The financial implications of cover crops in summer cereal systems in the Eastern Free State area over the long term.

by

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Abstract

Global population growth places tremendous pressure on the world's natural resources. One of the greatest challenges for South Africa's agricultural sector is to produce enough food for a growing population, with less available arable land. Conventional farming practices therefore need to be replaced by more sustainable farming practices. These practices will ensure sustained food security by efficiently utilising natural resources and thereby optimising agricultural productivity.

Conservation agriculture (CA) is the most holistic approach to sustainable agriculture based on the three main principles namely: minimum soil disturbance, maximum soil coverage, and crop rotations. South African farmers began implementing crop rotation practices after the deregulation of the agricultural sector in the 1990s. It was implemented to counteract the risks associated with the liberalised market. Introducing cover crops in a rotation system is a conservation agriculture practice of which the physical/biological benefits are well known. However, the financial implications relating to implementing cover crops in a summer cereal rotation system at farm-level is unknown. This study makes use of three different systems to evaluate the financial implications over an extended time period.

For this study the complex, interrelated components and multi-faceted farm system requires a systems approach, more specifically a typical farm approach. Whole-farm budget models which are based on a typical farm within a relative homogenous area in the Eastern Free State, are developed to compare the various systems. The models, developed in Microsoft Excel spreadsheet programs, are used to bridge the gap between various disciplines relating to scientific knowledge. Multidisciplinary group discussions further assisted in integrating knowledge between disciplines and ensured accurate representations of the various systems developed in the models. The components in the model are all interrelated; therefore, a change in one component has a latter effect on the profit of the whole-farm system.

The whole-farm profitability for various crop rotation systems were measured based on the Internal Rate of Return (IRR) and Net Present Value (NPV) during the financial evaluation. The evaluation concluded that System 1, which is a maize-soya bean rotation system, is the most profitable at this point in time. The system

achieves an IRR value of 17 percent over a random 20-year period. The other two systems are also profitable but obtained lower IRR values. The lower overall profitability of the systems is attributed to the non-cash crops planted. The financial benefits of cover crops are directly related to improved overall soil health, yields, and lower weed and pest infestations.

Opsomming

Die toenemende wêreldbevolking plaas geweldige druk op die aarde se natuurlike hulpbronne. Een van die grootste uitdagings vir Suid-Afrika se landbousektor is om meer voedsel vir die groeiende bevolking te produseer met al minder bewerkbare grond. Konvensionele boerderypraktyke moet dus vervang word met meer volhoubare landboupraktyke. Hierdie praktyke sal volhoubare voedelsekuriteit verseker deur natuurlike hulpbronne effektief te benut wat verder tot verbetererde landbou produktiwiteit lei.

Tot op hede is bewaringslandbou die mees holistiese benadering tot volhoubare landboupraktyke. Dit is gebasseer op drie geïntegreerde beginsels naamlik: minimum grondversteuring, maksimum grondbedekking en wisselbou. Na die deregulering van die Suid-Afrikaanse landbousektor in die 1990's, het al meer boere wisselbou praktyke begin implementeer. Die hoofrede was om risko's te verskans wat met die geliberaliseerde mark gepaard gegaan het. Dekgewasse wat in 'n wisselboustelsel geïmplementeer word, vorm ook deel van bewaringslandbou waarvan die fisies/biologies voordele alom bekend is. Die finansiële implikasie wat gepaard gaan met dekgewasse in somergraan wisselboustelsels op plaasvlak, is minder bekend op die stadium. Hierdie studie maak dus gebruik van drie verskillende stelsels om sodoende die finansiële implikasie te identifiseer oor 'n gegewe tydperk.

Die komplekse, interafhanklike komponente en multi-fasette van die boerderystelsel in hierdie studie benodig 'n stelselsraamwerk, meer spesifiek 'n tipiese plaasstelsel. 'n Geheelplaas begrotingsmodel word as basis gebruik om vergelykings mee te tref. Die modelle is gebasseer op 'n tipiese plaasstelsel in die relatief homogene boerderygebied in die Oos-Vrystaat en word met behulp van Microsoft Excel geskep. Die modellering van volledige boerdery modelle skep die geleentheid vir die navorser om die kennis van die multi-dissiplinêre groepsgesprekke te integreer binne meerjarige begrotings en so ook die gaping tussen verskillende dissiplines verder te verklein. Die groepsbesprekings verseker die akkurate weerspieëling van die verskeie stesels wat geskep word deur middel van die begrotingsmodelle. Al die

komponente in die model is geïntegreer, wat daartoe lei dat indien een komponent verander, dit ‘n impak op die winsgewendheid van die boerderystelsel in geheel het.

Die geheelplaas winsgewendheid vir die verskillende wisselboustelsels is gemeet deur die Interne Opbrengskoers (IOK) en die Netto Huidige Waarde (NHW) gedurende die finansiële evaluasie. Na noukeurige evaluasie is dit duidelik dat Stelsel 1 wat ‘n mielie-sojaboon wisselboustelsel is, die mees winsgewende sisteem is. Hierdie stelsel behaal ‘n IOK van 17 persent oor die 20-jaar periode. Die ander twee stelsels is beide winsgewend maar behaal laer IOK persentasie waardes. Die hoofrede vir die laer winsgewendheid is die feit dat dekgewasse as ‘n nie-kontant gewas geklassifiseer word. Die finansiële voordele van dekgewasse word direk geassosieer met algehele verbeterder grondgesondheid, hoër opbrengste en laer onkruid- en plaag-druk.

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List of Abbreviations

BFAP – Bureau of Food and Agricultural Policy

CA – Conservation Agriculture

FAO – Food and Agricultural Organisation

GDP – Gross Domestic Product

IRR – Internal Rate of Return

NPV – Net Present Value

SACU – Southern African Customs Union

Chapter 1: Introduction

1.1. Background

Cover crops have successfully been integrated into conservation agricultural systems in many parts of the globe (Flower, Cordingley, Ward, *et al.*, 2012a). According to Gonzalez-Sanchez et al. (2015) conservation agriculture (CA) can be defined as, "*a sustainable agriculture production system comprising a set of farming practices adapted to the requirements of crops and local conditions of each region, whose farming and soil management techniques protect the soil from erosion and degradation, improve its quality and biodiversity, and contribute to the preservation of the natural resources, water and air, while optimizing yield*." Effective CA practices are based on three main principles namely, minimum soil disturbance (no tillage), maximum soil coverage (cover crops, or other organic residues/mulch), and crop rotations (FAO, 2011).

Cover crops are primarily used to provide soil cover, improve soil fertility and water content, and limit weed growth. An additional benefit of higher levels of soil coverage resulting from cover crops planted in a rotation system, is lower levels of soil erosion (Flower *et al.*, 2012a).

Some of the most important food crops for global food security include maize, together with wheat and rice. This along with the role of maize in the animal feed industry makes the maize industry one of the most critical commercial enterprises worldwide (Shiferaw, Prasanna, Hellin, *et al.*, 2011). Maize is the most important field crop in South Africa, as it is the most widely planted. This is due to the fact that it is the staple food for the larger part of the population, especially in the lower income bracket. In addition, maize has multiple relationships in the economy which include backward linkages into input industries and forward connections into processing industries (South African Maize Forum, no date). Other important crops in South Africa include wheat, soya beans and sunflower seed.

The world's population has doubled since 1960 to around 7.5 billion people in 2017 and is predicted to grow to about 10 billion by 2050 (FAO, 2018). The impact of the growth on the demand for maize and maize products are significant and is estimated to double from current developing world requirements by 2050. An increase in production and supply is therefore essential to satisfy this growing demand (Rosegrant et al., 2009).

Developing countries depend on maize as a bulk staple food. This is in contrasts with developed countries where an indirect dependence on eggs, corn, syrup, dairy, and meat products is more apparent (CGIAR, no date). The demand for maize has changed over the past few years, shifting from a focus on direct human consumption to a greater contribution to livestock feed. This change, caused largely by income growth in highly populated regions, has increased wealthy consumers' demand for livestock products (Delgado, 2003). The increase in demand for animal feed has seen a similar rise in maize prices, making this staple food less affordable for poorer consumers.

Increasing demand inevitably leads to greater areas of land under maize cultivation. This is not always sustainable and the environmental cost often manifests in the form of land degradation. One of the biggest challenges according to Tilman et al. (2002) is "*achieving significant growth in food production without compromising public health, environmental quality, and sustainability of farming systems*."

Over the past 40 years maize yields have doubled, largely due to technology developments brought about by the Green Revolution. Among the various improvements are more robust crop varieties and the more efficient application of fertiliser, water, and pesticides (Shiferaw *et al.*, 2011). However, more recently maize yields have declined and are predicted to fall even further as a result of severe drought and climate change associated with global warming. Declining maize yields increased pressure on maize prices, which has resulted in higher malnutrition rates in developing countries (CGIAR, no date).

The maize industry contributes significantly to food security. However, there are various collective challenges faced by the industry to negate food shortages, such as increasing demand, high poverty, and malnutrition levels, natural resource depletion and climate change (Shiferaw *et al.*, 2011). These need to be addressed in such a way that productivity would be doubled and at the same time improve the sustainability and resilience of maize-based farming systems. Commercial agricultural activities often harm soil fertility, water quality and contribute towards the negative effects of climate change (Derpsch & Friedrich, 2010). In the face of ever-increasing demand, farmers need to intensify and optimise crop production, while focusing on sustainable production through responsible use of the available natural resources.

Many areas in South Africa, specifically in Gauteng and the eastern parts of the Free State have a temperate climate. These regions experience relatively hot summers with temperatures below 40ºC, cool winters and summer rainfall. The drier and worsening climatic conditions, together with steadily increasing fuel prices could have a direct impact on maize production, forcing the country to import maize and associated products to meet the required demand (Market Litmus, no date). The issue is further complicated by the fact that South Africa is also the main producer and supplier in the Southern African Customs Union (SACU).

Given the maize industry's significant contribution to food security and the necessity of balancing production and soil restoration, it is critical to understand the financial implications of various alternative production methods. These methods are designed to better balance production and input costs. Few studies have been completed on the financial implications of cover crops in summer grain systems. There is thus limited knowledge on the financial aspects of cover crops in terms of suitability, sequence in systems, potential financial benefits, and managerial implications of implementation. The purpose of this study is to assess the financial implications and determine the economic benefits of cover crops in summer grain crop rotation systems on a whole-farm level.

1.2. Problem statement and research question

Various methods to increase maize yields and address resulting environmental degradation have been investigated. According to Hobbs et al. (2008), numerous environmental challenges are soil-based and can be corrected by implementing CA principles. Previous studies showed that cover crops increase wheat yields and lead to an improvement in soil nitrogen as well as soil organic carbon in no tillage crop rotation systems. It resulted in the increased use of this practice in the Swartland area (Agenbag, 2012). According to Blanco-Canqui et al. (2015a), cover crops were mainly used to improve and protect the soil, fix nitrogen levels, and manage pests and weeds. Currently, cover crops are viewed as a multifunctional tool in cropping systems. Not only are they used to improve soil quality and organic carbon, provide livestock fodder and for the production of biofuels but also to reduce greenhouse gas emissions, while ensuring increased profitability (Blanco-Canqui *et al.*, 2015a).

Enough is not known about the financial implications and benefits of cover crops in the Gauteng and central to Eastern Free State region over the long-term. The main question put forward by this study is thus what the longer term financial implications of cover crops in summer cereal rotation systems in the Eastern Free State area are?

1.3. Study objectives

The main objective of this study is to evaluate the financial implications of cover crops in summer cereal systems in the Eastern Free State over the long term.

The specific goals of the research project are to:

- Identify typical crops and crop sequences in rotation systems for a commercial maize farm system in the Eastern Free State region.
- Financially assess cover crops that are implemented in a crop rotation system with maize.
- Evaluate the profitability of whole-farm integration and the wider implications of livestock use and integration with cover crops.

1.4. Methodology of the study

To better understand the role of the South African maize industry within food security and other economic linkages, a literature review of the maize industry's history was conducted. It includes an investigation into the business environment and circumstances of the South African maize industry and its contribution to the national economy. In addition, a literature review assessment of the impact of crop rotation on maize was undertaken with specific reference to the importance of cover crops to maize production. The literature review was further enhanced by discussions with industry experts and agriculturalists making use of cover crops in rotation systems in these summer cereal producing areas in the Free State.

Evaluating the financial and technical results of ongoing cover crop trials in the Eastern Free State provides a clearer understanding of the financial implications of cover crops in the farming systems. Data from the past 15 years, including the various farming techniques employed was made available. The following aspects were included:

- Firstly, data from a typical commercial maize farm.
- Secondly, data from a maize farm using a crop rotation system with cover crops.
- Thirdly, data from a maize farm which integrates a livestock component together with cover crops in a crop rotation system.

For this study whole-farm simulation models are constructed to evaluate the most promising approach and techniques to improve profitable employment of cover crops. By using economic and financial criteria for longer term profitability the research aims to determine the most important considerations for including cover crops in dry-land summer cereal production systems in the Eastern Free State region.

The whole-farm, multi-period budget models are based on the norm of the typical or representative farm that aims at establishing a basis which producers can associate with. In order to determine the profitability impact of various farming systems a systems approach needs to be followed to cater for all possible impacts. Once typical farms are identified, multidisciplinary group discussions are used to validate all data and assumptions used in the models.

1.5. Outline of the study

Chapter 2 starts off with a comprehensive literature review on the importance and economic relevance of the South African maize industry. The second part of the chapter outlines the benefits and limitations of cover crops implemented in maize rotation systems together with integrating livestock.

Chapter 3 focuses on the complexity of the farm environment especially in relation with agricultural systems and decision making. The systems thinking approach is used as a tool to evaluate the whole-farm implications of adopting cover crops in maize based rotation systems. The systems approach is therefore discussed in depth together with multidisciplinary group discussion techniques to validate all the collected data. Budgeting models for a typical farm are used for evaluation in the study.

Chapter 4 describes the farm environment in Heidelberg, Gauteng on which the typical farm model is based. Using the data provided together with expert opinions during the group discussion, a typical farm is determined. Moreover, the dynamics of a whole-farm model is discussed in detail.

Chapter 5 continues to describe the dynamics of a whole-farm model as well as the characteristics and parameters. In the second part of the chapter the results of the scenarios ran through the model are discussed.

Chapter 6 provides a conclusion, summary and recommendations for future study purposes.

Chapter 2: Overview of the maize industry and cover crops

2.1. Introduction

The Food and Agricultural Organisation (FAO) estimates that the global population could reach 10 billion people by 2050 (FAO, 2018). This is a significant population growth that will require increased food production, coupled with intensifying the demand for fresh water and land resources. Expanding opportunities for cultivated land is limited and will prove insufficient in meeting the ever-increasing demand. This will require increased crop yields (FAO, 2018). The demand for maize and maize products is estimated to double by 2050 and production levels must increase to ensure future food security (FAO, 2018).

Commercial agricultural production activities has a negative impact on the environment, resulting in land degradation, deteriorating water quality and a decreased resilience in the negative effects of climate change (Derpsch & Friedrich, 2010). At the same time, agricultural markets globally are becoming progressively more competitive and consumer driven, especially in markets with product differentiation. Maize as a staple food may not be classed as such but maize as an input in the livestock feed market certainly is. In this competitive environment, producer prices come under increasing pressure and are kept relatively low.

To intensify crop production, farmers require sustainable production methods while utilising available natural resources. Food production can be stabilised or even enhanced over the medium-to-long term by means of conservation agricultural practices such as cover crops. The diversification of crops limits risk exposure while potentially improving profitability by reducing input cost.

The main aim of this research project is to evaluate the financial implications of cover crops integrated into a summer cereal system in the Eastern Free State. The aim of the research is addressed by firstly focusing on defining a typical maize farm with a maize-soya bean rotation system. After that a maize rotation system with cover crops is evaluated. Lastly a maize rotation system with cover crops including an integrated livestock component is also evaluated.

This chapter provides an overview of the maize industry. The economic relevance of maize in the South African context is highlighted together with new production methods. The focus then falls on the contribution of a rotation system, as well as the role of cover crops in a rotation system, with possible livestock integration on a typical maize farm.

2.2. Brief overview of the maize industry

Maize was first introduced in South Africa in 1655. It became one of the most dominant food crops in the country (Sihlobo, 2018). Globally, maize is one of the most important cereal crops and serves as staple food in many areas (Orhun, 2013). In South Africa, maize is still the most affordable staple food product (Meyer, 2020).

Because of its adaptability to differing environments, maize is widely planted with several countries cultivating more than 100 000 hectares (Dowswell, 2019). A total of 500 million tons of maize is produced per annum worldwide on 130 million hectares of land. Of the land used, 64 percent of global production is found in developing countries, where only 43 percent of the produce is harvested. Developing countries harvest only 2.5 tons per hectare, whereas developed countries harvest an average yield of 6.2 ton per hectare (Dowswell, 2019).

During the Great Depression in the early 1930’s, lower demand put the South African maize industry under severe pressure and prices dropped, hindering profitability. Surplus maize was exported at a loss. Producers tried to recover losses from the domestic market, causing instability in the price (Grain SA, 2016). This volatility, *inter alia*, led to the creation of the “Centraal Agentschap” with the purpose of limiting competition between producers, especially in terms of marketing grain. However, this organisation failed to meet the challenges of the time.

By the end of 1931, grain exports were subsidised by government, the start of grain price control. In 1937, the Marketing Act was published to govern the production and marketing of all agricultural products; resulting in price stability, increased productivity, more efficient marketing practices, and improved processing and distribution (Grain SA, 2016). In 1968, a new consolidated Marketing Act was implemented. It controlled various initiatives, namely: single channel fixed pricing schemes, single channel pool schemes, and surplus removal schemes.

A single channel fixed price scheme was broadly characterised by a monopoly buyer appointed by agents, a monopoly seller for trading, and a monopoly importer or exporter. The price was fixed and set by government, based on the average cost of production plus a profit margin. In the case of maize production, Government had the authority to set the quantity of product that would be exported per annum. The main objective of this scheme was to stabilise producer prices (Grain SA, 2016).

A single channel pool scheme was characterised by both a monopoly buyer and a seller, appointed by agents. An advance payment was made to the producer and the final proceeds paid on termination of the pool. To increase protection against excessive import tariffs, non-tariff barriers were implemented (Grain SA, 2016).

Surplus removal schemes attempted to stabilise producer prices in the market environment by setting a floor price. Prices would no longer fall below a specific value under this mechanism. The excess supply domestically was isolated within the market environment from which it would be exported to other countries (Grain SA, 2016).

The Maize Board was the first to operate under the new Marketing Act, aiming to control and set prices. Initially the Board used the single channel marketing scheme which entailed the following:

- Prices were fixed on an annual basis by the minister of agriculture, advised by reliable experts.
- All consumers were expected to contribute toward the costs associated with the handling and storage of maize.
- Consumers were certain of available supply at a set price.

Prices were set in May each year, enabling producers to effectively plan farming practices for the year in line with that price. The fixed price resulted in the development of maize farms in more marginal areas as the higher transport costs were covered in the price. Direct transactions between maize producers and consumers were no longer required. Producers no longer stored excess grain as supply was indirectly controlled by the Board (Grain SA, 2016), who planned effective distribution, addressing the highly ineffective and uncoordinated previous system.

The Maize Board also implemented the Joseph policy to ensure sufficient maize supply during seasons where shortages might occur. Maize imports became limited and the domestic market was protected by carry-over stock. The storage costs were fully subsidised by the government (Grain SA, 2016). Up until this point the agricultural sector was highly subsidised under the policy of food self-sufficiency and controlled by government to protect the domestic market.

In the 1980's, the set maize price became a point of debate as not all parties agreed with the annual increases. A more acceptable method of setting the price was needed given maize's consumption as a staple food by a significant sector of the population in South Africa (Grain SA, 2016). Producers decided to stop producing maize as an objection to set pricing. However, this protest was short lived, as the president of South Africa had power over the subsidy on interest rates. South Africa experienced a sharp increase in interest rates at the time. This had the potential to financially ruin maize producers if forced to pay outstanding amounts.

The Maize Board moved from being a management organisation to becoming a marketing organisation in 1987. The Board's purpose changed and so the focus moved to determining market related prices, risk management, product development, and market research (Grain SA, 2016). The first indications of possible deregulation of the market became apparent as the marketing of maize changed to a single channel pool scheme where the domestic price was determined by the difference between the Board's operating cost and the proceeds from sales. The careful consideration of expected domestic demand and supply together with the costs and proceeds of maize exports, lead to the calculation of producer price in terms of net maize yield divided by expected supply.

Over time the producer and consumer price gap widened, influenced by various market factors such as a weakening exchange rate, declining world prices, and rising supply leading to the export of excess maize supply at low prices. The export subsidy had fallen away, resulting in higher costs which further promoted relaxation of control in the sector.

The agricultural sector was finally deregulated in 1997. This heralded the demise of the South African Maize Board and the marketing of maize became the responsibility of individual producers (Bown, Ortmann & Darroch, 1999). Fixed prices and government financial interventions were a thing of the past and economies of scale became an important feature in ensuring financial success. Deregulated commodity pricing meant prices were determined by market forces only. This change fundamentally altered the South African agricultural sector, positively influencing farming practices, stimulating new farming methods and production techniques, diverse means of financing, alternative storage solutions, increased mechanisation, labour practice changes, and advancing research and development (Grain SA, 2016).

The SAFEX platform, based in Randfontein, now governed prices of listed agricultural commodities and monitored the trade between parties. However, transport costs to Randfontein had a negative impact on prices, further affected by rising diesel prices and the additional cost of maintaining a truck fleet (Grain SA, 2016).

In 1998, the Maize Trust replaced the Maize Board. The aim was to provide financial benefits for market and product related research and development, the distribution of market information across the maize industry, and promoting market access for South African maize especially in isolated rural areas deemed necessary (Grain SA, 2016).

The changes in the maize industry created an environment where farmers were forced to adopt new farming techniques to ensure efficient production. Access to land was constrained and higher yields were required to feed a growing population. Improvements in productivity were essential to sustain food security.

In response to the growing pressure to improve productivity, farmers worldwide looked to better soil health and crop rotation techniques. Cover crops were also seen as a viable option in rotation systems, the benefits of which will be discussed in depth later. To alleviate the various emerging risks related to these changes, farming practices diversified to ensure the financial success of the farming enterprise.

2.3. Economic relevance of the maize industry

Maize production has dominated the South African agricultural countryside in the summer rainfall areas for decades (Greyling & Pardey, 2019). Significant production takes place in the Free State, Mpumalanga, North West Province, and Gauteng, collectively accounting for approximately 87 percent of total production (Sihlobo, 2018). However, the Free State, which produces between 30 to 40 percent of output, remains the dominant producing area (Greyling & Pardey, 2019). On average, between 2.5 and 2.75 million hectares of commercial maize is planted annually in South Africa, equating to two-thirds of all commercial field crop production areas (Sihlobo, 2018). According to the Department of Agriculture Forestry and Fisheries, as stated in the Abstract of agricultural statistics (2019), South Africa produced on average 11.26 million tons of maize grain annually, on approximately three million hectares of land from 2000 to 2019. The average gross value of maize over this period equated to R18.02 billion.

The maize market price in South Africa is volatile relative to other grain commodities (Grain SA, 2018 & BFAP, 2020). This is due to the fact that maize is consumed as a primary food product, supplied by a large portion of the farmers in the country. The supply and demand for maize is influenced by a wide variety of factors with direct impact on price. For example, climatic conditions are a huge factor as a good season has higher yields, whereas poorer conditions will result in a lower yield. Other factors that could influence price include international market trends and fuel and transportation costs (Grain SA, 2018). The economic relevance of the maize industry and its contribution to the country's economy can therefore not be considered without taking into account a number of distinctive, yet interrelated aspects discussed below.

2.3.1. Employment

The agricultural sector in South Africa employs a diminutive percentage of the country's workforce. The maize sector forms an integral part of the agricultural sector, and it is difficult to distinguish it from other farming practices (Van Zyl & Nel, 1988). The maize industry employs a small number of the economically active population, and this figure is constantly declining. However, when considering the number of people economically dependant on maize farming, the number equates to a significant figure (De Klerk, 1984). In addition, forward and backward linkages in the maize sector increase this number further. Individuals can be directly employed on commercial maize farms or indirectly in the associated industries through the value chain including milling, formal animal feed, and processing (Department of Agriculture, Forestry and Fisheries, 2011).

2.3.2. Foreign exchange earnings

Brand (1969) and Kindleberger (1962) believed that maize exports significantly contributed to the economic development of South Africa. From 1981 the profitability of maize production decreased due to drought and other macro-economic factors, after which exports played a balancing role in economic development (Van Zyl & Nel, 1988). The export of maize is vital to secure foreign earnings and to sustain a positive trade balance for the country. African countries, including Botswana, Lesotho, Namibia, and Eswatini are the largest importers of South African maize.

2.3.3. Supplier of food / Food production

Two types of maize are produced, namely white and yellow maize. Yellow maize is used for livestock feed, whereas white maize is processed into different products for direct human consumption. It is important to note that the demand for the two products differ widely and are affected by different factors (Van Zyl & Nel, 1988).

The South African maize market is characterised by price rigid demand and supply (Van Zyl, 1986). This is the same for yellow and white maize as only a few substitutes exist. However, white maize demand is less price rigid relative to livestock demand (Van Zyl, 1986).

Human and livestock consumption of maize accounts for 95 percent of total demand, with the other five percent used for industrial purposes. As there are only a few alternative crops available in South Africa, the aggregate supply of maize is price inflexible, especially in the short to medium term. Annual maize supply is heavily dependent on climatic conditions resulting in major shifts in the supply curve (Van Zyl & Nel, 1988).

Another factor that must be considered is the fact that a rise in income changes the normal consumer basket from a staple food diet towards luxury goods including red meat, poultry, and dairy products (Van Zyl & Nel, 1988). As a result, when personal income increases in the country, the demand for maize for human consumption declines but the demand for livestock feed increases. This inverse relationship supports maize demand in the long term, whether for human or livestock consumption.

2.3.4. Contribution to GDP

The maize industry marginally contributes toward South Africa's Gross Domestic Product (GDP). However, the industry's contribution to food production, trade balance through exports, and employment figures should not be underestimated (Van Zyl & Nel, 1988). Strong forward and backward linkages play an important role in the economy giving rise to higher employment numbers. The grain and livestock feed processing industries lean heavily on the maize industry further contributing positively to South African GDP.

2.3.5. Current situation in South Africa

In 2020 the maize industry experienced an expansion of 14 percent in cultivated land area, resulting in an expected maize yield of 15.5 million tons (BFAP, 2020). This is the second largest yield gain yet recorded and a 38 percent increase in production volume year-on-year. The above average production ensured that maize stocks were replenished following previous seasons' below average maize crop production.

The above average production volumes in 2020 put pressure on local prices, pushing them down to export parity levels. The annual average price for white and yellow maize declined by 9.7 and three percent respectively from the previous season. COVID-19 and its associated challenges resulted in higher unemployment rates and many individuals' disposable incomes are under severe pressure and declining. Consumers switching from maize to more expensive wheat and rice grains which experienced a rise in import parity-based pricing, are switching back to maize meal. In the South African context, lower maize prices are critical to ensure the core staple food remains affordable to the majority in the economy (BFAP, 2020).

According to the BFAP (2020), per capita consumption of white maize is expected to increase by 0.5 percent per annum over the next 10 years. White maize for human consumption is expected to grow by 14 percent by 2029, while yellow maize consumption used as livestock feed is projected to grow by 22 percent over the next 10 years.

However, over the past decade consumption has decreased by 0.7 percent per annum. South Africa experienced lower levels of demand for animal feed, as it was negatively impacted by high yellow maize prices. Currently the domestic maize price is excessive, having reached export parity levels (Sihlobo and Davids, 2021).

In response, the South African Department of Trade and Industry (DTI) implemented the poultry masterplan with the main objective to stimulate and drive local demand, protecting local industries, boosting exports, and promoting and protecting feed costs, especially maize and soya beans. The commitments made in terms of the poultry masterplan added significant value to the maize and soya bean industry, resulting in increased maize production (Maluleke, 2020). Animal protein products imported for domestic consumption are expected to decline, while exports are driving expansion in the beef sector. The livestock industry is heavily dependent on the maize industry for animal feed and significant growth in the demand is expected in the coming decade.

The area available for white maize crop cultivation is continuously declining and is expected to contract by 12 percent in the next decade. In contrast, the area under yellow maize crops is expected to increase by nine percent (Meyer, 2020). Despite the decline in land under white maize production, the total white maize yield increased by 25 percent over the 10-year period. The reduction of cultivated areas in the western parts of South Africa were more than offset by gains on the back of improved technologies resulting in the higher national average yield level. In contrast, the expansion of the area under yellow maize resulted in rising yields but at much more subdued levels delivering 12 percent growth over the period.

The maize industry plays a critical role in maintaining food security in South Africa. It has many direct and indirect linkages into the market, critical in supporting the local economy.

2.4. Economic relevance of other industries

A discussion on the South African maize industry would not be complete without considering other related industries, namely soya beans and sunflowers. These industries also form part of the crop mix produced on farms in the study area. Maize, soya bean, and sunflower, all commodities listed under summer grains and oilseeds, are cultivated in the Eastern Free State region.

2.4.1. Soya beans

Although South Africa started producing soya beans in the early 1900's, it gained considerable momentum over the past two decades. It is considered as one of the most important oilseed crops, comprising half of global oilseed production (Department of Agriculture, Forestry and Fisheries, 2010). Soya beans are a versatile crop with high protein content. Therefore, it is mainly used to produce protein meal. Most soya beans are crushed and used to produce vegetable oil for human consumption as well as protein meal in animal feed rations (BFAP, 2020). They are also used in industrial processing.

Soya beans are grown in rotation systems, often together with maize. The plant can fix nitrogen levels depleted by maize crops and address other problems of mono-cropping related to disease and pest control (Department of Agriculture, Forestry and Fisheries, 2010).

Land under soya bean cultivation is expected to increase by 47 percent over the next 10 years, driven largely by expansion in the western regions of the country in areas originally seen as sub-optimal for soya bean production (BFAP, 2020). To sustain this growth, the yield volatility of the crop must be addressed to ensure the production risks are lower than for an alternative crop. Soya beans have the potential to provide favourable profit margins, even under severe pressure, while associated gross production value is expected to increase by approximately 30 percent in the ten-year period (BFAP, 2020).

The sustainability of soya bean production areas depend on farm level competitiveness, specifically relating to yields, costs, and gross margins (BFAP, 2020). Comparing the competitiveness of South African producers with key international producers, there is work to be done to increase yield levels and reduce input costs per ton. South African soya bean production is 15 percent more expensive per hectare than the international soya bean production average (BFAP, 2020).

Investment in domestic soya bean crushing capacity was intended to stimulate local production as part of the South African import substitution strategy (Sihlobo & Kapuya 2016). The demand for soya beans increased considerably with the rise in crushing capacity. Despite higher domestic production importing soya beans remain necessary for processors to achieve sufficient utilisation rates (BFAP, 2020; Sihlobo & Kapuya, 2016). South Africa is expected to be self-sufficient in soya bean production by 2029 when looking at current expansions. The sector experienced dynamic growth over the past decade; however, further expansion is likely to be much slower as the soya bean industry matures (BFAP, 2020).

2.4.2. Sunflower

Sunflowers are a versatile oilseed crop in South Africa, used predominantly in the production of vegetable oil (Department of Agriculture, Forestry and Fisheries, 2010). Sunflower is the fourth most important vegetable oil globally after soya bean, peanut, and rapeseed. The processing of sunflower seeds require advanced technology and knowledge and is capital intensive. Although South Africa produces vegetable oil, it is still one of the largest highly processed, non-perishable items to be imported (BFAP, 2020).

Sunflowers are not generally used in maize rotation systems in South Africa because of similar disease pressure. Sunflowers are often attacked by fungal pathogens which cause head or stem rot diseases and can further negatively affect a wide range of field crops (Flett, 2018).

The sunflower market is mature and finely balanced (BFAP, 2020). As prices rise toward import parity the area under sunflower cultivation expands. When prices fall and profitability deteriorates, producers plant fewer sunflowers.

Total sunflower yield is projected to rise by 21 percent over the next ten years because of improved farming practices and advances in technology (Meyer, 2020). During this period, the gross production value of the crop is expected to increase by 20 percent despite a decline in planted areas.

Weaker income growth is forecasted for the coming decade, translating into slower growth in demand for vegetable oil. Vegetable oil is a higher value, luxury food product and therefore sensitive to consumer spending ability. In the short term, demand is expected to decline as consumption slows but will rise in the longer term and is expected to increase by 17 percent over the coming decade (BFAP, 2020).

2.5. Typical crop rotation system in a maize-based farming system

Conservation agricultural (CA) practices are implemented to address various environmental issues, as well as related productivity and yield challenges. According to FAO (2010) CA is, "*a concept for resource efficient agricultural crop production based on an integrated management of soil, water and biological resources combined with external input.*" Yields and profitability can sustainably be increased by implementing CA practices (Hobbs *et al.*, 2008; Peiretti & Dumanski, 2014).

Conservation agriculture can vary from one location to another as the practices applied are site specific and time specific. All practices are still based on three core interconnected principles according to the FAO (2010), namely:

- Minimum soil disturbance, which entails agricultural practices of no-tillage.
- Maximum organic soil coverage which refers to cover crops, mulch from crop residues or organic mulch materials that cover the soil. The soil cover provides sufficient organic carbon which improves soil organic matter levels.
- Cropping system diversity which refers to various crop rotation techniques.

Placing the focus specifically on crop rotation, which is a main pillar of CA, Rodale Institute (no date, available online) define crop rotations as, "*the practices of planting* *different crops sequentially on the same plot of land to improve soil health, optimise nutrients in the soil, and combat pest and weed pressure.*" Crop rotation and diversification of crops play a critical role in improving the resilience of all agricultural systems, developing strategies that work against and limit the impact of climate change and improving ecosystem services (Kollas, Kersebaum, Nendel, *et al.*, 2015). Therefore, producers had the opportunity to minimise their exposure to financial risk and avoid the risk of land degradation through crop rotation, minimum soil disturbance, and maximum soil cover. This is created by continuous tillage practices used in maize mono-cropping.

Lawes and Gilbert (1895) state that "*crop rotation is one of the oldest and most fundamental agronomical practices*" (Castellazzi, Wood, Burgess, *et al.*, 2008). Crop rotation provides an excellent alternative to monoculture production, which has been proven to be less profitable and increasingly risky (Hoffmann, 2001). In previous research studies, empirical evidence indicates a complementary relationship between maize and soya beans as a sustained agricultural system across North and South America, parts of Eastern Europe, and numerous African countries within temperate, subtropical, and tropical agro-ecologies (Acevedo-Siaca & Goldsmith, 2020; Manda, Alene, Mukuma, *et al.*, 2017). Effective maize-soya bean rotation may significantly increase maize yields. The combination of legume and cereal crops creates a more stable system which leads to the diversification of diets, improved nutritional status, a reduction in abiotic and biotic stresses, as well as improved soil fertility, while reinforcing crop productivity, and generating increased income for farmers (Acevedo-Siaca & Goldsmith, 2020). The subsequent increased yields and consistently improving productivity can in turn enhance food security and the economic livelihoods of farmers.

