Farm Modelling for Interactive Multidisciplinary Planning of Small Grain Production Systems in South Africa

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“*Declaration*

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Summary

A complex and volatile decision-making environment and constant pressure on product prices, due to the cost-price squeeze, complicates decision-making for grain farmers in the Western Cape. Furthermore, available alternative crops and cultivation practices are limited due to local soil and climatic conditions. The farm system itself is complex due to the interdependence of a variety of factors and the synergy resulting from specific sequences of cash and pasture crops.

The aim of this research project was to establish a method that would contribute to identifying strategies to advance the profitability of grain production. Research in the grain industry is traditionally specialised within specific fields, such as, agronomy, soil science, entomology, agricultural economics, etc., causing a fragmentation of knowledge. To ensure that the systems nature of a complex farm is accommodated, various related research domains should be acknowledged and incorporated.

The use of expert group discussions, as a research method, is suitable, firstly, for gathering information in a meaningful manner and, secondly, to stimulate individual creativity by presenting alternative perspectives provided by various participating experts. In support of expert group discussions, simulation models in the form of multi-period whole-farm models were developed. This type of modelling supports the accurate financial simulation of farms, while the user-friendliness and adaptability thereof can accurately accommodate typical farm interrelationships, and quickly measure the financial impact of suggested changes to parameters. Suggestions made by experts during the group discussions can thus be quickly introduced into the model. The financial implications are instantly available to prevent further exploration of non-viable plans and to fine-tune the viable plans. Participants in the group discussions represent fields of expertise such as agronomy, soil science, entomology, plant pathology, the agricultural chemical industry, agricultural mechanisation. Also represented are professionals such as extension officers from local agribusinesses, local producers and agricultural economists. The dynamics of the group discussions are supported by each participant's specific strengths and perspectives.

For each relatively homogeneous production area of the Western Cape, a typical farm budget model was developed, which served as the basis for the group discussions. The budget models measure profitability in terms of the IRR (internal rate of return on capital investment) and affordability in terms of expected cash flow. For the Swartland, the homogeneous areas identified were Koeberg/Wellington, the Middle Swartland and the Rooi Karoo, and for the Southern Cape, the homogenous areas identified were, the Goue Rûens, Middle Rûens and Heidelberg Vlakte. A

model of a typical farm in the Wesselsbron area was developed for comparison with the Western Cape farms. For each area the expected impact of climate change, fluctuating product and input prices, and the possible impact of partial conversion to bio-fuel production were evaluated in terms of expected impact on profitability. Various area-specific strategies were identified that could enhance the profitability of grain production: most of the strategies focused on optimising machinery usage and expanding or intensifying the livestock enterprise. The repeated successful use of the model in support of the expert groups in all the chosen study areas illustrates the value thereof for identifying and evaluating plans to increase the profitability of small grain production.

Opsomming

’n Komplekse en wisselvallige besluitnemingsomgewing, en konstante druk op produkpryse weens die koste/prys knyptang bemoeilik besluitneming op graanplase in die Wes-Kaap terwyl die beskikbare alternatiewe verbouingsgewasse en -praktyke beperk is weens plaaslike grond en klimatologiese eienskappe. Die boerderystelsel self is kompleks weens die interafhanklikheid van die dele daarvan en die sinergisme verkry deur byvoorbeeld die spesifieke orde van opeenvolging van kontant- en weidingsgewasse in die wisselboustelsel. Hierdie navorsingsprojek se doel is om ’n werkwyse te vestig wat die identifisering van strategieë te ondersteun wat moontlik die winsgewendheid van graanproduksie kan bevorder. Navorsing in die graanbedryf is tradisioneel gespesialiseerd binne ’n spesifieke navorsingsveld soos agronomie, grondkunde, entomologie en landbou-ekonomie. Dit gee daartoe aanleiding dat elk van hierdie velde op dimensies van die boerderystelsel fokus asof dit in isolasie bestaan. Om te verseker dat die stelselsgeaardheid van ’n komplekse boerdery effektief verreken word behoort navorsing erkenning te gee die interafhanklikheid van die dimensies van ’n boerdery.

Ekspert groepbesprekings is ’n navorsingsmetode wat eerstens geskik is om kennis sinvol byeen te bring en tweedens om kreatiwiteit by deelnemers te stimuleer deur die blootstelling aan nuwe perspektiewe van kundiges van ander spesialiteitsvelde. Ter ondersteuning van die ekspert groepbesprekings is simulasiemodelle in die vorm van multi-periode geheelboerderybegrotings ontwikkel. Die tipe modellering ondersteun die akkurate simulasie van boerderye terwyl die gebruikersvriendelikheid en aanpasbaarheid daarvan die tipiese interverwantskappe van ’n boerdery akkuraat weergee en die impak van aanpassings aan die parameters van die boerdery model vinnig kan meet. Voorstelle deur die deelnemende eksperts kan dus vinnig aangebring word en die finansiële implikasie is dadelik beskikbaar. Deelnemers aan die ekspertgroepbesprekings het velde verteenwoordig soos agronomie, grondkunde, entomologie, die landbou chemiese bedryf, landbou meganisasie, plantpatologie, voorligtingsbeamptes van plaaslike agribesighede, plaaslike produsente en landbou-ekonome. Die dinamika van die groepbesprekings word ondersteun deur elke deelnemer se spesifieke sterkpunte en perspektief.

