	6 643
System 2 *S*	9 253 228	10 886	7 482 165	8 803	4 389 602	5 164
System 2 *BC*	9 036 115	10 631	7 265 052	8 547	4 172 489	4 909
System 2 *MX*	9 368 289	11 022	7 597 226	8 938	4 504 662	5 300

Note: *S* = sheep integration, *BC* = beef cattle integration, *MX* = mixed livestock integration

5.6 Variable costs

Variable costs variate with the scale or volume of production or output. Per hectare variable costs are allocated to the commodities that utilises the specific land. The variable cost per hectare for livestock is related to the cost per animal and the stocking rates. Supplement feed, fertilisers, fuel, transport, crop insurance, and veterinary costs are examples of variable costs. Input costs for the crops utilised in this study were derived from data collected from the Langgewens research farm. The costs were then validated by the experts during group discussions.

Accurate variable costs for livestock could not be obtained from the Langgewens experimental farm as the farm only had a sheep component. The variable costs allocated to sheep in the Langgewens crop rotation trials were used as a starting point in the group discussions. The established and validated variable costs for the different integration strategies are illustrated in **Figure 5.1**.

The variable costs were validated during group discussions through industry experts and producers that contributed their knowledge and experience. Supplementary feed for cattle was calculated after various feeding programs were evaluated. Female's supplementary needs during different seasons and production stages were established and the variable costs were calculated from that. Integration was crucial in determining these variable costs, as different assumptions and parameters are interconnected and CA principles should be fulfilled.

Variable costs per hectare are determined by the herd composition discussed in Section 5.3. Dosing and veterinary costs were established through consulting with veterinarians and livestock farmers. Packages per animal were then calculated and incorporated in the budget models. The average prices of bulls and rams were presented and validated in the group discussions. Other variable costs included in the calculations were shearing costs, wool packaging, transport costs, and identification equipment.

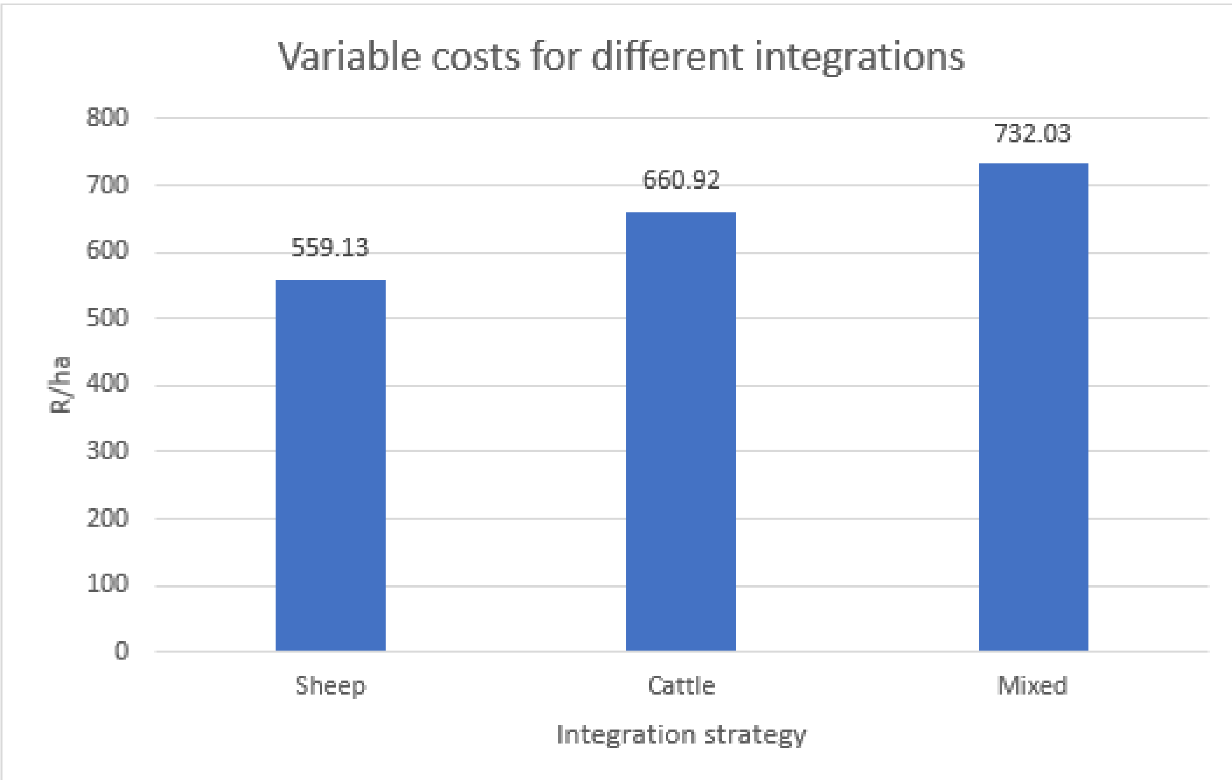

Figure 5.1: The per hectare variable costs for different integration strategies

The per hectare variable cost is R 559 for sheep, R 661 for beef cattle, and R 732 for a mixed livestock integration. Higher variable costs per hectare in cattle integration can be ascribed to, even though the stocking rate is much lower compared to sheep, the expensive supplementary feed required for cattle in livestock integrations of the Middle Swartland. The mixed livestock integration exceeds the other integrations because the stocking rate in this integration is more than halve of each livestock component. An example of the variable cost calculations in the budget models is illustrated in Annexure E: An example of the variable cost calculations in the budget models.

5.7 Gross margin summary

The total farm gross margin is the total farm income minus the direct cost of producing the farm products. **Table 5.10** illustrates the total farm gross margin for each crop rotation system and livestock integration strategy.

Table 5.10: Gross margin for crop rotations and livestock integrations

	Good		Average		Poor	
	R/farm	R/ha	R/farm	R/ha	R/farm	R/ha
System E	5 992 181	7 050	4 406 153	5 184	2 135 538	2 512
System1 *S*	5 133 020	6 039	3 836 660	4 514	1 243 939	1 463
System 1 *BC*	4 766 250	5 607	3 469 890	4 082	877 169	1 032
System 1 *MX*	5 235 801	6 160	3 939 441	4 635	1 346 720	1 584
System 2 *S*	5 657 145	6 655	3 908 342	4 598	868 150	1 021
System 2 *BC*	5 412 631	6 368	3 663 829	4 310	623 637	734
System 2 *MX*	5 725 665	6 736	3 976 863	4 679	936 671	1 102

Note: *S* = sheep integration, *BC* = beef cattle integration, *MX* = mixed livestock integration

Gross margin analyses are limited as they exclude capital requirements and fixed improvements. The full financial implications of certain changes in farm systems are not completely captured through these analyses. In Chapter 2: the financial contribution of livestock is explained. Although significant, it is little compared to that of cash crops in farm systems. This can cause the financial effect of different integration strategies to be unclear. The gross margin analyses of different integration strategies are beneficial in this study as beef cattle integrations are explored.

Figure 5.2 illustrates the average livestock gross margins (total income generated by livestock minus total allocated variable cost) of the different integration strategies in this study.

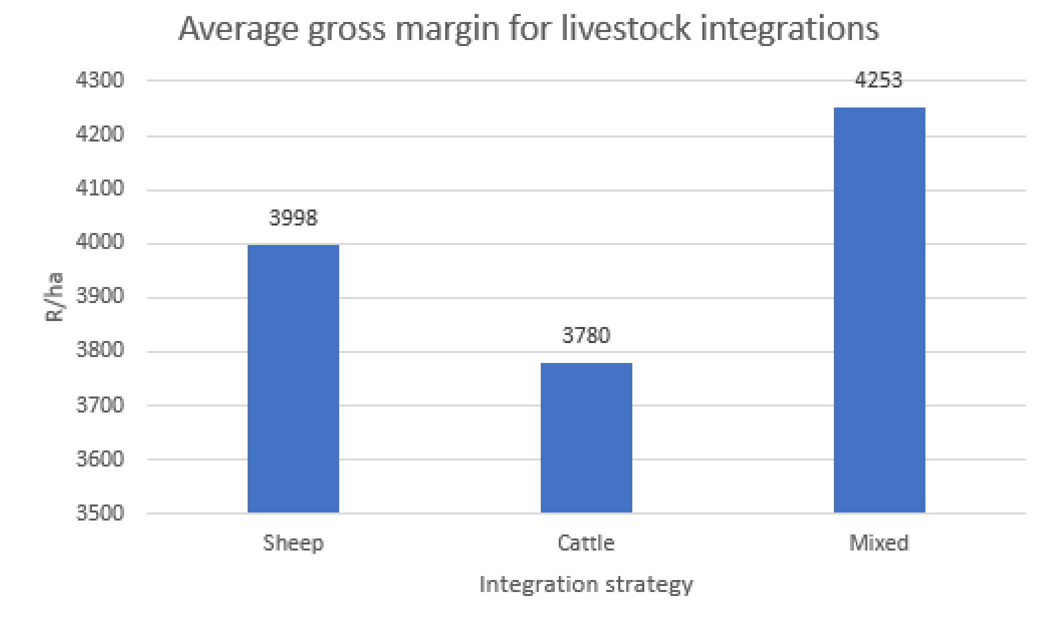

Figure 5.2: Average gross margin for livestock integration strategies

5.8 Overhead and fixed costs

Fixed costs remain unchanged regardless of production volume changes. These costs include wages of permanent personnel, insurance costs for permanent improvements, audit fees, banking costs, licences, and provision costs. Participants in the multidisciplinary group discussions calculated and established an amount for the yearly overhead and fixed costs of a typical farm in the Middle Swartland.

The fixed and overhead costs for different crop rotation systems were similar with little variation in the licence costs, as harvesters or trailer requirements changed. Livestock integration changes led to fluctuations in the provision costs associated with fences, water supply, and camps. Added managerial cost for mixed livestock integration was considered, but intense livestock management requirements are distributed when different livestock species are integrated, as their seasonal production systems differ.

The overhead and fixed costs of farms are unique, therefore, participants in the group discussions agreed upon general and normalised costs. The yearly overhead and fixed costs for a typical farm in the Middle Swartland, utilising crop rotation System 1 and following a mixed livestock integration, added up to R 1 839 468. Miscellaneous costs were also accounted for in the budget models and are computed at five percent of the established total fixed cost.

5.9 Financial performance

The projected profitability of a typical farm in the Middle Swartland, utilising various crop rotation systems and following different livestock integration strategies, was calculated using a multi-period capital whole-farm budget model. For each crop rotation system incorporated in this study and the applicable livestock integration strategies followed in these systems, the Internal Rate of Return (IRR) and Net Present Value (NPV) were computed. These financial indicators are for a typical farm in the Middle Swartland and considered as the primary profitability benchmark for different livestock integrations in rotation systems of the Middle Swartland region over a 20-year period.

The IRR and NPV of each system and integration are presented in real terms in Table 5.11. The average nominal interest rate of the last three years (2018 - 2020) was 5.7 percent (South African Reserve Bank, 2021), whilst the inflation was 3.9 percent (Statistics South Africa, 2021). The real interest rate is then calculated as 1.78 percent.

Table 5.11: Expected Internal Rate of Return (IRR) and Net Present Value (NPV) for each crop rotation system and livestock integration strategy

	Internal Rate of Return (%)	Net Present Value (R)
System E	2.05	2 386 315
System1 *S*	0.73	- 9 536 167
System 1 *BC*	0.06	- 16 134 188
System 1 *MX*	0.87	- 8 494 377
System 2 *S*	1.71	- 666 489
System 2 *BC*	1.27	- 4 447 354
System 2 *MX*	1.81	298 431

Note: *S* = sheep integration, *BC* = beef cattle integration, *MX* = mixed livestock integration

The financial performance of crop rotation systems and livestock integration strategies are determined by the IRR and NPV. Multi-period capital budgets for the rotation systems and integration strategies utilised in this study are illustrated in Annexure F: multi-period capital budgets for the rotation systems and integration strategies utilised.

5.10 Cash flow and liquidity

The sustainability of whole-farm systems can be predicted by the agricultural enterprise's liquidity. This is measured in the projected cash flow of a whole farm. The IRR and NPV are unable to completely quantify the feasibility of agricultural operations as farmers regularly depend on credit for various agricultural transactions. These payments have long-term liquidity implications. Hoffmann (2001) described liquidity as the ability to afford short-term responsibilities, whilst daily business is as usual. Thus, the focus is on the relationship between the yearly in- and outflow of cash.

Exclusively cash transactions are included. The flow of capital is not fully considered but the cash required for the availability of capital is. During group discussions the assumption was validated that 40 percent of the intermediate capital requirements are financed by foreign capital. The simulated whole-farm system's bank balance is thus influenced by the installments of the borrowed capital.

The 20-year cash-flow budget for each system and livestock integration started with an opening balance of zero. The calculated yearly cash flows are then incorporated to generate year end balances for each year. The budget models integrate interest rates for positive year end balances and the interest paid on negative balances. The year-end balance for each year is utilised as the opening balance of the next year. **Figure 5.3** demonstrates the projected closing cash balances for the crop rotation systems and livestock integrations over a 20-year period.

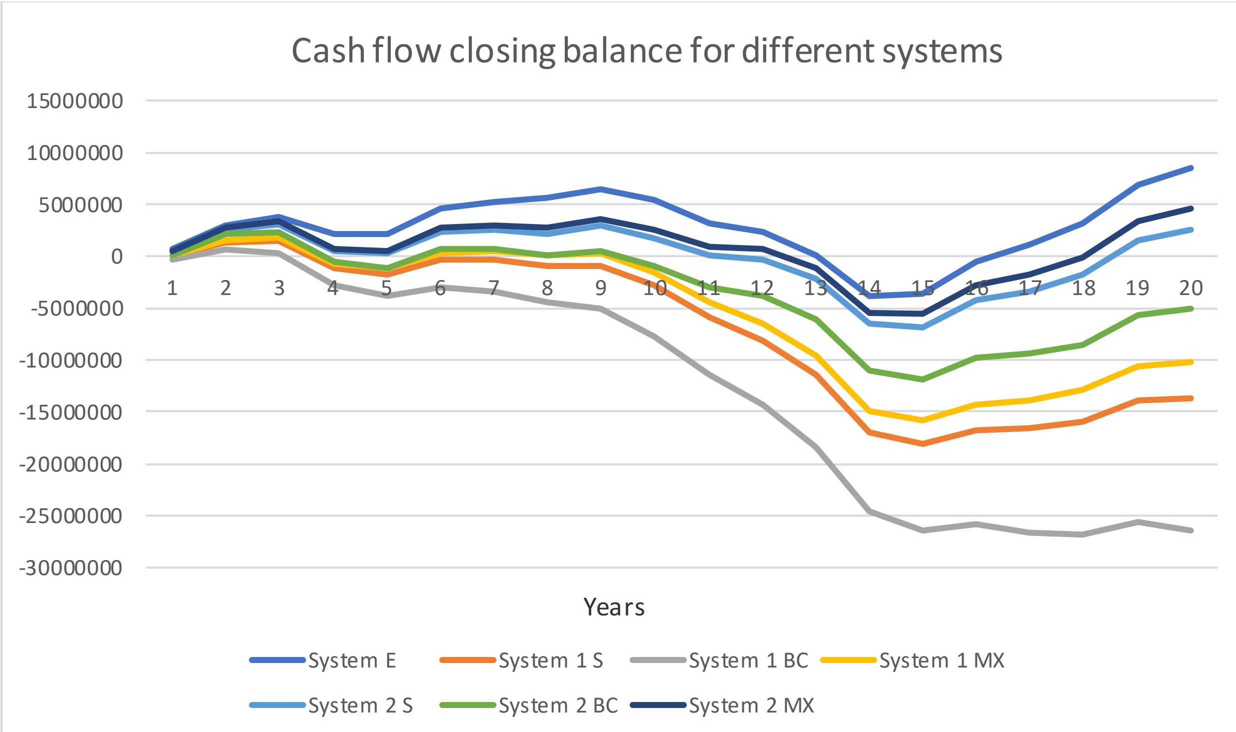

Figure 5.3: Projected closing cash balances on whole-farm level for modelled crop rotation systems and livestock integrations over a 20-year period

Note: *S* = sheep integration, *BC* = beef cattle integration, *MX* = mixed livestock integration

All the systems illustrated in **Figure 5.3** display a negative cash flow from the 9th to 14th year. This is due to the mechanisation replacement schedule. The effect of negative compound interest is evident in system 2 *BC,* 1 *MX,* 1 *S,* and 1 *BC.* These systems struggle to close with a positive bank balance. System E, 2 *S,* and 2 *MX* show good growth, especially in the closing years of the 20-year budget.