2.5.1. North America

Studies conducted in North America proved that crop diversity was lost due to input intensification and specialisation, which resulted in high yield gains in staple crops. Of the 55 million hectares available for intensive grain crops, 90 percent of the area is used to produce maize and soya beans (Bowles, Mooshammer, Socolar, *et al.*, 2020). The central agricultural region of the United States, which is mainly cultivated under rainfed crops, is extremely susceptible to weather conditions such as drought (Bowles *et al.*, 2020). Adverse climatic factors can reduce the maize yield in the current and even following seasons. Therefore, there is a need for yield risk-reduction strategies, which will increase climate change adaptations.

Crop diversity techniques have the potential to reduce climate change risks. It also reduces the production and economic risks due to the portfolio effect. The techniques include crop rotation used in the past to improve yields by regenerating soil health and breaking cycles of weeds and diseases and sustain livestock (McDaniel, Tiemann & Grandy, 2014; Tiemann, Grandy, Atkinson, *et al.*, 2015). Studies have proved that crops benefited from two-crop rotation of maize and soya bean resulting in a five to 10 percent increased maize yield on average (Bowles *et al.*, 2020; Gentry, Ruffo & Below, 2013). The studies conducted comprised maize monoculture or two-crop rotation trials compared to more diverse rotations.

The results showed that diversity in crop rotation led to higher maize yields and affects how maize responds to growing conditions (Bowles *et al.*, 2020). Diversity limits the adverse impact of weather conditions on future maize production, however; increased diversity in crop rotation results in a decline of total maize production. The decline in total yield is due to maize being grown every second or third year rather than annually. However, if maize is the main commodity produced in a two-crop rotation system, the production process will be more efficient resulting in higher maize yields in the subsequent years.

2.5.2. South America

In the Argentine Pampas region in South America, a study was conducted to quantify the effect on nitrogen availability and microbial activity in the soil of full-season, no-till soya bean in a continuous no-till maize production system (Conti, Palma, Arrigo, *et al.*, 1998). In this region, maize-soya bean rotation systems have been implemented for many years but the effect of specific nitrogen dynamic in crops was still unclear (Conti *et al.*, 1998). Nonetheless, a higher microbial activity was present in the maize-soya bean samples which gave rise to a greater capacity for soil organic nitrogen mineralisation.

In turn, the inclusion of soya beans in the rotation system was beneficial as it increased the mineralisation and nitrogen uptake of the subsequent maize crop (Vanotti & Bundy, 1995). According to Ma & Subedi (2005) and Grzebisz & Potarzycki (2008), maize crops are highly sensitive to the supply of both nitrogen and zinc, which are required to ensure optimal yield quantities from the beginning of plant growth until maturity. Soya beans are leguminous plants. It means the secondary crop can reduce the fertiliser application level of the main crop as no additional nitrogen in fertilisers is necessary during production. Reduced input cost and higher yields result in higher profit margins.

Further studies on maize-soya bean rotation systems were performed in the subtropical regions of Argentina. The rotation systems were implemented to determine the feasibility of land intensification and increased productivity per unit of land (Giménez, Micheloud & Maddonni, 2018). The historical data of the two commodities relating to prices and on-farm costs revealed that the maize-soya bean rotation system had a higher gross margin when compared to monoculture systems (Giménez *et al.*, 2018). However, the feasibility and overall gross margin was highly dependent on the price of soya bean or maize at a specific point in time. The study proved that the maize-soya bean system in the humid subtropical areas of Argentina was a viable alternative to monoculture resulting in higher returns.

2.5.3. Sub-Saharan African countries

Many African countries are regarded as developing countries and often struggle with poverty and food security. According to Kalinda, Tembo and Kuntashula et al. (2014) developing agricultural productivity is a critical objective to promote sustainable economic growth, poverty alleviation, improved nutrition, health, and overall social well-being. A maize-soya bean rotation system has proven to offer many benefits including improved soil fertility, nitrogen fixation, reduced diseases, weed and insect suppression, and increased soil carbon content. These factors increase yields and limit the effects of climate change on produce (Manda *et al.*, 2017). Studies proved that maize yields following soya beans in a rotation system, increase meaningfully in countries such as Zambia, Zimbabwe, and countries in West Africa (Manda *et al.*, 2017). The study in Zambia further showed that maize-soya bean rotation systems can be used to reduce poverty among farmers as yields are increased and the application rate of expensive inorganic fertilisers are limited (Manda *et al.*, 2017), improving soil health and food security.

2.6. Potential role of cover crops in maize-based farming systems

2.6.1. Definition of cover crops

Cover crops are defined by the UC Sustainable Agriculture Research and Education Program (2017) as, *"Any non-cash crop grown in addition to the primary cash crop. These crops have the potential to increase soil organic matter and fertility, reduce erosion, improve soil structure, promote water infiltration, and limit pest and disease outbreaks."* Therefore, as cover crops are a non-cash crop it is not usually planted to generate an income but it will improve the subsequent cash crop. Thus, cover crops are crops planted between two cash crop seasons to provide some form of ecosystem services (Dabney, Delgado & Reeves, 2001; Wendling, Büchi, Amossé, et al., 2017). Cover crops have been successfully integrated into many conservation agriculture systems worldwide (Flower et al., 2012b).

2.6.2. Role of cover crops in the system

Cover crops can be implemented within conservation agricultural systems where the three main principles are maximizing organic soil cover, limiting soil disturbance, and implementing diverse crop rotations. Cover crops are not planted solely for market purposes but rather to provide soil cover and limit weed outbreaks (Fageria, Baligar & Bailey, 2005). In addition, cover crops offer the opportunity for diversification when planted in a rotation system, the benefits of which will be discussed later.

In the past the purpose of cover crops was mainly for nitrogen fixation, the control of weeds, the management of pests, and improving overall soil quality. Recently the scope has broadened to improving soil organic carbon quality, the provision of additional fodder for livestock, biofuel production, limiting greenhouse gas emissions, and maintaining and improving the profitability of the system (Blanco-Canqui, Shaver, Lindquist, *et al.*, 2015b).

Cover crops can be either leguminous or non-leguminous and are included in systems as nutrient management tools (Ruffo & Bollero, 2003). Leguminous cover crops are mainly used as a source of nitrogen for the subsequent cash crop as they fix atmospheric nitrogen in the soil (Frye, Blevins, Smith, *et al.*, 1988; Smith, Frye & Varco, 1987). Increased available nitrogen leads to an increased nitrogen uptake in the succeeding summer crop, resulting in a higher yield (Decker et al., 1994 and Kuo et al., 1996).

Non-leguminous crops are often quicker to establish and produce a more extensive root system, compared to leguminous crops. Their role is to minimise nitrogen leaching by removing nitrates from the soil (Kuo & Sainju, 1998) thus preventing the contamination of groundwater due to the use of nitrogen fertilisers.

A mixture of leguminous and non-leguminous cover crops are used to lower the nitrogen fertiliser required by summer crops and limit nitrate leaching during the wet season (Kuo & Sainju, 1998). The combination used for cover crops is determined by the specific location and other external factors such as climate and soil type. The wrong combination of cover crops can lead to less positive or even a negative impact on the soil and subsequent crops. Therefore, it is critical to have a thorough understanding of cover crop selection and have management practices in place to limit negative outcomes.

2.6.3. Benefits and limitations

There are numerous benefits associated with cover crops in agriculture. These include controlling soil erosion, limiting soil compaction, less nutrient leaching, higher water infiltration rates, weed control and disease reduction, improved soil diversity, higher carbon sequestration rates and maximum nutrient recycling, improved aeration, improved soil and water quality, and overall environmental enhancement (Hoorman et al., 2009).

2.6.3.1. Influence on weeds, diseases, and pests

Cover crops limit weed growth and consequently reduce the dependence on herbicides (Fageria *et al.*, 2005). Weed growth is suppressed due to the competition for water and nutrients, as well as the excess shading provided by the cover crop (Creamer, Plassman, Bennett, *et al.*, 1995). Cover crops should be planted densely and grown for the longest possible period to ensure efficient weed control (Brust, Claupein & Gerhards, 2014).

Diversifying crops by implementing cover crops in the rotation system interferes with pest cycles thereby controlling diseases and insects. In addition, cover crops increase the number of beneficial predators and parasitoid insects which limit the number of harmful insects (Brust *et al.*, 2014; Fageria *et al.*, 2005). According to Sayre (1986) soil-borne pathogenic fungal diseases and nematodes are more effectively controlled in the subsequent cash crop.

2.6.3.2. Influence on overall soil composition

Soil is the key component ensuring optimal yield gains are achieved and crop productivity is enhanced. Cover crops influence various parts of soil composition. Firstly, cover crops ensure that organic matter content in the soil is increased (Fageria *et al.*, 2005). Organic matter in the soil is critical to sustain productivity levels and improve soil fertility (Allison, 1973; Wilson, Dabney, McGregor, *et al.*, 2004). Increased organic matter ensures stabilised soil aggregates, eased soil cultivation, increased aeration, improved soil water holding and buffering capacity, and more available nutrients for plants from organic matter breakdown. Soil structure, soil aggregation, and aggregate stability are positively affected (Carter and Stewart, 1996).

From a chemical perspective, soil pH, available nutrients and nutrient cycling, cation exchange capacity, and buffering capacity are positively influenced by cover crops. Depending on the cover crop mixture, the timing and chemical benefits may differ (Smit, in press). Cover crops have the potential to increase the availability of nutrients in the soil. Other than nitrogen, decomposed cover crop tissue also supplies essential mineral nutrients to subsequent crops. In addition, there is a significant improvement in the soil structure which has an effect on the water infiltration, aeration, and plant root development (Fageria *et al.*, 2005). Nutrient availability is present in the form of increased organic carbon and nitrogen in the soil (Blanco-Canqui *et al.*, 2015b; Dabney *et al.*, 2001). Overall the application of fertilisers will decrease with the implementation of cover crops.

Previous studies have shown that a drastic improvement in soil aggregation was noted in maize, planted in a no-till system with crop residues, in comparison to those without (Karlen et al., 1994). Cover crops reduce soil erosion substantially as the surface of the soil is densely covered. Maximum soil coverage reduces the deterioration of the soil's physical, chemical, and biological properties, resulting in higher crop yields over the long term (Fageria *et al.*, 2005).

2.6.3.3. Yield improvement in subsequent crops

Yield increases in subsequent maize crops are generally expected after the implementation of leguminous cover crops. This is due to the nitrogen fixation properties of the leguminous cover crops (Daryanto, Fu, Wang, *et al.*, 2018). Previously conducted studies revealed that yield increases did in fact occur in succeeding crops after leguminous cover crops with no additional nitrogen fertiliser application. Smaller yield gains were observed with further applied nitrogen fertiliser (Daryanto *et al.*, 2018; Miguez & Bollero, 2005). Therefore, the specific mixture of cover crops can increase overall yield while reducing the input cost of the specific crop through lower use of fertilisers. Synthetic fertiliser application rates can be reduced significantly with the implementation of cover crop biomass according to Tonitto et al. (2006).

A farmer's main goal is to maximise profits. With careful planning and due consideration for rainfall distribution, climate, soil types, and other environmental factors, a combination of cover crops can be implemented to warrant subsequent yield increases together with the reduction of input costs.

2.6.3.4. Disadvantages of cover crops

Not many disadvantages are associated with the planting of cover crops in rotation systems. However, the management and selection of specific cover crops are critical in determining the success thereof (Daryanto *et al.*, 2018).

In some instances, the subsequent cash crop may be negatively impacted by the cover crop. The cover crop's water usage can limit the amount available to the following cash crop which can possibly lead to a lower yield gain (Reese, Clay, Clay, *et al.*, 2014). Furthermore, the planting of cover crops requires additional equipment as well as more complicated management practices and time spent on seeding and terminating crops (Hoorman et al., 2009). Extensive knowledge and intensive management input are needed to plant the correct cover crops at the right time to limit these negative effects.

Cover crops are usually non-cash crops that do not generate an income to the farmer. Thus it can often be difficult to generate a profit from the planted cover crops even though they have many benefits in terms of soil health and yield gains. To make cover crops financially viable, the benefits gained from cover crops need to outweigh the losses in production (Smit, in press).

2.6.4. Cover crop use with a livestock component

Cover crops integrated with a livestock enterprise can be used as a multifunctional tool in farming practices to overcome challenges such as limited crop diversity and fodder shortages. Under normal circumstances this approach is often underutilised. Gardner & Faulkner (1991) concluded that successfully implementing crop-livestock production systems result in economically viable, environmentally sound, and biologically efficient production systems, provided that the producer invests sufficient time and management resources. Cover crops substitute for a cash crop and it is therefore critical for producers to find alternative measures to generate an income from that cover crop phase in the rotation system. Crop residue obtained from cash and cover crops can be used as feed for livestock or to be grazed (Hoffmann, 2001) and can improve the cover crop cultivations' profitability. The removal of cover crop biomass in the form of hay or grazing for livestock or biofuel production do not negatively influence crop production and soil (Blanco-Canqui et al., 2015b).

One of the main incentives to integrate livestock into the cropping system is to best limit risk (Bell & Moore, 2012). Integrated crop-livestock systems serve to optimise land use, increase total output and mitigate economic risk through diversification (De Oliveira, Bremm, Anghinoni, *et al.*, 2014). In areas such as the Swartland, with variable land potential, the implementation of an enterprise, or sequence of enterprises, can result in profit maximisation (Basson, Hoffmann & Strauss, 2017). Thus, the risk exposure is decreased and potential income is stabilised. This makes the integration of livestock in a cropping system in the Eastern Free State a viable opportunity.

Including a livestock grazing component in a rotation system can have positive or negative effects on production in the system, depending on how strict grazing is managed (De Faccio Carvalho, Anghinoni, De Moraes, *et al.*, 2010; Fisher, Tozer & Abrecht, 2012). Crops and livestock in the same system have a complementary relationship and contribute to CA practices. A cycle exists where grazing animals ingest plant nutrients in the form of plant biomass, of which 70 to 90 percent is returned to the soil in the form of manure and urine (Martins, Andrade Costa, Anghinoni, *et al.*, 2014). The flow of nutrients is modified and accelerated by animals in the cycle. Incorporating livestock in a system is beneficial, especially in soil quality, nutrient cycling, and possible yield gains when compared to continuous cropping systems (Tracy & Zhang, 2008).

Livestock grazing must be managed correctly to ensure that compaction due to trampling and overgrazing is limited. Overgrazing can lead to insufficient soil coverage (Smit, in press). Properly managed grazing can avoid compaction of soil and overgrazing completely. The livestock component integrated into the system significantly reduces inputs in terms of fertiliser, lime, and herbicides (FAO, 2009). Integrating livestock in the system is beneficial due to the positive synergistic effects on the physical, chemical, and biological soil properties. This approach results in limited land degradation and higher agricultural yields than other typical land use strategies (Lemaire, Franzluebbers, Carvalho, *et al.*, 2014; de Moraes, Carvalho, Anghinoni, *et al.*, 2014).

2.7. Conclusion

The first section of this chapter provides an overview of the importance and development of the maize industry in South Africa focusing on the economic importance of the industry. The role and importance of cover crops and livestock integration in rotation systems together with the benefits and limitations thereof is outlined. The implementation of cover crops in farming practices incorporates the three main principles of effective agricultural conservation. The integration of cover crops and livestock is seen as a holistic approach to sustainable agriculture, which in turn will contribute positively to the overall environment, natural resource stock, and the profitability of the farm, if managed correctly. The adoption of these practices allows the maize producer to remain competitive in the market environment because of the expected reduction in input costs and the potential for higher yields in the longer term.

Chapter 3: Overview of systems theory and farm simulation models

3.1. Introduction

The main aim of this research project is to evaluate the financial role of cover crops in maize production systems in the Eastern Free State. Chapter 2 emphasised the importance and economic relevance of the maize industry in South Africa. The growing population is placing increasing strain on the demand for agricultural products and driving the implementation of new production processes to sustainably intensify agriculture. To date various efforts made to maintain production levels have proved inadequate in the face of climate change, natural resource exhaustion, pollution, and urbanisation. As a result, producers have turned to alternative production methods to increase yields without increasing land under cultivation.

Agriculture is an increasingly complex sector that faces complex challenges. To be able to solve interconnected problems that are productive, environmentally, and socially sound, the incorporation of transdisciplinary, integrative, and innovative perspectives are required in terms of research (Rodriguez & Sadras, 2011).

Dealing with complex systems requires a multidisciplinary approach founded on systems thinking. This provides the opportunity to bridge the gap between different disciplines by incorporating and considering specialised knowledge. The first section of the chapter focuses on the systems approach and its usefulness in agricultural systems research.

This study evaluates the implications due to implementing cover crops in maize production systems from a whole-farm perspective. It is aimed to address the various interrelated components present within such a system. The methods of systems research in this context are presented, taking account of both its benefits and its limitations. A financial simulation model of a typical farm in the Eastern Free State is used over a 20-year period. This considers the potential impact of implementing cover crops in a rotation system.

3.2. Agricultural systems approach

Agriculture worldwide faces a combination of complex interconnected problems relating to productivity, environmental, and social challenges. To address and overcome these, the development and application of transdisciplinary, integrative and innovative solutions must be explored (Rodriguez & Sadras, 2011).

Agricultural systems comprise of many complex interrelated components, which impact and shape it. These could include ecological region, the mechanical processes used, methods and types of fertilisation, pest and weed management systems, the diversity and interrelationship of crop and livestock farming, product and input pricing, marketing systems, levels of consumerism, and sustainability issues (Hoffman, 2010). In such an environment where risk and uncertainty are prevalent, the entire system must be considered to make an informed decision.

Any study in this focus area should be done in the context of a systems approach to ensure the evaluation of relationships between objects as a whole, rather than focusing on each component individually (Jones, Antle, Basso, *et al.*, 2017). The aim is to integrate knowledge that may already exist but have become separated due to academic disciplinary research. As Hoffmann (2010) suggests, the objects included in a system are interrelated parts of a larger whole, which possesses attributes not always found in the individual parts. Consequently, the systems approach in this study is critical to understanding the system as a whole and the various complex interrelated challenges it faces.

Understanding the complex components inherent in an agricultural system require an analytical or reductionist approach. This entailed the deconstruction of the problem into smaller parts, which were then dealt with individually (Hirooka, 2010). This approach has many advantages but is not often used as the systems continued to exhibit unexpected and unexplainable dynamics (Schiere et al., 2012). The components of a system provide structure but the relationships between these components provide function. The functions often generate unexpected systems behavior and outcome. The reductionist approach therefore gave rise to the development of a more holistic approach to address these anomalies.

For the purpose of this study it was necessary to adopt a holistic approach when evaluating the impact of the interrelated components in the system and to apply principles of the systems approach. Farm financial modelling lends itself to systems thinking (Kooper, 2020), creating greater understanding and enabling holistic forecasting in highly sensitive agricultural production systems, assisting informed decision-making for the farmer (Jones *et al.*, 2017).

3.3. Modelling and simulation

Models are constructed and designed to represent and describe something visually that cannot be observed directly (Daellenbach & McNickle, 2005). Strauss (2005) concurs, describing modelling as, "*building a representation of a system*". Models allow for the testing of various scenarios in a system and more accurate evaluations of the possible outcomes, the results of which can be compared with actual data or knowledge (Hoffman, 2010). Farm modelling provides an interpretative solution that is practical to use and easy to understand (Hoffman, 2010). In addition, this approach clearly maps out the available knowledge within the system, revealing research gaps and areas which are not clearly understood (Hirooka, 2010).

Models are an ideal research tool in a farming system as input data and system parameters can be manipulated to evaluate a variety of possible outcomes (Knott, 2015). Development in computer and software technology has further advanced data analysis and the multiple calculations required in such system models.

Simulation techniques applied in a system model are recognised forms of experimentation with the main purpose of reproducing and representing the relationships between real-world objects (Hoffman, 2010) and predicting the possible and most likely outcomes of a specific scenario within the system (Strauss, 2005) According to Dent and Anderson (1971), simulation is a technique where a replica model of a real system is created and where tests are performed to assess the impact within the real system. The simulation process in the system approach is illustrated in Figure 3.1, as illustrated in (Strauss, 2005).

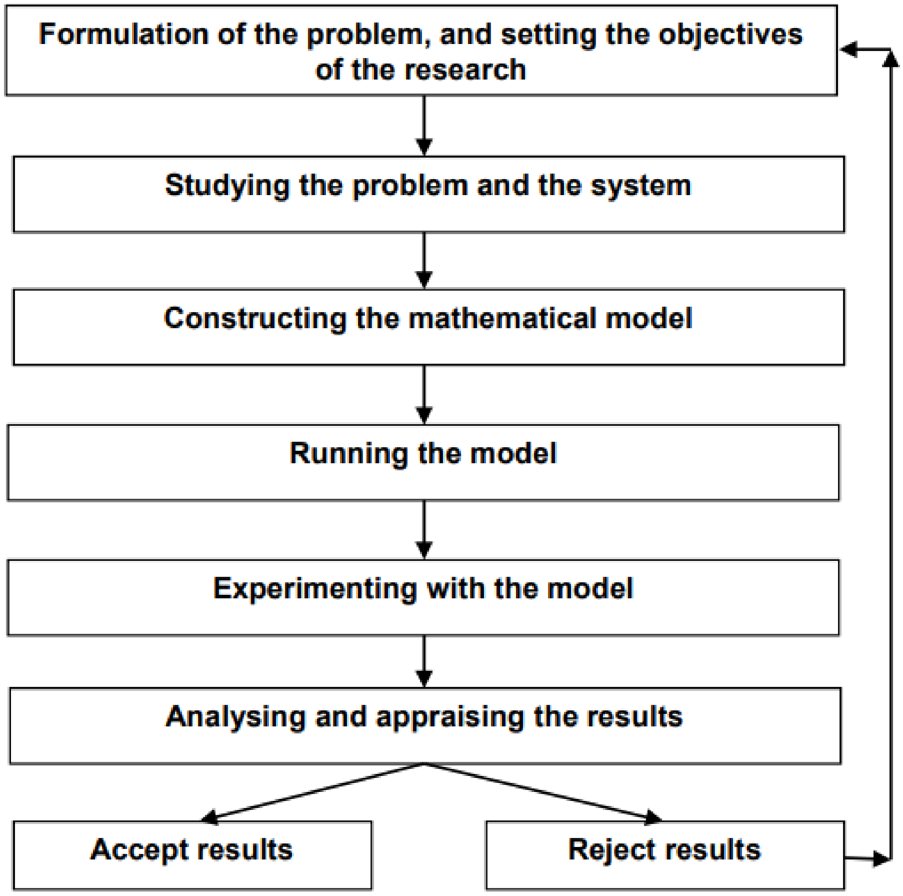

Figure 3.1 The order of implementation of simulating economic problems.

Source: Strauss, 2005

Modelling and simulation techniques are both time and cost efficient approaches to observe large systems and evaluating them against real-life experiments (Kooper, 2020). Simulation models of an agri-ecosystem, has one main limitation in that they are unable to accurately incorporate and assess the impulses of human behaviour (Hoffman, 2010).

Economic analysis assumes humans are rational and their main goal is to maximise profits. However, Hardakar et al. (2015) showed that farmers are not completely rational but rather distinctly risk averse. Farmers operate in a complex and volatile environment. They have no set standards or guidelines to follow when challenges arise, and the decisions and choices made are heavily dependent on the specific situation confronting them. It is therefore critical for modellers to understand and take cognisance of human behaviour and its role in the operation of agricultural systems (Strauss, 2005). Multidisciplinary and expert group discussion techniques are used in modelling studies to incorporate and address the impact of human behaviour. Group discussions have many benefits but also exhibit limitations which are discussed in Section 3.5.

3.3.1. Stochastic vs deterministic models

Models are either stochastic or deterministic. The nature of the model depends on the type of system being modelled and the purpose for which it is being used (Strauss, 2005).

Stochastic models contain random variables including probability distributions. Levels of risk are incorporated by assigning density functions to specific exogenous and endogenous input/output variables (Hirooka, 2010; Strauss, 2005). Deterministic models, on the other hand, use specific inputs to simulate specific outcomes (Hoffman, 2010).

For this study a deterministic model was constructed to evaluate the financial impact of a specific set of variables on expected whole-farm profitability. No random variables or probabilities were considered and all relationships within the system were kept constant. Further, the input values used were known and fixed, while the use of different scenarios considered the risks within the system. The main goal of the modelling was to evaluate and analyse the profitability of various strategies to include cover crops into an existing maize production system. To have random maize prices for instance would hardly affect the way in which cover crops can be utilised. The deterministic model was thus the ideal tool for this study.

3.3.2. Approaches to modelling

It is important to consider the key objective of the study when constructing a model design and simulation to achieve desired outcomes. Approaches to modelling can be either normative or positive.

A normative approach according to Hoffman (2010) describes the system as it is expected to operate under normal circumstances – how it 'ought to be'. These models are often prescriptive in nature and are based on value judgements created by philosophical, cultural, and religious systems and beliefs. As a result, normative statements and questions cannot be answered by empirical fact or historical data but rather rely on basic knowledge.

The normative approach is often used in optimisation models where the decision-maker's main objective is utility maximisation (Buyse et al., 2007). Normative models are useful in predicting consequences, recommending outcomes, displaying sensitivity, and providing solutions to systems of equations (Hoffman, 2010), but are limited by their rigidity and inability to assess and account for a lack of available data. These models generally do not describe facts within scenarios but rather focus on optimisation and consequently lack a calibration mechanism. In the context of production economic theory, a normative approach tends to focus narrowly on a specific problem and does not adequately consider alternatives (Malcolm, 1990).

A positive approach to modelling, on the other hand, is factually based, understanding 'what is', 'what was', and/or 'what will be'. These models are generally descriptive and non-optimising (Hoffman, 2010). As they are based on fact, they can be proved correct or incorrect. These types of models can be used to explain the impact of different externalities and the options available in the system which could be implemented by decision makers. Positive models are empirically reliable (Buysse et al., 2007) as they describe observable situations, but can be costly and time consuming to ensure that the model is valid and verifiable (Strauss, 2005).

A positive approach is well suited to a deterministic model where the nature of the real system is described and requires analysis. The purpose of this research is to evaluate and determine the financial implications of cover crops in summer grain systems in the central Free State over the long term. This approach is therefore appropriate for this specific study.

3.4. Budgeting models

Budgeting models are popular in research and financial planning because they are easy to use and understand. They aid in the experimental approach to decision-making as opposed to using an analytical framework (Rehman & Dorward, 1984). Budgeting evaluates future plans in both physical and financial terms. In its simplest form a budget considers the income and expenditure of a farm, with the difference between these two representing either a profit or a loss. Because of their simplicity and the ease with which they are understood by producers, researchers, and policy makers the technique is well suited to aligning academics' and producers' understanding of a situation.

With the advancement in software and computer technologies, budgeting has developed to consider evermore complex systems. It is a dynamic tool, which uses simulation techniques founded on accounting principles (Hoffman, 2010). The key advantage is that physical/biological factors and relationships can be directly translated into financial outcomes through the sequences of equations that integrate these factors with social/economic factors and relationships.

Whole-farm budgets are generally designed and constructed using spreadsheet programmes. These user-friendly programmes simplify complex and sophisticated calculations and relationships within the system, catering for fine detail and greater flexibility (Hoffman, 2010). An added benefit is that producers and scientists from other disciplines can easily be included in the research design, as the way assumptions influence outcome is relatively transparent.

To successfully model a whole-farm budget requires experience and extensive insight into the physical dimensions of the farm system being modelled. Projections of the expected costs and returns of the farm system are directly influenced by the physical dimensions and how accurately they are interconnected. The relationship between these components ensures their feasibility in the modelled system and the system as a whole. The accurate representation of the physical dimensions of a farm depends on various scientific disciplines often outside the field of focus. To ensure the validity of key inputs, data from other scientific disciplines can be used. Alternatively, conservative estimates can be generated from a range of relevant parameters. Some principles are set in a budgeting framework, such as fixed values assigned to prices and costs and valid input-output coefficients (Knott, 2015).

According to Nuthall (2011) budgets are valuable decision-making tools in comparing alternative systems. These alternative systems include partial budgets which enables comparison among the different parts of the farming system. This is done by either using conventional partial budgets or a gross margin analysis of a technical unit (Nuthall, 2011).

Gross margin budgets are beneficial when a comparison of different enterprises in a farm system is required. Obtaining this information through model simulation of the expected financial performance of a unit, the decision maker can assess the implications of manipulating specific components in the system. In addition, budget simulation can help assess the potential impact of novel technologies such as the adoption of cover crops in this study.

Budgets, mostly used as a financial planning tool, are often long term and future oriented. It is also useful in determining the required capital investment needed to promote growth and development of the farm system. Capital budgets are integrated into the simulation to determine the extent of capital investment required over a period of time (Knott, 2015).

Adapting maize production systems from a continuous cash crop to a crop-pasture with a livestock component, an initial capital investment is required. Farm budget models are ideal to explore long-term financial viability, determined by the net present value (NPV) and internal rate of return (IRR) as indicators of expected profit. Insight gained from multidisciplinary expert group members can be integrated into multi-period budgets to validate the representation of the real farm system. Whole-farm budgets do not always provide complete solutions, despite their aim to solve whole-farm problems. The aim of budget systems is to test or simulate alternative strategies in physical/biological terms and profitability, and not necessarily to optimise the use of resources. However, insight gained from budget modelling is more useful in solving whole-system interrelated problems, than attempting to solve consecutive singular problems. Barnard and Nix (1979) believe that capital flow budgets are imperative in providing the decision maker with a complete knowledge base when making investment decisions.

3.5. Multidisciplinary group discussions

A systems approach is used, underpinned by Hoffman's observation (2010) that, "all objects in a system are interrelated parts of a larger whole and the whole often contains attributes not necessarily found in individual parts".

The multidisciplinary group discussion is an effective research method with the ability to support and accommodate a systems approach (Hoffman, 2010). The concept of group discussions originated in the military during World War II and is currently widely used in farm and operations management (Hoffman, 2001; Jabbar et al., 2001; Haggar et al., 2001). Young (1995) defines multidisciplinary group discussions as a research method where researchers and scientist from different areas of expertise work together to solve a collective problem. It is an effective method or technique to generate extensive knowledge and information on a topic or area of interest.

Problems experienced by humans in their day to day lives stimulate the need for increased knowledge (Gadner et al., 2004). Knowledge consists of three levels, lay-, scientific-, and meta-science knowledge. Lay knowledge utilised in everyday life is gained by experience, learning, and reflection. It is used to solve day to day problems, reach consensus, and to acquire further insight (Hoffman, 2010). Scientific knowledge is acquired through the systematic and analytical study of real-life problems with the aim to generate explanations, descriptions, models, and theories. Meta-science knowledge relates to the nature of scientific enquiry and deals with the selection of theory, research approach, and indicators implemented in the research (Hoffman, 2010). It conceptualises the problem and how to solve it, including the necessary approach.

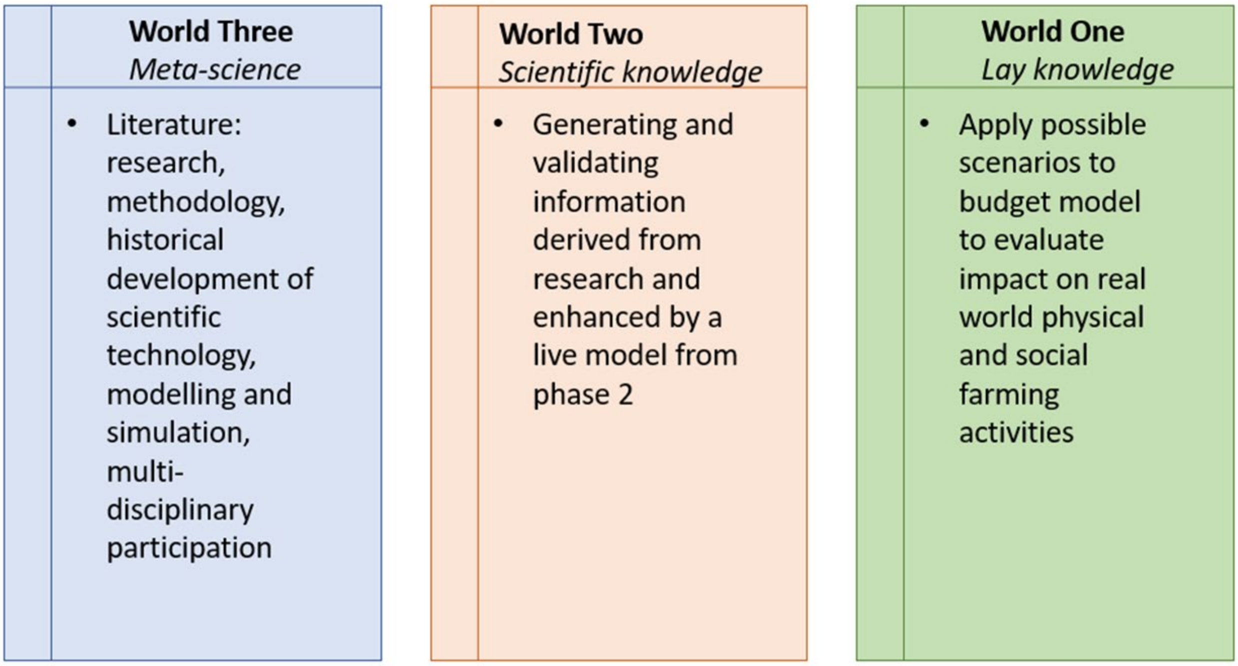

Figure 3.2 Schematic representation of the role and impact of scientific knowledge.

Source: Adopted from Hoffmann, 2010 and Knott, 2015

The model depicts the different levels of knowledge and demonstrates the gap in knowledge and understanding between researchers and producers. Multidisciplinary discussions provide a way to bridge this gap. Gaps between scientific fields often occur due to specialisation. The gap between farmers and researchers is due to specific needs. Ensuring that decision makers within a system produce and operate at optimal levels, it is necessary that the relevant information reaches the necessary participants timeously and accurately. It is important, however; that researchers have a thorough understanding of the dynamics of the whole-farm business, ensuring the development of a realistic model which simulates real world scenarios.

A lack of information has implications for research studies. Multidisciplinary expert group discussions support exploratory research aimed at improving whole-farm profitability. Input from experts is critical to ensure a correct assessment of the implications of changes in the input parameters for the whole farm (Hoffman, 2010). Expert experience and knowledge are invaluable in this instance, while discussions are more time efficient compared to other methods in generating accurate information. Expert knowledge can also be in the form of lay knowledge that is gained through experience; this is the reason why farmer participation in expert groups is critical. Farmers practically implement suggestions from research and that is what the model aim to simulate.

During group discussions many elements play a role which can either prove beneficial or constrain the debate. Multidisciplinary discussions stimulate creative thinking by introducing different perspectives on a specific matter (Hoffman, 2010). Differing points of view challenge perceptions and generate new ways of thinking about conventional farming methods or the application of novel technologies. Group discussions facilitate enquiries into data trends and applied knowledge but can also validate current thinking. Constructive debate among experts from different backgrounds produces alternative perspectives and new ideas. The risk that some views may overshadow others requires researchers to play an important role in mediating the discussion, avoiding potential deviations to ensure an objective outcome is reached (Hoffman, 2010; Knott, 2015).