Vir elke homogene produksiegebied in die Wes-Kaap is ’n aparte begrotingsmodel van ’n tipiese plaas vir daardie area ontwikkel. Hierdie modelle het gedien as die basis van die groepbesprekings. Die modelle meet die winsgewendheid van boerderye oor die langtermyn deur middel van die IOK (interne opbrengskoers op kapitaal investering) en die bekostigbaarheid in terme van verwagte kontantvloei. Binne die Swartland is die Koeberg/Wellington, Middel Swartland en Rooi Karoo as homogeen geïdentifiseer en vir die Suid-Kaap die areas van die Goue Rûens,

die Middel Rûens en die Heidelberg Vlakte. 'n Tipiese plaas model is ook vir die Wesselsbron area ontwikkel om te vergelyk met die Wes-Kaap areas se modelle. Vir elke area is die verwagte impak van klimaatveranderings, fluktuerende produk- en insetpryse en die moontlike impak van 'n bio-brandstofbedryf geëvalueer in terme van die verwagte impak op winsgewendheid. Verskeie area spesifieke strategieë is geïdentifiseer wat moontlik die winsgewendheid van graanproduksie kan bevorder. Die meeste strategieë fokus op die optimalisering van masjineriegebruik en die uitbreiding of intensifisering van die veevertakkings. Die herhaalde suksesvolle gebruik van die modelle ter ondersteuning van die ekspertgroepe in al die gekose studie areas illustreer die waarde daarvan vir die identifisering en evaluering van planne om die winsgewendheid van kleingraanproduksie te verhoog.

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Chapter 1

Introduction and background

1.1 Introduction

The Southern Cape and Swartland regions contribute 85 percent of the wheat produced in the Western Cape (The Directorate: Agricultural Statistics, 2007:10; SAGIS, 2008:1-3 and Statistics SA, 2002:8). These two areas employ approximately 27 percent of the regular agricultural workforce in the Western Cape (Punt, 2007 and Statistics South Africa, 2002:3-8).

Before the deregulation of agricultural marketing in 1996, the Wheat Board was particularly powerful and fixed producer prices on a production cost-plus basis, which favoured producers under the protectionist government policy of self-sufficiency (Kleynhans et al., 2008:5 and National Agricultural Marketing Council (NAMC), 1999:10-11). This lead to the cultivation of wheat in increasingly marginal areas and caused a shift towards wheat monoculture production in most of the grain production areas of the Western Cape and elsewhere in South Africa. During the era of controlled marketing, wheat was given preferential treatment over other crops. Consequently, following the abolishment of the Wheat Board, the relative contribution of wheat decreased, with barley, canola and oats gaining in relative importance (Edwards & Leibrandt, 1998:246). The increase in the variety of the product mix and greater exposure to volatile markets caused an increase in the complexity of crop rotation systems in particular, and enlargement of the farm-level decision-making environment in general. Producers of agricultural products operate in a volatile and complex decision-making environment with socio-economic and physical-biological dimensions.

Within this complex environment there is constant pressure on farm-level profitability. This pressure on the profitability of most agricultural commodities is caused mainly by a constant input-output price squeeze. The options available to producers to overcome this problem are limited, due to physical and biological constraints, the typical fixity of assets in agriculture and the risks involved in switching to untested practices in a particular area. The producer is thus caught in the predicament of not being able to continue with the same practices, yet ill-considered alterations to the farm system may do severe damage to the farm's financial position. Added to the issue of profitability is a constantly growing awareness of environmental responsibility, which adds an ecological dimension to the producer's goals.

The challenge to overcoming the pressure on whole-farm profitability lies in being able to identify physically and biologically feasible strategies aimed at increasing profitability, and then being able to examine their wider consequences within the farming system in financial terms. For instance, an alteration to a crop rotation system can have significant ripple effects on the rest of the farm.

1.2 The farm decision-making environment in dry-land grain production

In agriculture, the biophysical system plays the role that machines do in industrial manufacturing, except that these natural systems cannot be precisely optimised for human purposes. The socio-economic environment is more multidimensional and less controllable by producers. The farm decision-making environment is more hazardous, more complex and less standardised than industrial production systems (Cros et al., 2004:25 and Petherham & Clark, 1998:102).

A system or object is termed complex when it consists of a large number of parts and relationships among these parts (Blauberg et al., 1977:29; Checkland, 1993:61 and Flood & Carson, 1988:21). All of the following contribute to the complex nature of the farming system: the diversity of crops and livestock; the implementation of new technology; the role and contribution of livestock; the multiple interactions and the interrelatedness among crops; various disease, pest and weed problems; constantly changing product and input prices; consumerism; and awareness about sustainability. The financial performance of the farm is no longer the sole criterion for farmers and researchers, there now also is an ecological dimension (McCown et al., 2006:144). The farm's financial system consists of investment decisions, financing decisions, and decisions relating to recordkeeping systems and assessment, as well as financial planning systems. It is influenced by the external environment, the physical-biological system, as well as the management system.

Typical exogenous factors contributing towards complexity include increasing pressure from consumers for more environmentally sustainable production of food and fibre, pressure from labour unions for increased salaries for farm labourers, the traceability of the origin of production, land reform and climatic variability, which is expected to become even more unpredictable due to global warming. Producer prices are derived from the international commodity markets and are influenced by numerous factors. These factors include international grain stock levels; international production and consumption; freight costs; exchange rates; trade duties and levies; food export policies; transport costs; insurance costs; silo costs and handling costs.

An example of the complexity of the physical-biological system is the synergism obtained via the particular sequence of crops included in the crop rotation cycle. For instance, the interaction between crops in a crop rotation system causes yield increases, breaks in disease life cycles and a decrease in fertilisation requirements. The complexity and continuous expansion of the external environment of systems requires a growing need to incorporate human interaction in management decision-making (Ison et al., 1996:260; Jackson, 2006:648 and Leleur, 2008:73).

Within this complex decision-making environment, farm-level research is usually focused on a certain aspect of the broader system and falls within a specific discipline. The next part of the chapter describes some research conducted in the grain industry, focusing on the Western Cape, in order to establish the extent to which this research adheres to the principles of the systems approach.