5.11 Conclusion

The accurate financial simulation of a typical farm in the Middle Swartland depends on validated parameters. The financial performance of livestock integration strategies in different crop rotation systems was projected by constructing whole-farm multi-period budget models. The model's dexterity enabled it to account for the complex, multifaceted, and interrelated nature of farm systems on whole-farm level.

The expected long-term profitability of different livestock integration strategies in various crop rotation systems was evaluated with the focus on the financial viability of beef cattle integrations. The typical farm models are not an exact decision-making tool for farm managers but rather a guideline for consideration. After validated typical farm information and assumptions are constructed into the budget models, different livestock integration strategies can be examined to assist with these types of considerations in practise. Rigorous research and consulting with specialists formed the foundational parameters for the typical farm model. These parameters were then presented in the multidisciplinary group discussions for validation. Farm size, stocking rates, crop rotations, inventory requirements, herd compositions, and supplement feed requirements were some of the parameters that were established. The expected return on investment for each of the livestock integrations and crop rotations on a typical farm was calculated and indicated in terms of Internal Rate of Return on capital investment (IRR), Net Present Value (NPV), and cash flows. These financial assessments were calculated within standard accounting principles.

The budget models indicated that the traditional crop rotation of System E (wheat - medic rotation, with sheep utilising the medic pastures) would outperform all the other rotation systems and livestock integrations in terms of profitability. When cover crops are included in crop rotations and grazing opportunities increase, System 2 with its mixed livestock integration performed most profitable. The financial budget models projected that sheep integration is more profitable than beef cattle integration but that a mixed livestock integration is more profitable than both the individual livestock integrations. This integration also increases the diversity in crop rotations and whole-farm systems.

Exploring the financial implications of beef cattle integration had to be done with care as not to demolish achieved benefits gained through practising principles of conservation agriculture. Aggressive livestock integrations were therefore not considered, as farmers in the Middle Swartland are primarily seen as cereal producers.

Chapter 6: Conclusions, Summary and Recommendations

6.1 Management conclusions

The application of conservation agricultural principles is widely applied in the Middle Swartland winter cereal production area of the Western Cape. Especially rotation cropping and minimum soil disturbance have been successfully implemented. Permanent soil cover is the last of the three main pillars that are now being enhanced by research and the application of cover crops. Cover crop mixes are used in sequence with traditional cash-crops and pastures. The main function of cover crops is not to generate income, but rather aimed at soil moisture retention and soil structure enhancement. Cattle cannot graze directly on annual pastures, mostly medics, because of digestive problems often leading to deaths. With cover crops beef cattle do, however, become an option for famers and hold the added benefits of being less management intensive and less susceptible to livestock theft.

The management implications when integrating beef cattle into crop rotation systems of the Middle Swartland were discussed in Chapter 2:. It is difficult to indicate all the management implications when livestock integration is changed or alternated, as management styles and preferences differ between farms and individuals.

When livestock are integrated into crop rotations, it should be done with the aim to achieve a constructive synergy and rhythm between the components on the farm. This entails that peak management requirement periods of livestock (lambing, calving, weaning, or shearing), should not overlap peak crop production periods (planting or harvesting). Identifying the "ideal" management strategy will demand achieving specific crop rotation and farm system goals.

Through multidisciplinary group discussions it was established that a beef cattle component is less management intensive than a sheep component. This is due to sheep giving birth to multiple lambs more frequently and to the management associated with lactating ewes and wool shearing. At the start of this study it was hypothesised that the risk of livestock theft is higher for sheep compared to that of beef cattle, although the group discussions confirmed the possibility, no proof was available to validate this assumption. The seasonal production systems of beef cattle's ability to integrate with the seasonal patterns of crops in the Middle Swartland will be discussed in Section 6.3.

The management implications when a mixed livestock component of sheep and cattle are integrated is two folded. The different production cycles of cows and ewes signify less intensive, but more frequent, peak management times. The “ideal” management strategy and synergy between livestock and crop management may be more difficult to master but when mastered it may be unmatched. A mixed livestock integration also requires more specialised management. When beef cattle are integrated into farming systems for the first time, a learning period occur.

Producers in the multidisciplinary group discussions highlighted that farm systems and the management of farms pose unique considerations. It is important for managers, producers, and farmers to respect their interests and passion. Animals are living beings and the willingness and enthusiasm to successfully manage them is a necessary requirement.

6.2 Financial conclusions

World population and thus food demand are growing at a rapid annual pace. The land and water resources needed to achieve food security are diminishing though. Ethical and environmentally sound food production techniques are becoming increasingly important. Conservation agriculture is widely regarded as one of the most comprehensive approaches to long-term agricultural production.

The main objective of this study was to determine the financial implications when integrating beef cattle into crop rotation systems of the Middle Swartland. This is proactive as crop rotation systems and whole-farm systems are constantly evolving and the pursuit for increased sustainability and profitability should be a persistent one. Livestock integrations should have a constructive impact on cereal production systems in the Middle Swartland as the socioeconomic impact of crop production surpasses that of livestock in this region.

A whole-farm multi-period budget model was constructed for a typical farm in the Middle Swartland. The financial model incorporated numerous assumptions and parameters that were validated by experts and producers. The integration of beef cattle is complex which necessitates systems thinking to capture the interrelatedness of different variables. Multidisciplinary group discussions were a critical part of this study as it ensured that the budget models were constructed with accurate assumptions and parameters to simulate whole-farm systems that project practical financial guidelines. Group discussions were held at the Langgewens experimental farm and involved experts from various fields such as crop sciences, animal sciences, agricultural economics, agronomy, and producers from the region.

Hot and dry summers in the mediterranean climate of the Middle Swartland imply that forage is limited during these months, therefore, cattle require expensive supplement feed to perform efficiently. Limited forage during summer and the commitment to CA principles meant that a low stocking rate of beef cattle had to be followed.

The following conclusions were drawn from the financial analysis:

- The wheat - medic rotation system of System E, with a sheep livestock component is the most lucrative system over a 20-year period.
- From the systems that include cover crop (and therefore cattle integrations) rotation, System 2 with its mixed livestock integration performed the best financially.
- Beef cattle integration is the least profitable livestock integration strategy, whilst a mixed livestock integration of sheep and cattle showed the best financial performance.

It is possible that the long-term financial benefits of cover crop utilisation are not fully captured in the budget models from this study. As the viability of cover crop inclusion becomes clearer in the winter rainfall region of the Middle Swartland, cover crop utilisation may increase. The integration of beef cattle into crop rotation systems that does not include cover crops was found to be unpractical. One can thus conclude that where cover crops are included in crop rotation systems and extensive livestock integrations are considered, a mixed livestock integration is a financially viable option. Increasing the crop and livestock diversity in production systems of the Middle Swartland poses both economic and environmental benefits.

6.3 Summary

Chapter 1: introduced the Middle Swartland region and established that sustainability can be achieved through a holistic CA approach. Livestock in the Middle Swartland graze on pastures in rotation with cereals and cereal residue. Rainfall in the Middle Swartland is concentrated during the winter, with hot and dry summers. Sheep has traditionally been the predominant livestock component for farm systems in the Swartland. Evolving crop rotation systems pose advanced grazing possibilities. The main research question therefore was: What are the financial and management implications of integrating beef cattle into crop rotation systems of the Middle Swartland?

Chapter 2: consists of two parts. In the first section the principles, benefits, and constraints of conservation agriculture are explained. The biological and ecological benefits from improved soil fertility, decreased erosion, and moisture retention was identified as the driving forces to implement CA. One of the principles of CA is the rotation of crops. Including cover crops in crop rotation systems has the potential to improve the yield of subsequent crops, whilst reducing input costs. The need for livestock integration is evident as it poses the opportunity to mitigate risk and to generate income. Integrating beef cattle into crop rotation systems will generate complex financial and management consequences. The general profitability of sheep and beef cattle livestock components was assessed. The production cycles of cattle and sheep are different which poses various management considerations. The literature overview further identified the potential benefits of mixed livestock integration. This strategy increases the diversity of crop rotations and can be a lucrative option.

In the second part of Chapter 2: the methods utilised to accurately achieve the objectives of the study were explained. With the systems approach it is possible to conceptualise the interaction within agricultural systems and to anticipate the long-term consequences of decisions and actions. Multidisciplinary group discussions as a research method facilitate the systems approach. The exploratory nature of this study motivates the utilisation of multidisciplinary group discussions since the objective is to improve whole-farm systems and some of the required information does not yet exist. Systems thinking and multidisciplinary group discussions will enable the construction of an accurate whole-farm multi-period budget model. Such models can incorporate the complexity of farm systems and are convenient when different integration strategies are being simulated.

The Langgewens crop rotation trials provide valuable information for various agricultural role players. The crop rotation trials on the Langgewens farm are discussed and evaluated in Chapter 3:. The average gross margin for crop-pasture rotation systems and continuous cash cropping systems were compared. It was evident that sustainability was able through effective CA practices, more specifically crop rotations. The Langgewens trials form the foundation of this study and the construction of the typical farm budget models.

Chapter 4: focus on the development and construction of a whole-farm multi-period budget model. The model was built in a spreadsheet program where numerous equations were used to evaluate a typical farm's performance. The data, assumptions, and parameters of the model were validated by heterogeneous experts during group discussions and meetings. It was important to establish accurate cattle integration data as the Langgewens crop rotation trials only accommodated sheep. It was also important to simulate beef cattle integration into appropriate rotation systems. The group discussions further focussed on how this integration would change whole-farm systems and the farm's long-term financial position. The input component of the budget model was validated to assure that the implications of integrating cattle are captured effectively. The model simulates the physical and biological farm system and expresses the farm's financial state in standardised profitability criteria. The accuracy of the input components and the effectiveness of the calculations are highlighted, as this will determine how realistically the financial implications of integrating beef cattle are explored.

The budget models in Chapter 5: projected that the traditional crop rotation of system E (wheat - medic rotation, with sheep utilising the medic pastures) would outperform all the other rotation systems and livestock integrations. When cover crops are included in crop rotations and grazing opportunities increase, System 2 with its mixed livestock integration performed the best. The financial budget model projected that sheep integration are more profitable than beef cattle, but a mixed livestock integration is more profitable than both the individual livestock integrations. This integration also increases the diversity in crop rotations and whole-farm systems.

6.4 Recommendations

The project's main goal was to explore the financial and management implications when integrating beef cattle into crop rotations of the Middle Swartland. Livestock integrations of beef cattle and sheep as exclusive livestock components, and a mixed livestock component of both species, were financially evaluated. Multidisciplinary group discussions were used to construct whole-farm budget models. These models financially simulate livestock integrations into the crop rotations of an established typical farm in the Middle Swartland, whilst adhering to conservation agriculture principles.

The Middle Swartland was selected as the homogenous producing region for this research. The conclusions and findings of this study is site specific. Other regions in the Western Cape such as the Southern Cape, Overberg and Rûens region, Southern Swartland, Northern Swartland, and the Hopefield/Darling regions can also benefit from livestock integration research. Further research on beef cattle integration is needed for these regions.

The amount and type of plant species included in cover crop mixtures vary significantly. These mixtures of species are designed to accomplish certain goals within farm systems. Further research is required to evaluate the effect of changing the relationship of species in these mixtures, for instance more grass and less legumes or vice versa. If the same biological goals can be reached with different cover crop mixtures that provide more feeding potential, it may be profitable to invest in these mixes. Further research is required to evaluate the feeding quality of different cover crop mixtures. Producers can engineer their cover crop mixtures to fit their specific production goals and their livestock integration, as different livestock components would benefit more from different cover crop mixes.

Producers in the multidisciplinary group discussions stated that the Angus breed adapts well to the conditions of the Middle Swartland as they can efficiently utilise the wheat residues. Different beef cattle breeds will perform differently in crop rotation systems. Further research is required to evaluate the performance of beef cattle breeds in crop rotations.

Extensive beef cattle integration is explored in this study. There are numerous intensive cattle integration considerations that pose opportunities when cover crops are included in crop rotation systems. Herd compositions and production systems can be designed to enable producers to feed their own weaners until they are ready to be slaughtered. Weaners from other farms can also be bought in. Further research regarding this topic is needed as it may create new opportunities. Many agricultural economic forecasts predict that the demand for grass fed beef will grow immensely over the next few years. The fattening of calves on cover crops poses financial benefits as producers gain value chain advantages. It poses the opportunity to increase diversity in rotation systems and it provides numerous environmental benefits.

A synergy between beef production in the Western Cape and the dryer parts of the Northern Cape and Northwest is possible. The summer rainfall and natural veld of the Northern Cape and Northwest pose opportunities for the weaners produced in the Western Cape to utilise the forage of farmers in the North. The wider implications regarding the supply chain for cattle require further research.