This study aims to evaluate the financial implications of cover crops in summer grain systems in the Eastern Free State on a whole-farm level. The chosen participants in the group discussion were from the surrounding areas, ensuring accurate and relevant information. Discussions focused on issues regarding the physical and financial extent of a typical farm and the technical implications of various strategies to incorporate cover crops within systems in the Eastern Free State area. The group discussions took place on various online platforms, including e-mail and Zoom/Teams online/virtual meetings. Due to Covid related restrictions a group discussion was not an option. A limited number of face-to-face discussions were had. This approach was time and cost efficient in the collection of information, causing minimal disruption for participants with busy schedules. Group discussions took place during June 2021. Assumptions on the model and farm strategies were accepted when the whole group reached consensus on such assumptions.

3.6. Theory of a typical whole-farm model

Whole-farm budgeting is used to view the farming system in its entirety. It is essential to conduct studies in a whole-farm context instead of viewing and analysing individual components separately (Hardaker & Hardaker, 2004). Farming is an inherently risky business due largely to unpredictable climatic conditions. Farming systems are often diversified to counteract this uncertainty and to minimise the risk exposure. As a result, operations in the farming system become increasingly complex. The system is highly sensitive towards changes in components within the system, as well as attributes independent from the enterprise but which may affect other aspects in the whole farming system (Hardaker & Hardaker, 2004; Hoffman, 2010). Given this complexity, the farm system is best analysed within a systems approach.

A typical farm, as paraphrased by Kooper (2020), can be defined as, "*a simulation farm with frequency distributions of farms in the same homogenous area*." This approach, first implemented in 1928 by Elliot with the aim of limiting the effects of outliers such as excellently performing and poorly performing farms, provides an empirical tool for agricultural research and extension. The model, therefore, considers farms in a homogenous area to determine size, profitability, management quality, market access, cropping systems, and cultivation practices (Hoffman, 2010).

The typical whole-farm approach is frequently used to determine farm profitability and analyse the impact of changing variables on farm level profitability (Knott, 2015). The effects of these changes, options, and specific managerial decisions can be deduced from these models by effective evaluation and comparison, thereby determining the most promising strategy. It should be noted that these models are hypothetical and cannot be used to make managerial decisions on a specific farm. However, the possibility of adapting the model to guide decisions on a specific farm is possible. Typical farm models are preferred to farm surveys, as it is cheaper and less time consuming. In addition, it creates a basis for comparison and analysis of potential impacts from different scenarios (Knott, 2015).

3.7. Conclusion

This chapter focused on the use and usefulness of the systems approach in agricultural research. The discussion considered a number of methods used in systems research and evaluated the most appropriate and practical method and approach.

A farm is a complex system comprised of various interrelated components which often function in an uncertain and volatile environment. Using the systems approach to study farm-level problems is becoming increasingly popular. The approach involves *inter alia* the modelling and simulation of a real system and benefits academics and farm managers in creating an understanding of the synergies within the farm environment.

Advances in computer technology and programmes enable the structuring of formulas and data within the context of the farm system to evaluate the impact of changes on farm profitability within various scenarios. The model makes it possible to compare and evaluate the implications and effect of the changes. The typical farm aims to be representative within a homogenous area and forms the basis.

Budget models are generally used as financial and physical planning tools across various disciplines. These models are easy to use and understand and can simulate complex systems through sequences of equations, allowing for the integration of physical/biological factors with the financial reporting structure. Multi-period budgets can be incorporated to provide decision makers with an extended time for evaluation, while cash-flow budgets aid in capital investment decisions.

To create a reliable budget model for a typical whole farm requires an extensive and thorough understanding of the system being modelled. Multidisciplinary group discussions provide the ideal platform to gain knowledge on the complex system, while enabling the opportunity to verify and validate data and opinions. The inclusion of various experts in the group discussions bridges the knowledge gap. It also provides the opportunity to fully comprehend the complexity of the system, as well as promote comparison within the systems for further farm-level research.

Chapter 4: Crop rotation systems at gross margin level and model construction

4.1. Introduction

The main aim of this research project is to evaluate the financial implications of including cover crops in a maize crop rotation system in the Eastern Free State area. In Chapter 3 the whole-farm system is presented as a complex object of study and the subsequent necessity to evaluate whole-farm profitability from a systems approach. The interrelatedness of components in a farming system requires a systems thinking approach to effectively mimic the whole-farm system.

This chapter provides a detailed description of the farm that serves as basis for the identification of the typical farm for the area. This "model farm" will be used to evaluate the inclusion of cover crops into the maize production system. The farm, situated in Heidelberg Gauteng, is just outside of the Free State but forms part of the homogenous production area. It is used as a basis to construct a financial model for a typical, or representative, farm in the area. This chapter introduces the physical farm, the various crop rotations systems, data compilation, and the modelling of the financial budgets. The financial performance of each crop rotation system is evaluated at gross margin level. Gross margin budgets for each enterprise operating under different rotation systems is created to enable analysis of the system and to identify present and predicted trends.

The chapter concludes with the need for whole-farm analysis with an overview of the whole-farm multi-period budget construction and the importance thereof.

4.2. Description of Modderfontein farm in Heidelberg, Gauteng

A combination of international literature and real-life farm system data was used for this study. The combination ensures an accurate simulation of an operational, practical farm system in the Eastern Free State with the associated costs. Currently there is insufficient historical data available relating to cover crops in summer grain areas, thus a combination of relevant international literature where studies have been performed is used in coherence with a real-life situation. The depiction of a real farm system was confirmed during a multidisciplinary group discussion. The gross margin derived can be simulated in a typical farm model to further evaluate the implications of differing systems.

4.2.1. Description of farm site

The main objective of the study is to evaluate the financial implications of cover crops in summer cereal systems in the Eastern Free State area. An analysis of real-life farm system data was used to ensure the accurate simulation of practical farm systems and their cost structures, in the eastern Free State. This farm served only as basis for constructing the model. The farm size and yields were discussed during a multidisciplinary expert group discussion and adjusted until it was accepted as typical and representative by the group. Currently there is insufficient data available on the impact and use of cover crop in this area. This required an additional study of relevant international literature where studies have been performed in coherence with real-life situations. This approach provided the most accurate possible depiction of a real farm system. The ability to derive gross margins from a typical farm model simulation enables further evaluation of the specific implications of various different systems.

Modderfontein farm is situated 23 kilometers outside Heidelberg in Gauteng, close to the border of the Free State province (26º 40’ 55.1’’ S and 28º 21’ 18.9’’ E; altitude 1 500m). The climate is temperate and the area receives a long-term average rainfall of 600mm per season during the summer months. See Annexure A (personal communication Kriek, 2020). Soil in the area is predominantly Tukulu and Oakleaf soil types, see Annexure A. The Free State generally receives an annual summer rainfall of between 700 and 800 mm, and has a temperate climate with cold winters with low minimum temperatures.

Figure 4.1 The location of Modderfontein farm in Heidelberg, Gauteng in South Africa.

Source: Google maps, 2021

4.2.2. The different maize crop production systems being modelled

This study employs three different techniques to understand and explain the research question. The farm used as the norm for comparison is a mimicked real-life farm system and not an experimental trial farm. The study and analysis of the real farm system and international literature enables the inclusion of validated data to answer the research question.

In physical terms the farm operates on 1 150 hectares of arable land. An additional 627 hectares is used for buildings, farmyard, wasteland, and grazing for non-commercial purposes. Maize is the main commercial commodity produced, including both white and yellow varieties. Soybeans and other cover crops are also produced.

The first rotation system in the sequence is as follows: *maize – soybeans – maize – soybeans*, alternating annually with each summer growing season. This system is the baseline used for comparisons in this study. It represents a typical summer grain rotation pattern.

The second rotation system is: *maize – cover crops – maize – cover crops*, alternating with each growing season. Soybeans used in the first rotation system are replaced with cover crops which regenerate soil health rather than provide income.

The third rotation system uses the same rotation sequence as the second system but integrates an additional livestock component. In this system, cover crops are not only used for soil cover but also for livestock grazing purposes.

4.3. Establishing of typical or representative system

All aspects of the typical or representative farm were identified using budget models mimicking the real farm system and thus creating and comparing similar systems using an analysis of international literature to enhance accuracy. Budget models were constructed in Excel spreadsheets. A separate sheet models the different annual activities of a typical rotation system using maize and soybeans. This included details of land preparation, planting, the application of fertilisers, herbicides, pesticides and fungicides, and harvesting. Annual input prices were also determined on a three-year average to be used over the full time span of the model.

The base model was then sent to various experts, including local farmers, scientists and professionals from agribusinesses. These experts included:

- Dr. Hendrik Smith
- Gerrie Trytsman
- Dr. Jaap Knot
- Prof. James Blignaut
- Carel Kriek (farmer, Heidelberg)
- Izak Dreyer (farmer, Vrede)
- Danie Slabbert (farmer, Reitz)
- Hendrik Odendaal (farmer, Standerton)
- Hannes Botha (farmer, Carolina)
- Nicol de Vos (farmer, Kinross)
- Chris Bender (farmer, Clocolan)
- Hennie Vermooten (farmer, Ficksburg)
- Hans van Rooyen (farmer, Clocolan)

- Henk Vermooten (agricultural economist, Clocolan)
- Christoff Botha (farmer, Ladybrand)
- Henry du Preez (farmer, Ficksburg)
- Egon Zunckle (farmer, Bergville)
- Bred Muirhead (MSc student University of Pretoria, Winterton)

Discussions were conducted with these individuals to determine a standard model representing a typical real-life farm situation. A smaller group took part in the group discussion.

4.3.1. Data compilation and formulation of financial budgets

Financial budgets were constructed based on data from a real farm system and the study of related literature. These budgets adhere to standard accounting principles. It allows for comparison with other systems and countries, making it user friendly because well-known definitions are used and makes it easy to replicate. Currently, there is insufficient long-term data available on summer grain systems using cover crop rotation. Therefore, this study mimicked a real-life system to create simulated budget models which were then confirmed by experts. The whole study thus follows an explorative nature.

Data was structured into a simulation model of a farm in the form of a multi-period whole-farm budget. An evaluation was done to assess the production cost of system activities and the relative gross margin of the different systems for a 20 year period of which 2020 is assumed to be the first year.

Some accounting terms will briefly be defined for clarification purposes. All definitions are based on Standard Bank Agribusiness SA's Finance and Farm Management book. Thus, the gross margin of an enterprise is the gross production value for that enterprise less the variable cost. The enterprise's gross production value is defined as the total production from that specific enterprise as derived from marketable output. Variable costs are those that may vary in proportion to changes in the scale of the production of the enterprise. Variable costs consist of directly and non-directly allocated costs. Directly allocated costs are easily allocated to an enterprise and include costs associated with seed, fertilisers, herbicides, pesticides, contract work, crop insurance, *et cetera*. Non-directly allocated costs are variable costs that require detailed records including costs associated with machinery, for example the maintenance of machinery, *et cetera* (Louw, Geyser et al., 2017).

Total gross production value and directly and non-directly allocated costs, are calculated by integrating the expected quantities with the relevant prices. This was necessary to determine the gross margins of each enterprise in the different systems to enable economic analyses and evaluation. Spreadsheets in the workbook included:

- Farm description and assumptions – This sheet includes all relevant information of the farm layout and value, as well as activities undertaken including their specific related costs.
- Commodity prices were based on SAFEX's trading prices and other relevant literature sources. Input prices associated with various activities, including the application of fertilisers, chemicals, *et cetera*, were based on the real farm system and confirmed by experts.
- Gross margins – a budget was compiled for each enterprise to derive its gross margin. This is shown in Annexure D.
- Gross margin analysis – a summary of all related system costs and margins is available in Annexure D.
- Multi-period budget and cash-flow budget – including all enterprises of the three systems with all variable-, fixed, and overhead costs to indicate the whole-farm profitability figure. In addition, it is also used to calculate the IRR and NPV values. Refer to Annexure F.

4.4. Crops utilised on the farm

4.4.1. Maize

According to the BFAP Baseline (BFAP, 2020), white and yellow maize used for commercial purposes are two of the main summer crops produced in South Africa. Together, they make up the largest percentage share in terms of area under major summer crops.

The largest portion of maize production in South Africa occurs in the Free State, followed by Mpumalanga and the North West provinces (Greyling & Pardey, 2019). As previously mentioned under Section 2.3, maize is one of the most important food crops to ensure food security. Broadly analysing white and yellow maize production trends; indicates the total hectares of marginal land used is decreasing, while prices are volatile and display a decline. This underlines the need for sustainable alternative measures, ensuring increased profitability and maize yields.

4.4.2. Soya beans

South African's ever increasing soya bean production is predicted to grow even further in future. From 2000 the hectares planted under soya beans were relatively low, but by 2029 production is expected to grow, making it the third largest major summer crop production area in South Africa (Meyer, 2020). Soya beans demand high prices, which further support ongoing expansion. Soya bean crops are an excellent choice in a rotation system as they fixate nitrogen into the soil promoting overall soil health, which results in increasing maize yields.

4.4.3. Teff

Teff is an annual grass, often planted as a forage crop. It is grown on lower quality soils which do not provide high maize yields, making it an unfeasible crop in economic terms. Teff is harvested and used as a hay crop to feed livestock. The root system is shallow, therefore; overgrazing can easily occur making the management of grazing critical. The crop provides good soil coverage throughout the year and may generate a small income.

4.4.4. Cover crops

A mixture of both winter and summer cover crops are used on the farm, selected in terms of the specific goal for the given season. Often cover crops are planted to rebuild and regenerate overall soil health, which in turn delivers higher yields. The yields of a cash crop season are closely monitored to determine the effect on future yields.

4.5. Construction of the whole-farm budget model

The profitability of a typical farm is heavily influenced by the prices associated with inputs and outputs, and the quantities used and produced. Hoffman (2010) states that although producers can influence the magnitude of inputs and yields through effective farm management strategies, exogenous factors are generally determined by the market and macro environments and cannot be controlled by individual producers or producer groups.

The focus of this study is to evaluate the financial implications of cover crops in a summer grain system. To financially evaluate the profitability of various systems, multiple whole-farm, multi-period budgets were constructed. The effect of cover crops is expected to manifest over time, as well as the impact on area covered, investment requirements, and livestock management. This necessitates a longer-term view of the system and the alternatives.

Firstly, the model determines the expected profitability of the typical farm. This is followed by the construction of alternative production systems, which are compared to the original system of the typical farm to determine the financial implications inherent in each system. Lastly, the impact of exogenous variables on the profitability of each system is assessed. The model provides insight into the interrelatedness of factors that influence whole-farm profitability.

The models are founded on standard accounting principles and incorporate a standardised format for the calculation of income, costs, and margins. The models are flexible in terms of farm structure. Changes can be made to farm size, inventory replacement periods, prices associated with inputs and outputs, production systems, and structural farm parameters. All variables are interrelated, making Excel spreadsheets the ideal tool to measure the impact of one variable on another. The whole-farm budget consists of three main components, ordered logically to evaluate data and calculate outputs. Figure 4.2 illustrates the three components.

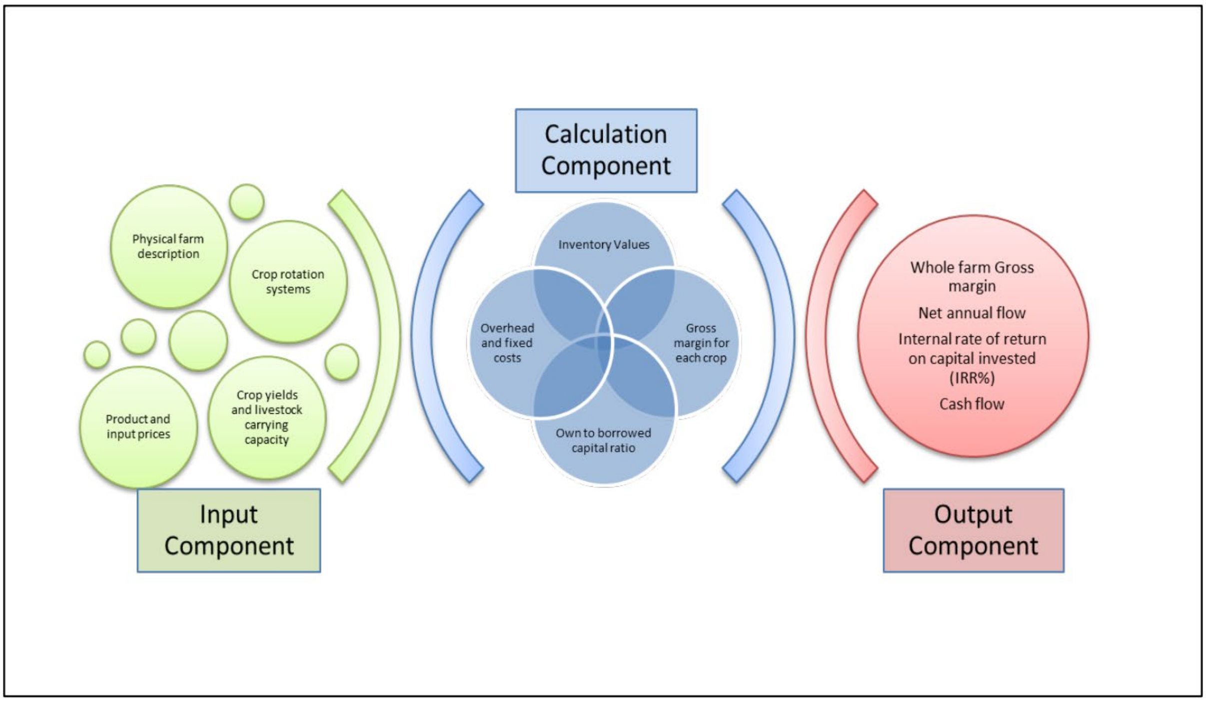

Figure 4.2 Components of a whole-farm, multi-period budget model.

Source: Adapted from: (Hoffman, 2010)

4.5.1. Input component

The input component of the model comprises data relating to the parameters of the farm, including its physical description, details of crop rotation systems and farming practices, land utilisation patterns, assumptions regarding yield, and input and output prices. A change in the input component will directly influence and cause a change in the output component, making it ideal to display cause and effect for any modifications.

4.5.1.1. Physical description and dimensions of typical maize farm

The main purpose of generating a typical farm model is to provide a basis for comparison with farms in similar areas. The typical farm is modelled by mimicking a farm in the same location based on the general physical parameters.

The selected typical farm parameters were presented to the group of experts in the multidisciplinary discussion and consensually agreed to.

The typical size of the farm influences various factors within the whole-farm model, including the area under cultivation, utilised land, level of mechanisation, labour requirements, livestock carrying capacity, livestock replacement policies, and the investment required for fixed improvements.

Farms always have non-arable land which includes rocky areas, roads, riverbeds, steep inclinations, protected areas, and poor soils among others. Non-arable land, not suitable for cultivation, is indicated as a percentage of land use in a farm system. Land usage refers to the area under cultivation, whether it be for crops or pasture in a rotation system.

It is important to determine land usage patterns as they impact the profitability of the farm. Non-arable land has an associated capital requirement but it does not contribute to the productive area of the farm and does not generate an income. Under different land use patterns whole-farm profitability may vary as a result of different combinations of crops within a given crop rotation system.

Land ownership is another critical factor that can influence the profitability of the farm. The whole-farm model accounts for owned land as well as rented land. Rented land generally affects the factor cost component in the model which in turn affects the profitability of the farm business. In this study, it is assumed that no land is rented; therefore; the profitability will remain unaffected by the ownership structure.

4.5.1.2. Financial description of the farm

A typical maize farm in the Eastern Free State is described in financial terms, presented in the form of an inventory or asset register. The farm inventory generally includes land, fixed improvements, equipment, implements, machinery, and livestock. The amount and size of machinery and equipment is directly dependant on the size of the farm. This information is detailed in the whole-farm budget and further validated through the expert group discussions.

4.5.1.3. Data on input and output prices

All the data is recorded in an Excel workbook where spreadsheet functions can easily be used by the user to adapt the model according to objectives. Input and output prices are listed in a data table, together with typical application rates for all inputs. The data table forms the base of all calculations made in each enterprise budget relating to input prices. The sales unit of produce, prices, and expected yield per hectare are translated into values per hectare in enterprise budgets.

The input costs included in the model was obtained from the Modderfontein farm in Heidelberg, Gauteng. To ensure accuracy the values were compared to literature and validated by the expert group discussions. Section 4.3.1 and Annexure E displays and explains how data is captured and recorded.

4.5.2. Calculation component

The calculations comprise a sequence of interrelated equations. It creates a critical structure which abides by two principles. Firstly, it ensures that financial results are universally comparable and all physical and biological interrelations adhere to standard accounting principles. Secondly, the accurate simulation of processes on the farm is required to ensure reliable outcomes.

The calculation component links the input to the output components, using the input component to generate results which are presented in the output component. By using various Excel functions, assumptions on the parameters of a typical maize farm are used to calculate the enterprise's budget for various commodities and determine the gross margin. The gross margin is used in the multi-period budget calculation, which in turn is used to determine the internal rate of return (IRR) and net present value (NPV).

4.5.2.1. Farm inventory

The farm inventory is used to determine the expected capital required for the whole farm to operate effectively and sustainably. The capital requirement comprises of the farm assets, which includes land, fixed improvements, machinery and equipment, and livestock. The general inventory required for the Modderfontein farm is shown in Annexure C. It includes financial and physical descriptions of asset items on the farm. The information includes age, the expected lifetime, annual usage, quantities, depreciation, and current value.

Each system may require different inventory items. While the purpose of this study is to evaluate the financial implications of cover crops in summer grain systems, one of the research objectives is to assess cover crops used as pasture where livestock integration takes place in one of the three systems used in this study. The sum of the inventories required for one system therefore would differ from another. The profitability of the farm is influenced by its specific investment requirement, which is displayed in the output component.

The inventories of each system were confirmed by the multidisciplinary group. According to the group the typical size of a maize farm in the area is 1777 hectares. The price of farmland, validated consensually by the group, was determined by valuations done in the area, influenced by soil types, fixed on-site improvements, water accessibility, and general location. Prices of farm equipment and implements were confirmed by local farmers to avoid discrepancies and inconsistency. The farmers shared information with respect to prices paid, expected lifetime, and intensity of usage of machinery. The reason for this approach was that local farmers used machines to the same extent and equipment had similar lifetimes. In addition it had to be taken into consideration that they often purchase second hand implements in good condition at a fraction of the original price.

The investment requirement for livestock was determined by the farm's available pasture, grazing capacity, and herd composition. Assumptions were made relating to herd composition, including the ram to ewe ratio, and the ewe replacement policy. These assumptions were sourced from previous studies and confirmed by expert group discussions (Hoffman, 2010). The remaining values relevant to livestock farming was obtained from industry experts and validated in the group discussion.

4.5.2.2. Gross margin calculations

The multiple whole-farm budget models included a typical maize farm rotation system with soya bean, a maize farm rotation system with cover crops, and a maize farm rotation system with cover crops and an integrated livestock component for grazing purposes. Refer to Section 4.2.2. for more details.

Gross margins, the accepted measure to compare different enterprises with one another, were calculated for each rotation crop in the entire farm system (Louw et al., 2017). Regional rainfall dispersion was used to determine the seasonal variation of good, average, and poor yield performance years. The gross margin for each of these seasonal variations for each enterprise was calculated and is depicted in Annexure D.

As rainfall in the area is unpredictable, the seasonal variation sequence over the 20-year period is also unpredictable. Changes in the pattern of the sequence are thus highly likely.

Selecting the seasonal variation sequence for this study was based on historical rainfall patterns obtained from farmers in the area and validated in the group discussions. When rain falls at the right time and in sufficient quantity to ensure maximum plant growth, it is seen as a good year. An average year entails sufficient rainfall but lacks adequate dispersion over a growing season (Hoffman, 2010). Whereas, a poor year has a low total annual rainfall with erratic dispersion resulting in reduced yields.

The multi-period budget reflects the frequency of seasonal variations by displaying gross margins for either good, average, or poor years by means of a series of 'IF-statements'. Gross margins for the various scenarios are calculated by subtracting the total variable cost from the total production value, as mentioned in Section 4.3.1. The study provides a total of three multi-period budgets for the various systems, which are also used to calculate the internal rate of return (IRR) and the net present value (NPV).

4.5.2.3. Overhead and fixed costs

Fixed costs make up a portion of the total cost of the enterprise and remain fixed in the short term. These costs do not vary with the intensity or scale of production over the short term. Overhead costs refer to the portion of total costs, not associated with the activities to produce a product (Louw et al., 2017).

The overhead and fixed cost values were determined by farmers' personal experiences and approved in the group discussions. The cost generally includes accountants' fees, electricity, insurance, licenses, and permanent labour. These values can be seen in the overhead and fixed costs section in Annexure F.

4.5.3. Output component

The output component of the model contains two key financial indicators. Firstly, whole-farm profitability is expressed in terms of IRR and NPV and secondly, cash flows are used to determine the sensitivity of farm cash flow in various rotation system scenarios.

4.5.3.1. Profitability

Whole-farm budget models were calculated over 20-year planning periods. The reason for such an extensive period is largely due to the nature of the extended rotation systems and to allow for the replacement of farm inventory. A full evaluation of various crop rotation systems, their yield sequences due to rainfall patterns, and respective replacement schedules can be ascertained by an analysis of the profitability of the various production systems.

The main goal of the multi-period whole-farm budget is to determine the current financial performance of a typical maize farm in the eastern parts of the Free State. The financial impact of various risky input or output factors on the profitability of the farm can easily be assessed using this model.

The gross margin and cost per hectare for each crop enterprise is individually calculated. In the multi-period budgets, gross margins are calculated based on the sequence of seasonal variation according to good, average, and poor years. The summation of all the crop enterprises' gross margins provides the whole-farm's gross margin. Overhead and fixed costs were kept constant over the 20-year planning period. The costs were determined following engagements with local farmers and consensus in group discussions.

The net flow of all funds was calculated in the multi-period budget models. The net flow of funds includes the enterprise's gross profit less fixed and overhead costs, and capital expenditure on newly bought inventory. In addition, the profitability of the farm was evaluated and assessed in terms of its internal rate of return (IRR) and net present value (NPV).

Net present value refers to the minimum monetary value a farm must earn to maintain its market value (Louw et al., 2017). It is a monetary measure in present value terms of expected future cash flow.

The internal rate of return measures the return on capital investment. It measures the growth generated by cash flow, as a percentage return on initial capital investment. Where competing projects have different start times, capital investment, or periods, the IRR and NPV are important. In this study, the IRR and NPV provide an ideal comparison between the various scenarios and a measure of the impact on whole-farm profitability. Refer to Annexure F where the multi-period budget model for each enterprise in the crop rotation systems indicates the appeal of investment using IRR and NPV.

4.5.3.2. Cash flow

A multi-period cash-flow budget reveals useful information and explanations for the application of cash expenditure during a specific period. The budget indicates whether sufficient cash is available to cover expenses (Louw et al., 2017) and is critical in determining the affordability of an investment. The impact of different farming rotation systems can be observed using a cash-flow analysis. Additionally, the effect of machinery replacement schedules on cash flow is clearly observable. Break-even years and periods of positive or negative cash flows, are calculated in this specific budget.

The cash flows for the 20-year period are calculated from the profit after tax which is incorporated into the model. The amount of tax paid by the farmer varies considerably from one farm to another. In this model it is assumed that a standard 28 percent tax is paid on the income generated.

4.6. Conclusion

Firstly all the features and components of the farm located in, Heidelberg Gauteng, is described extensively. Physical and financial information, crop rotation systems with the specific crops, management of the farm, and the data collection and use is presented. Moreover, the method of gross margin analysis is explained together with its benefits. The data, captured into farm budgeting models, is used to calculate gross margin per hectare to reveal trends in factors of production.

The agronomic, scientific, and economic performance of three different crop rotation systems is investigated during a gross margin analysis. To accurately interpret whole-farm results, a process is required that constantly adheres to the systems thinking approach, as changes in a system have knock-on-effects.

The data developed in the budget models require validation from experts in the industry. This is done through the multidisciplinary group discussions that include producers, agricultural economists, agronomists, and soil scientists. The values that need confirmation include typical farm characteristics, input and output relationships and prices, farm inventory and replacement schedule, and livestock carrying capacity. The typical farm that is modelled serves as a basis of comparison to identify the effects of changes in the various systems. The model simulates the physical and biological farm system and transposes data into a standardised accounting format enabling the evaluation of the financial performance of the different systems.

Chapter 5: Financial evaluation of cover crops in different crop rotation systems at the whole-farm level for maize producing farms in Eastern Free State areas

5.1. Introduction

Chapter 4 provides a description of the theoretical foundations for constructing and using a whole-farm budget model. The evaluation of available data and integration into budget models forms the basis for assumptions discussed during the multidisciplinary group discussions. According to Hoffmann (2010) once the typical farm information is converted into a whole-farm model the opportunity exists to evaluate and compare the differences between alternative farm management decisions.

The first part of Chapter 5 presents the validated assumptions regarding a typical farm in the Eastern Free State area. Whole-farm gross margin, variable cost structure and differences, and investment requirement, is presented. Attention is paid to the profitability of the three different crop rotation systems implemented at a whole-farm level with emphasis on the IRR and NPV values. The model measures the impact on profitability due to changes in key parameters of the different systems.

Lastly, financial implications of identified factors are evaluated. Scenarios are simulated to measure the sensitivity of whole-farm profitability to changes in these factors. The various applications of the model prove usefulness as a tool to evaluate different farming systems.

5.2. Assumptions regarding the physical farm description

The structure of the whole-farm calculation model was described in Section 4.5. The multidisciplinary group agreed to a typical farm size of 1777 hectares. Furthermore, the assumption is made that the whole farm is owned and managed by the farmer and no additional land is rented. Of this, 65 percent is arable and the remaining 35 percent non-arable which includes riverbeds, roads, wet areas, sandy soils which will not generate profits if cultivated, areas for buildings, and livestock handling areas.

Table 5.1 displays the physical characteristics of the typical farm in the Eastern Free State region as accepted through consensus by the expert group.

Table 5.1 Physical description of the typical farm in the Eastern Free State area

Homogenous area	Heidelberg, Gauteng
Typical farm size (ha)	1777
Land price (R/ha)	40 000
Percentage arable land	65%
Hectare arable land	1150

The whole-farm budget model serves as point of departure for comparisons to evaluate the effects of different scenarios. It is important to note that the assumptions are used for the purpose of comparison, and that farmers do not necessarily allocate land in the manner stated. It was agreed that between white maize, yellow maize and soya beans the available arable land will be equally proportioned between crops. Furthermore, when cover crops come into play the area under cover crops are much less than the amount of maize. The reason being, cover crops do not generate an income when implemented in a rotation system, causing reluctance among farmers to incorporate on a larger scale. However, a larger area of cover crops can be planted when intercropped among the maize. Generally, this practice will occur on soils that have a poorer yield potential. When livestock is included in a system the cover crops are used for grazing purposes.

Climatic condition can often be unpredictable. In the Eastern Free State, a trend can more or less be determined by historic data and calculating an average. The multi-period budget is modelled over a 20-year period. The expected profitability and cash flow of the farm is greatly influenced by the rainfall dispersion in the area. The rainfall prevalence average over the period was agreed upon by the multidisciplinary group which also allocated typical yields for each crop according to good, average, and poor years, as indicated in Table 5.2.

Table 5.2 Validated expected yields and associated prevalence of good, average, and poor yield years for white maize, yellow maize, soya beans, teff, winter cover crops and summer cover crops in the Eastern Free State area.

	White Maize		Yellow Maize		Soya beans		Teff		Winter cover crops		Summer cover crops	
	Yield (Ton/Ha)	Across 10 years	Yield (Ton/Ha)	Across 10 years	Yield (Ton/Ha)	Across 10 years	Yield (Ton/Ha)	Across 10 years	Yield (Kg/m²)	Across 10 years	Yield (Kg/m²)	Across 10 years
Good	9.2	3	9.2	3	3.4	3	6	3	3.5	3	7.3	3
Average	7.5	5	7.5	5	2.7	5	4.2	5	3.5	5	4.0	5
Poor	6.8	2	6.8	2	2.0	2	3.8	2	3.5	2	1.5	2

5.3. Farm inventory

To determine the capital investment required for the typical farm and different systems in the Eastern Free State area, a farm inventory is used. The total inventory value represents the required investment as previously discussed. The farm inventory includes land, fixed improvements, machinery, equipment, and livestock as described in Chapter 4 (see Annexure C).

The land value of a typical farm was obtained from land evaluators in the area (Kriek, personal communication, 2021). The multidisciplinary group agreed that the land price of farmland in the area is R40 000.00 per hectare. Land value constitutes a large part of the investment required.

The value of machinery was calculated based on best practices for a typical farm. The size of the farm and crop rotation systems operations influences the size and capacity of machinery as well as the maintenance and replacement thereof.

The composition and herd size of livestock also determines the investment requirement. The size and composition thereof are influenced by the available pasture and the stocking rate. The stocking rate was determined as two ewes per hectare, using the budget modelled for a typical farm in Heidelberg, validated by the discussion group. The overall value of the herd including rams, ewes, replacement ewes, and lambs were obtained from farmers and specialists in the industry.

The typical farm inventory list and associated values were confirmed by the expert group. The expected capital requirement for a typical maize farm with a soya bean rotation system is R16 649 000. Furthermore, the capital requirement for a system using cover crops in a maize-based rotation system amounts to R18 099 000 and integrating a livestock component will add additional value which finally amounts to R19 924 000. Refer to Annexure C for the detailed differences in equipment and livestock added in various system inventory lists. The increase in capital requirement is attributable to additional implements, machinery, and livestock that need to be purchased to implement alternative farming systems.

5.4. Gross production value

The gross production value refers to the total number of hectares allocated to a specific crop or product, multiplied by the expected total yield, and the expected price of the crop or product per hectare. Thus, the value in essence is the revenue generated by a specific product or enterprise before any costs is subtracted. The gross production value of the whole farm is the summation of each individual product or enterprise's gross production value. Table 5.3 indicated the average price of different commodities used in the study as incorporated in whole-farm budget models.

Table 5.3 Product prices for crops and livestock products

Product	Unit	Price per unit
White maize	Ton	R 3 000
Yellow maize	Ton	R 3 000
Soya beans	Ton	R 6 500
Teff	Ton	R 1 500
Eragrostis / Rhodes	Ton	R 1 000
Livestock	Per sheep	R 1 500

The values in Table 5.3 are based on actual market prices at a specific point in time, confirmed by the participants in the group discussions. Table 5.4 displays the whole-farm gross production value per system for a typical farm in the area with the associated yields as shown in Table 5.2.

Table 5.4 Gross production value per system for a typical farm in the Eastern Free State region for good, average, and poor years as determined by rainfall distribution.