1.3 Examples of current and completed research on grain production focusing on the Western Cape

In agriculture, two types of research exist. The first focuses on improved technology, such as, new enterprises, increased production, decreased production costs, increased product quality or reduced risk in terms of more stable varieties. The second type focuses on information, such as, the more rapid adoption of beneficial technology, better management decisions and reduced risk in terms of forecasting of climate (Pannell, 1999:126). The natural sciences such as agronomy, soil science, pathology and entomology are concerned with technology, while agricultural economics and farm management, as a profession, focuses particularly on information (Byerlee and Tripp, 1988:141).

A large body of literature exists on research done on various aspects of grain production practices in the Western Cape. A number of examples of such research are described to illustrate the dangers presented by focusing too narrowly on specific issues. The effect of soil preparation and cultivation methods on the soil, plant growth and yield of wheat cultivars was investigated for the Swartland region of the Western Cape (Agenbag, 1987:3). Bester (1990:22-24) evaluated the effect of various cultivation methods, crop rotation systems and stubble burn on the incidence of disease infections. De Wit (1994:vi) evaluated different spring wheat cultivars for quality selection. The physiological effects of drought on four spring-wheat cultivars were evaluated by Van Heerden (1995:iv). With a refinement in physiological research methods Strauss, (1999:15-16) identified genetic factors that should be bred into winter wheat cultivars to make them more drought tolerant. Wessels (1999:1) identified and mapped genes that showed resistance to stem rust and Russian wheat aphids in wheat. The response of wheat to the inclusion of canola and medics in crop rotation systems was studied by Wessels (2001:63-69).

Although all of the above-mentioned technical research cases are valuable and address critical issues in the industry or at the farm level, the effects of such factors on the profitability of the whole farm system have not been established. An assessment of the possible financial impact at the farm level, for instance, would add value to such research findings. However, determining the financial impact would require a method of measuring it at the whole-farm level. A broader view of the farming system is required to understand the wider impacts of technical changes in the farming system. The ability to assess beforehand the expected financial implications of technical innovations would prevent the adoption of inferior or unprofitable ones.

Macro-economic research traditionally focuses on industry- or sector-level impacts. The research results are often used to deduce farm-level financial implications of certain trends. Examples of such research include the following. De Kock (1991:5-11) used scenario planning to develop a strategic framework for the wheat industry. Edwards and Leibrandt (1998:246) showed that the wheat industry was previously more advantageously protected than some other industries, and after deregulation, this caused a shift away from wheat mono-cropping towards the inclusion of barley, oats, pastures, etc. Van Rooyen (2000:22-39) used the PAM (policy analyses matrix) method to establish the comparative advantage of Western Cape wheat producers compared over other international wheat producers. Troskie (2001:31-32) highlighted the persistence of the farm problem, which puts constant downward pressure on commodity prices in the wheat production areas of the Western Cape. Vink et al. (1998:261) used farm-level data to show that the Western Cape is in a relatively weak competitive position compared to other wheat-producing countries and production areas in South Africa because of high production costs. A combined research report by the BFAP (Bureau for Food and Agricultural Policy) integrates CGE (computable general equilibrium) models using various data sets with sector and farm-level models to determine farm-level financial performance and predict the impact of various factors on farm-level profitability (BFAP, 2005: 92).

A potential danger is that the goal of macro-economic studies is mostly not directly related to farm management issues. The complexity of the farming system and the balance and interactions between the physical-biological and socio-economic dimensions of the farming system are therefore often disregarded. Most macro-economic models either describe or predict certain trends and problems, but do not actively seek solutions to problems related to farming. Farm-level research focuses mostly on the financial implications of factors that influence the farming system from a problem-solving perspective.

Scheepers (1980:8) showed that Western Cape wheat producers are comparatively worse off than producers in the Northern production areas. Management skills were identified as a possible area for improvement. Van der Westhuyzen and Kleynhans (1987:27) analysed the effect of relative changes in the values of parameters on the relative profitability of different enterprises in the Middle Swartland. Using linear programming and optimisation of the farm's gross margin, the ideal crop enterprise combination at the full use of a harvester for a typical Middle Swartland farm was identified (Van der Westhuyzen & Kleynhans, 1988:1-3). Cost-saving production practices for the Southern Cape production area were identified and evaluated by Van Eeden (2000:5-6) by using expert group discussions. According to its purpose, the model and method used by Van Eeden, were able to handle some farm-level issues. However, the method and model lacked the necessary flexibility and capacity to capture the complexity of the farm system in terms of examining issues other than cultivation practices. The whole-farm profitability of crop rotation systems for the Middle Swartland was evaluated by Hoffmann and Laubscher (2002:342-345). This evaluation showed that crop rotation systems outperform wheat monoculture production over the longer term.

In the broader sense, farm management research into grain production systems is documented in various countries and regions. In most instances, either it focuses on part of the farming system, or it is an exercise in modelling that gathers knowledge for policy purposes. In one study in the Free State, a combination of farm-level and sector-level models was used to analyse the impact of various policies on a typical farm (Strauss, et al., 2008:355-358). Similar studies have been undertaken in the United States using the Simetar© program, which is an add-in programme in Microsoft Excel (Richardson et al., 2009:26-31). An optimisation approach has been followed in Australia using the MIDAS model, which represents equilibrium under average climatic conditions, which gathers valuable information for policy decision maker, but with limited use for producers (Pannell, 1996:374-375). In another instance in Iran, new technology under conditions of uncertainty and risk has been analysed with a whole-farm mathematical programming model to test for the suitability and affordability of such technology (Torkamani, 2005:141&150). Developing desirable production systems for Dutch farms using model-based exploration techniques shows the importance of a well-defined spectrum of possible technologies, early timing of prototyping and stakeholder involvement throughout (Ten Berge, et al., 2000:274).The role of perennial wheat in Australian dry-land farming is measured using a bio-economic model, showing that wheat for dual purpose grain and forage could be a profitable option for mixed farming (Bell et al., 2008:173). In cases where producers or scientists are involved in farm-level research, this is mostly limited to model development or model validation.