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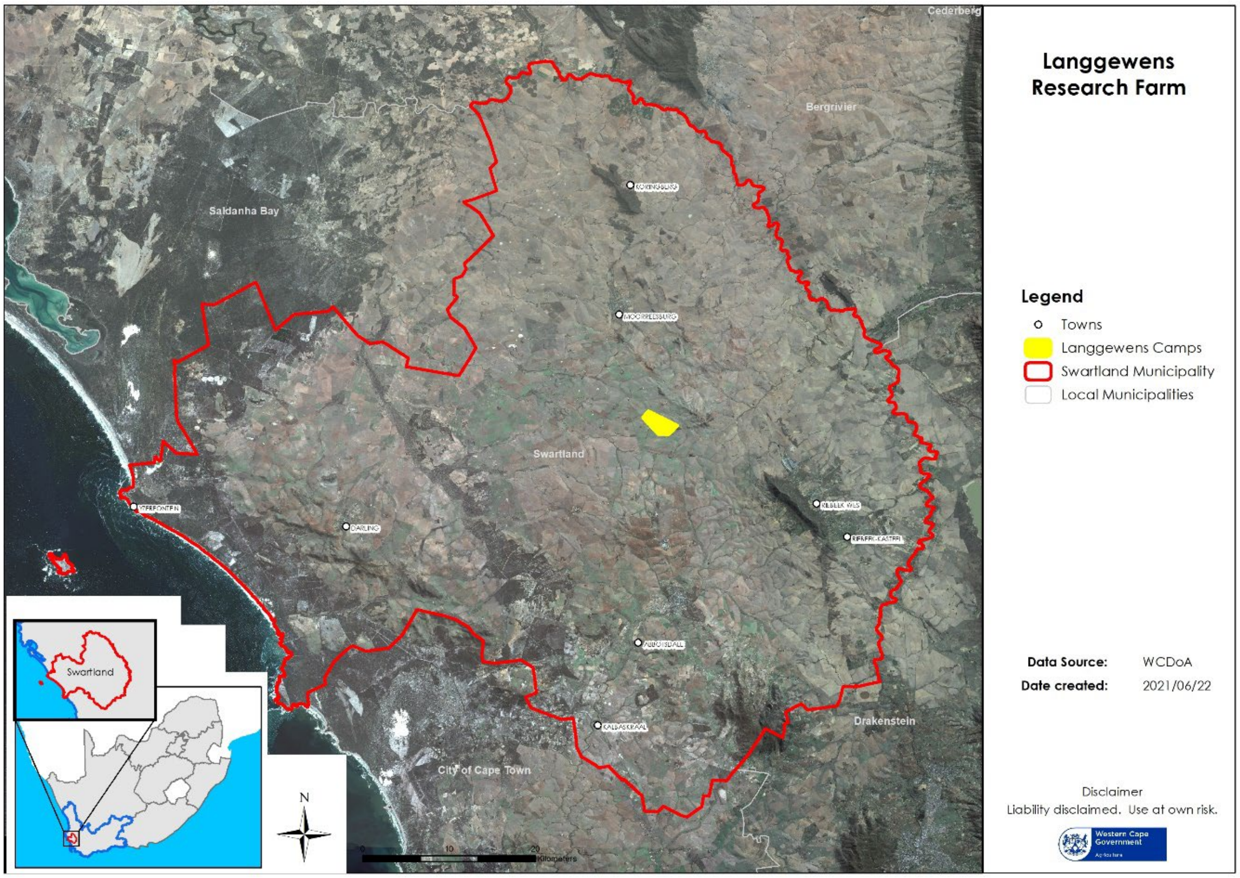
Annexures

Annexure A: Map indicating the location of the Langgewens experimental farm in the Middle Swartland



Annexure B: Example of gross margin calculations at Langgewens experimental farm

GROSS MARGIN & MARGIN ABOVE SPECIFIED COSTS:						
Crop:	Wheat			Date:	30-Mar-21	
				YEAR	2020	
Counrty:	SA					
Province:	Western Cape					
Location:	Langgewens					
Comment:	Swartland crop rotation trials					
Camp:	46/3	System:	B	Wheat-Wheat-Wheat-Canola		
		Unit	Price/unit Rand	Quantity	R per ha	R/yield unit
Gross Income						
Product income:						
Wheat						
Wheat: B3		ton	3926,00	3,93	15429,18	3926,00
Marketing cost:						
Gross income minus marketing cost					15429,18	3926,00
ALLOCATABLE VARIABLE COSTS:					4249,64	1087,62
Directly Allocatable Variable Costs:					3639,20	932,29
Pre Harvest Cost:					3275,68	833,51
Plant material:						
Seed						
SST0166		kg	4,66	60,00	279,60	71,15
Fertilizer:						
Geoflo 1:2:1		liter	8,63	96,000	828,48	210,81
Amiplus S		t	7107,00	0,080	568,56	144,67
Amiplus S		t	7107,00	0,05	355,35	90,42
#N/A		#N/A	#N/A		0,00	0,00
#N/A		#N/A	#N/A		0,00	0,00
#N/A		#N/A	#N/A		0,00	0,00
#N/A		#N/A	#N/A		0,00	0,00
#N/A		#N/A	#N/A		0,00	0,00
#N/A		#N/A	#N/A		0,00	0,00
Lime & Gypsum						
#N/A		#N/A	#N/A		0,00	0,00
#N/A		#N/A	#N/A		0,00	0,00
Weed Control:						
#N/A		#N/A	#N/A		0,00	0,00
#N/A		#N/A	#N/A		0,00	0,00
Skoffel		liter	113,28	1,50	169,92	43,24
Bladbuff		liter	82,80	0,12	9,94	2,53
2.4D		liter	57,21	0,50	28,61	7,28
Resolve		liter	422,82	0,75	317,12	80,69
Aurora		gram	4,95	10,00	49,50	12,60
#N/A		#N/A	#N/A		0,00	0,00
Pest Control:						
#N/A		#N/A	#N/A		0,00	0,00
#N/A		#N/A	#N/A		0,00	0,00
#N/A		#N/A	#N/A		0,00	0,00
#N/A		#N/A	#N/A		0,00	0,00
#N/A		#N/A	#N/A		0,00	0,00
#N/A		#N/A	#N/A		0,00	0,00
#N/A		#N/A	#N/A		0,00	0,00
#N/A		#N/A	#N/A		0,00	0,00
Fungicide control:						
#N/A		#N/A	#N/A		0,00	0,00
Abacus		liter	489,90	1,00	489,90	124,66
Prosper Trio		liter	357,42	0,50	178,71	45,47
#N/A		#N/A	#N/A		0,00	0,00
#N/A		#N/A	#N/A		0,00	0,00
Hire						
#N/A		#N/A	#N/A		0,00	0,00
#N/A		#N/A	#N/A		0,00	0,00
#N/A		#N/A	#N/A		0,00	0,00
#N/A		#N/A	#N/A		0,00	0,00
#N/A		#N/A	#N/A		0,00	0,00
#N/A		#N/A	#N/A		0,00	0,00
Harvest cost:					363,53	98,78
Grain						
Transport:		R/ton	92,50	3,93	363,53	98,78
MARGIN ABOVE DIRECTLY ALLOCATABLE COSTS:					11789,98	2993,71
In Directly Allocatable costs:					610,43	155,33
PRE HARVEST COST:					357,04	90,85
Energy					190,24	48,41
Repairs and Maintenance					162,62	41,38
Tyres					4,18	1,06
HARVEST COST:					253,40	64,48
Energy					123,46	31,41
Repairs and maintenance					128,73	32,76
Tyres					1,20	0,31
TOTAL PRE HARVEST COSTS					3632,71	924,35
TOTAL HARVEST COSTS					616,92	156,98
GROSS MARGIN ABOVE ALL ALLOCATABLE COSTS:					11179,54	2844,67

Annexure C: Guide used to determine machinery and activity cost

MECHANIZATION INFORMATION: **2020**

TRACTORS:

Salvage value = 10% of purchase price
Depreciation = (Purchase price - salvage value)/life (hrs)
Licence & insurance 2% of average investment / hours per annum
Interest = 10% of average investment / hours per annum
Repairs & maintenar 100% of purchase price/ lifetime (hrs)
Power **Fuel price =** 13,99 R/litre 3 year average price
Low **Fuel usage =** 35% of Tractor power (kW)
Litres used per kW h 0,4
Mediu **Fuel usage =** 45% of Tractor power (kW)
Litres used per kW h 0,35
High **Fuel usage =** 60% of Tractor power (kW)
Litres used per kW h 0,30

LOW POWER DEMAND:

	Tractor Power kW	Life (hrs)	Annual Use (hrs)	Purchase Price R	Salvage Value R	Average Investment R	Depre-ciation R/hr	Licence & Insurance R/hr	Interest R/hr	Total fixed costs R/hr	ot. Fixed cos cluding inter R/hr	Repairs & Maintenanc R/hr	Fuel cost R/hr	Tot. var. Costs R/hr	Total Costs R/hr	Tot. costs Excl interes R/hr	Fuel Usage Litre/hr	Cost for set of new tyres:	Life of set of tyres km	Tyre cost per km
	55	10000	750	560 000	56000	308000	50,40	8,21	41,07	99,68	58,61	56,00	146,90	202,90	302,58	261,51	10,50	4000,00	12000,00	0,33
	75	10000	750	824000	82400	453200	74,16	12,09	60,43	146,67	86,25	82,40	107,72	190,12	336,80	276,37	7,70	4000,00	12000,00	0,33
	95	10000	750	1124000	112400	618200	101,16	16,49	82,43	200,07	117,65	112,40	186,07	298,47	498,54	416,11	13,30	6000,00	12000,00	0,50
	105	10000	750	1287000	128700	707850	115,83	18,88	94,38	229,09	134,71	128,70	205,65	334,35	563,44	469,06	14,70	6000,00	12000,00	0,50
	135	10000	750	1786000	178600	982300	160,74	26,19	130,97	317,91	186,93	178,60	264,41	443,01	760,92	629,95	18,90	6000,00	12000,00	0,50
	160	10000	500	2206500	220650	1213575	198,59	48,54	242,72	489,84	247,13	220,65	313,38	534,03	1023,87	781,15	22,40	6000,00	12000,00	0,50
	180	10000	500	2563500	256350	1409925	230,72	56,40	281,99	569,10	287,11	256,35	352,55	608,90	1178,00	896,01	25,20	6000,00	12000,00	0,50
	225	10000	500	3317000	331700	1824350	298,53	72,97	364,87	736,37	371,50	331,70	440,69	772,39	1508,76	1143,89	31,50	6000,00	12000,00	0,50
	260	10000	500	3871000	387100	2129050	348,39	85,16	425,81	859,36	433,55	387,10	509,24	896,34	1755,70	1329,89	36,40	6000,00	12000,00	0,50
	300	10000	500	4454000	445400	2449700	400,86	97,99	489,94	988,79	498,85	445,40	587,58	1032,98	2021,77	1531,83	42,00	6000,00	12000,00	0,50
	300	10000	500	4454000	445400	2449700	400,86	97,99	489,94	988,79	498,85	445,40	587,58	1032,98	2021,77	1531,83	42,00	6000,00	12000,00	0,50
	300	10000	500	4454000	445400	2449700	400,86	97,99	489,94	988,79	498,85	445,40	587,58	1032,98	2021,77	1531,83	42,00	6000,00	12000,00	0,50
	300	10000	500	4454000	445400	2449700	400,86	97,99	489,94	988,79	498,85	445,40	587,58	1032,98	2021,77	1531,83	42,00	6000,00	12000,00	0,50
	300	10000	500	4454000	445400	2449700	400,86	97,99	489,94	988,79	498,85	445,40	587,58	1032,98	2021,77	1531,83	42,00	6000,00	12000,00	0,50
	300	10000	500	4454000	445400	2449700	400,86	97,99	489,94	988,79	498,85	445,40	587,58	1032,98	2021,77	1531,83	42,00	6000,00	12000,00	0,50
	300	10000	500	4454000	445400	2449700	400,86	97,99	489,94	988,79	498,85	445,40	587,58	1032,98	2021,77	1531,83	42,00	6000,00	12000,00	0,50
	Sprayer:																			
30m boom	175	5000	350	4005000	400500	2202750	720,90	125,87	629,36	1476,13	846,77	801,00	342,76	1143,76	2619,88	1990,53	24,50	6000,00	12000,00	0,50
	Swather:																			
Haybine 16ft(4,88m) he	90	5000	250	2283000	278500	1531750	501,30	122,54	612,70	1236,54	623,84	557,00	195,86	752,86	1989,40	1376,70	14,00	6000,00	12000,00	0,50
30ft(9,14m) header	100	5000	250	2785000	228300	1255650	410,94	100,45	502,26	1013,65	511,39	456,60	176,27	632,87	1646,53	1144,27	12,60	6000,00	12000,00	0,50
	Harvesters:																			
30ft(9,14m) header	240	4000	300	3825000	382500	2103750	860,63	140,25	701,25	1702,13	1000,88	956,25	470,06	1426,31	3128,44	2427,19	33,60	6000,00	12000,00	0,50
15ft pickup	250	4000	300	3940000	394000	2167000	886,50	144,47	722,33	1753,30	1030,97	985,00	489,65	1474,65	3227,95	2505,62	35,00	6000,00	12000,00	0,50

IMPLEMENTS:

Depreciation cost per hour =	(Purchase price - salvage value)/life period in hours
Salvage value =	10% of purchase price
Average investment =	(Purchase price + salvage value)/2
Interest cost =	10% of average investment per annum/hours per annum
Repairs and maintenance =	calculated as a percentage of purchase price divided by life expectancy
Licence & insurance =	2% of average investment / hours per annum

Code	IMPLEMENT: Description	Life (hrs)	Annual usage (hrs)	Purchase price (R)	Salvage Value (R)	Average nvestmen (R)	Licence & Insurance R/hr	Depre- ciation (R/hr)	Interest (R/hr)	Tot. fixed costs (R/hr)	ot. fixed cos excl interest (R/hr)	Repairs and maint as a % of new price %	Repairs & maint (R/hr)	Tot. var costs (R/hr)	Total costs (R/hr)	Total costs excl interest (R/hr)
101	Boom spayer 5600 liter 30m, pull type	2500	250	1248500	124850	686675	54,93	449,46	274,67	779,06	504,39	100%	499,40	499,40	1278,46	1003,79
102	preader, Fertilizer Ddisc 3000l(4.8t) 30r	1500	150	336500	33650	185075	24,68	201,90	123,38	349,96	226,58	80%	179,47	179,47	529,43	406,04
103	der, Fertilizer Ddisc 4000l(6.4t) precisio	1500	150	507500	50750	279125	37,22	304,50	186,08	527,80	341,72	80%	270,67	270,67	798,47	612,38
104	preader,Lime Ddisc 13cubic m, precisio	1500	150	680000	68000	374000	49,87	408,00	249,33	707,20	457,87	80%	362,67	362,67	1069,87	820,53
105	Tyres	1500	150	2500	250	1375	0,18	1,50	0,92	2,60	1,68	5%	0,08	0,08	2,68	1,77
106	Roller Crimper	2500	250	78100	7810	42955	3,44	28,12	17,18	48,73	31,55	30%	9,37	9,37	58,11	40,92
107	ont end loader forklift (60-90kw), heavy du	2500	250	163500	16350	89925	7,19	58,86	35,97	102,02	66,05	30%	19,62	19,62	121,64	85,67
108	ront end loader bales (60-90kw), heavy dut	2500	250	159000	15900	87450	7,00	57,24	34,98	99,22	64,24	30%	19,08	19,08	118,30	83,32
109	Graincart 20ton	10000	500	427500	42750	235125	9,41	38,48	47,03	94,91	47,88	75%	32,06	32,06	126,97	79,94
110	Planter 29t x 285mm, 8.3m	2000	200	1588500	158850	873675	87,37	714,83	436,84	1239,03	802,19	80%	635,40	635,40	1874,43	1437,59
111	Planter 35t x 285mm, 10m	2000	200	1969000	196900	1082950	108,30	886,05	541,48	1535,82	994,35	80%	787,60	787,60	2323,42	1781,95
112	lanter 48disc x 125mm, 6m (Vaderstad Rapi	2000	200	2591500	259150	1425325	142,53	1166,18	712,66	2021,37	1308,71	80%	1036,60	1036,60	3057,97	2345,31
113	Haybine 8 disc midddle pull roller 4m	2000	200	666500	66650	366575	36,66	299,93	183,29	519,87	336,58	60%	199,95	199,95	719,82	536,53
114	Finger wheel rakes, pull 7,4m	2000	200	309500	30950	170225	17,02	139,28	85,11	241,41	156,30	120%	185,70	185,70	427,11	342,00
115	Small square baler	2000	150	325500	32550	179025	23,87	146,48	119,35	289,70	170,35	80%	130,20	130,20	419,90	300,55
116	Hammermill, pull with intake meganisms	3000	300	231000	23100	127050	8,47	69,30	42,35	120,12	77,77	50%	38,50	38,50	158,62	116,27
117	ertical feed mixer, 12cubic m, single unloadi	3000	300	635239	63524	349381	23,29	190,57	116,46	330,32	213,86	60%	127,05	127,05	457,37	340,91
118	Road scraper 3.5m with hydrolics	3000	75	173000	17300	95150	25,37	51,90	126,87	204,14	77,27	60%	34,60	34,60	238,74	111,87
119	Water car	10000	100	201500	20150	110825	22,17	18,14	110,83	151,13	40,30	40%	8,06	8,06	159,19	48,36
120	Diesel car	10000	100	66500	6650	36575	7,32	5,99	36,58	49,88	13,30	40%	2,66	2,66	52,54	15,96
121	16ton Side tipper	10000	500	955500	95550	525525	21,02	86,00	105,11	212,12	107,02	75%	71,66	71,66	283,78	178,68
122	21ton Side tipper	10000	500	1005000	100500	552750	22,11	90,45	110,55	223,11	112,56	75%	75,38	75,38	298,49	187,94
123	Straight 30vt flex header	4000	300	587000	58700	322850	21,52	132,08	107,62	261,22	153,60	40%	58,70	58,70	319,92	212,30
124	Pick-up 30vt header	4000	300	500000	50000	275000	18,33	112,50	91,67	222,50	130,83	40%	50,00	50,00	272,50	180,83
125	Haybine header 16ft 4,88m	3750	200	6780000	678000	3729000	372,90	1627,20	1864,50	3864,60	2000,10	80%	1446,40	1446,40	5311,00	3446,50