Rotation system	Total income per hectare and for the whole farm					
	Good year		Average year		Poor year	
	R/Ha	R/Farm	R/Ha	R/Farm	R/Ha	R/Farm
System 1	16 778	29 815 000	13 586	24 142 500	11 745	20 870 000
System 2	16 044	28 509 600	13 033	23 160 000	10 814	19 215 600
System 3	16 550	29 409 600	13 540	24 060 000	11 320	20 115 600

Source: Own calculation

5.5. Variable cost

During production variable cost varies with scale and intensity. It depends on the specific product and the amount of hectares that is planted. The variable cost in this study remained constant irrespective of the seasonal performance. The items included under variable cost are as follows: fertlisers, chemicals, contract work, labour, seeds, and other consumables. The input cost prices were obtained from the actual farm in Heidelberg, which was then approved by the multidisciplinary group. In the gross margin analysis of each enterprise in Annexure D, the total input cost per individual crop is shown.

The totals included in the model serve as basis for the budgets. The marketing cost which includes storage and transportation cost are included in the variable cost of the models. Table 5.5 shows the average total variable cost per hectare of arable land on the farm.

Table 5.5 The total variable cost of each product included in the various systems.

Crop	**Total yearly variable cost per ha (R/Ha)**
White maize	R 12 636
Yellow maize	R 12 636
Teff	R 3 463
Rhodes / Eragrostis	R 2 499
Winter cover crops	R 6 380
Summer cover crops	R 3 090
Livestock	R 974
White maize after cover crops	R 11 816
Yellow maize after cover crops	R 11 816
White maize intercropping	R 9 422
Yellow maize intercropping	R 9 422

5.6. Gross margin

The total farm gross margin is in essence the total farm revenue less all the costs of production on the farm, where the costs refer to variable costs. A gross margin analysis for each enterprise within each seasonal variable: good, average, or poor according to rainfall distributions, was compiled and shown in Annexure D. Therefore, the gross margin of each enterprise is a function of the yield per hectare under each seasonal variable and the price of the products, less the variable cost per hectare. The gross margin of each crop is influenced by the total hectares planted. Hectare allocation for each commodity is determined by the rotation system and arable land available. The total amount of hectares planted per crop is multiplied by the gross margin of that specific crop to calculate the total gross margin. The summation of each crop's gross margin will result in a value for the whole-farm gross margin. Table 5.6 shows the expected whole-farm gross margin for the three different systems.

Table 5.6 Total whole-farm gross margin per system for a typical farm in the Eastern Free State area for good, average and poor years based on rainfall distribution.

Rotation system	Gross margins per hectare and for the whole farm					
	Good year		Average year		Poor year	
	R/Ha	R/Farm	R/Ha	R/Farm	R/Ha	R/Farm
System 1	9 562	16 992 365	6 370	11 319 865	4 529	8 047 365
System 2:	8 693	15 446 724	5 682	10 097 124	3 462	6 152 723
System 3:	9 131	16 226 344	6 136	10 903 506	3 916	6 959 256

Source: Model calculation

5.7. Fixed and overhead cost

Fixed and overhead costs are that which remain constant regardless of the scale or intensity of production. Generally fixed and overhead cost include the following: licenses, water and land tax, electricity, bookkeepers' fees, salaries of permanent workers, insurance cost for permanent improvements, bank charges, administration costs, communication costs, and maintenance cost on fixed improvements. These specific costs will vary from one farm to another with no set standard. However, during the multidisciplinary group discussions, the participants agreed on the total annual fixed and overhead cost for a typical farm in the area.

The model assumes the total fixed and overhead cost for a typical farm amounts to R2 339 631.00. Unforeseen expenses are included in this amount, calculated at five percent of the total fixed and overhead costs. The assumption was made that the total fixed and overhead cost remained constant over the 20-year budgeting period and the total value remained the same across all models. It should however, be noted that this constant amount is not always possible and can vary due to farmers varying perceptions, interest goals or even ability.

5.8. Profitability

It is assumed that the consumer is rational in making decisions with the main goal to maximise profitability with the lowest possible cost of production. Maximising profit rather than income is the main goal of almost all producers and businesses.

Sustaining profitability is generally challenging for farm managers in a volatile farm environment. The study makes use of a budget model for a typical farm over a period of 20 years to calculate the profitability. The financial performance is expressed in terms of internal rate of return (IRR) and net present value (NPV) of the future expected cash flow.

Components of the whole-farm budget model are discussed in Section 4.5. Multi-period capital budgets for the various systems are displayed in Annexure F. From the whole-farm multi-period budgets, the IRR and NVP are derived for the three different farming systems, specifically using the net flow of funds. The IRR and NPV for each crop rotation system over a 20-year period are displayed in Table 5.7. The average nominal interest rate was 9.0 percent, the inflation rate 6.1 percent, and the real interest rate 2.73 percent (The World Bank, online).

Table 5.7 The internal rate of return on capital investment (IRR) and net present value (NPV) for each typical crop rotation system

Crop rotation system	Internal Rate of Return (IRR)	Modified Internal Rate of Return (MIRR)	Net Present Value (NPV)
System 1	17%	11%	R 30 275 487
System 2:	15%	11%	R 17 328 020
System 3:	10%	9%	R 4 796 815

Source: Own calculation

There will be an expected negative net present value (NPV) if the internal rate of return (IRR) is at a value less than the real interest rate. If a negative NPV figure is obtained in a system, it indicates that the project is not profitable, and the farmer will receive a higher return by banking the extra money spent to bring about changes. All three systems displayed a positive NPV and an IRR value of 10 percent or higher. Thus all the systems evaluated in the study are profitable. The modified internal rate of return (MIRR) is used to demonstrate a more realistic assumption about the reinvestment rate.

System 1, a basic maize-soya bean rotation system, is the most profitable over a 20-year period in the Eastern Free State area displaying an expected IRR value of 17 percent. The reason for the higher profitability figures is that all arable land available is used to plant cash crops. Therefore, during good years the producer can take full advantage of arable land under cash crops which generate higher gross margins. The other two systems implement non-cash crop, cover crops, which reduces the overall total income as less cash crops are planted to generate income.

System 2 has the second highest expected IRR value of 15 percent making it less profitable than System 1. A lower IRR value was expected, as arable land is now used to plant non-cash crops with no additional value obtained from these crops. Only a small total amount of hectares is used to plant cover crops, therefore, a small amount of income from maize crops is sacrificed.

System 3 has the lowest IRR value at 10 percent. The system is the least profitable of the three, owing to the large additional capital requirement to integrate livestock into the system. This system remains profitable during the 20-year period and is the most diversified system. Farmers can aim to diversify and integrate natural resources that are available to counteract the risks associated with monoculture practices.

5.9. Cash flow and liquidity

The IRR does not predict the sustainability of the farm enterprise. Most farming enterprises in South Africa, especially cereal and grain farms, receive the bulk of their income once a year. Income is received after harvest when products are sold, but the expenses throughout the year are incurred monthly to ensure full operation continues. Thus, cash flow shortages can often occur during the year. The IRR value is used in a manner which does not always consider changes in bank balances. Therefore, it is critical to evaluate the liquidity of the expected cash flows of the farm enterprise to ensure sustainability. According to Hoffmann (2001) the liquidity of a production system measures the ability of that system to repay liabilities without interfering with normal operations on the farm.

Annexure F shows the expected cash flows of a typical farm for the 20-year period. The cash flow budget considers the yearly inflow and outflow of cash that reflects in the farm's bank balance. Borrowed capital is often used to finance capital items included in the inventory list which needs to be replaced during the 20-year period. Borrowed capital is used to maintain a positive cash flow during the year. In this study, borrowed capital is not incorporated in the model. It is therefore critical that own capital contributions need to be larger to maintain a positive cash flow.

5.10. Expected impact of key variables

In following section different scenarios are created to reveal the sensitivity of whole-farm profitability relating to changes in product and input prices. Different scenarios are used as a tool to display potential outcomes which allows the producers to create hedging strategies against likely obstacles. Therefore, a scenario analysis can ensure that farmers are able to evaluate the impact of possible future outcomes.

For this study, a *ceteris paribus* principle is applied, meaning that in the event of a price change, for example, all other things are kept constant. In economic terms it explains the effect of one economic variable on another (Knott, 2015). The following scenarios were selected and discussed to determine the sensitivity of the different systems to possible changes in current assumptions.

5.10.1. Scenario 1: cover crop intercropping between maize

The first scenario assessed the effect of cover crop intercropping among maize on the whole-farm profitability. Cover crops are brought into the system, not only in rotation systems but also by means of intercropping. Cover crops are planted among the maize, therefore, less income is lost by the non-cash crop. Based on personal communication with Hendrik Smith, input cost should decrease up to 50 percent within 4 years of intercropping. The input costs that are affected to the greatest extent are the fertilisers, lime, herbicides and pesticides. The yield gain of maize is not necessarily affected but the decreased input costs will result in larger profit margins.

To effectively indicate the impact of intercropping on profitability, scenarios of lowering input costs are simulated to evaluate the impact on IRR. The results are displayed in Table 5.8. The current situations, without intercropping, are depicted on the left-hand side of table under 'Whole-farm model'. The columns to the right show the decreasing input cost scenario due to intercropping as well as the relevant IRR values. The relative change in the IRR is the percentage change between the current IRR and the new IRR.

Table 5.8 Relative percentage change in IRR as a result of a decrease in the input costs.

Whole-farm model			**Decreasing input cost relating to intercropping**					
Crop rotation system	**Internal Rate of return (IRR, %)**	**Net Present Value (NPV)**	**15% ↓ IRR (%)**	**Relative change in IRR**	**30% ↓ IRR (%)**	**Relative change in IRR**	**50% ↓ IRR (%)**	**Relative change in IRR**
System 2	15.02	R17,328,020	16.85%	12.18%	17.16%	14.25%	17.57%	16.98%
System 3	9.85	R4,796,815	21.45%	117.77%	21.79%	121.22%	22.24%	125.79%

Source: Own calculation

System 2, as previously discussed, entails a rotation system between maize and cover crops. Every second season the land area planted under maize is replaced with cover crops to regain soil health in the long term. A certain amount of arable land is used to plant a non-cash crop; therefore, no income is generated from that specific piece of land, leading to smaller profitability margins. Instead of using an area for cover crops, the cover crops are now planted in between maize. The cover crops provide maximum soil coverage between crops, together with many other benefits associated with the implementation of cover crops as discussed in Chapter 2. Furthermore, System 3 entails a rotation system between maize and cover crop together with an integrated livestock component.

Comparing the current situation of the whole-farm model of System 2 and System 3 where cover crops are used in a rotation system, it is clear that the IRR is significantly lower. The reason is attributed to the fact that less land is generating an income as well as the lowered input cost caused by the intercropped cover crops.

Intercropping amongst maize significantly decreases the input cost and is clearly visible in the IRR value. Initially, the maize-cover crop rotation system displayed an IRR of 15 percent whereas the intercropping increased the IRR value to 17.57 percent with a 50% decrease in input cost for fertiliser, lime, herbicides, and pesticides application.

The integration of the livestock leads to a larger increase in IRR value. Initially, income is lost during the maize-cover crop rotation system together with an additional capital expenditure to purchase livestock. Therefore, the current IRR value is the lowest of all systems. However, intercropping ensures that arable land is used to full advantage while integrating cover crops together with an additional food source for livestock after harvest. The IRR value rises from 10 percent to 22.24 percent with intercropping. The system also obtained the highest NPV of R38 050 218, thus the additional investment required will return a profitable amount of cash inflow. The relative change in IRR for a 50 percent decrease in input cost is also the largest percentage change at 126 percent.

5.10.2. Scenario 2: increasing input cost

The following scenario is used to assess the impact on profitability with increased input costs. The reason for running this simulated scenario is to determine the impact of input price inflation on the typical farm for each of the different systems. The price increases were visible on all variable costs of the farm which include the fertiliser, chemicals, and fuel. The impact on the IRR is evaluated by simulating an increase in input costs at 10 percent, 20 percent, and 30 percent. Table 5.9 shows the results of the simulations. The first columns display the current situation under a whole-farm model. The columns to the right, under the rising input cost scenario heading, depicts the effect of percentage change in input prices on the IRR. The relative change in the IRR is the change in percentage between the current IRR and the new IRR.

Table 5.9 Relative percentage change in IRR as a result of an increase in input costs.

Whole-farm model			Rising input cost scenario					
			10% ↓		20% ↓		30% ↓	
Crop rotation system	Internal Rate of return (IRR, %)	Net Present Value (NPV)	IRR (%)	Relative change in IRR	IRR (%)	Relative change in IRR	IRR (%)	Relative change in IRR
System 1	17.38	R30,275,487	12.95%	25.49%	8.54%	50.86%	3.97%	77.16%
System 2	15.02	R17,328,020	11.14%	25.83%	7.23%	51.86%	3.13%	79.16%
System 3	9.85	R4,796,815	6.86%	30.36%	3.76%	61.83%	0.42%	95.74%

Source: Own calculation

The table depicts the extent of vulnerability of the various systems to an increase in variable input cost. System 3 is the most vulnerable to changes in input cost, leading to the system becoming unprofitable. A 30 percent increase in variable input cost will lead to a 77 to 80 percent decrease in IRR of the two most profitable systems. The same scenario will lead to a 96 percent decrease in IRR in system 3. It is clear that the variable input costs directly influences whole-farm profitability for farms in the Eastern Free State area.

5.10.3. Scenario 3: change in maize price

As previously discussed, the farm environment is extremely volatile and the only way to mitigate the effects of rising prices is to optimise productivity by producing more with less, therefore; expanding production to utilise economies of size and scale. Changes relating to the maize price may have a significant influence on the profitability of the farm. Producers globally experience rising input prices and sometimes declining commodity prices. Thus, the scenarios created are possibilities that are likely to occur. The declining prices can have detrimental effects on the farming business as shown in Table 5.10

Table 5.10 Relative percentage change in the IRR as a resultant of declining maize prices.

Whole-farm model			Declining maize price scenario					
Maize price R3000			10% ↓	R2700	20% ↓	R2300	30% ↓	R2100
Crop rotation system	Internal Rate of return (IRR, %)	Net Present Value (NPV)	IRR (%)	Relative change in IRR	IRR (%)	Relative change in IRR	IRR (%)	Relative change in IRR
System 1	17%	R30,275,487	10.59%	37.71%	3.35%	80.29%	-5.97%	135.12%
System 2	15%	R17,328,020	8.51%	43.27%	1.25%	91.67%	-9.01%	160.07%
System 3	10%	R 4,796,815	3.31%	66.90%	-5.00%	150.00%	-17.19%	271.90%

Source: Own calculations

A scenario is created where the maize price declines with 10 percent. As shown in Table 5.10 the decline will cause a relative change of 38 percent in IRR for System 1, the most profitable and up to a 67 percent relative change for the least profitable, System 3. In the event of a 30 percent decrease in the maize price, none of the systems will remain profitable. However, a 30% decrease in maize price is highly unlikely, as by all accounts the demand for maize for human and animal feed is increasing steadily. Structural change in SADC countries like Zambia and Zimbabwe could however unlock vast production capacities.

The reason for System1 showing the highest profitability is attributable to the fact that soya beans are planted in rotation with maize. The maize price decline will not affect the soya beans which will remain a stable form of income during the price decline. The other two systems are made up of a cash crop (maize) and a non-cash crop (cover crops). Therefore, if the maize price declines there is no other alternative form of income to support or stabilise the reduced overall income. The additional capital investment required for livestock in System 3 will have an even greater negative effect on the profitability of the farm when the income stream is under severe strain.

Table 5.11 demonstrates the opposite scenario, the effect of increases in the maize price. The scenario created would reveal even greater relative changes in the IRR for rotation systems that contain greater amounts of maize in the system.

Table 5.11 Relative percentage change in the IRR as a result of the increase in maize price.

Whole-farm model			**Rising maize price scenario**					
Maize price R3000			**10% ↑**	**R3300**	**20% ↑**	**R3600**	**30% ↑**	**R3900**
Crop rotation system	**Internal Rate of return (IRR)**	**Net Present Value (NPV)**	**Internal Rate of return (IRR)**	**Relative change in IRR**	**Internal Rate of return (IRR)**	**Relative change in IRR**	**Internal Rate of return (IRR)**	**Relative change in IRR**
System 1	17%	R30,275,487	24.28%	42.82%	31.58%	85.76%	39.51%	132.41%
System 2	15%	R17,328,020	21.42%	42.80%	28.02%	86.80%	35.01%	133.40%
System 3	10%	R 4,796,815	15.90%	59.00%	21.90%	119.00%	28.09%	180.90%

Source: Own calculation

An increase in maize price will automatically translate into more land being cultivated under maize. The producer would like to optimise income efficiently without other additional investments. However, the scenario does not take into account inflation on input costs in the long term, but only illustrates the impact of various changes taking place.

System 1 still contains the highest IRR value and highest profitability position of the three systems across maize price increases of 10 percent, 20 percent, and 30 percent. System 3 depicts the highest relative change in IRR value. This indicates that the system is a profitable proposition but the initial additional capital expenditure on livestock limits the profitability figure. In the long run, the additional investment will pay off and IRR value will only become larger.

5.10.4. Scenario 4: change in meat price of sheep

Globally, as household income increases their consumer basket and buying power will change. A shift from basic staple foods to more luxury goods such as a diet filled with meat products will occur. Lamb or sheep is the most expensive meat type in South Africa (BFAP, 2020). The currently weak economic conditions negatively affect the consumption of lamb and mutton. Furthermore, the price of meat is affected by the weak exchange rate, resulting in even higher prices. The high prices deter potential consumers as they have limited spending power (BFAP, 2020). The demand for lamb or mutton has a hefty impact on the price of the sheep. Therefore, Table 5.12 will demonstrate the effect of a decrease in meat price and the resultant profitability change.

Table 5.12 Relative percentage change in the IRR as a result of declining meat prices.

Whole-farm model			Declining meat price scenario					
Meat price R1500			10% ↓	R1350	20% ↓	R1200	30% ↓	R1050
Crop rotation system	Internal Rate of return (IRR)	Net Present Value (NPV)	Internal Rate of return (IRR)	Relative change in IRR	Internal Rate of return (IRR)	Relative change in IRR	Internal Rate of return (IRR)	Relative change in IRR
System 3	10.50%	R 4,796,815	10.25%	-2.38%	10.00%	-4.76%	9.75%	-7.14%

Source: Own calculation

A decrease in meat price will have a slight negative effect on the profitability of System 3. The system will however remain profitable even with a 30 percent decline in price. The relative change in IRR will be as much as seven percent. The reason the system is not severely impacted is largely attributable to the diversified system which includes maize. Therefore, income is not solely reliant on the income generated from the livestock and maize ensures stability in income.

On the other hand, Table 5.13 indicates the impact that rising meat price will have on the profitability of the system.

Table 5.13 Relative percentage change in the IRR as a resultant of rising meat prices.

Whole-farm model			Rising meat price scenario					
Meat price R1500			10% ↑	R1650	20% ↑	R1800	30% ↑	R1950
Crop rotation system	Internal Rate of return (IRR)	Net Present Value (NPV)	Internal Rate of return (IRR)	Relative change in IRR	Internal Rate of return (IRR)	Relative change in IRR	Internal Rate of return (IRR)	Relative change in IRR
System 3	10.50%	R 4,796,815	10.75%	2.38%	11.00%	4.76%	11.26%	7.24%

Source: Own calculation

As displayed in Table 5.13 a relative change of about seven percent is caused by a 30 percent increase in meat price. This indicates that the impact of a rise or decline in the price of meat is proportionally the same. In the case of a rising meat price, the profitability of the system will be higher as more overall income is generated.

5.10.5. Scenario 5: changes relating to livestock purchases and free range livestock

This scenario is implemented to demonstrate the impact on profitability of the livestock purchase and whether or not it is free range. Once livestock is free to roam and graze fields, a premium can be charged. Profitability is also affected if livestock is purchased based on speculation, for then, no additional capital is required to purchase permanent fixtures for the livestock. Animals are simply bought to graze fields for a certain length of time and then sold again. The strategies applied are limited to the specific farm and not necessarily the industry as a whole. Various factors can affect the implementation of the strategies such as the number of livestock available when required. Table 5.14 indicates the changes in the system for livestock purchased under speculation with or without a premium added, as well as normal livestock purchases with or without a premium added.

Table 5.14 Livestock purchases under speculation or to keep and prices with and without a premium profitability impact

	IRR	NPV	MIRR
Speculation purchase with premium	10.63%	R 6,747,534.31	9.14%
Speculation purchase without premium	10.01%	R 5,156,994.43	8.89%
Normal livestock purchase with premium	10.47%	R 6,387,354.84	9.07%
Normal livestock purchase without premium	9.85%	R 4,796,814.96	8.82%

Source: Own calculation

5.11. Conclusion

In the first part of the chapter the parameters agreed upon for a typical farm in the Eastern Free State area were presented. To determine the expected profitability of the typical farm as well as evaluate the impact of variations in the external environment on the profitability, a multi-period whole-farm budget model was constructed. The budget model accounts for the multidimensional whole-farm system with a number of interrelationships between variables and components. The whole-farm budget models were then applied to calculate the expected profitability of the typical farm under current crop rotation systems. It was then used to determine expected profitability under various systems introducing cover crops into the system.

The information required to model the typical farm with cultivation practices is gathered along with information from an actual farm. These physical parameters are presented and validated by experts during group discussions to resemble a typical or representative farm. Identifying the typical farm serves as a guiding tool to farm managers, as alternative rotation systems can then be evaluated and compared. The constructed models are then used to evaluate expected impact on profitability for variations in external factors, presented as scenarios. The scenarios include cover crop intercropping amongst maize, input cost shocks, change in maize price, and changes in meat price. During the group discussions the following scenarios were identified to be the most critical issues to significantly affect whole-farm profitability.

As expected the declining maize price scenario had the most adverse impact on profitability. If the maize price would decline by 30 percent no one of the three systems would be profitable, as maize is the main commodity produced in all three systems. The effect of the decline in maize price had a lesser impact on System 1 which includes soya beans in the rotation system. The additional cash crop ensures a steady line of income alternatively to the declining income obtained from maize.

Cover crop intercropping within the maize crop shows significant potential for impact on the profitability of the systems containing cover crops and maize. The increase in profitability is attributable to the fact that no arable land is given up to plant cover crops. All the available arable land will generate an income during the season. There is a significant effect on the input cost regarding fertilisers, lime, herbicides, and pesticides which further enhance profit margins. Intercropping together with an integrated livestock component show the most promising IRR together with the largest relative change in IRR. Initially a large capital investment is required to purchase livestock, but in the long run the amount will seem insignificant with a steady stream of income.

Chapter 6: Conclusion, summary, and recommendations

6.1. Conclusions

The world population is ever increasing and expected to grow to about 10 billion people by 2050. The population growth combined with limited available natural resources, forces producers to optimise production through the efficient use of natural resources. Land and water resources are especially constrained by the expected growth in population, consumer demand for ethical food production, and globalisation. To produce more food with less arable land, new production processes such as sustainable agricultural practices are required. Currently conservation agriculture is seen as the most holistic approach to sustainable agriculture.

Conservation agriculture is based on three main principles namely: minimum soil disturbance, maximum soil coverage, and crop rotation systems. There are clear benefits to implementing CA practices but the long-term financial implications are not well documented. The main objective when implementing CA practices is to counteract environmental degradation, together with increasing crop yields and overall profitability of farms.

During the deregulation of the agricultural sector in the late 1990's, especially the maize industry, farmers were diversifying farms and seeking new methods of production to limit risk exposure. Diversification included the adoption of crop rotation systems which signaled the start of CA practices in South Africa. Farms are idiosyncratic and thus practices implemented on one farm will not necessarily work on another. There are no set rules for CA practices, it will differ across various farms or even between fields on the same farm. Therefore, a chosen system will be specific to a farm, based on ecological resource availability.

The Free State is the most dominant maize production area, producing between 30 to 40 percent of South Africa's total maize production. The Eastern Free State predominantly produces maize. The area is characterised by a temperate climate, summer rainfall, and a relatively high potential for Tukulu and Oakleaf soils to be present. Including cover crops in rotation systems is part of CA practices as it provides maximum soil coverage, is part of crop rotations, and in turn contributes towards minimum soil disturbance. Cover crops planted in rotation systems brings various benefits relating to enhanced overall soil health, weed suppression, and moisture retention capacity. The farmer has a unique opportunity to reduce the input cost and increase yields in the following season. Productivity and the quality of natural resources should be maintained when adopting new production practices, as economic and financial viability is critical to producers. The main objective of this research project is to evaluate the effect of cover crops in maize production systems in the vicinity of the Eastern Free State. Farmers in this area can benefit from a financial evaluation of the implications of introducing cover crops in summer grain systems over the long term.

The decision-making environment of a farm is complex and multifaceted. Research should accommodate the complexity and interrelatedness of the system to evaluate the financial performance of a farm over the long-term. To determine the implication of this interrelatedness on the profitability for the whole-farm system, proposed production methods are evaluated within the whole-farm context. The systems approach provides the underlying structure for the ideal tools to fulfill the requirements. In addition to systems modelling, the multidisciplinary group discussion research technique was used. It provided active participation and validation from experts involved within the farming environment.

The discussions are useful as it bridges the gap both between science disciplines and scientists and producers. Individuals involved, generates and validates individual, component specific, and scientific knowledge, thereby; creating an environment in which specialised knowledge can be shared and evaluated to determine the implications and meaning on the whole-farm production system. Overall, group discussions will integrate the financial and technical aspects of the farm business.

To assess the financial implication of cover crops, the point of departure is to focus on profitability at a gross margin level for various systems. Changes in whole-farm profitability are expected due to the inclusion of various interdependent components of the farm system. Multi-period whole-farm budget models are designed to liaise with the interconnected factors. Whole-farm budget models are used in multidisciplinary group discussions to add a financial dimension.

A real-life farm system in the area served as basis to mimic a typical farm. The model was constructed in the spreadsheet programme, Microsoft Excel. A sequence of equations was designed to capture the complexity of the whole-farm system into one model. The farm characteristics, assumptions, and input data were captured in data sets to calculate the implications of profitability through a sequence of physical/biological and financial/accounting equations. The model itself is thus an integrated simulation of physical/biological and financial/accounting dimensions. A change in parameters will cause changes in the model which is consistent with a real-life farm situation. As point of departure current crop rotations and subsequent financial situations are measured in terms of the expected IRR and NPV.

Including whole-farm multi-period budget models combined with multidisciplinary discussions, proved to be successful in meeting requirements to answer the research question. Additionally the models were used to manipulate the input of the model structure indicating the impact of possible changes in crop production systems and external factors on the expected farm profitability. A sensitivity analysis of the various exogenous factors effecting farm profitability was included using the IRR and NPV as criteria.

System 1, the rotation system with maize and soya beans remained the most profitable system throughout the simulations. All available arable land is used to produce cash crops under this system, therefore; it will show the highest expected profit. With all the various simulated scenarios including increasing input costs and a change in maize price, System 1 remained the most profitable.

Special attention should be paid to the scenario created where cover crops are intercropped with maize. The intercropping systems revealed even higher profit figures than the rotation-based systems. Arable land is used for cash crop production in such a system and income is not forfeited. Intercropping contributes towards a more consistent maize yield while decreasing input costs up to 50 percent. Inputs include the application of fertilisers, lime, herbicides, and pesticide. An even higher profit is expected when livestock is integrated into an intercropping system. No arable land is wasted, no income is forfeited, and an additional food source is available to livestock during and after harvest. The input cost for livestock is also limited to a certain extent. This scenario showed the highest relative percentage change in IRR, 126 percent, making it a viable option to consider on a farm permitting the necessary conditions.

The main conclusions from the results of the financial evaluation are as follows:

- Intercropping cover crop within maize crops show some of the most promise in terms of profitability. All arable land is cultivated to generate an income together with a decrease in input costs that leads to larger profit margins.
- A diversified system potentially reduces the risks and sensitivity to external factors. If a commodity's price decreases significantly the effect on profitability may be buffered by an increased yield of another commodity together with the price stability, thereof; for example, a maize price decline and a stable price for soya beans.

6.2. Summary

Limited natural resources are the main concern driving the search for alternative approaches to food production. Global population growth increases pressure on limited natural resource available for agriculture. After the deregulation of the South African agricultural sector in the late 1990's, new production methods and the diversification of farms were established to limit risk exposure and counteract the volatile farm business environment. Conservation agriculture (CA), identified as the most holistic approach to sustainable agriculture is based on three principles. These include minimum soil disturbance, maximum soil coverage, and crop rotation systems. CA practices are adopted to mitigate environmental degradation and ensure increased crop yields and the profitability of farms.

It is necessary to assess the potential of implementing cover crops in summer grain rotation systems. To date limited studies are available on cover crops in maize-based rotation systems in the Eastern Free State. This is predominantly a summer grain producing area, mainly maize. The area is characterised by a temperate climate and summer rainfall.

The research project focuses on the financial implications of cover crops in summer grain systems over the long-term in the Eastern Free State area. Research on the benefits of implementing crop rotation in farming systems, as well as the beneficial effects of cover crops are available. There is however a lack of knowledge regarding the long-term impact of cover crops implemented in maize-based rotation systems for whole-farm profitability.

Chapter 2 provides a thorough background on the South African maize industry. The industry plays a key role in food security for the country. Maize is one of the most important cereal food crops and serves as a staple food to many countries. After the deregulation of the agricultural sector in 1997, fundamental changes such as free markets and prices which are determined by market forces, took place. The changes together with the volatile farm production environment stimulated the quest for new farming methods and production techniques. The economic relevance of the maize industry is highlighted by the impact thereof on employment, GDP, foreign exchange, food production, and supply.

The latter part of Chapter 2 describes typical maize-based rotation systems with soya beans. The various benefits of rotation are explained and a few countries that successfully implemented rotation systems are highlighted. The potential role of cover crops in maize-based rotation systems is discussed focusing on the role of cover crops, the benefits, challenges, limitations, and the integration of a livestock component.

Chapter 3 highlights the fact that farm systems consist of many interrelated components and cautions against the danger that it holds. It also indicates that the qualities of each individual system must be evaluated. It is also necessary to look at the system in its entirety rather than just trying to understand the individual parts to try and explain the working of the whole system. For this study a systems approach is suggested that focuses on the whole farm and promotes a holistic approach to problem solving.

Constructing a model of a system is generally a time and cost-efficient way to study farm systems. A whole-farm multi-period budget, together with multidisciplinary group discussions is used to ensure validity and trustworthiness of the structured model and its results. A typical farm budget is created to adhere to the overlapping characteristics of farms in a homogenous area and generate a representative situation that producers can relate to. The typical farm model can be used to show the simulated impact of certain factors on whole-farm profitability. Whole-farm profitability considers all the interrelationships and components that form the farm system. A full explanation of systems research, together with the system research method is presented, as applied in this specific project.

Chapter 4 explains the design of different crop rotation systems, and the management of related farm activities in the model. A description on the farm site served as basis for the initial model construction. This helped to structure the model assumptions which were discussed and validated by the expert group during discussions. The three rotation systems studied are a maize-soya bean rotation system, a maize-cover crop rotation system, and a maize-cover crop rotation system with an integrated livestock component for grazing the cover crops. The same farm serves as basis for comparing alternative systems. Thus focus can be put on the evaluation of differences in crop sequences and other variables such as area, soil quality, and when rainfall is constant. The different systems were evaluated in terms of profitability on a gross margin level. A gross margin analysis is employed for further evaluation of the system in its entirety, in the form of a whole-farm profitability analysis.

The last part of Chapter 4 describes the construction of a whole-farm budget that focusses on the components used in the budget model and how the interrelatedness of components is accommodated. The input component includes the physical description of the farm, crop rotation systems, farming practices, assumptions relating to yields, input and output price, and land utilisation patterns. Changing the input component in the model will result in changes in whole-farm profitability, owing to the sequence of mathematical and accounting equations used. The calculation component is comprised of all the formulas used in the model which will result in the output component thus, connecting the input component to the output component. The output component expresses the profitability of the whole farm in terms of IRR and NPV.

Standard accounting principles are applied throughout the model. Gross margin calculations of each system are based on the input data from the input component to calculate the gross margin per hectare. The margins are then used in the calculation of the net annual cash flows in the output component.

Chapter 5 builds on Chapter 4 by explaining the theoretical background of constructing a whole-farm budget with values obtained in the financial models. The physical dimensions and assumptions regarding the typical farm model are presented to and validated by experts based on consensus during the group discussions. The most important component in the model relates to the investment requirement, variable costs of each product, and the whole-farm gross margin. These considerations are critical to the decision maker, ensuring effective and efficient choices regarding the farm.

The profitability of the three systems in the study is evaluated at a whole-farm level and over the long term by IRR and NPV. The maize-soya bean rotation system, System 1, proved to be the most profitable system among the three. In this specific system all the arable land is used to plant cash crops which will generate income. The other two systems forfeit some of the arable land to plant non income generating crops. Additionally affecting the profitability of System 3, where livestock is integrated together with cover crops, the capital requirement needed to invest in livestock together with less land used under cash crops.

To illustrate the sensitivity of profitability of the systems to different exogenous factors, various scenarios were applied to the typical whole-farm model. The scenario that displayed the sharpest impact on the profitability of the farm was the declining maize price, the reason being relative contribution of maize to area planted. Furthermore, the intercropping of cover crops among maize also had a significant positive impact on the overall profitability. All arable land is used to generate an income together with additional food sources for livestock and declining input costs because of cover crop benefits. The profitability is also susceptible to rising input prices and the change in meat prices.

In conclusion the main objective of the research project was to evaluate the financial implications of cover crops in summer grain systems. The methods that were used during the research study proved to be effective to achieve the main objectives. The study can potentially assist with needed information regarding the implications of cover crops implemented in summer grain systems in South Africa.

6.3. Recommendations

This study focused on the implications of cover crops in summer grain systems in the Eastern Free State area of South Africa. The whole-farm profitability was evaluated by constructing a typical whole-farm budget model for maize producing farms. The models incorporated scientific and technical expert knowledge by means of multidisciplinary group discussions which aided in the validity of the study. The impact of different rotation systems was evaluated by focusing specifically on the expected profitability of the various systems. The typical whole-farm models served as a basis for comparison and the figures represented were the most likely to occur in that specific farm environment. The farming practices implemented depends on the producer, resources available, climatic conditions, and terrestrial factors. Therefore, to adopt cover crops as a means of a conservation agricultural practice on a farm, extensive knowledge applicable to the specific whole-farm system is required. It is recommended that a closer long-term working and research relationship between all scientific disciplines and producers are used if conservation agricultural practices are implemented. Some of the benefits are not easily translated into financial terms but are not necessarily less important.

One of the limitations of the whole-farm budget model used in the research study relates to the lack of optimisation. Therefore, the exact allocation of arable land between cash crops, non-cash crops, and livestock to maximise the farm revenue for a typical farm is not determined in the study. It is recommended that subsequent studies will specifically focus on the land allocation. Furthermore, the possibility of introducing other crop varieties in the systems to optimise the summer rainfall in the area should be explored.

The whole-farm budget proved to be useful to identify possible investment opportunities as well as the areas of research requirement in the industry. The models were used to successfully prove the impact of variations in exogenous factors affecting whole-farm profitability. To raise awareness to possible new investment opportunities and novel innovations caused by the variations in external factors, continuous industry assessments need to be performed within the same production area. The results can be presented to farmers aiding in the decision-making process.