1.4 Problem statement and research goals

The main challenge of this research project is to generate actionable knowledge that is relevant to producers in terms of the potential to enhance farm-level profitability. The object of study, in this instance the farming system, is complex and multifaceted. To describe such a system in financial terms requires a thorough understanding of the farming system and thus close participation by producers. This system consists of physical-biological, socio-economic and management dimensions, which on their own, are all specialised fields of study. It is difficult for one specialist to comprehend such a multidimensional system. The primary research question is how to generate farm management knowledge that is relevant and implementable by producers? In other words, how to develop strategies that may increase whole-farm profitability, given that such strategies may impact on various aspects of a complex farm system?

The research question of ‘how’ to generate relevant knowledge places the focus of this research on the process of knowledge generation. The main problem is that of generating knowledge that is relevant to producers in terms of identifying ways to enhance the profitability of the whole farm. The second problem is how to cope with and quantify the farm system in financial terms to allow speedy assessment of the financial implications of proposed changes to the system. Again, the suggestions must be physically-biologically and socio-economically feasible.

Identifying and exploring creative ways of enhancing the financial position of farms requires a method of identifying strategies and a way of measuring the expected financial impact on the farming system. Farm-level research needs to focus on the interrelatedness of the constituent parts of the system and thus requires the incorporation of expert knowledge from the various fields of natural science and economics. Experts, typically, are involved in either data generation or model validation during research projects. The possible areas for involving experts could however be expanded to include constructing models, generating knowledge and identifying strategies, in other words, model implementation or use.

The main aim of this research project is therefore to design and validate a method for enhancing creative thinking, in order to increase farm-level profitability and implement a method to accommodate and accurately relate the complex system in financial terms. The specific goals of the research are as follows:

- To generate ideas to improve the profitability of the farming operation by using a multi-disciplinary discussion group consisting of experts from various disciplines, extension officers and producers, and
- To develop a financial model to show the financial impact of an innovative idea generated by the discussion group, in order to establish the viability of the innovation, and to refine the proposed innovation in an interactive manner.

1.5 Hypothesis

Some of the main reasons why farm management is often not relevant to farmers have to do with the gap that exists between farm management practiced by producers, and farm management as a professional and research activity (McCown and Parton, 2006:170). This gap is embedded in the difference between the perspective and understanding of the system among modellers and producers, and the preoccupation of modellers with model development and not model usage. The hypothesis of this study is that combining expert group discussions and using multi-period budgets to immediately show the financial implications of their suggestions may lead to the identification of strategies aimed at enhancing the profitability of the entire farm. The expected financial impacts of such suggestions on the whole-farm system must then be measured while the expert group validates the ecological viability of such suggestions.

1.6 Contribution of the research

In most instances, farm-level and farm management research are focused on diagnosing current situations rather than on searching for solutions. Early work done by academics in farm management was, to an extent, not based purely on economic theory, but made considerable contributions to solving farm problems, because farm problems were dealt with. A range of 'simple' models were employed to assist producers in decision-making and showing possible outcomes on gross margin and farm income level (McCown et al., 2006:148). A gap started to open between contributions to real farm problems, and research-output farm management became a subsection of production economics. The reason for this gap is that the focus of economics is more on theory and generating adaptable knowledge that is relevant in principle. The gap between farm-level research and practical farming lies in management as an action and science-based best practices, the focus of research. The reason for this gap is that research is underpinned by analysis, and practical farming is underpinned by judgement (McCown, 2002:187). The immediate concern of producers and farm managers is actionable knowledge and generating ideas of 'what should be done in a specific situation' (McCown et al., 2006:145).

Even new developments in farm management, such as, linear programming, stochastic modelling, risk analysis and decision analysis, have failed to an extent to be relevant, which is due largely to not matching the requirements of producers. For management purposes, producers' desire information on what the expected outcome of a decision or scenario would be, not avoiding risk per se. The requirement of the farm manager as an academic is therefore to provide a tool to define the expected outcome, and together with the farm manager as a practitioner to apply logic to reach a decision (Malcolm 1990:29 and Pannell et al., 2000:71&76).

The gaps between research output delivered by farm modelling and real farm problems are threefold, the first being the gap between the model and the real world, the second being between the modeller and the producer (McCown and Parton, 2006:159) and the third being a preoccupation with model building rather than model application (Doyle 1990:170). The gap between the real world and the model is caused by the problem of the farm system in essence being too complex and multifaceted to simulate all the facets thereof simultaneously, which can be overcome by clearly defining the goal of the model. The requirement of farm management as a discipline is to be relevant to producers, which necessitates that farm management research and modelling should begin with an understanding of the problems of producers (Norman and Matlon, 2000:25 and McCown and Parton, 2006:163). Producers as practitioners of farm management are in the best position to understand fully the whole farm system and should therefore be included in the research process in farm management research (Van Eijk, 2000:328). Farm management should assist producers in solving their own problems, with the help of tools such as modelling (Flood, 2001:137-138, Okali et al., 1994:96 and Van Eijk, 2000:324&328).

The issue that stands out in farm management is a lack of relevance. Underpinning this issue is a need for the inclusion of farm managers and other experts in research and the need to focus more on model application, and not only on model development. The proposed method for this project could not only include producers and experts from various disciplines to ensure that relevant issues are researched but also enhance the validity of the method and models, and it could go a step further in applying the models and group discussions for strategy identification or development to enhance profitability.

1.7 Research method

The research method had to be able to accommodate complexity and the multifaceted nature of the farming system. Expert group discussions as a research technique allow for the simultaneous consideration of a specific object of study from the various perspectives of specialised disciplines. The main aim of using expert group discussions, as a participatory research method, is to pool knowledge that may already exist, but which has become fragmented due to specialisation. A second, but equally important characteristic of group discussions is the stimulation of creative thinking. Because experts operate in the presence of experts from other disciplines during workgroup discussions, innovative and creative thinking are often stimulated by recognising aspects of the farm system from alternative perspectives. Experts from fields such as agronomy, soil science, plant protection, pasture management, agricultural mechanisation, and practitioners such as producers and extension officers for agricultural chemical companies, as well as extension officers for local agribusinesses were included. Expert group members challenge the relevance and connections of each component with other components of the farm system, thereby ensuring the validity of the method and the information generated.