Annexure D: Farm inventories according to crop rotations and livestock integrations

System E

Inventory							
Item	**Description**	**Amount**	**R/item**	**Value**			
Land & fixed improvements:							
Land(a)	Value includes all improvements	850	50000	R 42,500,000			
Fixed improvements:							
Farmhouse	Farmstead	1	750000	750000			
Worker's homes	1 per worker	5	90000	450000			
Buildings	2 offices and storing rooms	2	60000	120000			
Sheds	1 big shed for tractors & impl.	1	750000	750000			
Shaving camps	1 for sheep shaving purposes	1	100000	100000			
Watersupply	Livestock drinking system	1	150000	150000			
Fence	Livestock camps	1	500000	500000			
Total for fixed improvements (b)	Included in R30000/ha for land			R 2,820,000			
Mechanization:							
Item	**Description**	**R/new**	**Age**	**Depreciation**	**Value**	**Lifespan**	**Yearly deprecia**
Harvesters:	kW						
Harvester with straight header	240	3825000	5	1275000	2550000	15	238000
Harvester with straight header	240	3825000	6	1530000	2295000	15	238000
Tractors:	kW						
1	75	824000	10	549333.3333	274666.6667	15	51271.11111
2	95	1124000	11	824266.6667	299733.3333	15	69937.77778
3	135	1786000	7	833466.6667	952533.3333	15	111128.8889
4	160	2206500	8	1176800	1029700	15	137293.3333
5	260	3871000	6	1548400	2322600	15	240862.2222
Sprayer:	Code						
Boom	101	1248500	7	582633	665867	15	77684.44444
Spreaders:							
Fertilizer 6.4t precision	103	507500	6	203000	304500	15	31577.77778
Planters:							
1	111	1969000	3	393800	1575200	15	122515.5556
Swather:							
Haybine	90	2283000	11	1674200	608800	15	142053.3333
Loaders:							
Front end general	107	163500	2	21800	141700	15	10173.33333
Haymaking equipment:							
Finger wheel rake	114	309500	7	144433	165067	15	19257.77778
Baler	115	325500	7	151900	173600	15	20253.33333
Feeding equipment:							
Milling feed	116	231000	8	123200	107800	15	14373.33333
Feed mixing	117	635239	8	338794	296445	15	39525.98222
Other:							
Roller crimper	106	78100	8	41653	36447	15	4859.555556
Road scraper	118	173000	3	34600	138400	15	10764.44444
Water car	119	201500	4	53733	147767	15	12537.77778
Diesel car	120	66500	5	22167	44333	15	4137.777778
Side tipper	121	955500	11	700700	254800	15	59453.33333
Lorrie	205	1172500	10	781667	390833	15	72955.55556
Bakkies:							
1	202	453400	6	181360	272040	15	28211.55556
2	203	495000	5	165000	330000	15	30800
General tools	Tools, livestock handling equipment etc.				200000		R 1,787,628
Total mechanization & equipment (c)					R 15,577,832		
Livestock			Amount	R/ssu	Value		
Rams			40	5000	201875		
Ewes			808	1250	1009375		
Replacement ewes			202	900	181688		
Lambs			929	250	232156		
Total small livestock: (d)					R 1,625,094		
Total assets: (a+b+c+d)					**R 59,702,925**		

System 1 *S*

Inventory							
Item	**Description**	**Amount**	**R/item**	**Value**			
Land & fixed improvements:							
Land (a)	Value includes all improvements	850	50000	R 42,500,000			
Fixed improvements:							
Farmhouse	Farmstead	1	750000	750000			
Worker's homes	1 per worker	5	90000	450000			
Buildings	2 offices and storing rooms	2	60000	120000			
Sheds	1 big shed for tractors & impl.	1	750000	750000			
Shaving camps	1 for sheep shaving purposes	1	100000	100000			
Watersupply	Livestock drinking system	1	150000	150000			
Fence	Livestock camps	1	500000	500000			
Total for fixed improvements (b)	Included in R30000/ha for land			R 2,820,000			
Mechanization:							
Item	**Description**	**R/new**	**Age**	**Depreciation**	**Value**	**Lifespan**	**Yearly deprecia**
Harvesters:	kW						
Harvester with straight header	240	3825000	5	1275000	2550000	15	238000
Harvester with straight header	240	3825000	6	1530000	2295000	15	238000
Tractors:	kW						
1	75	824000	10	549333.3333	274666.6667	15	51271.11111
2	95	1124000	11	824266.6667	299733.3333	15	69937.77778
3	135	1786000	7	833466.6667	952533.3333	15	111128.8889
4	160	2206500	8	1176800	1029700	15	137293.3333
5	260	3871000	6	1548400	2322600	15	240862.2222
Sprayer:	Code						
Boom	101	1248500	7	582633	665867	15	77684.44444
Spreaders:							
Fertilizer 6.4t precision	103	507500	6	203000	304500	15	31577.77778
Planters:							
1	111	1969000	3	393800	1575200	15	122515.5556
Swather:							
Haybine	90	2283000	11	1674200	608800	15	142053.3333
Loaders:							
Front end general	107	163500	2	21800	141700	15	10173.33333
Haymaking equipment:							
Finger wheel rake	114	309500	7	144433	165067	15	19257.77778
Baler	115	325500	7	151900	173600	15	20253.33333
Feeding equipment:							
Milling feed	116	231000	8	123200	107800	15	14373.33333
Feed mixing	117	635239	8	338794	296445	15	39525.98222
Other:							
Roller crimper	106	78100	8	41653	36447	15	4859.555556
Road scraper	118	173000	3	34600	138400	15	10764.44444
Water car	119	201500	4	53733	147767	15	12537.77778
Diesel car	120	66500	5	22167	44333	15	4137.777778
Side tipper	121	955500	11	700700	254800	15	59453.33333
Lorrie	205	1172500	10	781667	390833	15	72955.55556
Bakkies:							
1	202	453400	6	181360	272040	15	28211.55556
2	203	495000	5	165000	330000	15	30800
General tools	Tools, livestock handling equipment etc.				200000		R 1,787,628
Total mechanization & equipment (c)					R 15,577,832		
Livestock: Sheep			Amount	R/ssu	Value		
Rams			40	5000	201875		
Ewes			808	1250	1009375		
Replacement ewes			202	900	181688		
Lambs			929	250	232156		
Cattle							
Bulls			0	35000	0		
Cows			0	17000	0		
Calves			0	2500	0		
Total livestock: (d)					R 1,625,094		
Total assets: (a+b+c+d)					**R 59,702,925**		

System 1 *BC*

Inventory							
Item	**Description**	**Amount**	**R/item**	**Value**			
Land & fixed improvements:							
Land(a)	Value includes all improveme	850	50000	R 42,500,000			
Fixed improvements:							
Farmhouse	Farmstead	1	750000	750000			
Worker's homes	1 per worker	5	90000	450000			
Buildings	2 offices and storing rooms	2	60000	120000			
Sheds	1 big shed for tractors & impl	1	750000	750000			
Watersupply	Livestock drinking system	1	150000	150000			
Fence	Livestock camps	1	500000	500000			
Total for fixed improvements (b)	Included in R30000/ha for land			R 2,720,000			
Mechanization:							
Item	**Description**	**R/new**	**Age**	**Depreciation**	**Value**	**Lifespan**	**Yearly deprec**
Harvesters:	kW						
Harvester with straight header	240	3825000	5	1275000	2550000	15	238000
Harvester with straight header	240	3825000	6	1530000	2295000	15	238000
Tractors:	kW						
1	75	824000	10	549333.3333	274666.6667	15	51271.11111
2	95	1124000	11	824266.6667	299733.3333	15	69937.77778
3	135	1786000	7	833466.6667	952533.3333	15	111128.8889
4	160	2206500	8	1176800	1029700	15	137293.3333
5	260	3871000	6	1548400	2322600	15	240862.2222
Sprayer:	Code						
Boom	101	1248500	7	582633	665867	15	77684.44444
Spreaders:							
Fertilizer 6.4t precision	103	507500	6	203000	304500	15	31577.77778
Planters:							
1	111	1969000	3	393800	1575200	15	122515.5556
Swather:							
Haybine	90	2283000	11	1674200	608800	15	142053.3333
Loaders:							
Front end general	107	163500	2	21800	141700	15	10173.33333
Haymaking equipment:							
Finger wheel rake	114	309500	7	144433	165067	15	19257.77778
Baler	115	325500	7	151900	173600	15	20253.33333
Feeding equipment:							
Milling feed	116	231000	8	123200	107800	15	14373.33333
Feed mixing	117	635239	8	338794	296445	15	39525.98222
Other:							
Roller crimper	106	78100	8	41653	36447	15	4859.555556
Road scraper	118	173000	3	34600	138400	15	10764.44444
Water car	119	201500	4	53733	147767	15	12537.77778
Diesel car	120	66500	5	22167	44333	15	4137.777778
Side tipper	121	955500	11	700700	254800	15	59453.33333
Lorrie	205	1172500	10	781667	390833	15	72955.55556
Bakkies:							
1	202	453400	6	181360	272040	15	28211.55556
2	203	495000	5	165000	330000	15	30800
General tools	Tools, livestock handling equipment etc.				200000		R 1,787,628
Total mechanization & equipment (c)					R 15,577,832		
Livestock: Sheep			Amount	R/ssu	Value		
Rams			24	5000	121125		
Ewes			485	1250	605625		
Replacement ewes			121	900	109013		
Lambs			557	250	139294		
Cattle							
Bulls			2.907	35000	101745		
Cows			96.9	17000	1647300		
Calves			94.962	2500	237405		
Total livestock: (d)					R 2,961,506		
Total assets: (a+b+c+d)					**R 61,039,338**		

System 2 *MX*

Inventory								
Item	**Description**	**Amount**	**R/item**	**Value**				
Land & fixed improvements:								
Land(a)	Value includes all improver	850	50000	R 42,500,000				
Fixed improvements:								
Farmhouse	Farmstead	1	750000	750000				
Worker's homes	1 per worker	5	90000	450000				
Buildings	2 offices and storing room:	2	60000	120000				
Sheds	1 big shed for tractors & in	1	750000	750000				
Shaving camps	1 for sheep shaving purpo:	1	100000	100000				
Watersupply	Livestock drinking system	1	150000	150000				
Fence	Livestock camps	1	500000	500000				
Total for fixed improvements (b)	Included in R30000/ha for land			R 2,820,000				
Mechanization:								
Item	**Description**	**R/new**	**Age**	**Depreciation**	**Value**	**Lifespan**	**Yearly depreciation**	
Harvesters:	kW							
Harvester with straight header	240	3825000	5	1275000	2550000	15	238000	
Tractors:	kW							
1	75	824000	10	549333.3333	274666.6667	15	51271.11111	
2	95	1124000	11	824266.6667	299733.3333	15	69937.77778	
3	135	1786000	7	833466.6667	952533.3333	15	111128.8889	
4	160	2206500	8	1176800	1029700	15	137293.3333	
5	260	3871000	6	1548400	2322600	15	240862.2222	
Sprayer:	Code							
Boom	101	1248500	7	582633	665867	15	77684.44444	
Spreaders:								
Fertilizer 6.4t precision	103	507500	6	203000	304500	15	31577.77778	
Planters:								
1	111	1969000	3	393800	1575200	15	122515.5556	
Swather:								
Haybine	90	2283000	11	1674200	608800	15	142053.3333	
Loaders:								
Front end general	107	163500	2	21800	141700	15	10173.33333	
Haymaking equipment:								
Finger wheel rake	114	309500	7	144433	165067	15	19257.77778	
Baler	115	325500	7	151900	173600	15	20253.33333	
Feeding equipment:								
Milling feed	116	231000	8	123200	107800	15	14373.33333	
Feed mixing	117	635239	8	338794	296445	15	39525.98222	
Other:								
Roller crimper	106	78100	8	41653	36447	15	4859.555556	
Road scraper	118	173000	3	34600	138400	15	10764.44444	
Water car	119	201500	4	53733	147767	15	12537.77778	
Diesel car	120	66500	5	22167	44333	15	4137.777778	
Side tipper	121	955500	11	700700	254800	15	59453.33333	
Livestock Trailer	126	95000	6	38000	57000	15	5911.111111	
Lorrie	205	1172500	10	781667	390833	15	72955.55556	
Bakkies:								
1	202	453400	6	181360	272040	15	28211.55556	
2	203	495000	5	165000	330000	15	30800	
General tools (Mixed Livestock)	Tools, livestock handling equipment etc.				320000		R 1,555,539	
Total mechanization & equipment (c)					R 13,459,832			
Livestock			Amount	R/ssu	Value			
Rams			16	5000	80750			
Ewes			323	1250	403750			
Replacement ewes			81	900	72675			
Lambs			371	250	92863			
Total small livestock: (d)					R 650,038			
Total assets: (a+b+c+d)					**R 56,609,869**			

Annexure E: An example of the variable cost calculations in the budget models

ALLOCATABLE VARIABLE COSTS:					**5045.70**	**749.73**	Code
Directly Allocatable Variable Costs:					**4512.37**	**670.49**	
Pre Harvest Cost: Livestock					**732.03**	**108.77**	
Sheep:	335.48						
Feed purchased:							
Supplement		head	92	1.2	110.40	16.40	608
#N/A		#N/A	#N/A		0.00	0.00	
Vet and AI:							
#N/A		#N/A	#N/A		0.00	0.00	
Dosing:							304
Sponge		Mililitre	30.52667	1.2	36.63	5.44	617
PMSG		Mililitre	31.98	1.2	38.38	5.70	618
Ewe Package		Per ewe	23.93413	1.2	28.72	4.27	619
Lamb Pakage		per lamb	4.689967	1.68	7.88	1.17	620
#N/A		#N/A	#N/A		0.00	0.00	
#N/A		#N/A	#N/A		0.00	0.00	
#N/A		#N/A	#N/A		0.00	0.00	
#N/A		#N/A	#N/A		0.00	0.00	
#N/A		#N/A	#N/A		0.00	0.00	
#N/A		#N/A	#N/A		0.00	0.00	
Contract work:							
Shear costs		head	11.83333	1.56	18.46	2.74	632
Packaging:							
Wool bale		bale	196.8767	0.0252	4.96	0.74	634
Miscellaneous:							
Transport costs		Head	9.06	1.44	13.05	1.94	636
Ram costs		R/ewe	64.16667	1.2	77.00	11.44	635
#N/A		#N/A	#N/A		0.00	0.00	
Cattle:	396.55						
Purchases:							
Bulls		head	33667	0.0072	242.40		640
Heifers		head	0	0	0.00		641
Feed:							
Superfos		head	262.8	0.24	63.072		642
Premix		head	128.4	0.24	30.816		643
Fosfaat		head	146	0.24	35.04		644
Vet and AI:							
Pregnacy		head	0	0	0		645
AI		head	0	0	0		646
Hoof trimming		head	0	0	0		647
							648
Animal Plaque:							
Cow Package		per cow	34.5628	0.24	8.295072		649
Calve Pakage		per calve	33.72973	0.2352	7.93323328		650
Bull package		per bull	101.7856	0.0072	0.732857053		651
Pour on Dip		Per dose	0	0.4752	0		652
Contract work:							
Transport		Head	0	0	0		658
Micellaneous:							
Transport costs		Head	36.24	0.228	8.26272		659
Slaughter costs		Head	0	0	0		660