The effect of incorporating livestock with a maize-cover crop rotation system was done on a broad level. The study proved that the integration of livestock and the additional capital requirement for investment will not negatively affect profitability of the whole-farm but does however slightly, lower the overall profitability. It is recommended that a more in-depth analysis of the impact of livestock within a conservation system should be performed. Focus should be placed on the effect of livestock on soil compaction, the financial implications of reduced stocking rates or alternative feeding systems. Detailed research studies relating to the many benefits associated with integrating livestock in a system should be undertaken to manage livestock optimally. Furthermore, cover crop mixes was not used in this particular study such as grass to broadleaf's to legumes. Further studies can be performed to reveal the effects of different cover crop mixes on yield and overall soil health, as well as the costs involved with differing cover crop mixes.

Finally, it is recommended that research studies should be performed to identify the main drivers influencing farmers' adoption of conservation agricultural practices. The study will ease the implementation of CA practices as the drawbacks and concerns relating to the practices can be addressed. Moreover, the reasons and process of adoption should be fully evaluated to determine whether policy needs to be adapted. The possible change in policies can assist in the transitional phases of adoption for reluctant or lagging adoptees.

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Personal Communications (Direct, telephonic or written communications)

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Knott, J. 2021. Personal communication. Agricultural specialist. Eastern Free State region.

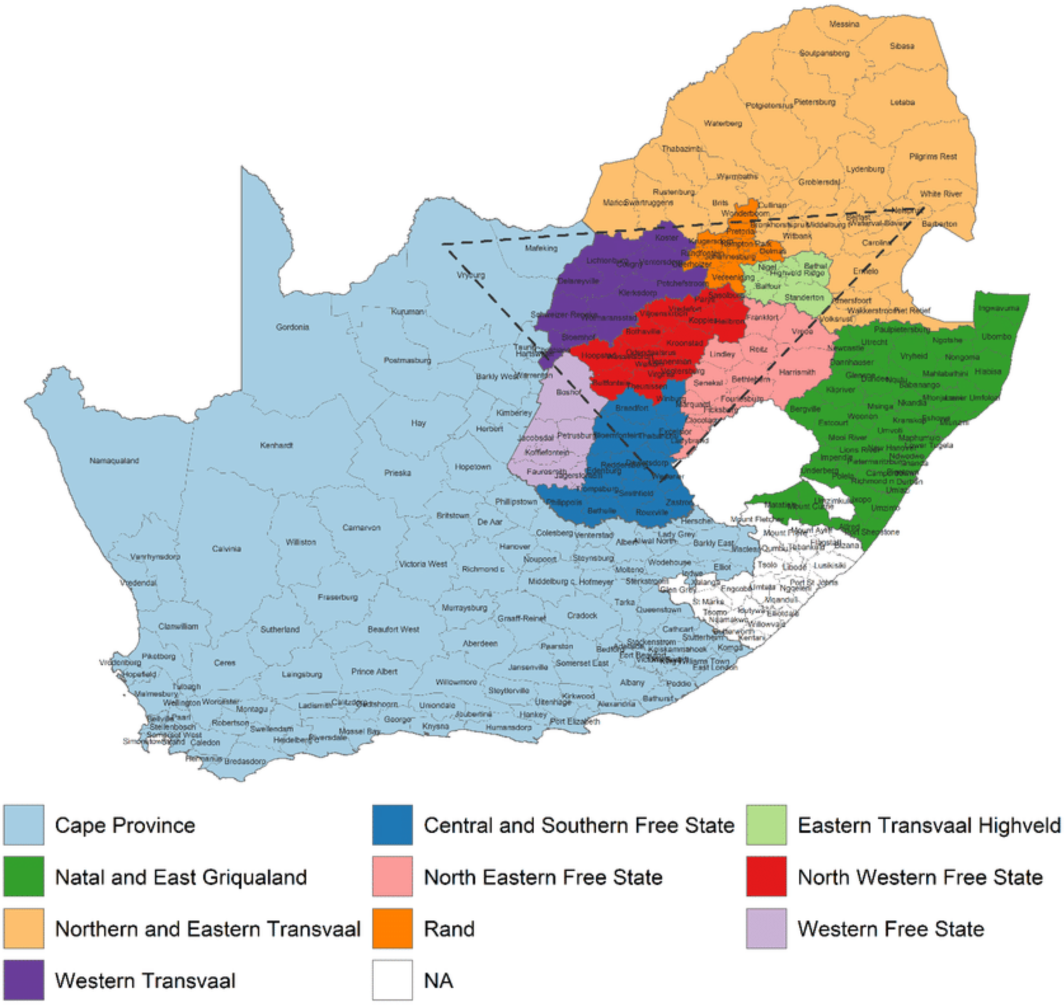
Kriek, C. 2021. Personal communication. Producer. Heidelberg.

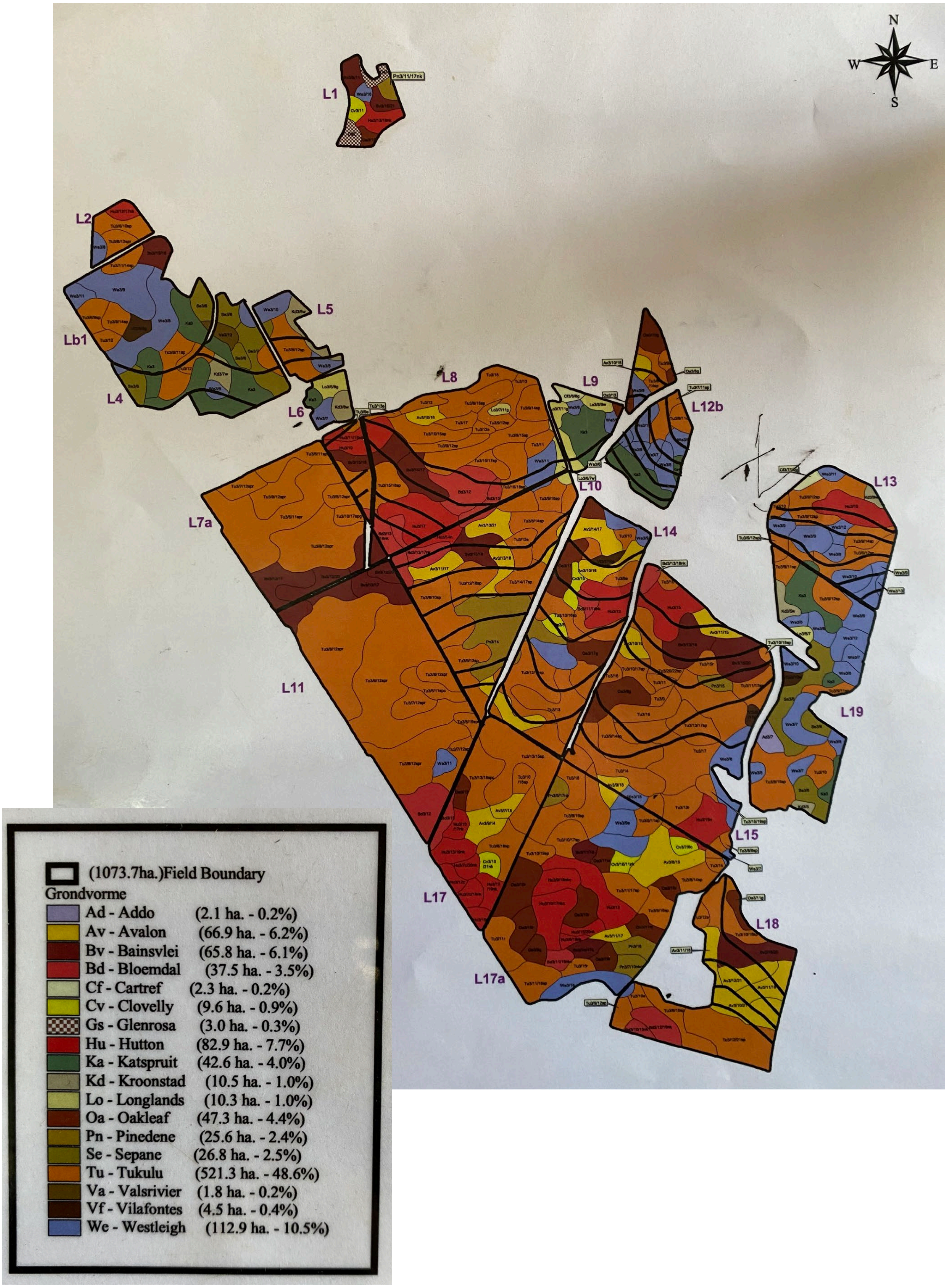
Smit, H. 2021. Personal communication. Conservation Agriculture Facilitator at Grain SA. Johannesburg.

Trytsman, G. 2021. Personal communication. Chief Technician at Agricultural Research Council. And Master of Sustainable Agriculture. Eastern Free State region.

Annexures

Annexure A: Maps indicating the homogenous area of the Eastern Free State, soil type, rainfall pattern


Cape Province
Central and Southern Free State
Eastern Transvaal Highveld
Natal and East Griqualand
North Eastern Free State
North Western Free State
Northern and Eastern Transvaal
Rand
Western Free State
Western Transvaal
NA


N
W
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L1
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L7a
L8
L9
L10
L11
L12b
L13
L14
L15
L17
L17a
L18
L19
(1073.7ha.)Field Boundary
Grondvorme
Ad - Addo (2.1 ha. - 0.2%)
Av - Avalon (66.9 ha. - 6.2%)
Bv - Bainsvlei (65.8 ha. - 6.1%)
Bd - Bloemdal (37.5 ha. - 3.5%)
Cf - Cartref (2.3 ha. - 0.2%)
Cv - Clovelly (9.6 ha. - 0.9%)
Gs - Glenrosa (3.0 ha. - 0.3%)
Hu - Hutton (82.9 ha. - 7.7%)
Ka - Katspruit (42.6 ha. - 4.0%)
Kd - Kroonstad (10.5 ha. - 1.0%)
Lo - Longlands (10.3 ha. - 1.0%)
Oa - Oakleaf (47.3 ha. - 4.4%)
Pn - Pinedene (25.6 ha. - 2.4%)
Se - Sepane (26.8 ha. - 2.5%)
Tu - Tukulu (521.3 ha. - 48.6%)
Va - Valsrivier (1.8 ha. - 0.2%)
Vf - Vilafontes (4.5 ha. - 0.4%)
We - Westleigh (112.9 ha. - 10.5%)

Annexure B: Land usage pattern of three different systems

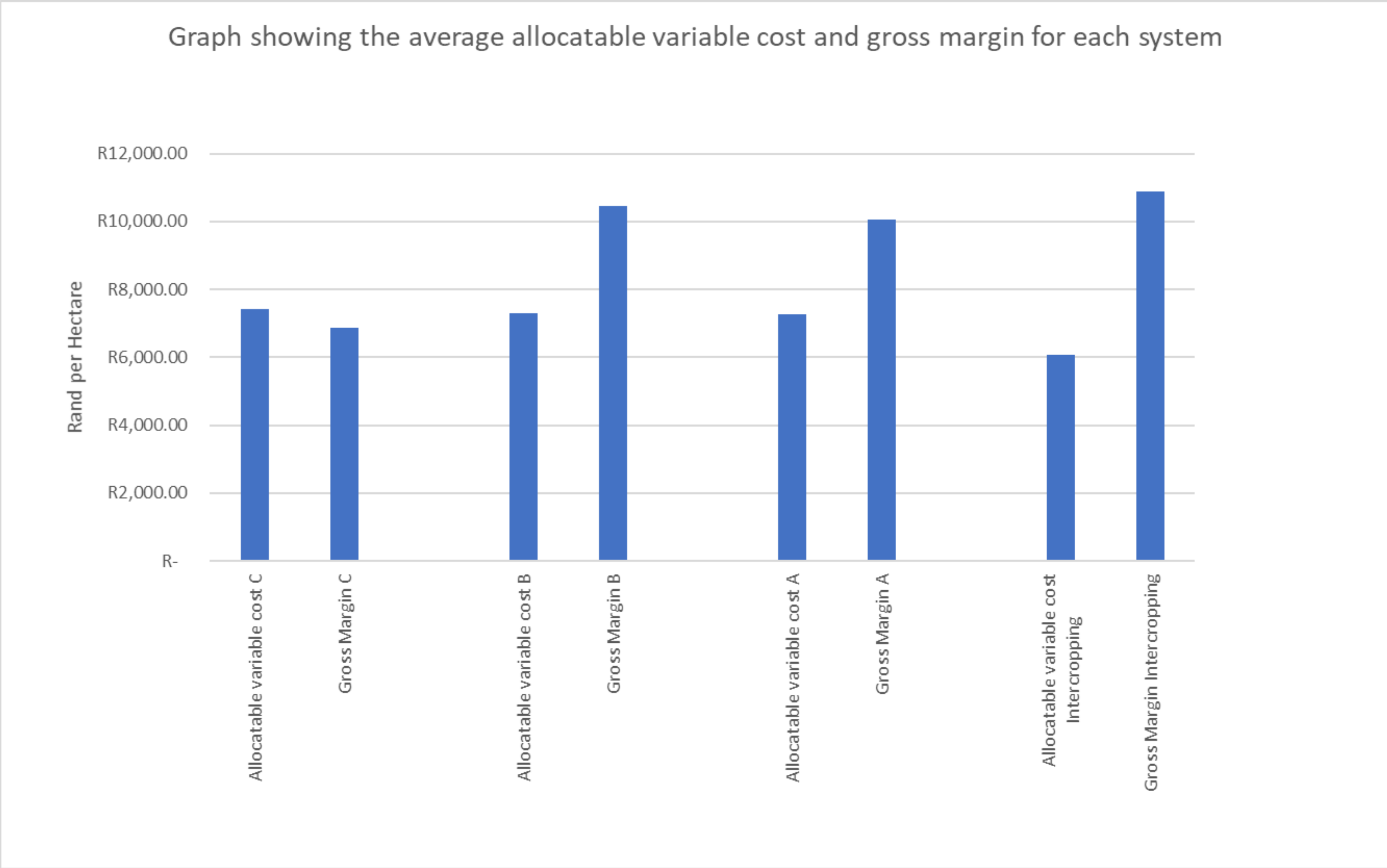
Annexure C: Farm inventory list under different rotation systems

Annexure D: Enterprise gross margin analysis

Annexure E: Summary of costs and margins

Annexure F: Whole-farm multi-period budgets for different crop rotation systems

Annexure G: Gross margin and average variable cost graph

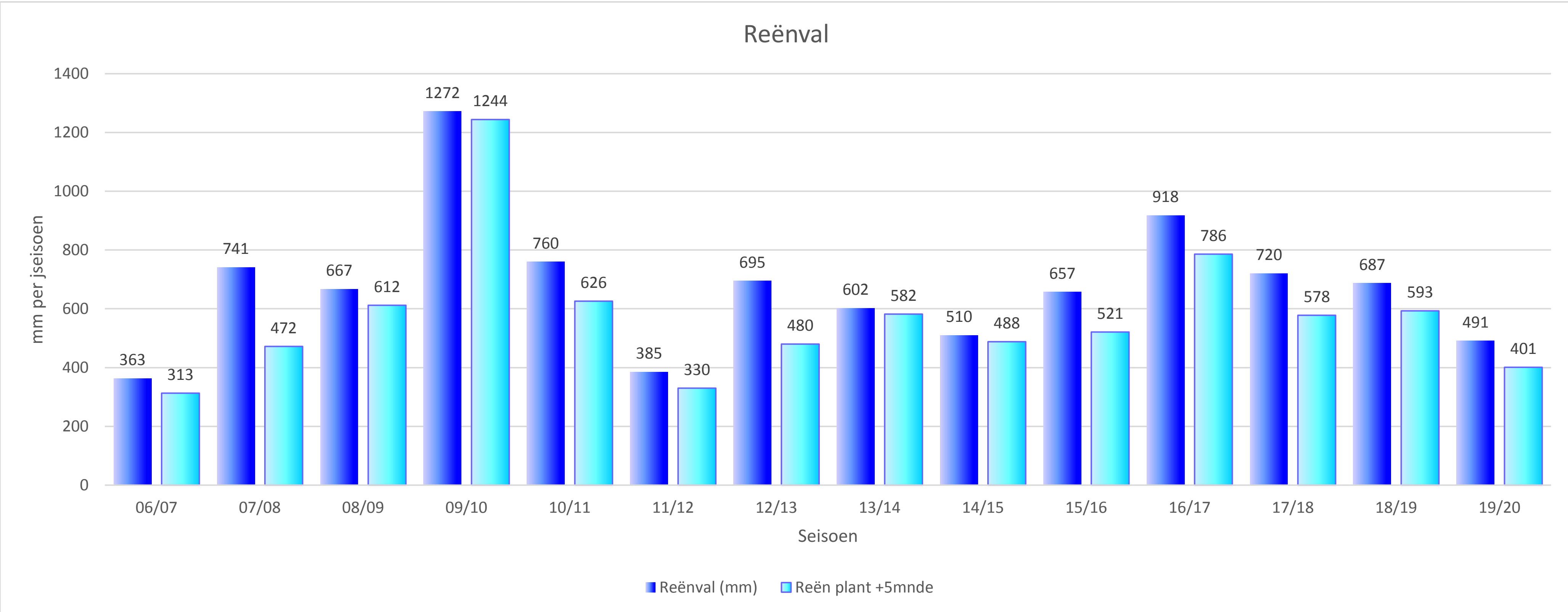

Graph showing the average allocatable variable cost and gross margin for each system
Rand per Hectare
R12,000.00
R10,000.00
R8,000.00
R6,000.00
R4,000.00
R2,000.00
R-
Allocatable variable cost C
Gross Margin C
Allocatable variable cost B
Gross Margin B
Allocatable variable cost A
Gross Margin A
Allocatable variable cost Intercropping
Gross Margin Intercropping

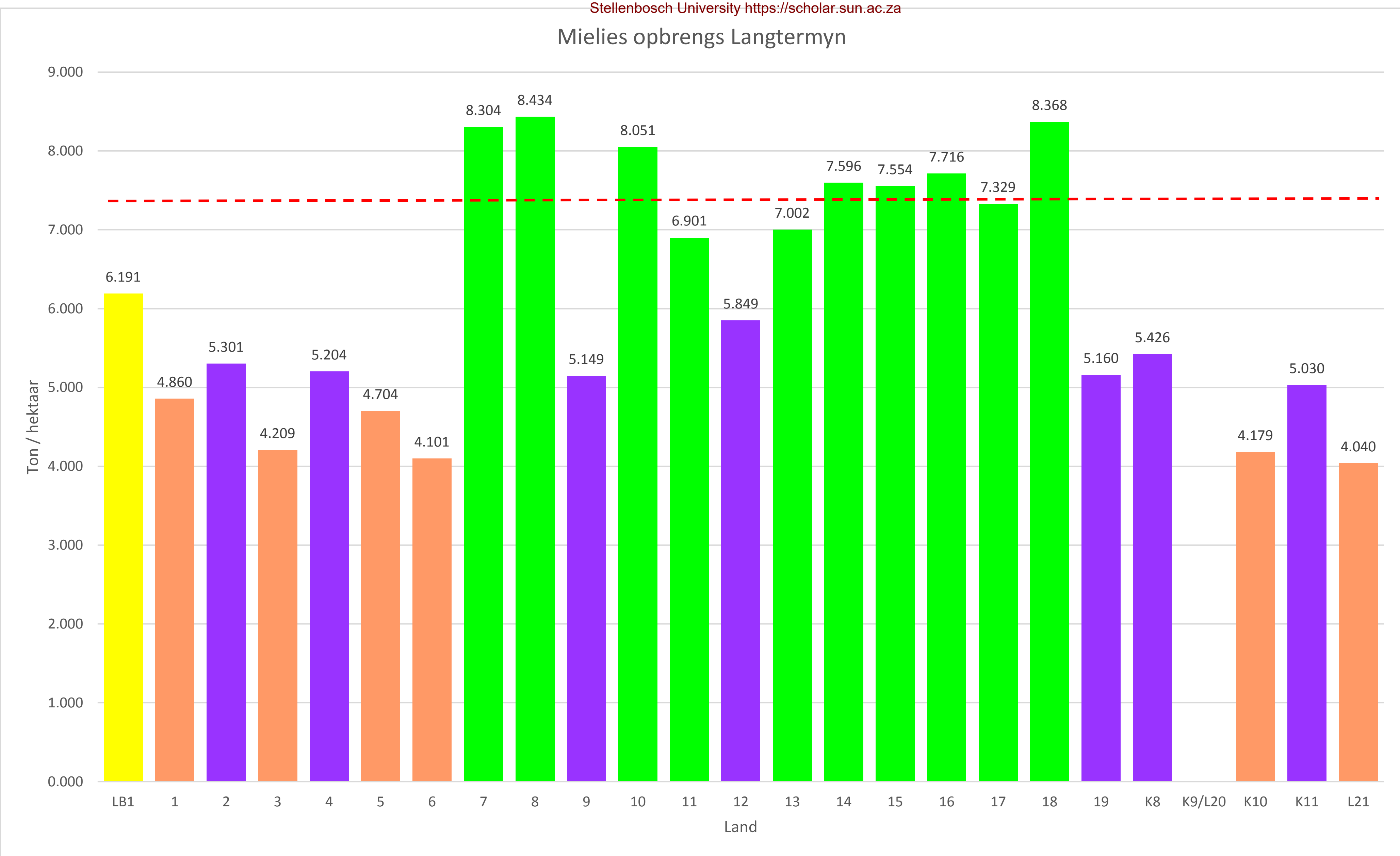
Mielies gestroop

Vergelyking tussen verskillende jare

Land	Ha	06/07	07/08	08/09	09/10	10/11	11/12	12/13	13/14	14/15	15/16	16/17	17/18	18/19	19/20	Gem t/ha
LB1	40.64	1.350	11.310	10.479	9.989	3.841	1.987	4.624	5.737		3.490		8.000	7.100	6.382	6.191
1	13.52	1.380												5.900	7.301	4.860
2	8.79	2.430	8.173	8.718			1.875	4.810	5.205		3.060			7.100	6.341	5.301
3	4.19	2.130	8.775	8.820	7.220	4.895	1.920	4.035	4.292					5.900	6.382	4.209
4	34.18	2.700	8.555	7.012	6.404	3.725	1.705	5.816	5.603		3.580			5.800	6.340	5.204
5	12.83	2.070		7.647			2.712	5.276	5.077		3.245			5.900	5.702	4.704
6	7.21	2.410					3.969	4.934	5.090							4.101
7	69.66	4.200	9.834	7.810	9.519	8.746	7.917	8.430	9.668	7.376	6.150	10.600	9.540	8.100	8.361	8.304
8	90.86	4.870	10.436	8.780	9.514	7.451	8.952	8.953	9.163	7.018	6.420	10.000	9.000	8.100	9.424	8.434
9	14.89	2.880	8.572	9.425	4.252	0.183	5.884	6.417	4.031		4.197	5.650				5.149
10	78.47	5.010	9.326	8.346	6.776	7.195	8.673	7.743	9.256	8.298	5.860	10.510	9.920	7.400	8.396	8.051
11	100.2	2.290	9.026	9.555	9.545	7.573	6.485	6.937	7.485	4.864	3.730		7.320	7.000	7.903	6.901
12	30.81	2.170	8.439	8.315	4.745		4.123	6.536	6.547	4.426	6.610			6.100	6.332	5.849
13	42.3	2.270	9.001	9.637	9.273	5.102	7.488	4.856	6.660		6.230	9.390		7.100	7.022	7.002
14	72.7	4.650	9.026	7.795	6.968	4.664	6.815	7.134	8.190	6.370	4.980	9.477		7.400	7.681	7.596
15	118.66	5.660	8.089	7.040	6.723	6.386	6.802	7.672	8.441	6.753	8.193	9.080		9.100	8.269	7.554
16	54.14	3.250	10.687	8.723	10.114	7.384	5.260	7.008	8.387	5.604		8.760	9.090	7.700	8.337	7.716
17	123.27	5.120	8.711	6.832	8.378	6.644	5.442	7.364	8.162	3.845	7.868	10.120	8.100	7.800	8.213	7.329
18	60.07	8.230	8.653	7.970	7.468	7.292	8.878	9.030	9.453	6.370		10.038	9.070	7.700	8.632	8.368
19	69.3						4.968	5.905	5.891		6.748	3.805		3.800	5.001	5.160
K8	61.28											5.581			5.270	5.426
K9/L20	25.09															
K10	15.1										6.100	3.130			3.308	4.179
K11	6.75										5.030					5.030
L21	14.6											4.040				4.040
Totaal	**1169.51**															
Gemiddeld		4.220	9.185	8.154	8.091	6.500	6.390	7.210	7.901	6.067	6.061	9.200	9.300	7.400	7.850	7.395
Reënval (Jaar)		363	741	667	1272	760	385	695	602	510	657	918	720	687	491	641
Verhouding		11.63	12.40	12.22	6.36	8.55	16.60	10.37	13.12	11.90	9.23	10.02	12.92	10.77	15.99	10.43

Seisoen	06/07	07/08	08/09	09/10	10/11	11/12	12/13	13/14	14/15	15/16	16/17	17/18	18/19	19/20	Gem
Gemiddeld	4.220	9.185	8.154	8.091	6.500	6.390	7.210	7.901	6.067	6.061	9.200	9.300	7.400	7.850	7.395
Reënval (Jaar)	363	741	667	1272	760	385	695	602	510	657	918	720	687	491	641
Verhouding	11.63	12.40	12.22	6.36	8.55	16.60	10.37	13.12	11.90	9.23	10.02	12.92	10.77	15.99	10.43
Reën plant + 5 mnde	313	472	612	1244	626	330	480	582	488	521	786	578	593	401	545
Verhouding	13.48	19.46	13.32	6.50	10.38	19.36	15.02	13.58	12.43	11.63	11.70	16.09	12.48	19.58	13.58





Gem t/ha in %		Ha	%
	0-5 t/ha	67.45	5.89
	5-6 t/ha	226.00	19.75
	6-7 t/ha	40.64	3.55
	7+ t/ha	810.33	70.81
		1 144.42	

Mielies gestroop

Vergelyking tussen verskillende jare

Land	Ha	06/07	07/08	08/09	09/10	10/11	11/12	12/13	13/14	14/15	15/16	16/17	17/18	18/19	19/20	Gem t/ha
LB1	40.64	1.350	11.310	10.479	9.989	3.841	1.987	4.624	5.737		3.490		8.000	7.100	6.382	6.191
1	13.52	1.380												5.900	7.301	4.860
2	8.79	2.430	8.173	8.718			1.875	4.810	5.205		3.060			7.100	6.341	5.301
3	4.19	2.130	8.775	8.820	7.220	4.895	1.920	4.035	4.292					5.900	6.382	4.209
4	34.18	2.700	8.555	7.012	6.404	3.725	1.705	5.816	5.603		3.580			5.800	6.340	5.204
5	12.83	2.070		7.647			2.712	5.276	5.077		3.245			5.900	5.702	4.704
6	7.21	2.410					3.969	4.934	5.090							4.101
7	69.66	4.200	9.834	7.810	9.519	8.746	7.917	8.430	9.668	7.376	6.150	10.600	9.540	8.100	8.361	8.304
8	90.86	4.870	10.436	8.780	9.514	7.451	8.952	8.953	9.163	7.018	6.420	10.000	9.000	8.100	9.424	8.434
9	14.89	2.880	8.572	9.425	4.252	0.183	5.884	6.417	4.031		4.197	5.650				5.149
10	78.47	5.010	9.326	8.346	6.776	7.195	8.673	7.743	9.256	8.298	5.860	10.510	9.920	7.400	8.396	8.051
11	100.20	2.290	9.026	9.555	9.545	7.573	6.485	6.937	7.485	4.864	3.730		7.320	7.000	7.903	6.901
12	30.81	2.170	8.439	8.315	4.745		4.123	6.536	6.547	4.426	6.610			6.100	6.332	5.849
13	42.30	2.270	9.001	9.637	9.273	5.102	7.488	4.856	6.660		6.230	9.390		7.100	7.022	7.002
14	72.70	4.650	9.026	7.795	6.968	4.664	6.815	7.134	8.190	6.370	4.980	9.477		7.400	7.681	7.596
15	118.66	5.660	8.089	7.040	6.723	6.386	6.802	7.672	8.441	6.753	8.193	9.080		9.100	8.269	7.554
16	54.14	3.250	10.687	8.723	10.114	7.384	5.260	7.008	8.387	5.604		8.760	9.090	7.700	8.337	7.716
17	123.27	5.120	8.711	6.832	8.378	6.644	5.442	7.364	8.162	3.845	7.868	10.120	8.100	7.800	8.213	7.329
18	60.07	8.230	8.653	7.970	7.468	7.292	8.878	9.030	9.453	6.370		10.038	9.070	7.700	8.632	8.368
19	69.30						4.968	5.905	5.891		6.748	3.805		3.800	5.001	5.160
K8	61.28											5.581			5.270	5.426
K9/L20	25.09															
K10	15.10										6.100	3.130			3.308	4.179
K11	6.75										5.030					5.030
L21	14.60											4.040				4.040
Totaal	**1169.51**															
Gemiddeld		4.220	9.185	8.154	8.091	6.500	6.390	7.210	7.901	6.067	6.061	9.200	9.300	7.400	7.850	7.395
Reënval (Jaar)		363	741	667	1272	760	385	695	602	510	657	918	720	687	491	641
Verhouding		11.63	12.40	12.22	6.36	8.55	16.60	10.37	13.12	11.90	9.23	10.02	12.92	10.77	15.99	10.43

Land usage and distribution of System A

Distribution of land:

Item	Ha	Value	
		R/Ha	Total
Uncultivated land:	627	R 96,000.00	R 22,605,000.00
Buidlings, farmyard and wasteland	200	R 81,000.00	R 16,200,000.00
Grazing (non commercial purposes)	427	R 15,000.00	R 6,405,000.00
Cultivated land:	1150	R 73,000.00	R 31,908,000.00
High potential	850	R 30,000.00	R 25,500,000.00
Medium potential	144	R 25,000.00	R 3,600,000.00
Low potential	156	R 18,000.00	R 2,808,000.00
Total	1777	R 169,000.00	R 54,513,000.00

Land components valued:

	Area (Ha)	R/Ha	Total
Land - Dry land	1150	R 42,000.00	R 48,300,000.00
Natural Grazing	450	R 10,000.00	R 4,500,000.00
Natural Grazing - boundary game fenced	100	R 15,000.00	R 1,500,000.00
Established Pasture	54	R 13,000.00	R 702,000.00
Water Way Pasture	21	R 15,000.00	R 315,000.00
Silos	2	R 4,500,000.00	R 9,000,000.00
Total	1777	R 36,194.15	R 64,317,000.00
Water Rights	90	R 50,000.00	R 4,500,000.00
Improvements			R 3,500,000.00
Total	1777	R 40,696.12	R 72,317,000.00

Land Usage Pattern:

Item	Block no.	Ha.	Year planted	Age	Lifetime	Percentage of total	Price (R/Ha)
White mielies							
	1	150	2019/2020	1	1	13.04%	R 22,500.00
	2	150	2019/2020	1	1	13.04%	R 22,500.00
	3	100	2019/2020	1	1	8.70%	R 22,500.00
Yellow mielies							
	4	100	2019/2020	1	1	8.70%	R 22,500.00
	5	100	2019/2020	1	1	8.70%	R 22,500.00
	6	100	2019/2020	1	1	8.70%	R 22,500.00
	7	100	2019/2020	1	1	8.70%	R 22,500.00
Soya beans							
	8	150	2019/2020	1	1	13.04%	R 17,550.00
	9	100	2019/2020	1	1	8.70%	R 17,550.00
	10	100	2019/2020	1	1	8.70%	R 17,550.00
Total dry land:		1150				100.00%	R 210,150.00

Land usage and distribution of System B

Distribution of land:

Item	Ha	Value	
		R/Ha	Total
Uncultivated land:	627	R 96,000.00	R 22,605,000.00
Buidlings, farmyard and wasteland	200	R 81,000.00	R 16,200,000.00
Grazing	427	R 15,000.00	R 6,405,000.00
Cultivated land:	1150	R 73,000.00	R 31,880,000.00
High potential	850	R 30,000.00	R 25,500,000.00
Medium potential	140	R 25,000.00	R 3,500,000.00
Low potential	160	R 18,000.00	R 2,880,000.00
Total	1777	R 169,000.00	R 54,485,000.00

Land components valued:

	Area (Ha)	R/Ha	Total
Land - Dry land	1150	R 42,000.00	R 48,300,000.00
Natural Grazing	450	R 10,000.00	R 4,500,000.00
Natural Grazing - boundary game fenced	100	R 15,000.00	R 1,500,000.00
Established Pasture	54	R 13,000.00	R 702,000.00
Water Way Pasture	21	R 15,000.00	R 315,000.00
Silos	2	R 4,500,000.00	R 9,000,000.00
Total	1777	R 36,194.15	R 64,317,000.00
Water Rights	90	R 50,000.00	R 4,500,000.00
Improvements			R 3,500,000.00
Total	1777	R 40,696.12	R 72,317,000.00

Land Usage Pattern:

Item	Block no.	Ha.	Year planted	Age	Lifetime	Percentage of total	Price (R/Ha)	Total
White mielies								
	1	150	2019/2020	1	1	13.04%	R 3,000.00	R 450,000.00
	2	150	2019/2020	1	1	13.04%	R 3,000.00	R 450,000.00
	3	140	2019/2020	1	1	12.17%	R 3,000.00	R 420,000.00
Yellow mielies								
	4	190	2019/2020	1	1	16.52%	R 3,000.00	R 570,000.00
	5	160	2019/2020	1	1	13.91%	R 3,000.00	R 480,000.00
	6	110	2019/2020	1	1	9.57%	R 3,000.00	R 330,000.00
	7	90	2019/2020	1	1	7.83%	R 3,000.00	R 270,000.00
Teff								
	8	40	2019/2020	1	1	3.48%	R 1,500.00	R 60,000.00
	9	30	2019/2020	1	1	2.61%	R 1,500.00	R 45,000.00
	10	30	2019/2020	1	1	2.61%	R 1,500.00	R 45,000.00
Rhodes / Erigrostis								
	11	10	2019/2020	1	3	0.87%	R 1,000.00	R 10,000.00
	12	10	2019/2020	1	3	0.87%	R 1,000.00	R 10,000.00
Cover crops								
Winter cover crops	13	20	2019/2022	1	1	1.74%		
Summer cover crops	14	20	2019/2023	1	1	1.74%		
Total dry land:		1150				100.00%	R 27,500.00	R 3,140,000.00

Land usage and distribution of System C

Distribution of land:

Item	Ha	Value	
		R/Ha	Total
Uncultivated land:	627	R 96,000.00	R 22,605,000.00
Buidlings, farmyard and wasteland	200	R 81,000.00	R 16,200,000.00
Grazing	427	R 15,000.00	R 6,405,000.00
Cultivated land	1150	R 73,000.00	R 31,908,000.00
High potential	850	R 30,000.00	R 25,500,000.00
Medium potential	144	R 25,000.00	R 3,600,000.00
Low potential	156	R 18,000.00	R 2,808,000.00
Total	1777	R 169,000.00	R 54,513,000.00