The stimulation of creative thinking was further enhanced by using a tool during the group discussions that could immediately measure the financial impacts of suggestions on the whole farm. This tool had to be able to accurately capture the complex nature of the farm system in financial terms. A simulation of the farm system has the potential to accurately describe the farm system in financial terms, and to allow a sensitivity analysis of changes in the values of parameters of the farm model. Multi-period whole-farm budget models have been developed to fulfil this purpose via a system of interrelated mathematical and accounting equations. The budget models measure the sensitivity of various parameters and variables by quantifying their impact on whole-farm profitability. The models thus needed to be parameterised to a level that would allow for quick and interactive detailed adaptations of price and input levels, and they needed to measure the effect of structural changes on the internal rate of return on capital investment (IRR). The models thus had to allow for immediate evaluation of the effect of changes in farm structure, parameters, assumptions and inputs. The validity of the model and the inputs, such as the parameters and constraints imposed on the farm, needs to be maintained.

1.8 Layout of the rest of the study

Chapter 2 presents a literature overview of group discussion methods with a special focus on how interaction among participants adds value to the outcome. The ways in which the dynamics of group discussions can enhance creative thinking are highlighted. It further consists of a literature overview of the different quantitative methods commonly used in agricultural economics to evaluate farm-level financial-economic problems. It ends with an overview of the literature focused on budget models as the proper tools for this research project.

Chapter 3 describes how this research project was designed and implemented, focusing specifically on how group participation was implemented and on the design of the budgeting models. The models themselves are based on standard and recognised accounting principles, while the information regarding the farms' physical parameters, assumptions and inputs is validated by the expert group discussion method. Chapter 3 focuses mainly on the principles employed in modelling the farm system. These include the identification of homogeneous farming areas, the description of the typical farm, and the assumptions, parameters and inputs that the model can accommodate, which allows for adaptability and accuracy of the calculations.

Chapter 4 describes the output of the group discussions and models in terms of the development of a typical farm model for each relatively homogeneous area. Chapter 5 focuses on and describes the sensitivity of whole-farm profitability to exogenous factors such as input and output price fluctuations and changes in yields. The financial implication of a possible opportunity from the external environment in the form of bio-ethanol production is evaluated. Chapter 6 includes a description of the farm system in financial terms. It ends with financial evaluations of the proposals that the expert group made aimed at enhancing the profitability of the typical farm. Chapter 7 provides conclusions, a summary and recommendations.

Chapter 2

Group discussions and whole-farm modelling as supporting tools for generating ideas to enhance farm profitability

2.1 Introduction

To improve whole-farm profitability, promoting creative thinking among participants in an expert group was proposed in Chapter 1. The first part of Chapter 2 comprises a literature overview of the characteristics, functioning and advantages of group discussion as a method for generating and validating information. The importance of group discussions in research lies, firstly, in the comprehension of complex objects of study such as the farm system; secondly, in bridging gaps caused by discipline based research and specialisation; thirdly, in its ability to bring about a fertile environment for creative thinking. The interaction between participants in discussion groups stimulates creative thinking by constantly challenging the perspectives of the participants.

Before new strategies aimed at improving farm profitability can be developed, the current financial position of farms must be established. The reliability of the information generated on the current financial performance of grain farming in the Western Cape depends on two factors. The first factor is the validity and applicability of the method. The second factor is the validity of the parameters, assumptions and inputs relating to the whole farm. The validity of the proposals for improving the profitability of the farm lies in the physical biological feasibility of the proposals and the expected farm-level financial impact. The first part of Chapter 2 explores the use of group discussion as a method for generating coherent and valid information.

The second part of Chapter 2 evaluates quantitative methods that could be employed to capture the complex nature of a farm in financial terms. Various quantitative methods employed to support decision-making are evaluated in terms of their suitability to whole-farm financial evaluation. These methods are also evaluated for their ability to accommodate complexity and adaptability. Simulation modelling presents a technique for representing the real world, in this instance the real farm, relatively accurately by capturing the unique interactions contained within the farming system, in a series of mathematical, financial and statistical relationships. For this enquiry, a budget model, which is based on accounting principles, rather than on mathematical and statistical relationships, is proposed for its ability to accommodate a large number of variables expressed in financial terms. Through simulation modelling the current financial performance of the farm can be established and evaluated in terms of its sensitivity to changes in certain parameters and variables. The methods of modelling and multidisciplinary group discussions are combined to establish the farm's current financial performance and to identify ways of improving profitability.

2.2 Multidisciplinary group discussion techniques

The systems approach is well developed and documented, but is possibly under-utilised in practice. The core concept of the systems approach is the principle of the irreducibility of the whole. In other words, all objects in a system are interrelated parts of a larger whole and the whole often contain attributes not necessarily found in the individual parts (Ackoff, 1974:12; Blauberg et al., 1977:26; Hammond, 2003:11 and Severence, 2001:24). A research method that accommodates and supports a systems approach is that of multidisciplinary group discussions.

Multidisciplinary group discussions, as a method or technique for generating information and knowledge, started in the military during World War II and evolved to become widely used in operations management and farm management (Calheiros et al., 2000:685; Colin & Crawford, 2000:195; Conradie, 1995:21-22; Doll & Francis, 1992:474; Fildes & Ranyard, 1997:336-338; Haggar et al., 2001:418; Hoffmann 2001:10-11; Jabbar et al., 2001:258; Linstone & Turoff, 1975:3; Van Eeden, 2000:13 and Whyte, 1989:368).