Annexure F: multi-period capital budgets for the rotation systems and integration strategies utilised

System E

Whole-farm multi-peri	**System E**																				
Yield potential based on rainfall distribution																					
1	**Poor**																				
2	**Average**																				
3	**Good**																				
Year		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Wheat aft medics: Year	clasification (poo	2	3	2	1	2	3	2	2	3	2	2	3	2	1	2	3	2	2	3	2
Gross Margin																					
Crop	Hectares																				
Wheat after medics gra	404	3824557	5410585	3824557	1553942	3824557	5410585	3824557	3824557	5410585	3824557	3824557	5410585	3824557	1553942	3824557	5410585	3824557	3824557	5410585	3824557
Medics	404	581597	581597	581597	581597	581597	581597	581597	581597	581597	581597	581597	581597	581597	581597	581597	581597	581597	581597	581597	581597
Capital sales		0	0	0	0	363542	166375	0	262570	305792	721408	365542	16792	178500	13625	0	0	0	0	0	363542
Gross margin: total fa	**808**	**4406153**	**5992181**	**4406153**	**2135538**	**4769695**	**6158556**	**4406153**	**4668723**	**6297973**	**5127562**	**4771695**	**6008973**	**4584653**	**2149163**	**4406153**	**5992181**	**4406153**	**4406153**	**5992181**	**4769695**
Overhead and fixed costs																					
Municipal taxes		14875	14875	14875	14875	14875	14875	14875	14875	14875	14875	14875	14875	14875	14875	14875	14875	14875	14875	14875	14875
Insurance (overall)		450000	450000	450000	450000	450000	450000	450000	450000	450000	450000	450000	450000	450000	450000	450000	450000	450000	450000	450000	450000
Licenses		21500	21500	21500	21500	21500	21500	21500	21500	21500	21500	21500	21500	21500	21500	21500	21500	21500	21500	21500	21500
Electricity		200000	200000	200000	200000	200000	200000	200000	200000	200000	200000	200000	200000	200000	200000	200000	200000	200000	200000	200000	200000
Banking fees		50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000
Telephone		20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000
Administration		30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000
Auditors & Consultation fees		80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000
Provision: camps		20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000
Provision: water distribution		20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000
Provision: buildings		45000	45000	45000	45000	45000	45000	45000	45000	45000	45000	45000	45000	45000	45000	45000	45000	45000	45000	45000	45000
Employee wages		250500	250500	250500	250500	250500	250500	250500	250500	250500	250500	250500	250500	250500	250500	250500	250500	250500	250500	250500	250500
Owners remuneration		550000	550000	550000	550000	550000	550000	550000	550000	550000	550000	550000	550000	550000	550000	550000	550000	550000	550000	550000	550000
Miscellaneous costs (5%)		87594	87594	87594	87594	87594	87594	87594	87594	87594	87594	87594	87594	87594	87594	87594	87594	87594	87594	87594	87594
Totaal:		**1839468,8**	**1839469**	**1839468,75**	**1839468,75**	**1839468,75**	**1839468,75**	**1839469**	**1839469**	**1839469**	**1839469**	**1839469**	**1839469**	**1839469**	**1839469**	**1839469**	**1839469**	**1839469**	**1839469**	**1839469**	**1839468,8**
Margin above overhead and fixed costs		**2566684**	**4152712**	**2566684**	**296070**	**2930226**	**4319087**	**2566684**	**2829254**	**4458504**	**3288093**	**2932226**	**4169504**	**2745184**	**309695**	**2566684**	**4152712**	**2566684**	**2566684**	**4152712**	**2930226**
Foreign factor cost:																					
Rent																					
Hired management																					
Interest																					
Total		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Margin above foreign factor costs		**2566684**	**4152712**	**2566684**	**296070**	**2930226**	**4319087**	**2566684**	**2829254**	**4458504**	**3288093**	**2932226**	**4169504**	**2745184**	**309695**	**2566684**	**4152712**	**2566684**	**2566684**	**4152712**	**2930226**

Capital																					
Long term:																					
Land and fixed improvements		42500000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Intermediate:	Age																				
Harvesters:																					
rvester with straight header	5	2550000	0	0	0	0	0	0	0	0	0	3825000	0	0	0	0	0	0	0	0	0
rvester with straight header	6	2295000	0	0	0	0	0	0	0	0	3825000	0	0	0	0	0	0	0	0	0	0
Tractors:																					
1	10	274667	0	0	0	0	824000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	11	299733	0	0	0	1124000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1124000
3	7	952533	0	0	0	0	0	0	0	1786000	0	0	0	0	0	0	0	0	0	0	0
4	8	1029700	0	0	0	0	0	0	2206500	0	0	0	0	0	0	0	0	0	0	0	0
5	6	2322600	0	0	0	0	0	0	0	0	3871000	0	0	0	0	0	0	0	0	0	0
Sprayer:																					
Boom	7	665867	0	0	0	0	0	0	0	1248500	0	0	0	0	0	0	0	0	0	0	0
Spreaders:	0																				
Fertilizer 6.4t precision	6	304500	0	0	0	0	0	0	0	0	507500	0	0	0	0	0	0	0	0	0	0
Planters:																					
1	3	1575200	0	0	0	0	0	0	0	0	0	0	0	1969000	0	0	0	0	0	0	0
Swather:																					
Haybine	11	190250	0	0	0	2283000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2283000
Loaders:																					
Front end general	2	141700	0	0	0	0	0	0	0	0	0	0	0	0	163500	0	0	0	0	0	0
Haymaking equipment:																					
Finger wheel rake	7	165067	0	0	0	0	0	0	0	309500	0	0	0	0	0	0	0	0	0	0	0
Baler	7	173600	0	0	0	0	0	0	0	325500	0	0	0	0	0	0	0	0	0	0	0
Feeding equipment:																					
Milling feed	8	107800	0	0	0	0	0	0	231000	0	0	0	0	0	0	0	0	0	0	0	0
Feed mixing	8	296445	0	0	0	0	0	0	635239	0	0	0	0	0	0	0	0	0	0	0	0
Other:																					
Roller crimper	8	36447	0	0	0	0	0	0	78100	0	0	0	0	0	0	0	0	0	0	0	0
Road scraper	3	138400	0	0	0	0	0	0	0	0	0	0	0	173000	0	0	0	0	0	0	0
Water car	4	147767	0	0	0	0	0	0	0	0	0	0	201500	0	0	0	0	0	0	0	0
Diesel car	5	44333	0	0	0	0	0	0	0	0	0	66500	0	0	0	0	0	0	0	0	0
Side tipper	11	254800	0	0	0	955500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	955500
Lorrie	10	390833	0	0	0	0	1172500	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bakkies:																					
1	6	272040	0	0	0	0	0	0	0	0	453400	0	0	0	0	0	0	0	0	0	0
2	5	330000	0	0	0	0	0	0	0	0	0	495000	0	0	0	0	0	0	0	0	0
General tools		200000																			
Total intermediary capital:		15159282	0	0	0	4362500	1996500	0	3150839	3669500	8656900	4386500	201500	2142000	163500	0	0	0	0	0	4362500
Livestock		1625094																			
Total capital:		59284375	0	0	0	4362500	1996500	0	3150839	3669500	8656900	4386500	201500	2142000	163500	0	0	0	0	0	4362500
Net annual flow:		-56717691	4152712	2566684	296070	-1432274	2322587	2566684	-321585	789004	-5368807	-1454274	3968004	603184	146195	2566684	4152712	2566684	2566684	4152712	54094304
IRR	2,05%																				
NPV	R2 386 314,67																				
Cashflow:																					
Opening balance		0	675549	2977395	3705958	2136450	2188885	4617217	5305181	5527872	6545425	5374772	3256145	2311474	138763	-3847745	-3552219	-501227	1053730	3142681	6921742
Inflow		4406153	5992181	4406153	2135538	4769695	6158556	4406153	4668723	6297973	5127562	4771695	6008973	4584653	2149163	4406153	5992181	4406153	4406153	5992181	4769695
Outflow		3742422	3742422	3742422	3742422	4755552	3810999	3810999	4542737	5394927	6392241	6947285	6994081	6759792	5945573	3935129	2916426	2869630	2372180	2334210	3347339
Flow before interest		663731	2925308	3641126	2099074	2150593	4536443	5212372	5431167	6430918	5280745	3199181	2271037	136335	-3657646	-3376721	-476464	1035296	3087703	6800653	8344098
Interest		11818	52087	64832	37375	38293	80774	92809	96705	114506	94027	56963	40437	2428	-190099	-175498	-24763	18434	54978	121090	148572
Closing balance		675549	2977395	3705958	2136450	2188885	4617217	5305181	5527872	6545425	5374772	3256145	2311474	138763	-3847745	-3552219	-501227	1053730	3142681	6921742	8492669

System 1 *S*

Whole-farm multi-period bu	**System 1 S**																				
Yield potential based on rainfall distribution																					
1	**Poor**																				
2	**Average**																				
3	**Good**																				
Year		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Wheat: Year clasification (poor, avergae, g		2	3	2	1	2	3	2	2	3	2	2	3	2	1	2	3	2	2	3	2
Gross Margin																					
Crop	Hectares																				
Wheat after cover grazed	403,75	3964089,25	5260449,75	3964089,25	1371368,25	3964089,25	5260449,75	3964089,25	3964089,25	5260449,75	3964089,25	3964089,25	5260449,75	3964089,25	1371368,25	3964089,25	5260449,75	3964089,25	3964089,25	5260449,75	3964089,25
Cover crops	403,75	-127429,36	-127429,36	-127429,36	-127429,36	-127429,36	-127429,36	-127429,36	-127429,36	-127429,36	-127429,36	-127429,36	-127429,36	-127429,36	-127429,36	-127429,36	-127429,36	-127429,36	-127429,36	-127429,36	-127429,36
Capital sales		0,00	0,00	0,00	0,00	363541,67	166375,00	0,00	262569,92	305791,67	721408,33	365541,67	16791,67	178500,00	13625,00	0,00	0,00	0,00	0,00	0,00	363541,67
Gross margin: total farming	**807,50**	**3836659,90**	**5133020,40**	**3836659,90**	**1243938,90**	**4200201,56**	**5299395,40**	**3836659,90**	**4099229,81**	**5438812,06**	**4558068,23**	**4202201,56**	**5149812,06**	**4015159,90**	**1257563,90**	**3836659,90**	**5133020,40**	**3836659,90**	**3836659,90**	**5133020,40**	**4200201,56**
Overhead and fixed costs																					
Municipal taxes		14875	14875	14875	14875	14875	14875	14875	14875	14875	14875	14875	14875	14875	14875	14875	14875	14875	14875	14875	14875
Insurance (overall)		450000	450000	450000	450000	450000	450000	450000	450000	450000	450000	450000	450000	450000	450000	450000	450000	450000	450000	450000	450000
Licenses		21500	21500	21500	21500	21500	21500	21500	21500	21500	21500	21500	21500	21500	21500	21500	21500	21500	21500	21500	21500
Electricity		200000	200000	200000	200000	200000	200000	200000	200000	200000	200000	200000	200000	200000	200000	200000	200000	200000	200000	200000	200000
Banking fees		50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000
Telephone		20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000
Administration		30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000
Auditors & Consultation fees		80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000
Provision: camps		20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000
Provision: water distribution		20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000
Provision: buildings		45000	45000	45000	45000	45000	45000	45000	45000	45000	45000	45000	45000	45000	45000	45000	45000	45000	45000	45000	45000
Employee wages		250500	250500	250500	250500	250500	250500	250500	250500	250500	250500	250500	250500	250500	250500	250500	250500	250500	250500	250500	250500
Owners remuneration		550000	550000	550000	550000	550000	550000	550000	550000	550000	550000	550000	550000	550000	550000	550000	550000	550000	550000	550000	550000
Miscellaneous costs (5%)		87593,75	87593,75	87593,75	87593,75	87593,75	87593,75	87593,75	87593,75	87593,75	87593,75	87593,75	87593,75	87593,75	87593,75	87593,75	87593,75	87593,75	87593,75	87593,75	87593,75
Totaal:		**1839468,75**	**1839468,75**	**1839468,75**	**1839468,75**	**1839468,75**	**1839468,75**	**1839468,75**	**1839468,75**	**1839468,75**	**1839468,75**	**1839468,75**	**1839468,75**	**1839468,75**	**1839468,75**	**1839468,75**	**1839468,75**	**1839468,75**	**1839468,75**	**1839468,75**	**1839468,75**
Margin above overhead and fixed costs		**1997191,15**	**3293551,6**	**1997191,15**	**-595529,85**	**2360732,81**	**3459926,65**	**1997191,15**	**2259761,06**	**3599343,31**	**2718599,48**	**2362732,81**	**3310343,31**	**2175691,15**	**-581904,85**	**1997191,15**	**3293551,65**	**1997191,15**	**1997191,15**	**3293551,65**	**2360732,81**
Foreign factor cost:																					
Rent																					
Hired management																					
Interest																					
Total		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Margin above foreign factor costs		**1997191,15**	**3293551,65**	**1997191,15**	**-595529,85**	**2360732,81**	**3459926,65**	**1997191,15**	**2259761,06**	**3599343,31**	**2718599,48**	**2362732,81**	**3310343,31**	**2175691,15**	**-581904,85**	**1997191,15**	**3293551,65**	**1997191,15**	**1997191,15**	**3293551,65**	**2360732,81**