Land components valued:

	Area (Ha)	R/Ha	Total
Land - Dry land	1150	R 42,000.00	R 48,300,000.00
Natural Grazing	450	R 10,000.00	R 4,500,000.00
Natural Grazing - boundary game fenced	100	R 15,000.00	R 1,500,000.00
Established Pasture	54	R 13,000.00	R 702,000.00
Water Way Pasture	21	R 15,000.00	R 315,000.00
Silos	2	R 4,500,000.00	R 9,000,000.00
Total	1777	R 36,194.15	R 64,317,000.00
Water Rights	90	R 50,000.00	R 4,500,000.00
Improvements			R 3,500,000.00
Total	1777	R 40,696.12	R 72,317,000.00

Land Usage Pattern:

Item	Block no.	Ha.	Year planted	Age	Lifetime	Percentage o	Price (R/Ha)	Total
White mielies								
	1	150	2019/2020	1	1	13.04%	R 3,000.00	R 450,000.00
	2	150	2019/2020	1	1	13.04%	R 3,000.00	R 450,000.00
	3	140	2019/2020	1	1	12.17%	R 3,000.00	R 420,000.00
Yellow mielies								
	4	190	2019/2020	1	1	16.52%	R 3,000.00	R 570,000.00
	5	160	2019/2020	1	1	13.91%	R 3,000.00	R 480,000.00
	6	110	2019/2020	1	1	9.57%	R 3,000.00	R 330,000.00
	7	90	2019/2020	1	1	7.83%	R 3,000.00	R 270,000.00
Teff								
	8	40	2019/2020	1	1	3.48%	R 1,500.00	R 60,000.00
	9	30	2019/2020	1	1	2.61%	R 1,500.00	R 45,000.00
	10	30	2019/2020	1	1	2.61%	R 1,500.00	R 45,000.00
Rhodes / Erigrostis								
	11	10	2019/2020	1	3	0.87%	R 1,000.00	R 10,000.00
	12	10	2019/2020	1	3	0.87%	R 1,000.00	R 10,000.00
Cover crops								
Winter cover crops	13	20	2019/2022	1	1	1.74%		
Summer cover crops	14	20	2019/2023	1	1	1.74%		
Total dry land:		1150				100.00%	R 27,500.00	R 3,140,000.00

Inventory list System A

Land and Fixed improvements											
Item	Number	Area (m²)	Year built	Age (years)	Expected lifetime (years)	Insurance	Cost price	Replacement value	Yearly depreciation	Accumulated depreciation	Current value
Main house	1	440	1990	31	60	R 2,500.00	R 2,400,000.00	R 6,372,089.36	R 106,201.49	R 3,292,246.17	R 3,079,843.19
House 2	1	160	1987	34	60	R 2,500.00	R 400,000.00	R 1,167,265.63	R 19,454.43	R 661,450.53	R 505,815.11
Workers housing	4	200	2010	11	60	R 1,000.00	R 400,000.00	R 565,635.50	R 9,427.26	R 103,699.84	R 461,935.66
Implements store	2	1200	2017	4	50	R 2,000.00	R 1,100,000.00	R 1,247,703.73	R 24,954.07	R 99,816.30	R 1,147,887.43
Fencing		20000m	2010	11	5	R 5,000.00		R -	R -	R -	R -
Office	1	40	2006	15	60	R 2,000.00	R 200,000.00	R 320,793.42	R 5,346.56	R 80,198.36	R 240,595.07
Silos	6	2000	2005	16	60	R 10,000.00	R 7,000,000.00	R 11,587,058.42	R 193,117.64	R 3,089,882.25	R 8,497,176.18
Total						R 25,000.00	R 11,500,000.00	R 21,260,546.08	R 358,501.45	R 7,327,293.44	R 13,933,252.64

Inflation rate:	3.20%

Machinery												
Item	Size/kW	Year	Age	Cost price (R)	Expected lifetime (Year)	Herw Waarde 10% of cost price (R)	Depreciation (R/year)	Depreciation Total (R)	Current value	Insurance	Licenses	Total fixed cost
Tractors												
230 kW	230	2016	4	R 4,000,000.00	15	R 400,000.00	R 240,000.00	R 960,000.00	R 3,040,000.00	R 5,000.00	R 600.00	R 965,600.00
120 kW	123	2013	7	R 2,200,000.00	15	R 220,000.00	R 132,000.00	R 924,000.00	R 1,276,000.00	R 5,000.00	R 600.00	R 929,600.00
75 kW		2018	2	R 330,000.00	20	R 33,000.00	R 14,850.00	R 29,700.00	R 300,300.00	R 2,500.00		R 32,200.00
65 kW		2012	8	R 281,000.00	25	R 28,100.00	R 10,116.00	R 80,928.00	R 200,072.00	R 2,000.00		R 82,928.00
65 kW		2012	8	R 211,000.00	25	R 21,100.00	R 7,596.00	R 60,768.00	R 150,232.00	R 1,900.00		R 62,668.00
Vehicles												
Double cab 4x4		2017	3	R 550,000.00	5	R 55,000.00	R 99,000.00	R 297,000.00	R 253,000.00	R 4,000.00	R 900.00	R 301,900.00
2.8 Extended cab 4x4		2016	4	R 450,000.00	5	R 45,000.00	R 81,000.00	R 324,000.00	R 126,000.00	R 4,000.00	R 900.00	R 328,900.00
2.8 Single cab		2014	6	R 450,000.00	10	R 45,000.00	R 40,500.00	R 243,000.00	R 207,000.00	R 4,000.00	R 900.00	R 247,900.00
Lorrie												
UD 490 Lorrie		2010	10	R 1,000,000.00	30	R 100,000.00	R 30,000.00	R 300,000.00	R 700,000.00	R 10,000.00	R 24,000.00	R 334,000.00
Trailers						R -						
Trailer Wit massa 12m		2008	12	R 235,000.00	30	R 23,500.00	R 7,050.00	R 84,600.00	R 150,400.00	R 1,000.00	R -	R 85,600.00
Trailer Blou massa 12m		2006	14	R 173,000.00	30	R 17,300.00	R 5,190.00	R 72,660.00	R 100,340.00	R 1,000.00	R -	R 73,660.00
Trailer Wit massa 7m		2009	11	R 105,000.00	30	R 10,500.00	R 3,150.00	R 34,650.00	R 70,350.00	R 1,000.00	R -	R 35,650.00
Trailer Groen massa 7m		2008	12	R 110,000.00	30	R 11,000.00	R 3,300.00	R 39,600.00	R 70,400.00	R 1,000.00	R -	R 40,600.00
Trailer Wit hoespoed 7m		2010	10	R 143,000.00	30	R 14,300.00	R 4,290.00	R 42,900.00	R 100,100.00	R 1,300.00	R -	R 44,200.00
Implements												
Sem Laaigraaf		2017	3	R 449,000.00	25	R 44,900.00	R 16,164.00	R 48,492.00	R 400,508.00	R 3,000.00		R 51,492.00
Interlink Sidetipper		2010	10	R 358,000.00	30	R 35,800.00	R 10,740.00	R 107,400.00	R 250,600.00	R 2,700.00		R 110,100.00
						R -						
Tapkar		2007	13	R 483,000.00	20	R 48,300.00	R 21,735.00	R 282,555.00	R 200,445.00	R 3,000.00		R 285,555.00
Jan strooier		2008	12	R 313,000.00	30	R 31,300.00	R 9,390.00	R 112,680.00	R 200,320.00	R 2,500.00		R 115,180.00
Radium		2015	5	R 402,000.00	35	R 40,200.00	R 10,337.14	R 51,685.71	R 350,314.29	R 2,800.00		R 54,485.71
Straatmanshouer		2010	10	R 646,000.00	40	R 64,600.00	R 14,535.00	R 145,350.00	R 500,650.00	R 4,000.00		R 149,350.00
Kunsmis strooier		2011	9	R 169,000.00	20	R 16,900.00	R 7,605.00	R 68,445.00	R 100,555.00	R 1,000.00		R 69,445.00
Eqvalue Planter		2015	5	R 2,185,000.00	10	R 218,500.00	R 196,650.00	R 983,250.00	R 1,201,750.00	R 6,000.00		R 989,250.00
Ripper		2011	9	R 337,000.00	20	R 33,700.00	R 15,165.00	R 136,485.00	R 200,515.00	R 2,600.00		R 139,085.00
Lenkem		2016	4	R 489,000.00	20	R 48,900.00	R 22,005.00	R 88,020.00	R 400,980.00	R 3,100.00		R 91,120.00
Dus		2006	14	R 174,000.00	30	R 17,400.00	R 5,220.00	R 73,080.00	R 100,920.00	R 1,400.00		R 74,480.00
Kongskilde		2006	14	R 406,000.00	20	R 40,600.00	R 18,270.00	R 255,780.00	R 150,220.00	R 2,750.00		R 258,530.00
Total				R 16,649,000.00		R 1,664,900.00	R 1,025,858.14	R 5,847,028.71	R 10,801,971.29	R 78,550.00	R 27,900.00	R 5,953,478.71

Inventory list System B

Land and Fixed improvements											
Item	Number	Area (m²)	Year built	Age (years)	Expected lifetime (years)	Insurance	Cost price	Replacement value	Yearly depreciation	Accumulated depreciation	Current value
Main house	1	440	1990	31	60	R 2,500.00	R 2,400,000.00	R 6,372,089.36	R 106,201.49	R 3,292,246.17	R 3,079,843.19
House 2	1	160	1987	34	60	R 2,500.00	R 400,000.00	R 1,167,265.63	R 19,454.43	R 661,450.53	R 505,815.11
Workers housing	4	200	2010	11	60	R 1,000.00	R 400,000.00	R 565,635.50	R 9,427.26	R 103,699.84	R 461,935.66
Implements store	2	1200	2017	4	50	R 2,000.00	R 1,100,000.00	R 1,247,703.73	R 24,954.07	R 99,816.30	R 1,147,887.43
Fencing		20000m	2010	11	5	R 5,000.00		R -	R -	R -	R -
Office	1	40	2006	15	60	R 2,000.00	R 200,000.00	R 320,793.42	R 5,346.56	R 80,198.36	R 240,595.07
Silos	6	2000	2005	16	60	R 10,000.00	R 7,000,000.00	R 11,587,058.42	R 193,117.64	R 3,089,882.25	R 8,497,176.18
Total						R 25,000.00	R 11,500,000.00	R 21,260,546.08	R 358,501.45	R 7,327,293.44	R 13,933,252.64

Inflation rate:	3.20%

Machinery												
Item	Size/kW	Year	Age	Cost price (R)	Expected lifetime (Year)	Herw Waarde 10% of cost price (R)	Depreciation (R/year)	Depreciation Total (R)	Current value	Insurance	Licenses	Total fixed cost
Tractors												
230 kW	230	2016	4	R 4,000,000.00	15	R 400,000.00	R 240,000.00	R 960,000.00	R 3,040,000.00	R 5,000.00	R 600.00	R 965,600.00
120 kW	123	2013	7	R 2,200,000.00	15	R 220,000.00	R 132,000.00	R 924,000.00	R 1,276,000.00	R 5,000.00	R 600.00	R 929,600.00
75 kW		2018	2	R 330,000.00	20	R 33,000.00	R 14,850.00	R 29,700.00	R 300,300.00	R 2,500.00		R 32,200.00
65 kW		2012	8	R 281,000.00	25	R 28,100.00	R 10,116.00	R 80,928.00	R 200,072.00	R 2,000.00		R 82,928.00
65 kW		2012	8	R 211,000.00	25	R 21,100.00	R 7,596.00	R 60,768.00	R 150,232.00	R 1,900.00		R 62,668.00
Vehicles												
Double cab 4x4		2017	3	R 550,000.00	5	R 55,000.00	R 99,000.00	R 297,000.00	R 253,000.00	R 4,000.00	R 900.00	R 301,900.00
2.8 Extended cab 4x4		2016	4	R 450,000.00	5	R 45,000.00	R 81,000.00	R 324,000.00	R 126,000.00	R 4,000.00	R 900.00	R 328,900.00
2.8 Single cab		2014	6	R 450,000.00	10	R 45,000.00	R 40,500.00	R 243,000.00	R 207,000.00	R 4,000.00	R 900.00	R 247,900.00
Lorrie												
UD 490 Lorrie		2010	10	R 1,000,000.00	30	R 100,000.00	R 30,000.00	R 300,000.00	R 700,000.00	R 10,000.00	R 24,000.00	R 334,000.00
Trailers						R -						
Trailer Wit massa 12m		2008	12	R 235,000.00	30	R 23,500.00	R 7,050.00	R 84,600.00	R 150,400.00	R 1,000.00	R -	R 85,600.00
Trailer Blou massa 12m		2006	14	R 173,000.00	30	R 17,300.00	R 5,190.00	R 72,660.00	R 100,340.00	R 1,000.00	R -	R 73,660.00
Trailer Wit massa 7m		2009	11	R 105,000.00	30	R 10,500.00	R 3,150.00	R 34,650.00	R 70,350.00	R 1,000.00	R -	R 35,650.00
Trailer Groen massa 7m		2008	12	R 110,000.00	30	R 11,000.00	R 3,300.00	R 39,600.00	R 70,400.00	R 1,000.00	R -	R 40,600.00
Trailer Wit hoespoed 7m		2010	10	R 143,000.00	30	R 14,300.00	R 4,290.00	R 42,900.00	R 100,100.00	R 1,300.00	R -	R 44,200.00
Implements												
Sem Laaigraaf		2017	3	R 449,000.00	25	R 44,900.00	R 16,164.00	R 48,492.00	R 400,508.00	R 3,000.00		R 51,492.00
Interlink Sidetipper		2010	10	R 358,000.00	30	R 35,800.00	R 10,740.00	R 107,400.00	R 250,600.00	R 2,700.00		R 110,100.00
						R -						
Tapkar		2007	13	R 483,000.00	20	R 48,300.00	R 21,735.00	R 282,555.00	R 200,445.00	R 3,000.00		R 285,555.00
Jan strooier		2008	12	R 313,000.00	30	R 31,300.00	R 9,390.00	R 112,680.00	R 200,320.00	R 2,500.00		R 115,180.00
Radium		2015	5	R 402,000.00	35	R 40,200.00	R 10,337.14	R 51,685.71	R 350,314.29	R 2,800.00		R 54,485.71
Straatmanshouer		2010	10	R 646,000.00	40	R 64,600.00	R 14,535.00	R 145,350.00	R 500,650.00	R 4,000.00		R 149,350.00
Kunsmis strooier		2011	9	R 169,000.00	20	R 16,900.00	R 7,605.00	R 68,445.00	R 100,555.00	R 1,000.00		R 69,445.00
Eqvalue Planter		2015	5	R 2,185,000.00	10	R 218,500.00	R 196,650.00	R 983,250.00	R 1,201,750.00	R 6,000.00		R 989,250.00
Cover crop planter		2019	2	R 800,000.00	10	R 80,000.00	R 72,000.00	R 144,000.00	R 656,000.00	R 3,500.00		R 147,500.00
Ripper		2011	9	R 337,000.00	20	R 33,700.00	R 15,165.00	R 136,485.00	R 200,515.00	R 2,600.00		R 139,085.00
Lenkem		2016	4	R 489,000.00	20	R 48,900.00	R 22,005.00	R 88,020.00	R 400,980.00	R 3,100.00		R 91,120.00
Dus		2006	14	R 174,000.00	30	R 17,400.00	R 5,220.00	R 73,080.00	R 100,920.00	R 1,400.00		R 74,480.00
Kongskilde		2006	14	R 406,000.00	20	R 40,600.00	R 18,270.00	R 255,780.00	R 150,220.00	R 2,750.00		R 258,530.00
Hooitoerusting												
Klaas Baler		2012	8	R 350,000.00	10	R 35,000.00	R 31,500.00	R 252,000.00	R 98,000.00	R 3,500.00	R 2,000.00	R 257,500.00
Tolhark		2012	8	R 10,000.00	20	R 1,000.00	R 450.00	R 3,600.00	R 6,400.00	R 2,000.00	R 2,000.00	R 7,600.00
Tedder		2015	5	R 80,000.00	15	R 8,000.00	R 4,800.00	R 24,000.00	R 56,000.00	R 2,000.00		R 26,000.00
Tedder		2015	5	R 80,000.00	15	R 8,000.00	R 4,800.00	R 24,000.00	R 56,000.00	R 2,000.00		R 26,000.00
Sny masjien		2013	7	R 130,000.00	7	R 13,000.00	R 16,714.29	R 117,000.00	R 13,000.00	R 3,500.00	R 2,000.00	R 122,500.00
Total				R 18,099,000.00		R 1,809,900.00	R 1,156,122.43	R 6,411,628.71	R 11,687,371.29	R 95,050.00	R 33,900.00	R 6,540,578.71

Inventory list System C

Land and Fixed improvements											
Item	Number	Area (m²)	Year built	Age (years)	Expected lifetime (years)	Insurance	Cost price	Replacement value	Yearly depreciation	Accumulated depreciation	Current value
Main house	1	440	1990	31	60	R 2,500.00	R 2,400,000.00	R 6,372,089.36	R 106,201.49	R 3,292,246.17	R 3,079,843.19
House 2	1	160	1987	34	60	R 2,500.00	R 400,000.00	R 1,167,265.63	R 19,454.43	R 661,450.53	R 505,815.11
Workers housing	4	200	2010	11	60	R 1,000.00	R 400,000.00	R 565,635.50	R 9,427.26	R 103,699.84	R 461,935.66
Implements store	2	1200	2017	4	50	R 2,000.00	R 1,100,000.00	R 1,247,703.73	R 24,954.07	R 99,816.30	R 1,147,887.43
Fencing		20000m	2010	11	5	R 5,000.00		R -	R -	R -	R -
Office	1	40	2006	15	60	R 2,000.00	R 200,000.00	R 320,793.42	R 5,346.56	R 80,198.36	R 240,595.07
Silos	6	2000	2005	16	60	R 10,000.00	R 7,000,000.00	R 11,587,058.42	R 193,117.64	R 3,089,882.25	R 8,497,176.18
Total						R 25,000.00	R 11,500,000.00	R 21,260,546.08	R 358,501.45	R 7,327,293.44	R13,933,252.64

Inflation rate:	3.20%

Skape										
Item	Number	Area (m²)	Year built	Age (years)	Expected lifetime (years)	Cost price	Replacement value	Yearly depreciation	Accumulated depreciation	Current value
Hekkies			2019	2	30	R 25,000.00	R 64,317.76	R 2,143.93	R 4,287.85	R 60,029.91
Drukgang			2019	2	30	R 60,000.00	R 154,362.63	R 5,145.42	R 10,290.84	R 144,071.79
Lamhokke			2019	2	30	R 30,000.00	R 77,181.31	R 2,572.71	R 5,145.42	R 72,035.89
Skaapkrat en skaal			2019	2	30	R 22,000.00	R 56,599.63	R 1,886.65	R 3,773.31	R 52,826.32
Slaap krale			2019	2	30	R 25,000.00	R 64,317.76	R 2,143.93	R 4,287.85	R 60,029.91
Total										R 388,993.83

Machinery												
Item	Size/kW	Year	Age	Cost price (R)	Expected lifetime (Year)	Herw Waarde 10% of cost price (R)	Depreciation (R/year)	Depreciation Total (R)	Current value	Insurance	Licenses	Total fixed cost
Tractors												
230 kW	230	2016	4	R 4,000,000.00	15	R 400,000.00	R 240,000.00	R 960,000.00	R 3,040,000.00	R 5,000.00	R 600.00	R 965,600.00
120 kW	123	2013	7	R 2,200,000.00	15	R 220,000.00	R 132,000.00	R 924,000.00	R 1,276,000.00	R 5,000.00	R 600.00	R 929,600.00
75 kW		2018	2	R 330,000.00	20	R 33,000.00	R 14,850.00	R 29,700.00	R 300,300.00	R 2,500.00		R 32,200.00
65 kW		2012	8	R 281,000.00	25	R 28,100.00	R 10,116.00	R 80,928.00	R 200,072.00	R 2,000.00		R 82,928.00
65 kW		2012	8	R 211,000.00	25	R 21,100.00	R 7,596.00	R 60,768.00	R 150,232.00	R 1,900.00		R 62,668.00
Vehicles												
Double cab 4x4		2017	3	R 550,000.00	5	R 55,000.00	R 99,000.00	R 297,000.00	R 253,000.00	R 4,000.00	R 900.00	R 301,900.00
2.8 Extended cab 4x4		2016	4	R 450,000.00	5	R 45,000.00	R 81,000.00	R 324,000.00	R 126,000.00	R 4,000.00	R 900.00	R 328,900.00
2.8 Single cab		2014	6	R 450,000.00	10	R 45,000.00	R 40,500.00	R 243,000.00	R 207,000.00	R 4,000.00	R 900.00	R 247,900.00
Lorrie												
UD 490 Lorrie		2010	10	R 1,000,000.00	30	R 100,000.00	R 30,000.00	R 300,000.00	R 700,000.00	R 10,000.00	R 24,000.00	R 334,000.00
Trailers						R -						
Trailer Wit massa 12m		2008	12	R 235,000.00	30	R 23,500.00	R 7,050.00	R 84,600.00	R 150,400.00	R 1,000.00	R -	R 85,600.00
Trailer Blou massa 12m		2006	14	R 173,000.00	30	R 17,300.00	R 5,190.00	R 72,660.00	R 100,340.00	R 1,000.00	R -	R 73,660.00
Trailer Wit massa 7m		2009	11	R 105,000.00	30	R 10,500.00	R 3,150.00	R 34,650.00	R 70,350.00	R 1,000.00	R -	R 35,650.00
Trailer Groen massa 7m		2008	12	R 110,000.00	30	R 11,000.00	R 3,300.00	R 39,600.00	R 70,400.00	R 1,000.00	R -	R 40,600.00
Trailer Wit hoespoed 7m		2010	10	R 143,000.00	30	R 14,300.00	R 4,290.00	R 42,900.00	R 100,100.00	R 1,300.00	R -	R 44,200.00
Implements												
Sem Laaigraaf		2017	3	R 449,000.00	25	R 44,900.00	R 16,164.00	R 48,492.00	R 400,508.00	R 3,000.00		R 51,492.00
Interlink Sidetipper		2010	10	R 358,000.00	30	R 35,800.00	R 10,740.00	R 107,400.00	R 250,600.00	R 2,700.00		R 110,100.00
						R -						
Tapkar		2007	13	R 483,000.00	20	R 48,300.00	R 21,735.00	R 282,555.00	R 200,445.00	R 3,000.00		R 285,555.00
Jan strooier		2008	12	R 313,000.00	30	R 31,300.00	R 9,390.00	R 112,680.00	R 200,320.00	R 2,500.00		R 115,180.00
Radium		2015	5	R 402,000.00	35	R 40,200.00	R 10,337.14	R 51,685.71	R 350,314.29	R 2,800.00		R 54,485.71
Straatmanshouer		2010	10	R 646,000.00	40	R 64,600.00	R 14,535.00	R 145,350.00	R 500,650.00	R 4,000.00		R 149,350.00
Kunsmis strooier		2011	9	R 169,000.00	20	R 16,900.00	R 7,605.00	R 68,445.00	R 100,555.00	R 1,000.00		R 69,445.00
Eqvalue Planter		2015	5	R 2,185,000.00	10	R 218,500.00	R 196,650.00	R 983,250.00	R 1,201,750.00	R 6,000.00		R 989,250.00
Cover crop planter		2019	2	R 800,000.00	10	R 80,000.00	R 72,000.00	R 144,000.00	R 656,000.00	R 3,500.00		R 147,500.00
Ripper		2011	9	R 337,000.00	20	R 33,700.00	R 15,165.00	R 136,485.00	R 200,515.00	R 2,600.00		R 139,085.00
Lenkem		2016	4	R 489,000.00	20	R 48,900.00	R 22,005.00	R 88,020.00	R 400,980.00	R 3,100.00		R 91,120.00
Dus		2006	14	R 174,000.00	30	R 17,400.00	R 5,220.00	R 73,080.00	R 100,920.00	R 1,400.00		R 74,480.00
Kongskilde		2006	14	R 406,000.00	20	R 40,600.00	R 18,270.00	R 255,780.00	R 150,220.00	R 2,750.00		R 258,530.00
Hooitoerusting												
Klaas Baler		2012	8	R 350,000.00	10	R 35,000.00	R 31,500.00	R 252,000.00	R 98,000.00	R 3,500.00	R 2,000.00	R 257,500.00
Tolhark		2012	8	R 10,000.00	20	R 1,000.00	R 450.00	R 3,600.00	R 6,400.00	R 2,000.00	R 2,000.00	R 7,600.00
Tedder		2015	5	R 80,000.00	15	R 8,000.00	R 4,800.00	R 24,000.00	R 56,000.00	R 2,000.00		R 26,000.00
Tedder		2015	5	R 80,000.00	15	R 8,000.00	R 4,800.00	R 24,000.00	R 56,000.00	R 2,000.00		R 26,000.00
Sny masjien		2013	7	R 130,000.00	7	R 13,000.00	R 16,714.29	R 117,000.00	R 13,000.00	R 3,500.00	R 2,000.00	R 122,500.00
Total				R 18,099,000.00		R 1,809,900.00	R 1,156,122.43	R 6,411,628.71	R 11,687,371.29	R 95,050.00	R 33,900.00	R 6,540,578.71

Livestock			
Item	Number	R/SSU	Value
Breeding ewes	226	R 3,500.00	R 791,000.00
Replacement ewes	86	R 3,500.00	R 301,000.00
Lambs	130	R 500.00	R 65,000.00
Ewes with lambs	152	R 4,000.00	R 608,000.00
Rams	6	R10,000.00	R 60,000.00
Total sheep:	600		R1,825,000.00

Enterprise budgets at a gross margin level for System A

Yield potential based on rainfall distribution

		Ton/Ha	
1	Good	9.2	9.5
2	Average	7.5	
3	Poor	6.8	5.5

Enterprise budget of White Mielies

Information	
Cultivar	White Maize
Units	400
Yield (Ton/Ha)	7.5
Average price (R/ton)	R 3,900.00
Dryland Contribution	39%

Gross Production Value				
Item	per Ha	Total Good year	Total Average year	Total Poor year
White Mielies	R 35,880.00	R 14,352,000.00	R 11,700,000.00	R 10,608,000.00
Total GPV	R 35,880.00	R 14,352,000.00	R 11,700,000.00	R 10,608,000.00

Variable costs				
	per Ha (R)	Total (R)		
Directly-allocated costs				
Seed: Production	R 2,284.17	R 913,667.65	R 913,667.65	R 913,667.65
Fertilisers	R 3,575.22	R 1,430,088.50	R 1,430,088.50	R 1,430,088.50
Sprays/Weed-killers	R 1,529.40	R 611,760.08	R 611,760.08	R 611,760.08
Lime	R 521.14	R 208,456.24	R 208,456.24	R 208,456.24
Labour Casual	R 117.99	R 47,197.64	R 47,197.64	R 47,197.64
Labour Permanent	R 572.27	R 228,908.55	R 228,908.55	R 228,908.55
Crop insurance	R 515.31	R 206,125.86	R 206,125.86	R 206,125.86
Transport	R 117.99	R 47,197.64	R 47,197.64	R 47,197.64
Harvesting cost	R 737.46	R 294,985.25	R 294,985.25	R 294,985.25
Contract work	R 294.99	R 117,994.10	R 117,994.10	R 117,994.10
Non-directly allocated cost				
Fuel	R 1,412.15	R 564,861.36	R 564,861.36	R 564,861.36
Lubricants	R 59.00	R 23,598.82	R 23,598.82	R 23,598.82
Maintenance / Repairs / Parts	R 871.19	R 348,475.91	R 348,475.91	R 348,475.91
Total Variable Cost	R 12,608.29	R 5,043,317.60	R 5,043,317.60	R 5,043,317.60
Gross Margin White Maize	R 23,271.71	R 9,308,682.40	R 6,656,682.40	R 5,564,682.40

Yield potential based on rainfall distribution

		Ton/Ha
1	Good	9.2
2	Average	7.5
3	Poor	6.8

Enterprise budget of Yellow Mielies

Information	
Cultivar	Yellow Maize
Units	500
Yield (Ton/Ha)	7.5
Average price (R/ton)	R 3,900.00
Dryland Contribution	49%

Gross Production Value				
Item	per Ha	Total Good year	Total Average year	Total Poor year
Yellow Mielies	R 35,880.00	R 17,940,000.00	R 14,625,000.00	R 13,260,000.00
Total GPV	R 35,880.00	R 17,940,000.00	R 14,625,000.00	R 13,260,000.00

Variable costs				
	per Ha (R)	Total (R)		
Directly-allocated costs				
Seed: Production	R 2,284.17	R 1,142,084.56	R 1,142,084.56	R 1,142,084.56
Fertilisers	R 3,575.22	R 1,787,610.62	R 1,787,610.62	R 1,787,610.62
Sprays/Weed-killers	R 1,529.40	R 764,700.10	R 764,700.10	R 764,700.10
Lime	R 521.14	R 260,570.30	R 260,570.30	R 260,570.30
Labour Casual	R 117.99	R 58,997.05	R 58,997.05	R 58,997.05
Labour Permanent	R 572.27	R 286,135.69	R 286,135.69	R 286,135.69
Crop insurance	R 515.31	R 257,657.33	R 257,657.33	R 257,657.33
Transport	R 117.99	R 58,997.05	R 58,997.05	R 58,997.05
Harvesting cost	R 737.46	R 368,731.56	R 368,731.56	R 368,731.56
Contract work	R 294.99	R 147,492.63	R 147,492.63	R 147,492.63
Non-directly allocated cost				
Fuel	R 1,412.15	R 706,076.70	R 706,076.70	R 706,076.70
Lubricants	R 59.00	R 29,498.53	R 29,498.53	R 29,498.53
Maintenance / Repairs / Parts	R 871.19	R 435,594.89	R 435,594.89	R 435,594.89
Total Variable Cost	R 12,608.29	R 6,304,147.00	R 6,304,147.00	R 6,304,147.00
Gross Margin Yellow Maize	R 23,271.71	R 11,635,853.00	R 8,320,853.00	R 6,955,853.00

Yield potential based on rainfall distribution

		Ton/Ha
1	Good	3.4
2	Average	2.7
3	Poor	2

Enterprise budget of Soya Beans

Information	
Cultivar	Soya beans
Units (Ha)	150
Yield (Ton/Ha)	2.7
Average price (R/ton)	R 6,500.00
Dryland Contribution	12%

Gross Production Value				
Item	per Ha	Total Good year	Total Average year	Total Poor year
Soya beans	R 22,100.00	R 3,315,000.00	R 2,632,500.00	R 1,950,000.00
Total GPV	R 22,100.00	R 3,315,000.00	R 2,632,500.00	R 1,950,000.00

Variable costs				
	per Ha (R)	Total (R)		
Directly-allocated costs				
Seed: Production	R 1,781.65	R 267,247.79	R 267,247.79	R 267,247.79
Fertilisers	R 2,788.67	R 418,300.88	R 418,300.88	R 418,300.88
Sprays/Weed-killers	R 1,192.93	R 178,939.82	R 178,939.82	R 178,939.82
Lime	R 406.49	R 60,973.45	R 60,973.45	R 60,973.45
Labour Casual	R 92.04	R 13,805.31	R 13,805.31	R 13,805.31
Labour Permanent	R 446.37	R 66,955.75	R 66,955.75	R 66,955.75
Crop insurance	R 401.95	R 60,291.81	R 60,291.81	R 60,291.81
Transport	R 92.04	R 13,805.31	R 13,805.31	R 13,805.31
Harvesting cost	R 575.22	R 86,283.19	R 86,283.19	R 86,283.19
Contract work	R 575.22	R 86,283.19	R 86,283.19	R 86,283.19
Non-directly allocated cost				
Fuel	R 1,101.48	R 165,221.95	R 165,221.95	R 165,221.95
Lubricants	R 46.02	R 6,902.65	R 6,902.65	R 6,902.65
Maintenance / Repairs / Parts	R 679.53	R 101,929.20	R 101,929.20	R 101,929.20
Total Variable Cost	R 10,179.60	R 1,526,940.31	R 1,526,940.31	R 1,526,940.31
Gross Margin Soya Beans	R 11,920.40	R 1,788,059.69	R 1,105,559.69	R 423,059.69

Enterprise budgets at a gross margin level for System B

Yield potential based on rainfall distribution

		Ton/Ha
1	Good	9.2
2	Average	7.5
3	Poor	6.2

Enterprise budget of White Mielies

Information	
Cultivar	White Maize
Units (Ha)	420
Yield (Ton/Ha)	7.5
Average price (R/ton)	R 3,900.00
Dryland Contribution	41.11%
Overall Contribution	36.52%

Gross Production Value				
Item	per Ha	Total Good year	Total Average year	Total Poor year
White Mielies	R 35,880.00	R 15,069,600.00	R 12,285,000.00	R 10,155,600.00
Total GPV	R 35,880.00	R 15,069,600.00	R 12,285,000.00	R 10,155,600.00

Variable costs				
	per Ha	Total Good year	Total Average year	Total Poor year
Directly-allocated costs				
Seed: Production	R 2,346.46	R 985,515.15	R 985,515.15	R 985,515.15
Seed: Pasture	R -	R -	R -	R -
Fertilisers	R 3,600.00	R 1,512,000.00	R 1,512,000.00	R 1,512,000.00
Sprays/Weed-killers	R 1,522.45	R 639,430.08	R 639,430.08	R 639,430.08
Lime	R 535.35	R 224,848.48	R 224,848.48	R 224,848.48
Labour Casual	R 104.35	R 43,826.09	R 43,826.09	R 43,826.09
Labour Permanent	R 506.09	R 212,556.52	R 212,556.52	R 212,556.52
Crop insurance	R 529.37	R 222,334.85	R 222,334.85	R 222,334.85
Transport	R 121.21	R 50,909.09	R 50,909.09	R 50,909.09
Harvesting cost	R 734.11	R 308,327.48	R 308,327.48	R 308,327.48
Contract work	R 303.03	R 127,272.73	R 127,272.73	R 127,272.73
			R -	R -
Non-directly allocated cost			R -	R -
Fuel	R 1,405.74	R 590,410.12	R 590,410.12	R 590,410.12
Lubricants	R 60.61	R 25,454.55	R 25,454.55	R 25,454.55
Maintenance / Repairs / Parts	R 894.95	R 375,878.79	R 375,878.79	R 375,878.79
Total Variable Cost	R 12,663.72	R 5,318,763.92	R 5,318,763.92	R 5,318,763.92
Gross Margin White Maize	R 23,216.28	R 9,750,836.08	R 6,966,236.08	R 4,836,836.08

Yield potential based on rainfall distribution

1	Good	9.2	
2	Average	7.5	
3	Poor	6.2	

Enterprise budget of Yellow Mielies

Information	
Cultivar	Yellow Maize
Units (Ha)	530
Yield (Ton/Ha)	7.5
Average price (R/ton)	R 3,900.00
Dryland Contribution	51.88%
Overall Contribution	46.09%