2.2.1 The need for multidisciplinary group discussions

The quest for knowledge is stimulated by real-life problems experienced by humans in their every-day lives (Gadner et al, 2004:5, 47). Lay knowledge, the first level of knowledge, is normally required in everyday life. Lay knowledge is gained through experience, learning and reflection. Lay knowledge is applied to lead normal lives, to solve problems, to reach consensus and to gain insight. The second level of knowledge is that of science. Scientific research entails the study of real-life problems, which become objects of inquiry, in a systematic and rigorous manner. It is thus about the constant search for truth or truthful knowledge. The aim of science is to generate descriptions, explanations, models and theories of the world based on epistemic interest. A third level of knowledge or third context is that of meta-science, which is about reflection on the nature of scientific enquiry. Meta-science submits research decisions to critical reflection and conceptualisation. It is thus about issues of critical interest such as the selection of theory, research approach and indicators implemented in research (Mouton, 2008).

The importance of striving for truthful knowledge, in the form of scientific research, led to specialisation and the development of scientific disciplines (Mouton, 2008). Specialisation, however, often leads researchers to become growingly discrete from each other, and in the process it counters solutions to real-world problems (Malcolm, 1990:47-48). The cause of this discreteness is that the main goal of intra-disciplinary study (or research) is often the advancement of disciplinary understanding. A key characteristic of a scientific discipline is that the choice of topics is defined by the internal state of the discipline and not necessarily by the active search for solutions to real-world problems. This often inhibits communication between disciplines. Mostly, disciplines do not differ only in subject matter, but also in principle of scientific deduction. The combination of subject matter and method of deduction provides scientists with identity (Janssen & Goldsworthy, 1996:260). Multidisciplinary research methods are therefore used to accommodate participation across disciplinary gaps (Moore et al., 2007:37 and Young, 1995:122).

In agriculture, both farm management research and farm systems research, which aim to generate information about general principles and theories related to the management of farms, may lean more towards research in one of these disciplines (Malcolm, 1990:49). This shows that a gap exists between the findings of research and the management of farms. It should also serve to remind researchers that agricultural science and agricultural economics are not about farm management as such.

Examples of scientific disciplines related to grain production include agricultural economics, agronomy, soil science, plant pathology, entomology and animal science. Disciplines usually maintain a close institutional compliance with certain professional standards, educational programmes and publication outlets. In South Africa, agricultural research has traditionally been further compartmentalised by commodities (e.g., wheat industry, wool industry, barley industry, etc.). Discipline-based research often causes the fragmentation of knowledge that may already exist. Multidisciplinary group discussions can bridge some disciplinary gaps. Farm management research, which by definition is multifaceted, relies on the use of a pool of knowledge in the form of the participation of experts from various disciplines (Bullock et al., 2007:1765 and Hoffmann, 2001:10). Such a group would include experts who use different methodologies, vocabularies and structures, not necessarily orientated toward financial management.

The challenge for researchers attempting to comprehend the whole-farm system, which requires exploring the complexity of interrelationships between the physical-biological, socio-economic and management dimensions of the farm system, lies in facilitating multidisciplinary participation (Bosch et al., 2007:218; Keating & McCown, 2001:556; McCown, 2001:3 and Röling &

Wagemakers, 1998:10-16). Bridging the gap between scientific and research disciplines requires integrating natural science, social science and indigenous knowledge (McGregor et al., 2001:79). Contemporary research in agriculture is moving towards multidisciplinary research between agricultural economists and other scientists in agriculture, by focusing on the same problem or topic (Francois, 2006:619; Jeffrey, 2003:540; Vandermeulen & Van Huylenbroeck, 2008:352 and Young, 1995:120).

Another, more practical, reason for using multidisciplinary expert group discussions lies in the exploratory nature of that part of the research that is aimed at improving whole-farm profitability. The implication is that some of the required information does not exist at present. To generate valid exploratory information regarding the implications of changes in the parameters and inputs to the whole farm requires coherent inputs from experts. Experts can base their judgement of the impact of changes on the farm system on experience and knowledge. Compared to other methods, expert group discussions are more time efficient in generating information.

Group discussions as a technique for generating information do have potential limitations. Most of the participants may know each other and the familiarity may influence the willingness to disagree in such a group. Familiarity amongst members could present a more open discussion, but the presence of an influential figure may influence the opinion of other members. The awareness of the chairperson of this can be overcome by encouraging participation by other experts.

Often group discussions also become an exercise in model validation. Again, the chairperson's awareness of this can focus the discussions towards model usage and idea generation. The group members typically are from various disciplines characterised by specific languages, outlets and research methods. The material discussed should accommodate the potential inability of participants to understand sophisticated methods. One way to overcome this is to use relatively simple methods and models and make clear the goal of the research and importance of participation.

2.2.2 The dynamics that characterises group discussions

This section describes how group discussions, by creating an ideal environment for creative thinking, can enhance research output and decision-making. Creativity is a form of behaviour in individuals. The height of creativity is the creative shift, which often leads to new ideas. The creative shift happens when an individual realises that there is another way of looking at things. The advantage of group discussions is that other members in the group can initiate a state of creativity by challenging the individual's perspective. In expert groups, especially where open debate and discussion are encouraged, contextual change often occurs (Krueger, 1994:19; Litosseliti, 2003:2 and Porac et al., 2004:663). This creates an ideal situation for creative thinking (Leleur, 2008:68-70). Once the creative shift occurs and new ideas are generated, other group members can help to verbalise the new ideas. Two important levels of creative thinking are inventive and innovative thinking. Inventive thinking relates to the provision of new ways of solving existing problems. Innovative thinking relates to modification in approaches based on a thorough understanding of principles (Hare, 1983:156-161 and Linstone, 1984:46). The ability of a group to generate inventive and innovative ideas is determined by two factors. The first is the above-mentioned processes. The second is the resources that individual members contribute to the group. These resources are in the form of knowledge, experience and insight (Thompson & Choi, 2006:164). It is therefore important to select participants for group discussions carefully.