Capital																				
Long term:																				
Land and fixed improvements		42500000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Intermediate:	Age																				
Harvesters:																					
Harvester with straight header	5	2550000	0	0	0	0	0	0	0	0	0	3825000	0	0	0	0	0	0	0	0	0
Harvester with straight header	6	2295000	0	0	0	0	0	0	0	0	3825000	0	0	0	0	0	0	0	0	0	0
Tractors:																					
1	10	274667	0	0	0	0	824000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	11	299733	0	0	0	1124000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1124000
3	7	952533	0	0	0	0	0	0	0	1786000	0	0	0	0	0	0	0	0	0	0	0
4	8	1029700	0	0	0	0	0	0	2206500	0	0	0	0	0	0	0	0	0	0	0	0
5	6	2322600	0	0	0	0	0	0	0	0	3871000	0	0	0	0	0	0	0	0	0	0
Sprayer:																					
Boom	7	665867	0	0	0	0	0	0	0	1248500	0	0	0	0	0	0	0	0	0	0	0
Spreaders:	0																				
Fertilizer 6.4t precision	6	304500	0	0	0	0	0	0	0	0	507500	0	0	0	0	0	0	0	0	0	0
Planters:																					
1	3	1575200	0	0	0	0	0	0	0	0	0	0	0	1969000	0	0	0	0	0	0	0
Swather:																					
Haybine	11	608800	0	0	0	2283000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2283000
Loaders:																					
Front end general	2	141700	0	0	0	0	0	0	0	0	0	0	0	0	163500	0	0	0	0	0	0
Haymaking equipment:																					
Finger wheel rake	7	165067	0	0	0	0	0	0	0	309500	0	0	0	0	0	0	0	0	0	0	0
Baler	7	173600	0	0	0	0	0	0	0	325500	0	0	0	0	0	0	0	0	0	0	0
Feeding equipment:																					
Milling feed	8	107800	0	0	0	0	0	0	231000	0	0	0	0	0	0	0	0	0	0	0	0
Feed mixing	8	296445	0	0	0	0	0	0	635239	0	0	0	0	0	0	0	0	0	0	0	0
Other:																					
Roller crimper	8	36447	0	0	0	0	0	0	78100	0	0	0	0	0	0	0	0	0	0	0	0
Road scraper	3	138400	0	0	0	0	0	0	0	0	0	0	0	173000	0	0	0	0	0	0	0
Water car	4	147767	0	0	0	0	0	0	0	0	0	0	201500	0	0	0	0	0	0	0	0
Diesel car	5	44333	0	0	0	0	0	0	0	0	0	66500	0	0	0	0	0	0	0	0	0
Side tipper	11	254800	0	0	0	955500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	955500
Lorrie	10	390833	0	0	0	0	1172500	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bakkies:																					
1	6	272040	0	0	0	0	0	0	0	0	453400	0	0	0	0	0	0	0	0	0	0
2	5	330000	0	0	0	0	0	0	0	0	0	495000	0	0	0	0	0	0	0	0	0
General tools		200000																			
Total intermediary capital:		15577832	0	0	0	4362500	1996500	0	3150839	3669500	8656900	4386500	201500	2142000	163500	0	0	0	0	0	4362500
Livestock		1625094																			
Total capital:		59702925	0	0	0	4362500	1996500	0	3150839	3669500	8656900	4386500	201500	2142000	163500	0	0	0	0	0	4362500
Net annual flow:		-57705734,14	3293551,65	1997191,15	-595529,85	-2001767,19	1463426,65	1997191,15	-891077,94	-70156,69	-5938300,52	-2023767,19	3108843,31	33691,15	-745404,85	1997191,15	3293551,65	1997191,15	1997191,15	3293551,65	53524810,90
IRR		0,73%																			
NPV		-9536166,687																			

System 1 *BC*

Whole-farm multi-period bu	System 1 *BC*																				
Yield potential based on rainfall distribution																					
1	**Poor**																				
2	**Average**																				
3	**Good**																				
Year		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Wheat Year clasification (poor, avergae, good)		2	3	2	1	2	3	2	2	3	2	2	3	2	1	2	3	2	2	3	2
Gross Margin																					
Crop	Hectares																				
Wheat after cover grazed	404	3964089	5260450	3964089	1371368	3964089	5260450	3964089	3964089	5260450	3964089	3964089	5260450	3964089	1371368	3964089	5260450	3964089	3964089	5260450	3964089
Cover crops	404	-494200	-494200	-494200	-494200	-494200	-494200	-494200	-494200	-494200	-494200	-494200	-494200	-494200	-494200	-494200	-494200	-494200	-494200	-494200	-494200
Capital sales		0	0	0	0	363542	166375	0	262570	305792	721408	365542	16792	178500	13625	0	0	0	0	0	363542
Gross margin: total farming	**808**	**3469890**	**4766250**	**3469890**	**877169**	**3833431**	**4932625**	**3469890**	**3732460**	**5072042**	**4191298**	**3835431**	**4783042**	**3648390**	**890794**	**3469890**	**4766250**	**3469890**	**3469890**	**4766250**	**3833431**
Overhead and fixed costs																					
Municipal taxes		14875	14875	14875	14875	14875	14875	14875	14875	14875	14875	14875	14875	14875	14875	14875	14875	14875	14875	14875	14875
Insurance (overall)		450000	450000	450000	450000	450000	450000	450000	450000	450000	450000	450000	450000	450000	450000	450000	450000	450000	450000	450000	450000
Licenses		21500	21500	21500	21500	21500	21500	21500	21500	21500	21500	21500	21500	21500	21500	21500	21500	21500	21500	21500	21500
Electricity		200000	200000	200000	200000	200000	200000	200000	200000	200000	200000	200000	200000	200000	200000	200000	200000	200000	200000	200000	200000
Banking fees		50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000
Telephone		20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000
Administration		30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000
Auditors & Consultation fees		80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000
Provision: camps		20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000
Provision: water distribution		20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000
Provision: buildings		45000	45000	45000	45000	45000	45000	45000	45000	45000	45000	45000	45000	45000	45000	45000	45000	45000	45000	45000	45000
Employee wages		250500	250500	250500	250500	250500	250500	250500	250500	250500	250500	250500	250500	250500	250500	250500	250500	250500	250500	250500	250500
Owners remuneration		550000	550000	550000	550000	550000	550000	550000	550000	550000	550000	550000	550000	550000	550000	550000	550000	550000	550000	550000	550000
Miscellaneous costs (5%)		87594	87594	87594	87594	87594	87594	87594	87594	87594	87594	87594	87594	87594	87594	87594	87594	87594	87594	87594	87594
Totaal:		**1839469**	**1839469**	**1839469**	**1839469**	**1839469**	**1839469**	**1839469**	**1839469**	**1839469**	**1839469**	**1839469**	**1839469**	**1839469**	**1839469**	**1839469**	**1839469**	**1839469**	**1839469**	**1839469**	**1839469**
Margin above overhead and fixed costs		**1630421**	**2926781**	**1630421**	**-962300**	**1993963**	**3093156**	**1630421**	**1892991**	**3232573**	**2351829**	**1995963**	**2943573**	**1808921**	**-948675**	**1630421**	**2926781**	**1630421**	**1630421**	**2926781**	**1993963**
Foreign factor cost																					
Rent																					
Hired management																					
Interest																					
Total		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Margin above foreign factor costs		**1630421**	**2926781**	**1630421**	**-962300**	**1993963**	**3093156**	**1630421**	**1892991**	**3232573**	**2351829**	**1995963**	**2943573**	**1808921**	**-948675**	**1630421**	**2926781**	**1630421**	**1630421**	**2926781**	**1993963**

Capital																					
Long term:																					
Land and fixed improvements		42500000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Intermediate:	Age																				
Harvesters:																					
Harvester with straight header	5	2550000	0	0	0	0	0	0	0	0	0	3825000	0	0	0	0	0	0	0	0	0
Harvester with straight header	6	2295000	0	0	0	0	0	0	0	0	3825000	0	0	0	0	0	0	0	0	0	0
Tractors:																					
1	10	274667	0	0	0	0	824000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	11	299733	0	0	0	1124000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1124000
3	7	952533	0	0	0	0	0	0	0	1786000	0	0	0	0	0	0	0	0	0	0	0
4	8	1029700	0	0	0	0	0	0	2206500	0	0	0	0	0	0	0	0	0	0	0	0
5	6	2322600	0	0	0	0	0	0	0	0	3871000	0	0	0	0	0	0	0	0	0	0
Sprayer:																					
Boom	7	665867	0	0	0	0	0	0	0	1248500	0	0	0	0	0	0	0	0	0	0	0
Spreaders:	0																				
Fertilizer 6.4t precision	6	304500	0	0	0	0	0	0	0	0	507500	0	0	0	0	0	0	0	0	0	0
Planters:																					
1	3	1575200	0	0	0	0	0	0	0	0	0	0	0	1969000	0	0	0	0	0	0	0
Swather:																					
Haybine	11	608800	0	0	0	2283000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2283000
Loaders:																					
Frontend general	2	141700	0	0	0	0	0	0	0	0	0	0	0	0	163500	0	0	0	0	0	0
Haymaking equipment:																					
Finger wheel rake	7	165067	0	0	0	0	0	0	0	309500	0	0	0	0	0	0	0	0	0	0	0
Baler	7	173600	0	0	0	0	0	0	0	325500	0	0	0	0	0	0	0	0	0	0	0
Feeding equipment:																					
Milling feed	8	107800	0	0	0	0	0	0	231000	0	0	0	0	0	0	0	0	0	0	0	0
Feed mixing	8	296445	0	0	0	0	0	0	635239	0	0	0	0	0	0	0	0	0	0	0	0
Other:																					
Roller crimper	8	36447	0	0	0	0	0	0	78100	0	0	0	0	0	0	0	0	0	0	0	0
Road scraper	3	138400	0	0	0	0	0	0	0	0	0	0	0	173000	0	0	0	0	0	0	0
Water car	4	147767	0	0	0	0	0	0	0	0	0	0	201500	0	0	0	0	0	0	0	0
Diesel car	5	44333	0	0	0	0	0	0	0	0	0	66500	0	0	0	0	0	0	0	0	0
Side tipper	11	254800	0	0	0	955500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	955500
Lorrie	10	390833	0	0	0	0	1172500	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bakkies:																					
1	6	272040	0	0	0	0	0	0	0	0	453400	0	0	0	0	0	0	0	0	0	0
2	5	330000	0	0	0	0	0	0	0	0	0	495000	0	0	0	0	0	0	0	0	0
General tools		200000																			
Total intermediary capital:		15577832	0	0	0	4362500	1996500	0	3150839	3669500	8656900	4386500	201500	2142000	163500	0	0	0	0	0	4362500
Livestock		3310750																			
Total capital:		61388582	0	0	0	4362500	1996500	0	3150839	3669500	8656900	4386500	201500	2142000	163500	0	0	0	0	0	4362500
Net annual flow:		-59758161	2926781	1630421	-962300	-2368537	1096656	1630421	-1257848	-436927	-6305071	-2390537	2742073	-333079	-1112175	1630421	2926781	1630421	1630421	2926781	54843697
IRR	0.06%																				
NPV	-R16,134,187.74																				
Cashflow:																					
Opening balance		0	-341968	640524	321068	-2731687	-3898978	-2936069	-3461872	-4508556	-5096916	-7691520	-11379228	-14310965	-18342230	-24627393	-26411142	-25852214	-26578745	-26819733	-25669565
Inflow		3469890	4766250	3469890	877169	3833431	4932625	3469890	3732460	5072042	4191298	3835431	4783042	3648390	890794	3469890	4766250	3469890	3469890	4766250	3833431
Outflow		3794963	3794963	3794963	3794963	4808093	3824658	3824658	4556397	5408587	6405901	6960945	7007741	6773452	5959232	3948789	2930085	2883290	2385840	2347870	3360999
Flow before interest		-325073	629319	315451	-2596727	-3706348	-2791011	-3290837	-4285809	-4845101	-7311518	-10817034	-13603927	-17436027	-23410669	-25106292	-24574978	-25265614	-25494696	-24401353	-25197133
Interest		-16895	11205	5617	-134960	-192630	-145057	-171035	-222747	-251815	-380002	-562194	-707038	-906204	-1216724	-1304851	-1277237	-1313131	-1325037	-1268213	-1309572
Closing balance		-341968	640524	321068	-2731687	-3898978	-2936069	-3461872	-4508556	-5096916	-7691520	-11379228	-14310965	-18342230	-24627393	-26411142	-25852214	-26578745	-26819733	-25669565	-26506705

System 1 *MX*

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Whole-farm multi-period bu	**System 1 *MX***																				
Yield potential based on rainfall distribution																					
1	**Poor**																				
2	**Average**																				
3	**Good**																				
Year		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Wheat: Year clasification (poor, avergae, good)		2	3	2	1	2	3	2	2	3	2	2	3	2	1	2	3	2	2	3	2
Gross Margin																					
Crop	Hectares																				
Wheat after cover grazed	404	3964089	5260450	3964089	1371368	3964089	5260450	3964089	3964089	5260450	3964089	3964089	5260450	3964089	1371368	3964089	5260450	3964089	3964089	5260450	3964089
Cover crops	404	-24648	-24648	-24648	-24648	-24648	-24648	-24648	-24648	-24648	-24648	-24648	-24648	-24648	-24648	-24648	-24648	-24648	-24648	-24648	-24648
Capital sales		0	0	0	0	363542	166375	0	262570	305792	729325	365542	16792	178500	13625	0	0	0	0	0	363542
Gross margin: total farming	**808**	**3939441**	**5235801**	**3939441**	**1346720**	**4302983**	**5402176**	**3939441**	**4202011**	**5541593**	**4668766**	**4304983**	**5252593**	**4117941**	**1360345**	**3939441**	**5235801**	**3939441**	**3939441**	**5235801**	**4302983**
Overhead and fixed costs																					
Municipal taxes		14875	14875	14875	14875	14875	14875	14875	14875	14875	14875	14875	14875	14875	14875	14875	14875	14875	14875	14875	14875
Insurance (overall)		450000	450000	450000	450000	450000	450000	450000	450000	450000	450000	450000	450000	450000	450000	450000	450000	450000	450000	450000	450000
Licenses		21500	21500	21500	21500	21500	21500	21500	21500	21500	21500	21500	21500	21500	21500	21500	21500	21500	21500	21500	21500
Electricity		200000	200000	200000	200000	200000	200000	200000	200000	200000	200000	200000	200000	200000	200000	200000	200000	200000	200000	200000	200000
Banking fees		50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000
Telephone		20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000
Administration		30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000
Auditors & Consultation fees		80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000
Provision: camps		20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000
Provision: water distribution		20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000
Provision: buildings		45000	45000	45000	45000	45000	45000	45000	45000	45000	45000	45000	45000	45000	45000	45000	45000	45000	45000	45000	45000
Employee wages		250500	250500	250500	250500	250500	250500	250500	250500	250500	250500	250500	250500	250500	250500	250500	250500	250500	250500	250500	250500
Owners remuneration		550000	550000	550000	550000	550000	550000	550000	550000	550000	550000	550000	550000	550000	550000	550000	550000	550000	550000	550000	550000
Miscellaneous costs (5%)		87594	87594	87594	87594	87594	87594	87594	87594	87594	87594	87594	87594	87594	87594	87594	87594	87594	87594	87594	87594
Totaal:		**1839469**	**1839469**	**1839469**	**1839469**	**1839469**	**1839469**	**1839469**	**1839469**	**1839469**	**1839469**	**1839469**	**1839469**	**1839469**	**1839469**	**1839469**	**1839469**	**1839469**	**1839469**	**1839469**	**1839469**
Margin above overhead and fixed costs		**2099972**	**3396333**	**2099972**	**-492749**	**2463514**	**3562708**	**2099972**	**2362542**	**3702124**	**2829297**	**2465514**	**3413124**	**2278472**	**-479124**	**2099972**	**3396333**	**2099972**	**2099972**	**3396333**	**2463514**
Foreign factor cost:																					
Rent																					
Hired management																					
Interest																					
Total		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Margin above foreign factor costs		**2099972**	**3396333**	**2099972**	**-492749**	**2463514**	**3562708**	**2099972**	**2362542**	**3702124**	**2829297**	**2465514**	**3413124**	**2278472**	**-479124**	**2099972**	**3396333**	**2099972**	**2099972**	**3396333**	**2463514**