Gross Production Value				
Item	per Ha	Total Good year	Total Average year	Total Poor year
Yellow Mielies	R 35,880.00	R 19,016,400.00	R 15,502,500.00	R 12,815,400.00
Total GPV	R 35,880.00	R 19,016,400.00	R 15,502,500.00	R 12,815,400.00

Variable costs				
	per Ha	Total Good year	Total Average year	Total Poor year
Directly-allocated costs				
Seed: Production	R 2,346.46	R 1,243,626.26	R 1,243,626.26	R 1,243,626.26
Seed: Pasture	R -	R -	R -	R -
Fertilisers	R 3,600.00	R 1,908,000.00	R 1,908,000.00	R 1,908,000.00
Sprays/Weed-killers	R 1,522.45	R 806,899.86	R 806,899.86	R 806,899.86
Lime	R 535.35	R 283,737.37	R 283,737.37	R 283,737.37
Labour Casual	R 104.35	R 55,304.35	R 55,304.35	R 55,304.35
Labour Permanent	R 506.09	R 268,226.09	R 268,226.09	R 268,226.09
Crop insurance	R 529.37	R 280,565.40	R 280,565.40	R 280,565.40
Transport	R 121.21	R 64,242.42	R 64,242.42	R 64,242.42
Harvesting cost	R 734.11	R 389,079.91	R 389,079.91	R 389,079.91
Contract work	R 303.03	R 160,606.06	R 160,606.06	R 160,606.06
			R -	R -
Non-directly allocated cost			R -	R -
Fuel	R 1,405.74	R 745,041.34	R 745,041.34	R 745,041.34
Lubricants	R 60.61	R 32,121.21	R 32,121.21	R 32,121.21
Maintenance / Repairs / Parts	R 894.95	R 474,323.23	R 474,323.23	R 474,323.23
Total Variable Cost	R 12,663.72	R 6,711,773.52	R 6,711,773.52	R 6,711,773.52
Gross Margin Yellow Maize	R 23,216.28	R 12,304,626.48	R 8,790,726.48	R 6,103,626.48

Yield potential based on rainfall distribution

1	Good	R 3.50
2	Average	
3	Poor	

Enterprise budget of Winter Cover Crops

Information		Price per kg of seed	Price paid for seeds
Cultivar	Winter		
Units (Ha)	20	R 900.00	R 18,000.00
Yield (Kg/m²)	0.00000035		
Average price (R/Kg)			
Dryland Contribution	0%		
Overall Contribution	2%		

Gross Production Value		
Item	per Ha	Total
Winter cover crops	R -	R -
Total GPV	R -	R -

Variable costs		
	per Ha	Total
Directly-allocated costs		
Seed: Production	R -	
Seed: Pasture	R 900.00	R 18,000.00
Fertilisers	R 3,600.00	R 72,000.00
Roundup	R 65.00	R 1,300.00
Spray	R 100.00	R 2,000.00
Labour Casual	R 104.35	R 2,086.96
Labour Permanent	R 506.09	R 10,121.74
Crop insurance	R -	
Plat rol	R 28.90	R 578.00
Planting cost	R 600.00	R 12,000.00
Contract work	R -	
Non-directly allocated cost		
Fuel	R 476.00	R 9,520.00
Lubricants	R -	R -
Maintenance / Repairs / Parts	R -	R -
Total Variable Cost	R 6,380.33	R 127,606.70
Gross Margin Winter cover crops	-R 6,380.33	-R 127,606.70

Yield potential based on rainfall distribution

1	Good	R 7.30
2	Average	R 4.00
3	Poor	R 1.50

Enterprise budget of Summer Cover Crops

Information		Price per kg of seed	Price paid for seeds
Cultivar	Summer		
Units (Ha)	20	R 600.00	R 12,000.00
Yield (Kg/m²)	0.00000073		
Average price (R/Kg)			
Dryland Contribution	0%		
Overall Contribution	2%		

Gross Production Value		
Item	per Ha	Total
Summer cover crops	R -	R -
Total GPV	R -	R -

Variable costs		
	per Ha	Total
Directly-allocated costs		
Seed: Production	R -	R -
Seed: Pasture	R 600.00	R 12,000.00
Fertilisers	R -	R -
Sprays/Weed-killers	R -	R -
Bewerking	R 1,200.00	R 24,000.00
Labour Casual	R 104.35	R 2,086.96
Labour Permanent	R 506.09	R 10,121.74
Crop insurance	R -	R -
Transport	R -	R -
Harvesting cost	R -	R -
Contract work	R -	
Non-directly allocated cost		
Fuel	R 680.00	R 13,600.00
Lubricants	R -	R -
Maintenance / Repairs / Parts	R -	R -
Total Variable Cost	R 3,090.43	R 61,808.70
Gross Margin Summer cover crops	-R 3,090.43	-R 61,808.70

Yield potential based on rainfall distribution

1	Good	6
2	Average	4.2
3	Poor	3.8

Enterprise budget of Teff

Information				
Cultivar	Teff	Price per kg of seed	Seed needed per ha	Price paid for seeds
Units (Ha)	100	R 20.00	20	R 40,000.00
Yield (Ton/Ha)	4.2			
Average price (R/ton)	R 1,500.00			
Dryland Contribution	2.11%			
Overall Contribution	8.70%			

Gross Production Value				
Item	per Ha	Total Good year	Total Average year	Total Poor year
Teff	R 9,000.00	R 900,000.00	R 630,000.00	R 570,000.00
Total GPV	R 9,000.00	R 900,000.00	R 630,000.00	R 570,000.00

Variable costs				
	per Ha	Total Good year	Total Average year	Total Poor year
Directly-allocated costs				
Seed: Production	R -	R -	R -	R -
Seed: Pasture	R 400.00	R 40,000.00	R 40,000.00	R 40,000.00
Fertilisers	R -	R -	R -	R -
Sprays/Weed-killers	R 150.00	R 15,000.00	R 15,000.00	R 15,000.00
Bewerking	R 1,200.00	R 120,000.00	R 120,000.00	R 120,000.00
Labour Casual	R 104.35	R 10,434.78	R 10,434.78	R 10,434.78
Labour Permanent	R 506.09	R 50,608.70	R 50,608.70	R 50,608.70
Crop insurance	R -	R -	R -	R -
Biomuti	R 400.00	R 40,000.00	R 40,000.00	R 40,000.00
Harvesting cost	R 22.50	R 2,250.00	R 1,575.00	R 1,425.00
Contract work	R -	R -	R -	R -
Non-directly allocated cost				
Fuel	R 680.00	R 68,000.00	R 68,000.00	R 68,000.00
Lubricants	R -	R -	R -	R -
Maintenance / Repairs / Parts	R -	R -	R -	R -
Total Variable Cost	R 3,462.93	R 346,293.48	R 345,618.48	R 345,468.48
Gross Margin Teff	R 5,537.07	R 553,706.52	R 284,381.52	R 224,531.52

Enterprise budget of Rhodes / Erigrostis

Information				
Cultivar	Rhodes	Price per kg of seed	Seed needed per ha	Price paid for seeds
Units (Ha)	20	R 110.00	11	R 24,200.00
Yield (Ton/Ha)	6			
Average price (R/ton)	R 1,000.00			
Dryland Contribution	0.40%			
Overall Contribution	1.74%			

Gross Production Value				
Item	per Ha	Total Good year	Total Average year	Total Poor year
Rhodes / Erigrostis	R 6,000.00	R 120,000.00	R 120,000.00	R 120,000.00
Total GPV	R 6,000.00	R 120,000.00	R 120,000.00	R 120,000.00

Variable costs				
	per Ha	Total Good year	Total Average year	Total Poor year
Directly-allocated costs				
Seed: Production	R -	R -	R -	R -
Seed: Pasture	R 1,210.00	R 24,200.00	R 24,200.00	R 24,200.00
Fertilisers	R -	R -	R -	R -
Sprays/Weed-killers	R 150.00	R 3,000.00	R 3,000.00	R 3,000.00
Bewerking	R -	R -	R -	R -
Labour Casual	R 104.35	R 2,086.96	R 2,086.96	R 2,086.96
Labour Permanent	R 506.09	R 10,121.74	R 10,121.74	R 10,121.74
Crop insurance	R -	R -	R -	R -
Transport	R -	R -	R -	R -
Harvesting cost	R 18.75	R 375.00	R 375.00	R 375.00
Contract work	R -	R -	R -	R -
Non-directly allocated cost				
Fuel	R 510.00	R 10,200.00	R 10,200.00	R 10,200.00
Lubricants	R -	R -	R -	R -
Maintenance / Repairs / Parts	R -	R -	R -	R -
Total Variable Cost	R 2,499.18	R 49,983.70	R 49,983.70	R 49,983.70
Gross Margin Rhodes / Erigrostis	R 3,500.82	R 70,016.30	R 70,016.30	R 70,016.30

Yield potential based on rainfall distribution

1	Good	R 10.58
2	Average	R 8.63
3	Poor	R 7.13

Enterprise budget of White Mielies after cover crops

Information	
Cultivar	White Maize
Units (Ha)	20
Yield (Ton/Ha)	8.7
Average price (R/ton)	R 3,900.00
Dryland Contribution	
Overall Contribution	

Gross Production Value				
Item	per Ha	Total Good year	Total Average year	Total Poor year
White Mielies	R 41,262.00	R 825,240.00	R 672,750.00	R 556,140.00
Total GPV	R 41,262.00	R 825,240.00	R 672,750.00	R 556,140.00

Variable costs				
	per Ha	Total Good year	Total Average year	Total Poor year
Directly-allocated costs				
Seed: Production	R 2,346.46	R 46,929.29	R 46,929.29	R 46,929.29
Seed: Pasture	R -	R -	R -	R -
Fertilisers	R 3,060.00	R 61,200.00	R 61,200.00	R 61,200.00
Sprays/Weed-killers	R 1,294.08	R 25,881.69	R 25,881.69	R 25,881.69
Lime	R 481.82	R 9,636.36	R 9,636.36	R 9,636.36
Labour Casual	R 104.35	R 2,086.96	R 2,086.96	R 2,086.96
Labour Permanent	R 506.09	R 10,121.74	R 10,121.74	R 10,121.74
Crop insurance	R 529.37	R 10,587.37	R 10,587.37	R 10,587.37
Transport	R 121.21	R 2,424.24	R 2,424.24	R 2,424.24
Harvesting cost	R 734.11	R 14,682.26	R 14,682.26	R 14,682.26
Contract work	R 303.03	R 6,060.61	R 6,060.61	R 6,060.61
		R -		
Non-directly allocated cost		R -		
Fuel	R 1,405.74	R 28,114.77	R 28,114.77	R 28,114.77
Lubricants	R 60.61	R 1,212.12	R 1,212.12	R 1,212.12
Maintenance / Repairs / Parts	R 894.95	R 17,898.99	R 17,898.99	R 17,898.99
Total Variable Cost	R 11,841.82	R 236,836.41	R 236,836.41	R 236,836.41
Gross Margin WM after cover crops	R 29,420.18	R 588,403.59	R 435,913.59	R 319,303.59

Yield potential based on rainfall distribution

1	Good	R 10.58
2	Average	R 8.63
3	Poor	R 7.13

Enterprise budget of Yellow Mielies after cover crops

Information	
Cultivar	Yellow Maize
Units (Ha)	20
Yield (Ton/Ha)	8.7
Average price (R/ton)	R 3,900.00
Dryland Contribution	
Overall Contribution	

Gross Production Value				
Item	per Ha	Total Good year	Total Average year	Total Poor year
Yellow Mielies	R 41,262.00	R 825,240.00	R 672,750.00	R 556,140.00
Total GPV	R 41,262.00	R 825,240.00	R 672,750.00	R 556,140.00

Variable costs				
	per Ha	Total Good year	Total Average year	Total Poor year
Directly-allocated costs				
Seed: Production	R 2,346.46	R 46,929.29	R 46,929.29	R 46,929.29
Seed: Pasture	R -	R -	R -	R -
Fertilisers	R 3,060.00	R 61,200.00	R 61,200.00	R 61,200.00
Sprays/Weed-killers	R 1,294.08	R 25,881.69	R 25,881.69	R 25,881.69
Lime	R 481.82	R 9,636.36	R 9,636.36	R 9,636.36
Labour Casual	R 104.35	R 2,086.96	R 2,086.96	R 2,086.96
Labour Permanent	R 506.09	R 10,121.74	R 10,121.74	R 10,121.74
Crop insurance	R 529.37	R 10,587.37	R 10,587.37	R 10,587.37
Transport	R 121.21	R 2,424.24	R 2,424.24	R 2,424.24
Harvesting cost	R 734.11	R 14,682.26	R 14,682.26	R 14,682.26
Contract work	R 303.03	R 6,060.61	R 6,060.61	R 6,060.61
		R -		
Non-directly allocated cost		R -		
Fuel	R 1,405.74	R 28,114.77	R 28,114.77	R 28,114.77
Lubricants	R 60.61	R 1,212.12	R 1,212.12	R 1,212.12
Maintenance / Repairs / Parts	R 894.95	R 17,898.99	R 17,898.99	R 17,898.99
Total Variable Cost	R 11,841.82	R 236,836.41	R 236,836.41	R 236,836.41
Gross Margin YM aftercover crops	R 29,420.18	R 588,403.59	R 435,913.59	R 319,303.59

Enterprise budgets at a gross margin level for System C

(All enterprise budget including white maize, yellow maize, teff, erigrostis / rhodes, winter cover crops, summer cover crops, white maize after cover crops, and yellow maize after cover crops remain the same as the budgets in system B.)

Enterprise budget of Meatmaster Lamb

Information	
Commoditiy	Meatmaster Lamb
Units (Sheep)	600
Yield (Ton/Ha)	1
Average price (R/ton)	R 1,500.00
Overall Contribution	

Gross Production Value		
Item	per unit	Total (R)
Meatmaster Lamb	R 1,500.00	R 900,000.00
Total GPV	R 1,500.00	R 900,000.00

Variable costs		
	Total per unit	Total
Directly-allocated costs		
Vet / Medication / Dip & A.I.	R 50.00	R 30,000.00
Livestock fodder / Lick	R 750.00	R 450,000.00
Labour Casual	R 7.66	R 4,596.00
Labour Permanent	R 37.15	R 22,290.60
Transport	R 8.68	R 5,209.11
Contract work	R 20.83	R 12,498.64
Non-directly allocated cost		
Fuel	R -	R -
Security	R 100.00	R 60,000.00
Total Variable Cost	R 974.32	R 584,594.35
Gross Margin Livestock	R 525.68	R 315,405.65

Gross Margin Summary A			
	Good Year	Average Year	Poor Year
Total Production Income	R 35,607,000.00	R 28,957,500.00	R 25,818,000.00
Directly Attributable Variable Cost	R 10,440,475.00	R 10,440,475.00	R 10,440,475.00
Margin above Directly Attributable Variable Cost	R 25,166,525.00	R 18,517,025.00	R 15,377,525.00
Not Directly Attributable Costs	R 2,382,160.00	R 2,382,160.00	R 2,382,160.00
Gross Margin Above all Attributable Cost	**R 22,784,365.00**	**R 16,134,865.00**	**R 12,995,365.00**

Gross Margin Summary B			
	Good Year	Average Year	Poor Year
Total Production Income	R 28,509,600.00	R 23,160,000.00	R 19,215,600.00
Directly Attributable Variable Cost	R 10,634,275.19	R 10,634,275.19	R 10,634,275.19
Margin above Directly Attributable Variable Cost	R 17,875,324.81	R 12,525,724.81	R 8,581,324.81
Not Directly Attributable Costs	R 2,428,600.83	R 2,428,600.83	R 2,428,600.83
Gross Margin Above all Attributable Cost	**R 15,446,723.98**	**R 10,097,123.98**	**R 6,152,723.98**

Gross Margin Summary C			
	Good Year	Average Year	Poor Year
Total Production Income	R 29,409,600.00	R 24,060,000.00	R 20,115,600.00
Directly Attributable Variable Cost	R 10,884,711.57	R 10,884,711.57	R 10,884,711.57
Margin above Directly Attributable Variable Cost	R 18,524,888.43	R 13,175,288.43	R 9,230,888.43
Not Directly Attributable Costs	R 2,298,544.82	R 2,298,544.82	R 2,298,544.82
Gross Margin Above all Attributable Cost	**R 16,226,343.62**	**R 10,876,743.62**	**R 6,932,343.62**

Whole farm multi period budget A

Yield potential based on rainfall distribution

1 Good
2 Average
3 Poor

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
White maize: (good, average, poor)	3	3	2	2	1	2	2	1	2	2	2	1	2	2	2	1	2	2	1	1
Yellow maize: (good, average, poor)	3	3	2	2	1	2	2	1	2	2	2	1	2	2	2	1	2	2	1	1
Soya beans: (good, average, poor)	2	1	2	3	2	1	2	1	2	3	1	2	1	2	1	2	1	2	1	2

Cash inflow	Ha	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
White Maize	400	R 10,608,000.00	R 10,608,000.00	R 11,700,000.00	R 11,700,000.00	R14,352,000.00	R 11,700,000.00	R 11,700,000.00	R14,352,000.00	R 11,700,000.00	R11,700,000.00
Yellow Maize	500	R 13,260,000.00	R 13,260,000.00	R 14,625,000.00	R 14,625,000.00	R17,940,000.00	R 14,625,000.00	R 14,625,000.00	R17,940,000.00	R 14,625,000.00	R14,625,000.00
Soya Beans	150	R 2,632,500.00	R 3,315,000.00	R 2,632,500.00	R 1,950,000.00	R 2,632,500.00	R 3,315,000.00	R 2,632,500.00	R 3,315,000.00	R 2,632,500.00	R 1,950,000.00
Kapitaal verkope		0	R -	R 37,500.00	R 45,833.33	R -	R 37,500.00	R 182,083.33	R 71,333.33	R 86,083.33	R 183,333.33
Gross Income	1050	R 26,500,500.00	R 27,183,000.00	R 28,995,000.00	R 28,320,833.33	R34,924,500.00	R 29,677,500.00	R 29,139,583.33	R35,678,333.33	R 29,043,583.33	R28,458,333.33
Other Income:											
Loans granted		R - R -	R -	R -	R -	R -	R -	R -	R -	R -	R -
TOTAL INCOME:		R 26,500,500.00	R 27,183,000.00	R 28,995,000.00	R 28,320,833.33	R34,924,500.00	R 29,677,500.00	R 29,139,583.33	R35,678,333.33	R 29,043,583.33	R28,458,333.33
Expenses											
Cash outflow											
Production Cost:											
Seed: Production		R 2,323,000.00	R 2,323,000.00	R 2,323,000.00	R 2,323,000.00	R 2,323,000.00	R 2,323,000.00	R 2,323,000.00	R 2,323,000.00	R 2,323,000.00	R 2,323,000.00
Seed: Pasture		R 107,000.00	R 107,000.00	R 107,000.00	R 107,000.00	R 107,000.00	R 107,000.00	R 107,000.00	R 107,000.00	R 107,000.00	R 107,000.00
Fertilisers		R 3,636,000.00	R 3,636,000.00	R 3,636,000.00	R 3,636,000.00	R 3,636,000.00	R 3,636,000.00	R 3,636,000.00	R 3,636,000.00	R 3,636,000.00	R 3,636,000.00
Sprays/Weed-killers		R 1,555,400.00	R 1,555,400.00	R 1,555,400.00	R 1,555,400.00	R 1,555,400.00	R 1,555,400.00	R 1,555,400.00	R 1,555,400.00	R 1,555,400.00	R 1,555,400.00
Lime		R 530,000.00	R 530,000.00	R 530,000.00	R 530,000.00	R 530,000.00	R 530,000.00	R 530,000.00	R 530,000.00	R 530,000.00	R 530,000.00
Labour Casual		R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00
Labour Permanent		R 582,000.00	R 582,000.00	R 582,000.00	R 582,000.00	R 582,000.00	R 582,000.00	R 582,000.00	R 582,000.00	R 582,000.00	R 582,000.00
Crop insurance		R 524,075.00	R 524,075.00	R 524,075.00	R 524,075.00	R 524,075.00	R 524,075.00	R 524,075.00	R 524,075.00	R 524,075.00	R 524,075.00
Transport		R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00
Harvesting cost		R 750,000.00	R 750,000.00	R 750,000.00	R 750,000.00	R 750,000.00	R 750,000.00	R 750,000.00	R 750,000.00	R 750,000.00	R 750,000.00
Contract work		R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00
Fuel		R 1,436,160.00	R 1,436,160.00	R 1,436,160.00	R 1,436,160.00	R 1,436,160.00	R 1,436,160.00	R 1,436,160.00	R 1,436,160.00	R 1,436,160.00	R 1,436,160.00
Lubricants		R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00
Maintenance / Repairs / Parts		R 886,000.00	R 886,000.00	R 886,000.00	R 886,000.00	R 886,000.00	R 886,000.00	R 886,000.00	R 886,000.00	R 886,000.00	R 886,000.00
Overhead costs:											
Labour: Bonus / Rations / Protective clothing		R 240,000.00	R 240,000.00	R 240,000.00	R 240,000.00	R 240,000.00	R 240,000.00	R 240,000.00	R 240,000.00	R 240,000.00	R 240,000.00
Salary: Management		R 480,000.00	R 480,000.00	R 480,000.00	R 480,000.00	R 480,000.00	R 480,000.00	R 480,000.00	R 480,000.00	R 480,000.00	R 480,000.00
UIF 1% of salaries and wages		R 14,220.00	R 14,220.00	R 14,220.00	R 14,220.00	R 14,220.00	R 14,220.00	R 14,220.00	R 14,220.00	R 14,220.00	R 14,220.00
Local governement levy		R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00
Accident insurance: Employees		R 200,000.00	R 200,000.00	R 200,000.00	R 200,000.00	R 200,000.00	R 200,000.00	R 200,000.00	R 200,000.00	R 200,000.00	R 200,000.00
Short term insurance and policies		R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00
Electricity		R 397,000.00	R 397,000.00	R 397,000.00	R 397,000.00	R 397,000.00	R 397,000.00	R 397,000.00	R 397,000.00	R 397,000.00	R 397,000.00
Land Tax and Water		R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00
Licences		R 87,000.00	R 87,000.00	R 87,000.00	R 87,000.00	R 87,000.00	R 87,000.00	R 87,000.00	R 87,000.00	R 87,000.00	R 87,000.00
Phone / Cellphone / Stationary		R 144,000.00	R 144,000.00	R 144,000.00	R 144,000.00	R 144,000.00	R 144,000.00	R 144,000.00	R 144,000.00	R 144,000.00	R 144,000.00
Bank charges		R 36,000.00	R 36,000.00	R 36,000.00	R 36,000.00	R 36,000.00	R 36,000.00	R 36,000.00	R 36,000.00	R 36,000.00	R 36,000.00
Auditors' / Bookkeepers' fees		R 150,000.00	R 150,000.00	R 150,000.00	R 150,000.00	R 150,000.00	R 150,000.00	R 150,000.00	R 150,000.00	R 150,000.00	R 150,000.00
Unforeseen expenses (5%)		R 757,892.75	R 757,892.75	R 757,892.75	R 757,892.75	R 757,892.75	R 757,892.75	R 757,892.75	R 757,892.75	R 757,892.75	R 757,892.75
Total Production Cost		R 15,915,747.75	R 15,915,747.75	R 15,915,747.75	R 15,915,747.75	R15,915,747.75	R 15,915,747.75	R 15,915,747.75	R15,915,747.75	R 15,915,747.75	R15,915,747.75
Other expenses:											
Machinery purchases		R -	R -	R -	R -	R -	R -	R -	R -	R -	R -
Debt Redemption		R -	R -	R -	R -	R -	R -	R -	R -	R -	R -
TOTAL EXPENDITURE:		R 15,915,747.75	R 15,915,747.75	R 15,915,747.75	R 15,915,747.75	R15,915,747.75	R 15,915,747.75	R 15,915,747.75	R15,915,747.75	R 15,915,747.75	R15,915,747.75
Replacement Schedule		R -	R 610,000.00	R 750,000.00	R -	R 327,500.00	R 3,000,000.00	R 1,510,000.00	R 1,250,000.00	R 3,200,000.00	R -
NET YEARLY FLOW		R 10,584,752.25	R 10,657,252.25	R 12,329,252.25	R 12,405,085.58	R18,681,252.25	R 10,761,752.25	R 11,713,835.58	R18,512,585.58	R 9,927,835.58	R12,542,585.58
Profit / Loss Before Tax		R 10,584,752.25	R 10,657,252.25	R 12,329,252.25	R 12,405,085.58	R18,681,252.25	R 10,761,752.25	R 11,713,835.58	R18,512,585.58	R 9,927,835.58	R12,542,585.58
Taxation		R 2,963,730.63	R 2,984,030.63	R 3,452,190.63	R 3,473,423.96	R 5,230,750.63	R 3,013,290.63	R 3,279,873.96	R 5,183,523.96	R 2,779,793.96	R 3,511,923.96
Profit / Loss After Tax		R 7,621,021.62	R 7,673,221.62	R 8,877,061.62	R 8,931,661.62	R13,450,501.62	R 7,748,461.62	R 8,433,961.62	R13,329,061.62	R 7,148,041.62	R 9,030,661.62
CCF		-R 22,961,231.02	-R 15,288,009.40	-R 6,410,947.78	R 2,520,713.84	R15,971,215.46	R 23,719,677.08	R 32,153,638.70	R45,482,700.32	R 52,630,741.94	R61,661,403.56

Cash inflow	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
White Maize	R 11,700,000.00	R 14,352,000.00	R11,700,000.00	R 11,700,000.00	R 11,700,000.00	R 14,352,000.00	R 11,700,000.00	R 11,700,000.00	R 14,352,000.00	R 14,352,000.00
Yellow Maize	R 14,625,000.00	R 17,940,000.00	R14,625,000.00	R 14,625,000.00	R 14,625,000.00	R 17,940,000.00	R 14,625,000.00	R 14,625,000.00	R 17,940,000.00	R 17,940,000.00
Soya Beans	R 3,315,000.00	R 2,632,500.00	R 3,315,000.00	R 2,632,500.00	R 3,315,000.00	R 2,632,500.00	R 3,315,000.00	R 2,632,500.00	R 3,315,000.00	R 2,632,500.00
Kapitaal verkope	R -	R -	R 375,500.00	R -	R -	R 37,500.00	R 182,083.33	R 69,666.67	R 41,000.00	R 82,333.33
Gross Income	R 29,640,000.00	R 34,924,500.00	R30,015,500.00	R 28,957,500.00	R 29,640,000.00	R 34,962,000.00	R 29,822,083.33	R 29,027,166.67	R 35,648,000.00	R 35,006,833.33
Other Income:										
Loans granted	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -
TOTAL INCOME:	R 29,640,000.00	R 34,924,500.00	R30,015,500.00	R 28,957,500.00	R 29,640,000.00	R 34,962,000.00	R 29,822,083.33	R 29,027,166.67	R 35,648,000.00	R 35,006,833.33
Expenses										
Cash outflow										
Production Cost:										
Seed: Production	R 2,323,000.00	R 2,323,000.00	R 2,323,000.00	R 2,323,000.00	R 2,323,000.00	R 2,323,000.00	R 2,323,000.00	R 2,323,000.00	R 2,323,000.00	R 2,323,000.00
Seed: Pasture	R 107,000.00	R 107,000.00	R 107,000.00	R 107,000.00	R 107,000.00	R 107,000.00	R 107,000.00	R 107,000.00	R 107,000.00	R 107,000.00
Fertilisers	R 3,636,000.00	R 3,636,000.00	R 3,636,000.00	R 3,636,000.00	R 3,636,000.00	R 3,636,000.00	R 3,636,000.00	R 3,636,000.00	R 3,636,000.00	R 3,636,000.00
Sprays/Weed-killers	R 1,555,400.00	R 1,555,400.00	R 1,555,400.00	R 1,555,400.00	R 1,555,400.00	R 1,555,400.00	R 1,555,400.00	R 1,555,400.00	R 1,555,400.00	R 1,555,400.00
Lime	R 530,000.00	R 530,000.00	R 530,000.00	R 530,000.00	R 530,000.00	R 530,000.00	R 530,000.00	R 530,000.00	R 530,000.00	R 530,000.00
Labour Casual	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00
Labour Permanent	R 582,000.00	R 582,000.00	R 582,000.00	R 582,000.00	R 582,000.00	R 582,000.00	R 582,000.00	R 582,000.00	R 582,000.00	R 582,000.00
Crop insurance	R 524,075.00	R 524,075.00	R 524,075.00	R 524,075.00	R 524,075.00	R 524,075.00	R 524,075.00	R 524,075.00	R 524,075.00	R 524,075.00
Transport	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00
Harvesting cost	R 750,000.00	R 750,000.00	R 750,000.00	R 750,000.00	R 750,000.00	R 750,000.00	R 750,000.00	R 750,000.00	R 750,000.00	R 750,000.00
Contract work	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00
Fuel	R 1,436,160.00	R 1,436,160.00	R 1,436,160.00	R 1,436,160.00	R 1,436,160.00	R 1,436,160.00	R 1,436,160.00	R 1,436,160.00	R 1,436,160.00	R 1,436,160.00
Lubricants	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00
Maintenance / Repairs / Parts	R 886,000.00	R 886,000.00	R 886,000.00	R 886,000.00	R 886,000.00	R 886,000.00	R 886,000.00	R 886,000.00	R 886,000.00	R 886,000.00
Overhead costs:										
Labour: Bonus / Rations / Protective clothing	R 240,000.00	R 240,000.00	R 240,000.00	R 240,000.00	R 240,000.00	R 240,000.00	R 240,000.00	R 240,000.00	R 240,000.00	R 240,000.00
Salary: Management	R 480,000.00	R 480,000.00	R 480,000.00	R 480,000.00	R 480,000.00	R 480,000.00	R 480,000.00	R 480,000.00	R 480,000.00	R 480,000.00
UIF 1% of salaries and wages	R 14,220.00	R 14,220.00	R 14,220.00	R 14,220.00	R 14,220.00	R 14,220.00	R 14,220.00	R 14,220.00	R 14,220.00	R 14,220.00
Local governement levy	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00
Accident insurance: Employees	R 200,000.00	R 200,000.00	R 200,000.00	R 200,000.00	R 200,000.00	R 200,000.00	R 200,000.00	R 200,000.00	R 200,000.00	R 200,000.00
Short term insurance and policies	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00
Electricity	R 397,000.00	R 397,000.00	R 397,000.00	R 397,000.00	R 397,000.00	R 397,000.00	R 397,000.00	R 397,000.00	R 397,000.00	R 397,000.00
Land Tax and Water	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00
Licences	R 87,000.00	R 87,000.00	R 87,000.00	R 87,000.00	R 87,000.00	R 87,000.00	R 87,000.00	R 87,000.00	R 87,000.00	R 87,000.00
Phone / Cellphone / Stationary	R 144,000.00	R 144,000.00	R 144,000.00	R 144,000.00	R 144,000.00	R 144,000.00	R 144,000.00	R 144,000.00	R 144,000.00	R 144,000.00
Bank charges	R 36,000.00	R 36,000.00	R 36,000.00	R 36,000.00	R 36,000.00	R 36,000.00	R 36,000.00	R 36,000.00	R 36,000.00	R 36,000.00
Auditors' / Bookkeepers' fees	R 150,000.00	R 150,000.00	R 150,000.00	R 150,000.00	R 150,000.00	R 150,000.00	R 150,000.00	R 150,000.00	R 150,000.00	R 150,000.00
Unforeseen expenses (5%)	R 757,892.75	R 757,892.75	R 757,892.75	R 757,892.75	R 757,892.75	R 757,892.75	R 757,892.75	R 757,892.75	R 757,892.75	R 757,892.75
Total Production Cost	R 15,915,747.75	R 15,915,747.75	R15,915,747.75	R 15,915,747.75	R 15,915,747.75	R 15,915,747.75	R 15,915,747.75	R 15,915,747.75	R 15,915,747.75	R 15,915,747.75
Other expenses:										
Machinery purchases	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -
Debt Redemption	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -
TOTAL EXPENDITURE:	R 15,915,747.75	R 15,915,747.75	R15,915,747.75	R 15,915,747.75	R 15,915,747.75	R 15,915,747.75	R 15,915,747.75	R 15,915,747.75	R 15,915,747.75	R 15,915,747.75
Replacement Schedule	R -	R 6,010,000.00	R 1,120,000.00	R -	R 327,500.00	R -	R 1,960,000.00	R 750,000.00	R 1,890,000.00	R 270,000.00
NET YEARLY FLOW	R 13,724,252.25	R 12,998,752.25	R12,979,752.25	R 13,041,752.25	R 13,396,752.25	R 19,046,252.25	R 11,946,335.58	R 12,361,418.92	R 17,842,252.25	R 18,821,085.58
Profit / Loss Before Tax	R 13,724,252.25	R 12,998,752.25	R12,979,752.25	R 13,041,752.25	R 13,396,752.25	R 19,046,252.25	R 11,946,335.58	R 12,361,418.92	R 17,842,252.25	R 18,821,085.58
Taxation	R 3,842,790.63	R 3,639,650.63	R 3,634,330.63	R 3,651,690.63	R 3,751,090.63	R 5,332,950.63	R 3,344,973.96	R 3,461,197.30	R 4,995,830.63	R 5,269,903.96
Profit / Loss After Tax	R 9,881,461.62	R 9,359,101.62	R 9,345,421.62	R 9,390,061.62	R 9,645,661.62	R 13,713,301.62	R 8,601,361.62	R 8,900,221.62	R 12,846,421.62	R 13,551,181.62
CCF	R 71,542,865.18	R 80,901,966.80	R90,247,388.42	R 99,637,450.04	R 109,283,111.66	##############	R 131,597,774.90	R140,497,996.52	R153,344,418.14	R166,895,599.76

Whole farm multi period budget B

Yield potential based on rainfall distribution

1 Good
2 Average
3 Poor

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
White maize: (good, average, poor)	3	3	2	2	1	2	2	1	2	2	2	1	2	2	2	1	2	2	1	1
Yellow maize: (good, average, poor)	3	3	2	2	1	2	2	1	2	2	2	1	2	2	2	1	2	2	1	1
Teff: (good, average, poor)	2	1	2	3	2	1	2	1	2	3	1	2	1	2	1	2	1	2	1	2
White maize after cover crops	3	3	2	2	1	2	2	1	2	2	2	1	2	2	2	1	2	2	1	1
Yellow maize after cover crops	3	3	2	2	1	2	2	1	2	2	2	1	2	2	2	1	2	2	1	1