The generation of new, creative ideas in group discussion is embedded in a number of processes. The aforementioned creativity of individual participants is the key factor contributing to these processes. The first process involves crossing disciplinary boundaries. Group members are able to exchange and combine knowledge. The second process relates to knowledge sharing. Knowledge sharing in multidisciplinary group discussions is enhanced by the tendency of participants from different disciplines mainly to be more willing to share knowledge than members from the same discipline are. The third process is knowledge generation, where group members create knowledge by generating new or emergent ideas and knowledge through interaction and communication. In this instance, it is important that group members interact open-mindedly to stimulate inventive and innovation thinking. The fourth process is knowledge integration, when different perspectives of various disciplines merge. This process allows incorporation of the views, assumptions and ideas of each group member (Linstone, 1984:46). The fifth process involves collective learning, in which the group members, all of whom are experts with extensive experience, learn from the project or discussion of which they are a part. Group members are constantly confronted by new technologies, ideas and techniques suggested by other experts (Fong, 2003:482-484). From the general perspective of epistemological interest, the participant scientists will naturally look for opportunities for individual enquiry and learning.

2.2.3 Applications of group discussions in research

Group discussions and methods of generating ideas started in the 1950s with simple brainstorming in advertising (Thompson & Choi, 2006:162). Two of the most prominent group discussion methods that directly contribute to establishing an environment conducive to creativity in research include the Delphi method and Idealised Design method.

The Delphi Method is a structured communication process comprising a group of individuals who aim to solve complex problems (Kenis, 1995:1 and Linstone & Turoff, 1975:3). The most important features of Delphi as a research technique are the following:

- That anonymity is guaranteed,
- Iterations are made and fed back in a controlled manner, which achieves the objective of attaining reliable consensus, and
- Statistics are used to represent the status of the opinion of the group for a given response (Kenis, 1995:2).

The major advantage of Delphi is that it provides participants with a great degree of individuality and freedom because of its anonymity. The Delphi Method thus allows subjective information to be incorporated into models dealing with complex problems (Linstone & Turoff, 1975:11). A potential problem with Delphi is often the poor level of professionalism with which it is conducted. Poor design of questionnaires or poorly structured questions can lead to skewed results. Delphi relies on a questionnaire, and individuals are asked only to expand on points of view if they significantly differ from the group's results. The aim of this project is to identify ways to improve farm-level profitability. Interaction between participants is precisely what is required to stimulate creative thinking which is important to identify ways of improving profitability. The exclusive use of the Delphi method may not generate the same amount of creativity, as participants are actively kept apart. It is also, compared to group discussions, a time-consuming method.

Idealised design is a group exercise that involves planning with the idealised situation as its focal point. This idealised situation is established by starting from a zero base, with no constraints. The rest of the process is about identifying the means and resources required to bridge the gaps that are identified between the current and the ideal situation (Ackoff et al., 2006:7). The advantages of idealised design are:

- The promotion of an understanding of the issue by the design process,
- The transformation of the designers' concept of what is possible,
- It simplifies the planning process by limiting the amount of possibilities, by starting from the end, which is an ideal, zero base situation,
- It enhances creativity, especially as participants are encouraged to design beyond current limitations, and
- It facilitates implementation, as a sense of ownership is established throughout the organisation.

The problem with a pure form of idealised design in farm management is that, by definition, the farm's physical-biological environment and boundaries are set and beyond the control of management. It also requires a thorough knowledge of the specific organisation for which the design is being implemented. The concept of idealised design can however be utilised to promote creative thinking beyond the physical-biological and socio-economic limitations and boundaries of the farm system. A pure idealised design exercise is not viable, because these limitations cannot be ignored, as is required by the process of idealised design.

2.3 Suitability of the quantitative techniques to model the whole farm and support group discussions

Generating trustworthy information for the typical farm for each area relies on the validity of the method employed. The method employed must accommodate and capture the complexity and nature of the system being modelled (Marks, 2007:272-273). Generating ideas to improve the profitability of the farm system relies on creative thinking and examining the expected impact of such ideas. To describe the typical farm accurately in financial terms, the quantitative method needs to comply with two important demands:

- The necessity of stimulating creativity by utilising expert knowledge to describe, evaluate and validate the true character of the typical farm, and
- The ability to capture the complexity of the typical farm as accurately as possible, with a special focus on the factors and interrelationships that influence the performance of the typical farm.

These two general requirements of the quantitative method employed can be broken down further into more detailed requirements.

The first important requirement of the method is the ability to accommodate complexity. Accommodating complexity requires, *inter alia*, the ability to measure the sensitivity of certain performance criteria to variations in a range of variables, including structural variations. The ability to cope with complexity is embedded in the detailed quantification of the factors and interrelationships that comprise the farm system. Figure 2.1 shows the factors and relationships that the model needs to quantify and relate accurately. The method needs to not only show the effect of components on each other, but also to show the effect of variations in individual components on the whole farm.

Producers operate at the interface between physical-biological and financial-economical dimensions, which means that a considerable number of the variables will be physical quantities and parameters. The participants in the expert group discussions are also mostly natural scientists and producers who will contribute information of a physical-biological nature. The method needs to translate such inputs into financial data and inputs.

The most important requirement of the method is adaptability. The key to identifying viable strategies that could improve farm-level profitability is the creativity produced by the group discussions. To enhance creative thinking, the financial impact of suggestions on the whole farm should be presented immediately to indicate whether the proposed plans are financially viable and justify further exploration. The method should be able to examine the financial impact of variations in crop rotation system, farm size, yields, prices, input levels, and overhead and fixed costs. The ability of the model to show the financial impact immediately not only saves time and costs but also enhances the output of the group discussions. It can be expensive and time consuming to get all the participants together for a second or third round of discussions. By using the model during the group discussions, participants are immediately confronted by the impact of their suggestions on the financial performance of the whole farm. This not only keeps the group focused but also adds another perspective in the form of a financial dimension. The realisation of a new perspective should initiate the creative shift and increase the possibility of inventive and innovative ideas (Snabe & Gröfsler, 2006:468). These factors should enhance the quality and intensity of discussions.