Capital																					
Long term:																					
Land and fixed improvements		42500000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Intermediate:	Age																				
Harvesters:																					
Harvester with straight header	5	2550000	0	0	0	0	0	0	0	0	0	3825000	0	0	0	0	0	0	0	0	0
Harvester with straight header	6	2295000	0	0	0	0	0	0	0	0	3825000	0	0	0	0	0	0	0	0	0	0
Tractors:																					
1	10	274667	0	0	0	0	824000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	11	299733	0	0	0	1124000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1124000
3	7	952533	0	0	0	0	0	0	0	1786000	0	0	0	0	0	0	0	0	0	0	0
4	8	1029700	0	0	0	0	0	0	2206500	0	0	0	0	0	0	0	0	0	0	0	0
5	6	2322600	0	0	0	0	0	0	0	0	3871000	0	0	0	0	0	0	0	0	0	0
Sprayer:																					
Boom	7	665867	0	0	0	0	0	0	0	1248500	0	0	0	0	0	0	0	0	0	0	0
Spreaders:	0																				
Fertilizer 6.4t precision	6	304500	0	0	0	0	0	0	0	0	507500	0	0	0	0	0	0	0	0	0	0
Planters:																					
1	3	1575200	0	0	0	0	0	0	0	0	0	0	0	1969000	0	0	0	0	0	0	0
Swather:																					
Haybine	11	608800	0	0	0	2283000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2283000
Loaders:																					
Frontend general	2	141700	0	0	0	0	0	0	0	0	0	0	0	0	163500	0	0	0	0	0	0
Haymaking equipment																					
Finger wheel rake	7	165067	0	0	0	0	0	0	0	309500	0	0	0	0	0	0	0	0	0	0	0
Baler	7	173600	0	0	0	0	0	0	0	325500	0	0	0	0	0	0	0	0	0	0	0
Feeding equipment																					
Milling feed	8	107800	0	0	0	0	0	0	231000	0	0	0	0	0	0	0	0	0	0	0	0
Feed mixing	8	296445	0	0	0	0	0	0	635239	0	0	0	0	0	0	0	0	0	0	0	0
Other:																					
Roller crimper	8	36447	0	0	0	0	0	0	78100	0	0	0	0	0	0	0	0	0	0	0	0
Road scraper	3	138400	0	0	0	0	0	0	0	0	0	0	0	173000	0	0	0	0	0	0	0
Water car	4	147767	0	0	0	0	0	0	0	0	0	0	201500	0	0	0	0	0	0	0	0
Diesel car	5	44333	0	0	0	0	0	0	0	0	0	66500	0	0	0	0	0	0	0	0	0
Side tipper	11	254800	0	0	0	955500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	955500
Livestock Trailer	6	57000	0	0	0	0	0	0	0	0	95000	0	0	0	0	0	0	0	0	0	0
Lorrie	10	390833	0	0	0	0	1172500	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bakkies:																					
1	6	272040	0	0	0	0	0	0	0	0	453400	0	0	0	0	0	0	0	0	0	0
2	5	330000	0	0	0	0	0	0	0	0	0	495000	0	0	0	0	0	0	0	0	0
General tools (Mixed Livestock)		320000																			
Total intermediary capital:		15754832	0	0	0	4362500	1996500	0	3150839	3669500	8751900	4386500	201500	2142000	163500	0	0	0	0	0	4362500
Livestock		2961506																			
Total capital:		61216338	0	0	0	4362500	1996500	0	3150839	3669500	8751900	4386500	201500	2142000	163500	0	0	0	0	0	4362500
Net annual flow:		-59116366	3396333	2099972	-492749	-1898986	1566208	2099972	-788297	32624	-5922603	-1920986	3211624	136472	-642624	2099972	3396333	2099972	2099972	3396333	54887160
IRR	0.87%																				
NPV	-R8,494,377.11																				
Cashflow:																					
Opening balance		0	124436	1570530	1722930	-786383	-1381990	193130	307516	-55383	73126	-1779778	-4695566	-6815262	-9992284	-15378805	-16193999	-14616176	-14270858	-13384288	-11047961
Inflow		3939441	5235801	3939441	1346720	4302983	5402176	3939441	4202011	5541593	4668766	4304983	5252593	4117941	1360345	3939441	5235801	3939441	3939441	5235801	4302983
Outflow		3817182	3817182	3817182	3817182	4830312	3830435	3830435	4562173	5414363	6433740	6988784	7035580	6801291	5987071	3954565	2935862	2889066	2391617	2353646	3366776
Flow before interest		122259	1543055	1692789	-747532	-1313712	189752	302136	-52647	71847	-1691848	-4463580	-6478552	-9498612	-14619010	-15393929	-13894059	-13565801	-12723034	-10502133	-10111755
Interest		2177	27475	30141	-38852	-68278	3379	5380	-2736	1279	-87930	-231986	-336710	-493672	-759795	-800069	-722117	-705056	-661255	-545828	-525539
Closing balance		124436	1570530	1722930	-786383	-1381990	193130	307516	-55383	73126	-1779778	-4695566	-6815262	-9992284	-15378805	-16193999	-14616176	-14270858	-13384288	-11047961	-10637293

System 2 *S*

Whole-farm multi-period bu	**System 2 S**																				
Yield potential based on rainfall distribution																					
1	**Poor**																				
2	**Average**																				
3	**Good**																				
Year		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Wheat aft medics baled: Year clasification (p		2	3	2	1	2	3	2	2	3	2	2	3	2	1	2	3	2	2	3	2
Medics bale: Year clasification (poor, avergae		2	3	2	1	2	3	2	2	3	2	2	3	2	1	2	3	2	2	3	2
Gross Margin																					
Crop	Hectares																				
Wheat after medics baled	269	3027644	3666134	3027644	1097765	3027644	3666134	3027644	3027644	3666134	3027644	3027644	3666134	3027644	1097765	3027644	3666134	3027644	3027644	3666134	3027644
Cover crops	269	-84953	-84953	-84953	-84953	-84953	-84953	-84953	-84953	-84953	-84953	-84953	-84953	-84953	-84953	-84953	-84953	-84953	-84953	-84953	-84953
Medics baled	269	965651	2075963	965651	-144662	965651	2075963	965651	965651	2075963	965651	965651	2075963	965651	-144662	965651	2075963	965651	965651	2075963	965651
Capital sales		0	0	0	0	363542	166375	0	262570	305792	402658	365542	16792	178500	13625	0	0	0	0	0	363542
Gross margin: total farming	**538**	**3908342**	**5657145**	**3908342**	**868150**	**4271884**	**5823520**	**3908342**	**4170912**	**5962936**	**4311000**	**4273884**	**5673936**	**4086842**	**881775**	**3908342**	**5657145**	**3908342**	**3908342**	**5657145**	**4271884**
Overhead and fixed costs																					
Municipal taxes		14875	14875	14875	14875	14875	14875	14875	14875	14875	14875	14875	14875	14875	14875	14875	14875	14875	14875	14875	14875
Insurance (overall)		450000	450000	450000	450000	450000	450000	450000	450000	450000	450000	450000	450000	450000	450000	450000	450000	450000	450000	450000	450000
Licenses		21000	21000	21000	21000	21000	21000	21000	21000	21000	21000	21000	21000	21000	21000	21000	21000	21000	21000	21000	21000
Electricity		200000	200000	200000	200000	200000	200000	200000	200000	200000	200000	200000	200000	200000	200000	200000	200000	200000	200000	200000	200000
Banking fees		50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000
Telephone		20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000
Administration		30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000
Auditors & Consultation fees		80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000
Provision: camps		20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000
Provision: water distribution		20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000
Provision: buildings		45000	45000	45000	45000	45000	45000	45000	45000	45000	45000	45000	45000	45000	45000	45000	45000	45000	45000	45000	45000
Employee wages		250500	250500	250500	250500	250500	250500	250500	250500	250500	250500	250500	250500	250500	250500	250500	250500	250500	250500	250500	250500
Owners remuneration		550000	550000	550000	550000	550000	550000	550000	550000	550000	550000	550000	550000	550000	550000	550000	550000	550000	550000	550000	550000
Miscellaneous costs (5%)		87568.75	87568.75	87568.75	87568.75	87568.75	87568.75	87568.75	87568.75	87568.75	87568.75	87568.75	87568.75	87568.75	87568.75	87568.75	87568.75	87568.75	87568.75	87568.75	87568.75
Totaal:		**1838944**	**1838944**	**1838944**	**1838944**	**1838944**	**1838944**	**1838944**	**1838944**	**1838944**	**1838944**	**1838944**	**1838944**	**1838944**	**1838944**	**1838944**	**1838944**	**1838944**	**1838944**	**1838944**	**1838944**
Margin above overhead and fixed costs		**2069398**	**3818201**	**2069398**	**-970793**	**2432940**	**3984576**	**2069398**	**2331968**	**4123993**	**2472057**	**2434940**	**3834993**	**2247898**	**-957168**	**2069398**	**3818201**	**2069398**	**2069398**	**3818201**	**2432940**
Foreign factor cost:																					
Rent																					
Hired management																					
Interest																					
Total		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Margin above foreign factor costs		**2069398**	**3818201**	**2069398**	**-970793**	**2432940**	**3984576**	**2069398**	**2331968**	**4123993**	**2472057**	**2434940**	**3834993**	**2247898**	**-957168**	**2069398**	**3818201**	**2069398**	**2069398**	**3818201**	**2432940**

Capital																					
Long term:																					
Land and fixed improvements		42500000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Intermediate:	Age																				
Harvesters:																					
Harvester with straight header	5	2550000	0	0	0	0	0	0	0	0	0	3825000	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tractors:																					
1	10	274667	0	0	0	0	824000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	11	299733	0	0	0	1124000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1124000
3	7	952533	0	0	0	0	0	0	0	1786000	0	0	0	0	0	0	0	0	0	0	0
4	8	1029700	0	0	0	0	0	0	2206500	0	0	0	0	0	0	0	0	0	0	0	0
5	6	2322600	0	0	0	0	0	0	0	0	3871000	0	0	0	0	0	0	0	0	0	0
Sprayer:																					
Boom	7	665867	0	0	0	0	0	0	0	1248500	0	0	0	0	0	0	0	0	0	0	0
Spreaders:	0																				
Fertilizer 6.4t precision	6	304500	0	0	0	0	0	0	0	0	507500	0	0	0	0	0	0	0	0	0	0
Planters:																					
1	3	1575200	0	0	0	0	0	0	0	0	0	0	0	1969000	0	0	0	0	0	0	0
Swather:																					
Haybine	11	608800	0	0	0	2283000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2283000
Loaders:																					
Front end general	2	141700	0	0	0	0	0	0	0	0	0	0	0	0	163500	0	0	0	0	0	0
Haymaking equipment:																					
Finger wheel rake	7	165067	0	0	0	0	0	0	0	309500	0	0	0	0	0	0	0	0	0	0	0
Baler	7	173600	0	0	0	0	0	0	0	325500	0	0	0	0	0	0	0	0	0	0	0
Feeding equipment:																					
Milling feed	8	107800	0	0	0	0	0	0	231000	0	0	0	0	0	0	0	0	0	0	0	0
Feed mixing	8	296445	0	0	0	0	0	0	635239	0	0	0	0	0	0	0	0	0	0	0	0
Other:																					
Roller crimper	8	36447	0	0	0	0	0	0	78100	0	0	0	0	0	0	0	0	0	0	0	0
Road scraper	3	138400	0	0	0	0	0	0	0	0	0	0	0	173000	0	0	0	0	0	0	0
Water car	4	147767	0	0	0	0	0	0	0	0	0	0	201500	0	0	0	0	0	0	0	0
Diesel car	5	44333	0	0	0	0	0	0	0	0	0	66500	0	0	0	0	0	0	0	0	0
Side tipper	11	254800	0	0	0	955500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	955500
Lorrie	10	390833	0	0	0	0	1172500	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bakkies:																					
1	6	272040	0	0	0	0	0	0	0	0	453400	0	0	0	0	0	0	0	0	0	0
2	5	330000	0	0	0	0	0	0	0	0	0	495000	0	0	0	0	0	0	0	0	0
General tools		200000																			
Total intermediary capital:		13282832	0	0	0	4362500	1996500	0	3150839	3669500	4831900	4386500	201500	2142000	163500	0	0	0	0	0	4362500
Livestock		1083396																			
Total capital:		56866227	0	0	0	4362500	1996500	0	3150839	3669500	4831900	4386500	201500	2142000	163500	0	0	0	0	0	4362500
Net annual flow:		-54796829	3818201	2069398	-970793	-1929560	1988076	2069398	-818871	454493	-2359843	-1951560	3633493	105898	-1120668	2069398	3818201	2069398	2069398	3818201	54228320
IRR	1.71%																				
NPV	-R666,489.43																				
			-R666,489.43																		
Cashflow:																					
Opening balance		0	409154	2605535	3061083	430417	186081	2300615	2503520	2232516	2913256	1813814	92092	-292433	-2120057	-6557775	-6861806	-4270297	-3334565	-1826897	1585541
Inflow		3908342	5657145	3908342	868150	4271884	5823520	3908342	4170912	5962936	4311000	4273884	5673936	4086842	881775	3908342	5657145	3908342	3908342	5657145	4271884
Outflow		3506345	3506345	3506345	3506345	4519475	3749233	3749233	4480972	5333162	5442173	5997217	6044013	5809724	4995505	3873364	2854660	2807865	2310415	2272445	3285574
Flow before interest		401997	2559954	3007532	422888	182826	2260368	2459724	2193461	2862291	1782083	90480	-277985	-2015315	-6233786	-6522797	-4059322	-3169820	-1736639	1557803	2571850
Interest		7158	45581	53551	7530	3255	40247	43797	39056	50965	31731	1611	-14448	-104742	-323989	-339010	-210975	-164745	-90258	27738	45793
Closing balance		409154	2605535	3061083	430417	186081	2300615	2503520	2232516	2913256	1813814	92092	-292433	-2120057	-6557775	-6861806	-4270297	-3334565	-1826897	1585541	2617643

System 2 *BC*

Whole-farm multi-period bu	**System 2 *BC***																				
Yield potential based on rainfall distribution																					
1	**Poor**																				
2	**Average**																				
3	**Good**																				
Year		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Wheat aft medics baled: Year clasification (poo		2	3	2	1	2	3	2	2	3	2	2	3	2	1	2	3	2	2	3	2
Medics bale: Year clasification (poor, avergae,		2	3	2	1	2	3	2	2	3	2	2	3	2	1	2	3	2	2	3	2
Gross Margin																					
Crop	Hectares																				
Wheat after medics baled	269	3027644	3666134	3027644	1097765	3027644	3666134	3027644	3027644	3666134	3027644	3027644	3666134	3027644	1097765	3027644	3666134	3027644	3027644	3666134	3027644
Cover crops	269	-329466	-329466	-329466	-329466	-329466	-329466	-329466	-329466	-329466	-329466	-329466	-329466	-329466	-329466	-329466	-329466	-329466	-329466	-329466	-329466
Medics baled	269	965651	2075963	965651	-144662	965651	2075963	965651	965651	2075963	965651	965651	2075963	965651	-144662	965651	2075963	965651	965651	2075963	965651
Capital sales		0	0	0	0	363542	166375	0	262570	305792	402658	365542	16792	178500	13625	0	0	0	0	0	363542
Gross margin : total farming	**538**	**3663829**	**5412631**	**3663829**	**623637**	**4027370**	**5579006**	**3663829**	**3926398**	**5718423**	**4066487**	**4029370**	**5429423**	**3842329**	**637262**	**3663829**	**5412631**	**3663829**	**3663829**	**5412631**	**4027370**
Overhead and fixed costs																					
Municipal taxes		14875	14875	14875	14875	14875	14875	14875	14875	14875	14875	14875	14875	14875	14875	14875	14875	14875	14875	14875	14875
Insurance (overall)		450000	450000	450000	450000	450000	450000	450000	450000	450000	450000	450000	450000	450000	450000	450000	450000	450000	450000	450000	450000
Licenses		21000	21000	21000	21000	21000	21000	21000	21000	21000	21000	21000	21000	21000	21000	21000	21000	21000	21000	21000	21000
Electricity		200000	200000	200000	200000	200000	200000	200000	200000	200000	200000	200000	200000	200000	200000	200000	200000	200000	200000	200000	200000
Banking fees		50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000
Telephone		20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000
Administration		30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000
Auditors & Consultation fees		80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000
Provision: camps		20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000
Provision: water distribution		20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000
Provision: buildings		45000	45000	45000	45000	45000	45000	45000	45000	45000	45000	45000	45000	45000	45000	45000	45000	45000	45000	45000	45000
Employee wages		250500	250500	250500	250500	250500	250500	250500	250500	250500	250500	250500	250500	250500	250500	250500	250500	250500	250500	250500	250500
Owners remuneration		550000	550000	550000	550000	550000	550000	550000	550000	550000	550000	550000	550000	550000	550000	550000	550000	550000	550000	550000	550000
Miscellaneous costs (5%)		87569	87569	87569	87569	87569	87569	87569	87569	87569	87569	87569	87569	87569	87569	87569	87569	87569	87569	87569	87569
Totaal:		**1838944**	**1838944**	**1838944**	**1838944**	**1838944**	**1838944**	**1838944**	**1838944**	**1838944**	**1838944**	**1838944**	**1838944**	**1838944**	**1838944**	**1838944**	**1838944**	**1838944**	**1838944**	**1838944**	**1838944**
Margin above overhead and fixed costs		**1824885**	**3573688**	**1824885**	**-1215307**	**2188426**	**3740063**	**1824885**	**2087455**	**3879479**	**2227543**	**2190426**	**3590479**	**2003385**	**-1201682**	**1824885**	**3573688**	**1824885**	**1824885**	**3573688**	**2188426**
Foreign factor cost:																					
Rent																					
Hired management																					
Interest																					
Total		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Margin above foreign factor costs		**1824885**	**3573688**	**1824885**	**-1215307**	**2188426**	**3740063**	**1824885**	**2087455**	**3879479**	**2227543**	**2190426**	**3590479**	**2003385**	**-1201682**	**1824885**	**3573688**	**1824885**	**1824885**	**3573688**	**2188426**