Cash inflow	Ha	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
White Maize	420	R 10,155,600.00	R 10,155,600.00	R 12,285,000.00	R 12,285,000.00	R 15,069,600.00	R 12,285,000.00	R 12,285,000.00	R 15,069,600.00	R 12,285,000.00	R 12,285,000.00	R 12,285,000.00	R 15,069,600.00	R 12,285,000.00	R 12,285,000.00	R 12,285,000.00	R 15,069,600.00	R 12,285,000.00	R 12,285,000.00	R 15,069,600.00	R 15,069,600.00
Yellow Maize	530	R 12,815,400.00	R 12,815,400.00	R 15,502,500.00	R 15,502,500.00	R 19,016,400.00	R 15,502,500.00	R 15,502,500.00	R 19,016,400.00	R 15,502,500.00	R 15,502,500.00	R 15,502,500.00	R 19,016,400.00	R 15,502,500.00	R 15,502,500.00	R 15,502,500.00	R 19,016,400.00	R 15,502,500.00	R 15,502,500.00	R 19,016,400.00	R 19,016,400.00
Teff	100	R 630,000.00	R 900,000.00	R 630,000.00	R 570,000.00	R 630,000.00	R 900,000.00	R 630,000.00	R 900,000.00	R 630,000.00	R 570,000.00	R 900,000.00	R 630,000.00	R 900,000.00	R 630,000.00	R 900,000.00	R 630,000.00	R 900,000.00	R 630,000.00	R 900,000.00	R 630,000.00
Rhodes / Erigrostis	20	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00
Winter cover crops	20	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -
Summer cover crops	20	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -
White Maize after cover crops	20	R 556,140.00	R 556,140.00	R 672,750.00	R 672,750.00	R 825,240.00	R 672,750.00	R 672,750.00	R 825,240.00	R 672,750.00	R 672,750.00	R 672,750.00	R 825,240.00	R 672,750.00	R 672,750.00	R 672,750.00	R 825,240.00	R 672,750.00	R 672,750.00	R 825,240.00	R 825,240.00
Yellow Maize after cover crops	20	R 556,140.00	R 556,140.00	R 672,750.00	R 672,750.00	R 825,240.00	R 672,750.00	R 672,750.00	R 825,240.00	R 672,750.00	R 672,750.00	R 672,750.00	R 825,240.00	R 672,750.00	R 672,750.00	R 672,750.00	R 825,240.00	R 672,750.00	R 672,750.00	R 825,240.00	R 825,240.00
Kapitaal verkope		0	R -	R 37,500.00	R 45,833.33	R -	R 37,500.00	R 182,083.33	R 71,333.33	R 86,083.33	R 250,000.00	R -	R -	R 375,500.00	R -	R -	R 37,500.00	R 182,083.33	R 69,666.67	R 41,000.00	R 149,000.00
Gross Margin	1150	R 24,833,280.00	R 25,103,280.00	R 29,920,500.00	R 29,868,833.33	R 36,486,480.00	R 30,190,500.00	R 30,065,083.33	R 36,827,813.33	R 29,969,083.33	R 30,073,000.00	R 30,153,000.00	R 36,486,480.00	R 30,528,500.00	R 29,883,000.00	R 30,153,000.00	R 36,523,980.00	R 30,335,083.33	R 29,952,666.67	R 36,797,480.00	R 36,635,480.00
Other Income:																					
Loans granted		R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -
		R -																			
TOTAL INCOME:		R 24,833,280.00	R 25,103,280.00	R 29,920,500.00	R 29,868,833.33	R 36,486,480.00	R 30,190,500.00	R 30,065,083.33	R 36,827,813.33	R 29,969,083.33	R 30,073,000.00	R 30,153,000.00	R 36,486,480.00	R 30,528,500.00	R 29,883,000.00	R 30,153,000.00	R 36,523,980.00	R 30,335,083.33	R 29,952,666.67	R 36,797,480.00	R 36,635,480.00

Expenses

Cash outflow																					
Production Cost:																					
Seed: Production		R 2,323,000.00	R 2,323,000.00	R 2,323,000.00	R 2,323,000.00	R 2,323,000.00	R 2,323,000.00	R 2,323,000.00	R 2,323,000.00	R 2,323,000.00	R 2,323,000.00	R 2,323,000.00	R 2,323,000.00	R 2,323,000.00	R 2,323,000.00	R 2,323,000.00	R 2,323,000.00	R 2,323,000.00	R 2,323,000.00	R 2,323,000.00	R 2,323,000.00
Seed: Pasture		R 94,200.00	R 94,200.00	R 94,200.00	R 94,200.00	R 94,200.00	R 94,200.00	R 94,200.00	R 94,200.00	R 94,200.00	R 94,200.00	R 94,200.00	R 94,200.00	R 94,200.00	R 94,200.00	R 94,200.00	R 94,200.00	R 94,200.00	R 94,200.00	R 94,200.00	R 94,200.00
Fertilisers		R 3,636,000.00	R 3,636,000.00	R 3,636,000.00	R 3,636,000.00	R 3,636,000.00	R 3,636,000.00	R 3,636,000.00	R 3,636,000.00	R 3,636,000.00	R 3,636,000.00	R 3,636,000.00	R 3,636,000.00	R 3,636,000.00	R 3,636,000.00	R 3,636,000.00	R 3,636,000.00	R 3,636,000.00	R 3,636,000.00	R 3,636,000.00	R 3,636,000.00
Sprays/Weed-killers		R 1,559,393.32	R 1,559,393.32	R 1,559,393.32	R 1,559,393.32	R 1,559,393.32	R 1,559,393.32	R 1,559,393.32	R 1,559,393.32	R 1,559,393.32	R 1,559,393.32	R 1,559,393.32	R 1,559,393.32	R 1,559,393.32	R 1,559,393.32	R 1,559,393.32	R 1,559,393.32	R 1,559,393.32	R 1,559,393.32	R 1,559,393.32	R 1,559,393.32
Lime		R 530,000.00	R 530,000.00	R 530,000.00	R 530,000.00	R 530,000.00	R 530,000.00	R 530,000.00	R 530,000.00	R 530,000.00	R 530,000.00	R 530,000.00	R 530,000.00	R 530,000.00	R 530,000.00	R 530,000.00	R 530,000.00	R 530,000.00	R 530,000.00	R 530,000.00	R 530,000.00
Labour Casual		R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00
Labour Permanent		R 582,000.00	R 582,000.00	R 582,000.00	R 582,000.00	R 582,000.00	R 582,000.00	R 582,000.00	R 582,000.00	R 582,000.00	R 582,000.00	R 582,000.00	R 582,000.00	R 582,000.00	R 582,000.00	R 582,000.00	R 582,000.00	R 582,000.00	R 582,000.00	R 582,000.00	R 582,000.00
Crop insurance		R 524,075.00	R 524,075.00	R 524,075.00	R 524,075.00	R 524,075.00	R 524,075.00	R 524,075.00	R 524,075.00	R 524,075.00	R 524,075.00	R 524,075.00	R 524,075.00	R 524,075.00	R 524,075.00	R 524,075.00	R 524,075.00	R 524,075.00	R 524,075.00	R 524,075.00	R 524,075.00
Transport		R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00
Harvesting cost		R 729,396.91	R 729,396.91	R 729,396.91	R 729,396.91	R 729,396.91	R 729,396.91	R 729,396.91	R 729,396.91	R 729,396.91	R 729,396.91	R 729,396.91	R 729,396.91	R 729,396.91	R 729,396.91	R 729,396.91	R 729,396.91	R 729,396.91	R 729,396.91	R 729,396.91	R 729,396.91
Contract work		R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00
Fuel		R 1,493,001.00	R 1,493,001.00	R 1,493,001.00	R 1,493,001.00	R 1,493,001.00	R 1,493,001.00	R 1,493,001.00	R 1,493,001.00	R 1,493,001.00	R 1,493,001.00	R 1,493,001.00	R 1,493,001.00	R 1,493,001.00	R 1,493,001.00	R 1,493,001.00	R 1,493,001.00	R 1,493,001.00	R 1,493,001.00	R 1,493,001.00	R 1,493,001.00
Lubricants		R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00
Maintenance / Repairs / Parts		R 886,000.00	R 886,000.00	R 886,000.00	R 886,000.00	R 886,000.00	R 886,000.00	R 886,000.00	R 886,000.00	R 886,000.00	R 886,000.00	R 886,000.00	R 886,000.00	R 886,000.00	R 886,000.00	R 886,000.00	R 886,000.00	R 886,000.00	R 886,000.00	R 886,000.00	R 886,000.00
Overhead costs:																					
Labour: Bonus / Rations / Protective clothing		R 240,000.00	R 240,000.00	R 240,000.00	R 240,000.00	R 240,000.00	R 240,000.00	R 240,000.00	R 240,000.00	R 240,000.00	R 240,000.00	R 240,000.00	R 240,000.00	R 240,000.00	R 240,000.00	R 240,000.00	R 240,000.00	R 240,000.00	R 240,000.00	R 240,000.00	R 240,000.00
Salary: Management		R 480,000.00	R 480,000.00	R 480,000.00	R 480,000.00	R 480,000.00	R 480,000.00	R 480,000.00	R 480,000.00	R 480,000.00	R 480,000.00	R 480,000.00	R 480,000.00	R 480,000.00	R 480,000.00	R 480,000.00	R 480,000.00	R 480,000.00	R 480,000.00	R 480,000.00	R 480,000.00
UIF 1% of salaries and wages		R 14,220.00	R 14,220.00	R 14,220.00	R 14,220.00	R 14,220.00	R 14,220.00	R 14,220.00	R 14,220.00	R 14,220.00	R 14,220.00	R 14,220.00	R 14,220.00	R 14,220.00	R 14,220.00	R 14,220.00	R 14,220.00	R 14,220.00	R 14,220.00	R 14,220.00	R 14,220.00
Local governement levy		R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00
Accident insurance: Employees		R 200,000.00	R 200,000.00	R 200,000.00	R 200,000.00	R 200,000.00	R 200,000.00	R 200,000.00	R 200,000.00	R 200,000.00	R 200,000.00	R 200,000.00	R 200,000.00	R 200,000.00	R 200,000.00	R 200,000.00	R 200,000.00	R 200,000.00	R 200,000.00	R 200,000.00	R 200,000.00
Short term insurance and policies		R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00
Electricity		R 397,000.00	R 397,000.00	R 397,000.00	R 397,000.00	R 397,000.00	R 397,000.00	R 397,000.00	R 397,000.00	R 397,000.00	R 397,000.00	R 397,000.00	R 397,000.00	R 397,000.00	R 397,000.00	R 397,000.00	R 397,000.00	R 397,000.00	R 397,000.00	R 397,000.00	R 397,000.00
Land Tax and Water		R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00
Licences		R 87,000.00	R 87,000.00	R 87,000.00	R 87,000.00	R 87,000.00	R 87,000.00	R 87,000.00	R 87,000.00	R 87,000.00	R 87,000.00	R 87,000.00	R 87,000.00	R 87,000.00	R 87,000.00	R 87,000.00	R 87,000.00	R 87,000.00	R 87,000.00	R 87,000.00	R 87,000.00
Phone / Cellphone / Stationary		R 144,000.00	R 144,000.00	R 144,000.00	R 144,000.00	R 144,000.00	R 144,000.00	R 144,000.00	R 144,000.00	R 144,000.00	R 144,000.00	R 144,000.00	R 144,000.00	R 144,000.00	R 144,000.00	R 144,000.00	R 144,000.00	R 144,000.00	R 144,000.00	R 144,000.00	R 144,000.00
Bank charges		R 36,000.00	R 36,000.00	R 36,000.00	R 36,000.00	R 36,000.00	R 36,000.00	R 36,000.00	R 36,000.00	R 36,000.00	R 36,000.00	R 36,000.00	R 36,000.00	R 36,000.00	R 36,000.00	R 36,000.00	R 36,000.00	R 36,000.00	R 36,000.00	R 36,000.00	R 36,000.00
Auditors' / Bookkeepers' fees		R 150,000.00	R 150,000.00	R 150,000.00	R 150,000.00	R 150,000.00	R 150,000.00	R 150,000.00	R 150,000.00	R 150,000.00	R 150,000.00	R 150,000.00	R 150,000.00	R 150,000.00	R 150,000.00	R 150,000.00	R 150,000.00	R 150,000.00	R 150,000.00	R 150,000.00	R 150,000.00
Unforeseen expenses (5%)		R 759,264.31	R 759,264.31	R 759,264.31	R 759,264.31	R 759,264.31	R 759,264.31	R 759,264.31	R 759,264.31	R 759,264.31	R 759,264.31	R 759,264.31	R 759,264.31	R 759,264.31	R 759,264.31	R 759,264.31	R 759,264.31	R 759,264.31	R 759,264.31	R 759,264.31	R 759,264.31
Total Production Cost		R 15,944,550.54	R 15,944,550.54	R 15,944,550.54	R 15,944,550.54	R 15,944,550.54	R 15,944,550.54	R 15,944,550.54	R 15,944,550.54	R 15,944,550.54	R 15,944,550.54	R 15,944,550.54	R 15,944,550.54	R 15,944,550.54	R 15,944,550.54	R 15,944,550.54	R 15,944,550.54	R 15,944,550.54	R 15,944,550.54	R 15,944,550.54	R 15,944,550.54
Other expenses:																					
Machinery purchases		R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -
Debt Redemption		R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -
TOTAL EXPENDITURE:		R 15,944,550.54	R 15,944,550.54	R 15,944,550.54	R 15,944,550.54	R 15,944,550.54	R 15,944,550.54	R 15,944,550.54	R 15,944,550.54	R 15,944,550.54	R 15,944,550.54	R 15,944,550.54	R 15,944,550.54	R 15,944,550.54	R 15,944,550.54	R 15,944,550.54	R 15,944,550.54	R 15,944,550.54	R 15,944,550.54	R 15,944,550.54	R 15,944,550.54
Replacement Schedule		R 960,000.00	R 610,000.00	R 1,250,000.00	R -	R 327,500.00	R 3,000,000.00	R 1,510,000.00	R 1,410,000.00	R 3,200,000.00	R -	R 800,000.00	R 6,010,000.00	R 1,640,000.00	R -	R 487,500.00	R -	R 1,960,000.00	R 750,000.00	R 1,890,000.00	R 270,000.00
NET YEARLY FLOW		R 7,928,729.46	R 8,548,729.46	R 12,725,949.46	R 13,924,282.79	R 20,214,429.46	R 11,245,949.46	R 12,610,532.79	R 19,473,262.79	R 10,824,532.79	R 14,128,449.46	R 13,408,449.46	R 14,531,929.46	R 12,943,949.46	R 13,938,449.46	R 13,720,949.46	R 20,579,429.46	R 12,430,532.79	R 13,258,116.12	R 18,962,929.46	R 20,420,929.46
Profit / Loss Before Tax		R 7,928,729.46	R 8,548,729.46	R 12,725,949.46	R 13,924,282.79	R 20,214,429.46	R 11,245,949.46	R 12,610,532.79	R 19,473,262.79	R 10,824,532.79	R 14,128,449.46	R 13,408,449.46	R 14,531,929.46	R 12,943,949.46	R 13,938,449.46	R 13,720,949.46	R 20,579,429.46	R 12,430,532.79	R 13,258,116.12	R 18,962,929.46	R 20,420,929.46
Taxation		R 2,220,044.25	R 2,393,644.25	R 3,563,265.85	R 3,898,799.18	R 5,660,040.25	R 3,148,865.85	R 3,530,949.18	R 5,452,513.58	R 3,030,869.18	R 3,955,965.85	R 3,754,365.85	R 4,068,940.25	R 3,624,305.85	R 3,902,765.85	R 3,841,865.85	R 5,762,240.25	R 3,480,549.18	R 3,712,272.51	R 5,309,620.25	R 5,717,860.25
Profit / Loss After Tax		R 5,708,685.21	R 6,155,085.21	R 9,162,683.61	R 10,025,483.61	R 14,554,389.21	R 8,097,083.61	R 9,079,583.61	R 14,020,749.21	R 7,793,663.61	R 10,172,483.61	R 9,654,083.61	R 10,462,989.21	R 9,319,643.61	R 10,035,683.61	R 9,879,083.61	R 14,817,189.21	R 8,949,983.61	R 9,545,843.61	R 13,653,309.21	R 14,703,069.21
CCF		-R 26,323,567.43	-R 20,168,482.22	-R 11,005,798.61	-R 980,315.00	R 13,574,074.21	R 21,671,157.82	R 30,750,741.43	R 44,771,490.64	R 52,565,154.25	R 62,737,637.86	R 72,391,721.47	R 82,854,710.68	R 92,174,354.29	R 102,210,037.90	R 112,089,121.51	R 126,906,310.72	R 135,856,294.33	R 145,402,137.94	R 159,055,447.15	R 173,758,516.36

Whole farm multi period budget C

Yield potential based on rainfall distribution

1 Good
2 Average
3 Poor

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
White maize: (good, average, poor)	3	3	2	2	1	2	2	1	2	2	2	1	2	2	2	1	2	2	1	1
Yellow maize: (good, average, poor)	3	3	2	2	1	2	2	1	2	2	2	1	2	2	2	1	2	2	1	1
Teff: (good, average, poor)	2	1	2	3	2	1	2	1	2	3	1	2	1	2	1	2	1	2	1	2
White maize after cover crops	3	3	2	2	1	2	2	1	2	2	2	1	2	2	2	1	2	2	1	1
Yellow maize after cover crops	3	3	2	2	1	2	2	1	2	2	2	1	2	2	2	1	2	2	1	1

Cash inflow	Units	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
White Maize	420	R 7,812,000.00	R 7,812,000.00	R 9,450,000.00	R 9,450,000.00	R 11,592,000.00	R 9,450,000.00	R 9,450,000.00	R 11,592,000.00	R 9,450,000.00	R 9,450,000.00	R 9,450,000.00	R 11,592,000.00	R 9,450,000.00	R 9,450,000.00	R 9,450,000.00	R 11,592,000.00	R 9,450,000.00	R 9,450,000.00	R 11,592,000.00	R 11,592,000.00
Yellow Maize	530	R 9,858,000.00	R 9,858,000.00	R 11,925,000.00	R 11,925,000.00	R 14,628,000.00	R 11,925,000.00	R 11,925,000.00	R 14,628,000.00	R 11,925,000.00	R 11,925,000.00	R 11,925,000.00	R 14,628,000.00	R 11,925,000.00	R 11,925,000.00	R 11,925,000.00	R 14,628,000.00	R 11,925,000.00	R 11,925,000.00	R 14,628,000.00	R 14,628,000.00
Teff	100	R 630,000.00	R 900,000.00	R 630,000.00	R 570,000.00	R 630,000.00	R 900,000.00	R 630,000.00	R 900,000.00	R 630,000.00	R 570,000.00	R 900,000.00	R 630,000.00	R 900,000.00	R 630,000.00	R 900,000.00	R 630,000.00	R 900,000.00	R 630,000.00	R 900,000.00	R 630,000.00
Rhodes / Erigrostis	20	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00
Winter cover crops	20	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -
Summer cover crops	20	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -
Livestock	600	R 900,000.00	R 900,000.00	R 900,000.00	R 900,000.00	R 900,000.00	R 900,000.00	R 900,000.00	R 900,000.00	R 900,000.00	R 900,000.00	R 900,000.00	R 900,000.00	R 900,000.00	R 900,000.00	R 900,000.00	R 900,000.00	R 900,000.00	R 900,000.00	R 900,000.00	R 900,000.00
White Maize after cover crops	20	R 427,800.00	R 427,800.00	R 517,500.00	R 517,500.00	R 634,800.00	R 517,500.00	R 517,500.00	R 634,800.00	R 517,500.00	R 517,500.00	R 517,500.00	R 634,800.00	R 517,500.00	R 517,500.00	R 517,500.00	R 634,800.00	R 517,500.00	R 517,500.00	R 634,800.00	R 634,800.00
Yellow Maize after cover crops	20	R 427,800.00	R 427,800.00	R 517,500.00	R 517,500.00	R 634,800.00	R 517,500.00	R 517,500.00	R 634,800.00	R 517,500.00	R 517,500.00	R 517,500.00	R 634,800.00	R 517,500.00	R 517,500.00	R 517,500.00	R 634,800.00	R 517,500.00	R 517,500.00	R 634,800.00	R 634,800.00
Kapitaal verkope		0	R -	R 37,500.00	R 45,833.33	R -	R 37,500.00	R 182,083.33	R 71,333.33	R 86,083.33	R 250,000.00	R -	R -	R 375,500.00	R -	R -	R 37,500.00	R 182,083.33	R 69,666.67	R 41,000.00	R 149,000.00
Gross Margin		R 20,175,600.00	R 20,445,600.00	R 24,097,500.00	R 24,045,833.33	R 29,139,600.00	R 24,367,500.00	R 24,242,083.33	R 29,480,933.33	R 24,146,083.33	R 24,250,000.00	R 24,330,000.00	R 29,139,600.00	R 24,705,500.00	R 24,060,000.00	R 24,330,000.00	R 29,177,100.00	R 24,512,083.33	R 24,129,666.67	R 29,450,600.00	R 29,288,600.00
Other Income:																					
Loans granted		R - R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -
TOTAL INCOME:		R 20,175,600.00	R 20,445,600.00	R 24,097,500.00	R 24,045,833.33	R 29,139,600.00	R 24,367,500.00	R 24,242,083.33	R 29,480,933.33	R 24,146,083.33	R 24,250,000.00	R 24,330,000.00	R 29,139,600.00	R 24,705,500.00	R 24,060,000.00	R 24,330,000.00	R 29,177,100.00	R 24,512,083.33	R 24,129,666.67	R 29,450,600.00	R 29,288,600.00

Expenses

Cash outflow																					
Production Cost:																					
Seed: Production		R 2,323,000.00	R 2,323,000.00	R 2,323,000.00	R 2,323,000.00	R 2,323,000.00	R 2,323,000.00	R 2,323,000.00	R 2,323,000.00	R 2,323,000.00	R 2,323,000.00	R 2,323,000.00	R 2,323,000.00	R 2,323,000.00	R 2,323,000.00	R 2,323,000.00	R 2,323,000.00	R 2,323,000.00	R 2,323,000.00	R 2,323,000.00	R 2,323,000.00
Seed: Pasture		R 94,200.00	R 94,200.00	R 94,200.00	R 94,200.00	R 94,200.00	R 94,200.00	R 94,200.00	R 94,200.00	R 94,200.00	R 94,200.00	R 94,200.00	R 94,200.00	R 94,200.00	R 94,200.00	R 94,200.00	R 94,200.00	R 94,200.00	R 94,200.00	R 94,200.00	R 94,200.00
Fertilisers		R 3,614,400.00	R 3,614,400.00	R 3,614,400.00	R 3,614,400.00	R 3,614,400.00	R 3,614,400.00	R 3,614,400.00	R 3,614,400.00	R 3,614,400.00	R 3,614,400.00	R 3,614,400.00	R 3,614,400.00	R 3,614,400.00	R 3,614,400.00	R 3,614,400.00	R 3,614,400.00	R 3,614,400.00	R 3,614,400.00	R 3,614,400.00	R 3,614,400.00
Sprays/Weed-killers		R 1,392,181.39	R 1,392,181.39	R 1,392,181.39	R 1,392,181.39	R 1,392,181.39	R 1,392,181.39	R 1,392,181.39	R 1,392,181.39	R 1,392,181.39	R 1,392,181.39	R 1,392,181.39	R 1,392,181.39	R 1,392,181.39	R 1,392,181.39	R 1,392,181.39	R 1,392,181.39	R 1,392,181.39	R 1,392,181.39	R 1,392,181.39	R 1,392,181.39
Bewerking		R 156,578.00	R 156,578.00	R 156,578.00	R 156,578.00	R 156,578.00	R 156,578.00	R 156,578.00	R 156,578.00	R 156,578.00	R 156,578.00	R 156,578.00	R 156,578.00	R 156,578.00	R 156,578.00	R 156,578.00	R 156,578.00	R 156,578.00	R 156,578.00	R 156,578.00	R 156,578.00
Lime		R 530,000.00	R 530,000.00	R 530,000.00	R 530,000.00	R 530,000.00	R 530,000.00	R 530,000.00	R 530,000.00	R 530,000.00	R 530,000.00	R 530,000.00	R 530,000.00	R 530,000.00	R 530,000.00	R 530,000.00	R 530,000.00	R 530,000.00	R 530,000.00	R 530,000.00	R 530,000.00
Labour Casual		R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00
Labour Permanent		R 582,000.00	R 582,000.00	R 582,000.00	R 582,000.00	R 582,000.00	R 582,000.00	R 582,000.00	R 582,000.00	R 582,000.00	R 582,000.00	R 582,000.00	R 582,000.00	R 582,000.00	R 582,000.00	R 582,000.00	R 582,000.00	R 582,000.00	R 582,000.00	R 582,000.00	R 582,000.00
Crop insurance		R 524,075.00	R 524,075.00	R 524,075.00	R 524,075.00	R 524,075.00	R 524,075.00	R 524,075.00	R 524,075.00	R 524,075.00	R 524,075.00	R 524,075.00	R 524,075.00	R 524,075.00	R 524,075.00	R 524,075.00	R 524,075.00	R 524,075.00	R 524,075.00	R 524,075.00	R 524,075.00
Transport		R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00
Harvesting cost		R 648,277.17	R 648,277.17	R 648,277.17	R 648,277.17	R 648,277.17	R 648,277.17	R 648,277.17	R 648,277.17	R 648,277.17	R 648,277.17	R 648,277.17	R 648,277.17	R 648,277.17	R 648,277.17	R 648,277.17	R 648,277.17	R 648,277.17	R 648,277.17	R 648,277.17	R 648,277.17
Contract work		R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00
Vet / Medication / Dip & A.I.		R 30,000.00	R 30,000.00	R 30,000.00	R 30,000.00	R 30,000.00	R 30,000.00	R 30,000.00	R 30,000.00	R 30,000.00	R 30,000.00	R 30,000.00	R 30,000.00	R 30,000.00	R 30,000.00	R 30,000.00	R 30,000.00	R 30,000.00	R 30,000.00	R 30,000.00	R 30,000.00
Livestock fodder / Lick		R 450,000.00	R 450,000.00	R 450,000.00	R 450,000.00	R 450,000.00	R 450,000.00	R 450,000.00	R 450,000.00	R 450,000.00	R 450,000.00	R 450,000.00	R 450,000.00	R 450,000.00	R 450,000.00	R 450,000.00	R 450,000.00	R 450,000.00	R 450,000.00	R 450,000.00	R 450,000.00
Non-directly allocated cost																					
Fuel		R 1,292,544.82	R 1,292,544.82	R 1,292,544.82	R 1,292,544.82	R 1,292,544.82	R 1,292,544.82	R 1,292,544.82	R 1,292,544.82	R 1,292,544.82	R 1,292,544.82	R 1,292,544.82	R 1,292,544.82	R 1,292,544.82	R 1,292,544.82	R 1,292,544.82	R 1,292,544.82	R 1,292,544.82	R 1,292,544.82	R 1,292,544.82	R 1,292,544.82
Lubricants		R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00
Maintenance / Repairs / Parts		R 886,000.00	R 886,000.00	R 886,000.00	R 886,000.00	R 886,000.00	R 886,000.00	R 886,000.00	R 886,000.00	R 886,000.00	R 886,000.00	R 886,000.00	R 886,000.00	R 886,000.00	R 886,000.00	R 886,000.00	R 886,000.00	R 886,000.00	R 886,000.00	R 886,000.00	R 886,000.00
Security		R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00
Overhead costs																					
Labour: Bonus / Rations / Protective clothing		R 240,000.00	R 240,000.00	R 240,000.00	R 240,000.00	R 240,000.00	R 240,000.00	R 240,000.00	R 240,000.00	R 240,000.00	R 240,000.00	R 240,000.00	R 240,000.00	R 240,000.00	R 240,000.00	R 240,000.00	R 240,000.00	R 240,000.00	R 240,000.00	R 240,000.00	R 240,000.00
Salary: Management		R 480,000.00	R 480,000.00	R 480,000.00	R 480,000.00	R 480,000.00	R 480,000.00	R 480,000.00	R 480,000.00	R 480,000.00	R 480,000.00	R 480,000.00	R 480,000.00	R 480,000.00	R 480,000.00	R 480,000.00	R 480,000.00	R 480,000.00	R 480,000.00	R 480,000.00	R 480,000.00
UIF 1% of salaries and wages		R 14,220.00	R 14,220.00	R 14,220.00	R 14,220.00	R 14,220.00	R 14,220.00	R 14,220.00	R 14,220.00	R 14,220.00	R 14,220.00	R 14,220.00	R 14,220.00	R 14,220.00	R 14,220.00	R 14,220.00	R 14,220.00	R 14,220.00	R 14,220.00	R 14,220.00	R 14,220.00
Local governement levy		R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00	R 60,000.00
Accident insurance: Employees		R 200,000.00	R 200,000.00	R 200,000.00	R 200,000.00	R 200,000.00	R 200,000.00	R 200,000.00	R 200,000.00	R 200,000.00	R 200,000.00	R 200,000.00	R 200,000.00	R 200,000.00	R 200,000.00	R 200,000.00	R 200,000.00	R 200,000.00	R 200,000.00	R 200,000.00	R 200,000.00
Short term insurance and policies		R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00	R 300,000.00
Electricity		R 397,000.00	R 397,000.00	R 397,000.00	R 397,000.00	R 397,000.00	R 397,000.00	R 397,000.00	R 397,000.00	R 397,000.00	R 397,000.00	R 397,000.00	R 397,000.00	R 397,000.00	R 397,000.00	R 397,000.00	R 397,000.00	R 397,000.00	R 397,000.00	R 397,000.00	R 397,000.00
Land Tax and Water		R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00	R 120,000.00
Licences		R 87,000.00	R 87,000.00	R 87,000.00	R 87,000.00	R 87,000.00	R 87,000.00	R 87,000.00	R 87,000.00	R 87,000.00	R 87,000.00	R 87,000.00	R 87,000.00	R 87,000.00	R 87,000.00	R 87,000.00	R 87,000.00	R 87,000.00	R 87,000.00	R 87,000.00	R 87,000.00
Phone / Cellphone / Stationary		R 144,000.00	R 144,000.00	R 144,000.00	R 144,000.00	R 144,000.00	R 144,000.00	R 144,000.00	R 144,000.00	R 144,000.00	R 144,000.00	R 144,000.00	R 144,000.00	R 144,000.00	R 144,000.00	R 144,000.00	R 144,000.00	R 144,000.00	R 144,000.00	R 144,000.00	R 144,000.00
Bank charges		R 36,000.00	R 36,000.00	R 36,000.00	R 36,000.00	R 36,000.00	R 36,000.00	R 36,000.00	R 36,000.00	R 36,000.00	R 36,000.00	R 36,000.00	R 36,000.00	R 36,000.00	R 36,000.00	R 36,000.00	R 36,000.00	R 36,000.00	R 36,000.00	R 36,000.00	R 36,000.00
Auditors' / Bookkeepers' fees		R 150,000.00	R 150,000.00	R 150,000.00	R 150,000.00	R 150,000.00	R 150,000.00	R 150,000.00	R 150,000.00	R 150,000.00	R 150,000.00	R 150,000.00	R 150,000.00	R 150,000.00	R 150,000.00	R 150,000.00	R 150,000.00	R 150,000.00	R 150,000.00	R 150,000.00	R 150,000.00
Unforeseen expenses (5%)		R 2,887,382.82	R 2,887,382.82	R 2,887,382.82	R 2,887,382.82	R 2,887,382.82	R 2,887,382.82	R 2,887,382.82	R 2,887,382.82	R 2,887,382.82	R 2,887,382.82	R 2,887,382.82	R 2,887,382.82	R 2,887,382.82	R 2,887,382.82	R 2,887,382.82	R 2,887,382.82	R 2,887,382.82	R 2,887,382.82	R 2,887,382.82	R 2,887,382.82
Total Production Cost		R 18,298,859.20	R 18,298,859.20	R 18,298,859.20	R 18,298,859.20	R 18,298,859.20	R 18,298,859.20	R 18,298,859.20	R 18,298,859.20	R 18,298,859.20	R 18,298,859.20	R 18,298,859.20	R 18,298,859.20	R 18,298,859.20	R 18,298,859.20	R 18,298,859.20	R 18,298,859.20	R 18,298,859.20	R 18,298,859.20	R 18,298,859.20	R 18,298,859.20
Other expenses:																					
Machinery purchases		R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -
Debt Redemption		R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -	R -
TOTAL EXPENDITURE:		R 18,298,859.20	R 18,298,859.20	R 18,298,859.20	R 18,298,859.20	R 18,298,859.20	R 18,298,859.20	R 18,298,859.20	R 18,298,859.20	R 18,298,859.20	R 18,298,859.20	R 18,298,859.20	R 18,298,859.20	R 18,298,859.20	R 18,298,859.20	R 18,298,859.20	R 18,298,859.20	R 18,298,859.20	R 18,298,859.20	R 18,298,859.20	R 18,298,859.20
Replacement Schedule		R 960,000.00	R 610,000.00	R 1,250,000.00	R -	R 327,500.00	R 3,000,000.00	R 1,510,000.00	R 1,410,000.00	R 3,200,000.00	R -	R 800,000.00	R 6,010,000.00	R 1,640,000.00	R -	R 487,500.00	R -	R 1,960,000.00	R 750,000.00	R 1,890,000.00	R 270,000.00
NET YEARLY FLOW		R 916,740.80	R 1,536,740.80	R 4,548,640.80	R 5,746,974.13	R 10,513,240.80	R 3,068,640.80	R 4,433,224.13	R 9,772,074.13	R 2,647,224.13	R 5,951,140.80	R 5,231,140.80	R 4,830,740.80	R 4,766,640.80	R 5,761,140.80	R 5,543,640.80	R 10,878,240.80	R 4,253,224.13	R 5,080,807.47	R 9,261,740.80	R 10,719,740.80
Profit / Loss Before Tax		R 916,740.80	R 1,536,740.80	R 4,548,640.80	R 5,746,974.13	R 10,513,240.80	R 3,068,640.80	R 4,433,224.13	R 9,772,074.13	R 2,647,224.13	R 5,951,140.80	R 5,231,140.80	R 4,830,740.80	R 4,766,640.80	R 5,761,140.80	R 5,543,640.80	R 10,878,240.80	R 4,253,224.13	R 5,080,807.47	R 9,261,740.80	R 10,719,740.80
Taxation		R 256,687.42	R 430,287.42	R 1,273,619.42	R 1,609,152.76	R 2,943,707.42	R 859,219.42	R 1,241,302.76	R 2,736,180.76	R 741,222.76	R 1,666,319.42	R 1,464,719.42	R 1,352,607.42	R 1,334,659.42	R 1,613,119.42	R 1,552,219.42	R 3,045,907.42	R 1,190,902.76	R 1,422,626.09	R 2,593,287.42	R 3,001,527.42
Profit / Loss After Tax		R 660,053.38	R 1,106,453.38	R 3,275,021.38	R 4,137,821.38	R 7,569,533.38	R 2,209,421.38	R 3,191,921.38	R 7,035,893.38	R 1,906,001.38	R 4,284,821.38	R 3,766,421.38	R 3,478,133.38	R 3,431,981.38	R 4,148,021.38	R 3,991,421.38	R 7,832,333.38	R 3,062,321.38	R 3,658,181.38	R 6,668,453.38	R 7,718,213.38
CCF		-R 33,586,193.09	-R 32,479,739.71	-R 29,204,718.34	-R 25,066,896.96	-R 17,497,363.59	-R 15,287,942.21	-R 12,096,020.83	-R 5,060,127.46	-R 3,154,126.08	R 1,130,695.29	R 4,897,116.67	R 8,375,250.05	R 11,807,231.42	R 15,955,252.80	R 19,946,674.17	R 27,779,007.55	R 30,841,328.92	R 34,499,510.30	R 41,167,963.68	R 48,886,177.05