Capital																					
Long term:																					
Land and fixed improvements		42500000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Intermediate:	Age																				
Harvesters:																					
Harvester with straight header	5	2550000	0	0	0	0	0	0	0	0	0	3825000	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tractors:																					
1	10	274667	0	0	0	0	824000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	11	299733	0	0	0	1124000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1124000
3	7	952533	0	0	0	0	0	0	0	1786000	0	0	0	0	0	0	0	0	0	0	0
4	8	1029700	0	0	0	0	0	0	2206500	0	0	0	0	0	0	0	0	0	0	0	0
5	6	2322600	0	0	0	0	0	0	0	0	3871000	0	0	0	0	0	0	0	0	0	0
Sprayer:																					
Boom	7	665867	0	0	0	0	0	0	0	1248500	0	0	0	0	0	0	0	0	0	0	0
Spreaders:	0																				
Fertilizer 6.4t precision	6	304500	0	0	0	0	0	0	0	0	507500	0	0	0	0	0	0	0	0	0	0
Planters:																					
1	3	1575200	0	0	0	0	0	0	0	0	0	0	0	1969000	0	0	0	0	0	0	0
Swather:																					
Haybine	11	608800	0	0	0	2283000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2283000
Loaders:																					
Front end general	2	141700	0	0	0	0	0	0	0	0	0	0	0	0	163500	0	0	0	0	0	0
Haymaking equipment:																					
Finger wheel rake	7	165067	0	0	0	0	0	0	0	309500	0	0	0	0	0	0	0	0	0	0	0
Baler	7	173600	0	0	0	0	0	0	0	325500	0	0	0	0	0	0	0	0	0	0	0
Feeding equipment:																					
Milling feed	8	107800	0	0	0	0	0	0	231000	0	0	0	0	0	0	0	0	0	0	0	0
Feed mixing	8	296445	0	0	0	0	0	0	635239	0	0	0	0	0	0	0	0	0	0	0	0
Other:																					
Roller crimper	8	36447	0	0	0	0	0	0	78100	0	0	0	0	0	0	0	0	0	0	0	0
Road scraper	3	138400	0	0	0	0	0	0	0	0	0	0	0	173000	0	0	0	0	0	0	0
Water car	4	147767	0	0	0	0	0	0	0	0	0	0	201500	0	0	0	0	0	0	0	0
Diesel car	5	44333	0	0	0	0	0	0	0	0	0	66500	0	0	0	0	0	0	0	0	0
Side tipper	11	254800	0	0	0	955500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	955500
Lorrie	10	390833	0	0	0	0	1172500	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bakkies:																					
1	6	272040	0	0	0	0	0	0	0	0	453400	0	0	0	0	0	0	0	0	0	0
2	5	330000	0	0	0	0	0	0	0	0	0	495000	0	0	0	0	0	0	0	0	0
General tools		200000																			
Total intermediary capital:		13282832	0	0	0	4362500	1996500	0	3150839	3669500	4831900	4386500	201500	2142000	163500	0	0	0	0	0	4362500
Livestock		0																			
Total capital:		55782832	0	0	0	4362500	1996500	0	3150839	3669500	4831900	4386500	201500	2142000	163500	0	0	0	0	0	4362500
Net annual flow:		-53957947	3573688	1824885	-1215307	-2174074	1743563	1824885	-1063384	209979	-2604357	-2196074	3388979	-138615	-1365182	1824885	3573688	1824885	1824885	3573688	52900411
IRR	1.27%																				
NPV	-R4,447,354.31																				
Cashflow:																					
Opening balance		0	160287	2103370	2301109	-611827	-1161307	680368	605557	51892	444937	-979123	-3100134	-3907789	-6180536	-11086511	-11883136	-9809823	-9419218	-8485010	-5622610
Inflow		3663829	5412631	3663829	623637	4027370	5579006	3663829	3926398	5718423	4066487	4029370	5429423	3842329	637262	3663829	5412631	3663829	3663829	5412631	4027370
Outflow		3506345	3506345	3506345	3506345	4519475	3749233	3749233	4480972	5333162	5442173	5997217	6044013	5809724	4995505	3873364	2854660	2807865	2310415	2272445	3285574
Flow before interest		157483	2066573	2260853	-581600	-1103932	668466	594964	50984	437153	-930750	-2946971	-3714723	-5875185	-10538779	-11296046	-9325165	-8953859	-8065805	-5344823	-4880814
Interest		2804	36797	40256	-30228	-57375	11902	10594	908	7784	-48374	-153163	-193066	-305351	-547732	-587090	-484657	-465359	-419204	-277787	-253671
Closing balance		160287	2103370	2301109	-611827	-1161307	680368	605557	51892	444937	-979123	-3100134	-3907789	-6180536	-11086511	-11883136	-9809823	-9419218	-8485010	-5622610	-5134485

System 2 *MX*

Whole-farm multi-period bu	**System 2 *MX***																				
Yield potential based on rainfall distribution																					
1	**Poor**																				
2	**Average**																				
3	**Good**																				
Year		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Wheat aft medics baled: Year clasification (p		2	3	2	1	2	3	2	2	3	2	2	3	2	1	2	3	2	2	3	2
Medics bale: Year clasification (poor, averga		2	3	2	1	2	3	2	2	3	2	2	3	2	1	2	3	2	2	3	2
Gross Margin																					
Crop	Hectares																				
Wheat after medics baled	269	3027644	3666134	3027644	1097765	3027644	3666134	3027644	3027644	3666134	3027644	3027644	3666134	3027644	1097765	3027644	3666134	3027644	3027644	3666134	3027644
Cover crops	269	-16432	-16432	-16432	-16432	-16432	-16432	-16432	-16432	-16432	-16432	-16432	-16432	-16432	-16432	-16432	-16432	-16432	-16432	-16432	-16432
Medics baled	269	965651	2075963	965651	-144662	965651	2075963	965651	965651	2075963	965651	965651	2075963	965651	-144662	965651	2075963	965651	965651	2075963	965651
Capital sales		0	0	0	0	363542	166375	0	262570	305792	410575	365542	16792	178500	13625	0	0	0	0	0	363542
Gross margin: total farming	**538**	**3976863**	**5725665**	**3976863**	**936671**	**4340404**	**5892040**	**3976863**	**4239433**	**6031457**	**4387438**	**4342404**	**5742457**	**4155363**	**950296**	**3976863**	**5725665**	**3976863**	**3976863**	**5725665**	**4340404**
Overhead and fixed costs																					
Municipal taxes		14875	14875	14875	14875	14875	14875	14875	14875	14875	14875	14875	14875	14875	14875	14875	14875	14875	14875	14875	14875
Insurance (overall)		450000	450000	450000	450000	450000	450000	450000	450000	450000	450000	450000	450000	450000	450000	450000	450000	450000	450000	450000	450000
Licenses		21000	21000	21000	21000	21000	21000	21000	21000	21000	21000	21000	21000	21000	21000	21000	21000	21000	21000	21000	21000
Electricity		200000	200000	200000	200000	200000	200000	200000	200000	200000	200000	200000	200000	200000	200000	200000	200000	200000	200000	200000	200000
Banking fees		50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000
Telephone		20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000
Administration		30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000
Auditors & Consultation fees		80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000
Provision: camps		20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000
Provision: water distribution		20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000
Provision: buildings		45000	45000	45000	45000	45000	45000	45000	45000	45000	45000	45000	45000	45000	45000	45000	45000	45000	45000	45000	45000
Employee wages		250500	250500	250500	250500	250500	250500	250500	250500	250500	250500	250500	250500	250500	250500	250500	250500	250500	250500	250500	250500
Owners remuneration		550000	550000	550000	550000	550000	550000	550000	550000	550000	550000	550000	550000	550000	550000	550000	550000	550000	550000	550000	550000
Miscellaneous costs (5%)		87569	87569	87569	87569	87569	87569	87569	87569	87569	87569	87569	87569	87569	87569	87569	87569	87569	87569	87569	87569
Totaal:		**1838944**	**1838944**	**1838944**	**1838944**	**1838944**	**1838944**	**1838944**	**1838944**	**1838944**	**1838944**	**1838944**	**1838944**	**1838944**	**1838944**	**1838944**	**1838944**	**1838944**	**1838944**	**1838944**	**1838944**
Margin above overhead and fixed costs		**2137919**	**3886722**	**2137919**	**-902273**	**2501461**	**4053097**	**2137919**	**2400489**	**4192513**	**2548494**	**2503461**	**3903513**	**2316419**	**-888648**	**2137919**	**3886722**	**2137919**	**2137919**	**3886722**	**2501461**
Foreign factor cost:																					
Rent																					
Hired management																					
Interest																					
Total		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Margin above foreign factor costs		**2137919**	**3886722**	**2137919**	**-902273**	**2501461**	**4053097**	**2137919**	**2400489**	**4192513**	**2548494**	**2503461**	**3903513**	**2316419**	**-888648**	**2137919**	**3886722**	**2137919**	**2137919**	**3886722**	**2501461**

Capital																					
Long term:																					
Land and fixed improvements		42500000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Intermediate:	Age																				
Harvesters:																					
Harvester with straight header	5	2550000	0	0	0	0	0	0	0	0	0	3825000	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tractors:																					
1	10	274667	0	0	0	0	824000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	11	299733	0	0	0	1124000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1124000
3	7	952533	0	0	0	0	0	0	0	1786000	0	0	0	0	0	0	0	0	0	0	0
4	8	1029700	0	0	0	0	0	0	2206500	0	0	0	0	0	0	0	0	0	0	0	0
5	6	2322600	0	0	0	0	0	0	0	0	3871000	0	0	0	0	0	0	0	0	0	0
Sprayer:																					
Boom	7	665867	0	0	0	0	0	0	0	1248500	0	0	0	0	0	0	0	0	0	0	0
Spreaders:	0																				
Fertilizer 6.4t precision	6	304500	0	0	0	0	0	0	0	0	507500	0	0	0	0	0	0	0	0	0	0
Planters:																					
1	3	1575200	0	0	0	0	0	0	0	0	0	0	0	1969000	0	0	0	0	0	0	0
Swather:																					
Haybine	11	608800	0	0	0	2283000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2283000
Loaders:																					
Front end general	2	141700	0	0	0	0	0	0	0	0	0	0	0	0	163500	0	0	0	0	0	0
Haymaking equipment																					
Finger wheel rake	7	165067	0	0	0	0	0	0	0	309500	0	0	0	0	0	0	0	0	0	0	0
Baler	7	173600	0	0	0	0	0	0	0	325500	0	0	0	0	0	0	0	0	0	0	0
Feeding equipment:																					
Milling feed	8	107800	0	0	0	0	0	0	231000	0	0	0	0	0	0	0	0	0	0	0	0
Feed mixing	8	296445	0	0	0	0	0	0	635239	0	0	0	0	0	0	0	0	0	0	0	0
Other:																					
Roller crimper	8	36447	0	0	0	0	0	0	78100	0	0	0	0	0	0	0	0	0	0	0	0
Road scraper	3	138400	0	0	0	0	0	0	0	0	0	0	0	173000	0	0	0	0	0	0	0
Water car	4	147767	0	0	0	0	0	0	0	0	0	0	201500	0	0	0	0	0	0	0	0
Diesel car	5	44333	0	0	0	0	0	0	0	0	0	66500	0	0	0	0	0	0	0	0	0
Side tipper	11	254800	0	0	0	955500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	955500
Livestock Trailer	6	57000	0	0	0	0	0	0	0	0	95000	0	0	0	0	0	0	0	0	0	0
Lorrie	10	390833	0	0	0	0	1172500	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bakkies:																					
1	6	272040	0	0	0	0	0	0	0	0	453400	0	0	0	0	0	0	0	0	0	0
2	5	330000	0	0	0	0	0	0	0	0	0	495000	0	0	0	0	0	0	0	0	0
General tools (Mixed Livestock)		320000																			
Total intermediary capital:		13459832	0	0	0	4362500	1996500	0	3150839	3669500	4926900	4386500	201500	2142000	163500	0	0	0	0	0	4362500
Livestock		650038																			
Total capital:		56609869	0	0	0	4362500	1996500	0	3150839	3669500	4926900	4386500	201500	2142000	163500	0	0	0	0	0	4362500
Net annual flow:		-54471950	3886722	2137919	-902273	-1861039	2056597	2137919	-750350	523013	-2378406	-1883039	3702013	174419	-1052148	2137919	3886722	2137919	2137919	3886722	53786638
IRR	1.81%																				
NPV	R298,430.51																				
Cashflow:																					
Opening balance		0	456281	2700627	3204994	624017	430254	2612997	2885326	2684981	3437638	2396997	727064	404750	-1343843	-5698423	-5891786	-3183857	-2125654	-489150	3010968
Inflow		3976863	5725665	3976863	936671	4340404	5892040	3976863	4239433	6031457	4387438	4342404	5742457	4155363	950296	3976863	5725665	3976863	3976863	5725665	4340404
Outflow		3528564	3528564	3528564	3528564	4541694	3755010	3755010	4486748	5338938	5470012	6025056	6071852	5837563	5023344	3879140	2860437	2813641	2316192	2278221	3291351
Flow before interest		448298	2653382	3148925	613100	422727	2567285	2834849	2638010	3377500	2355064	714345	397670	-1277450	-5416891	-5600700	-3026558	-2020636	-464983	2958294	4060022
Interest		7982	47245	56068	10917	7527	45712	50476	46971	60138	41933	12719	7081	-66393	-281532	-291085	-157299	-105019	-24167	52674	72291
Closing balance		456281	2700627	3204994	624017	430254	2612997	2885326	2684981	3437638	2396997	727064	404750	-1343843	-5698423	-5891786	-3183857	-2125654	-489150	3010968	4132313