The model's user-friendliness allows for its utilisation and the interpretation of its results by stakeholders who are not necessarily from a financial or managerial background. User-friendliness can overcome the threat of expert group discussions being reduced to a diagnosis of the method. The group discussions are used to validate the model but should be focused on developing innovative ways of improving the problem (Janssen & Goldsworthy, 1996:276). User-friendliness also implies an understanding of and identification with the method by all participants, despite the diversity in mathematical and accounting knowledge among them. The model thus needs to accommodate and capture the complexity of the whole-farm system, yet present it in a simple way.

The method further needs to accommodate multi-period, whole-farm financial evaluation. The importance of this requirement is embedded in the systemic nature of the whole farm and its specific cropping systems. All the systems employed by producers in the study area are based on long-term goals and implications. For instance, the benefits of crop rotation systems are gained over time. The replacement of livestock and machinery are also long-term issues. The selected method needs to accommodate and accurately calculate these long-term implications in a valid way.

Figure 2.1 shows the more important factors that contribute to the complexity of farm financial decision-making. The arrows indicate the flow of materials, information, energy and impact. Figure 2.1 illustrates only factors that influence the financial system on the farm, while other closely related systems include the management system, production system and institutional system.

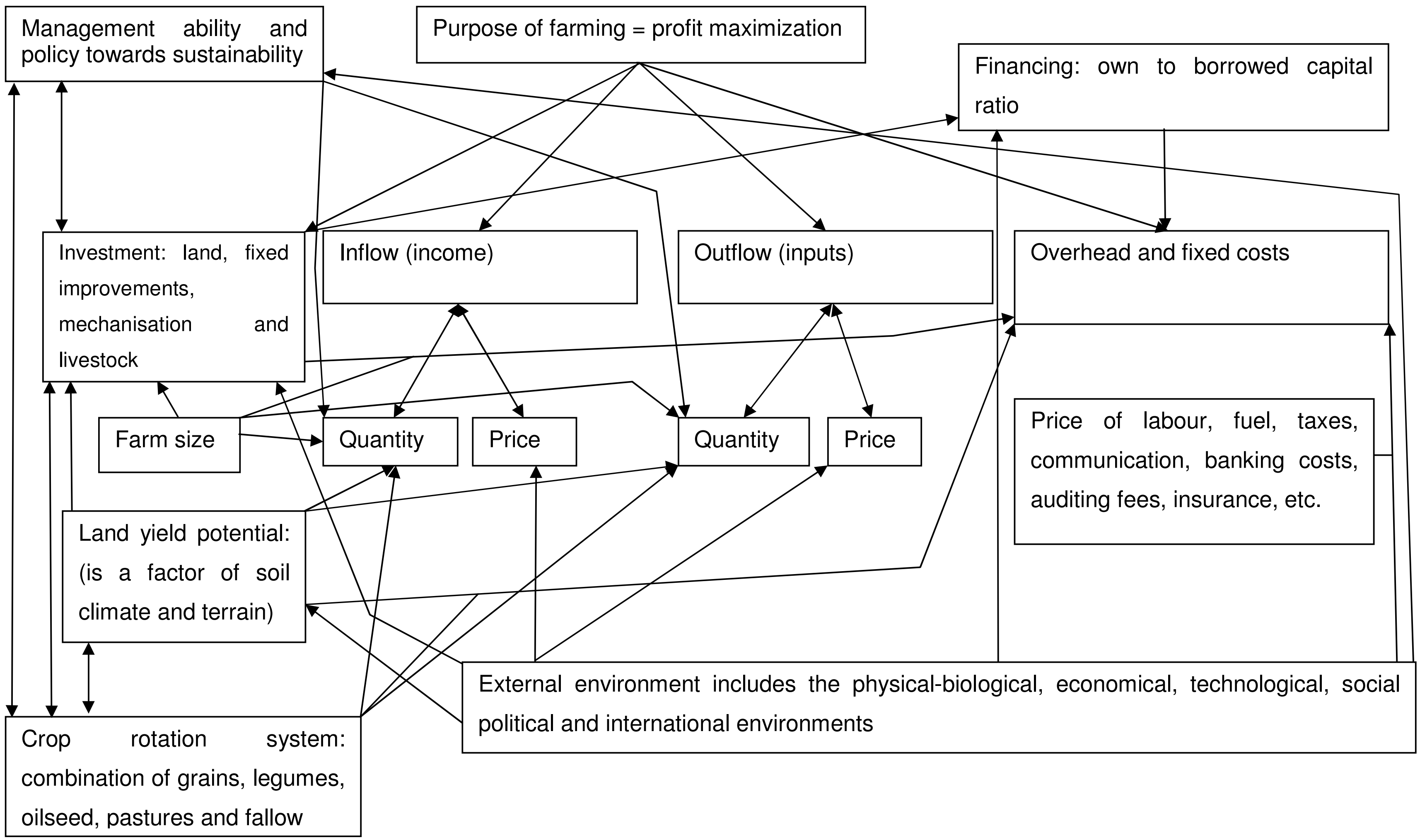

Figure 2.1: Indication of some of the more important factors contributing to the complexity of farm financial decision-making

2.4 The role of quantitative methods in farm decision-making and research

Farm management is defined as the process by which resources and situations are manipulated by the farm manager in trying, with less than full information, to achieve his goals (Dillon, 1980:257). This definition, in essence, relates to a decision-making process involving the identification and evaluation of alternatives. Various quantitative farm management tools have subsequently been developed to assist in decision-making. Although quantitative methods alone are not sufficient for decision-making, they do offer a way of evaluating alternatives. People still depend on judgement, experience, intuition and courage to make important decisions. An important aspect of human decision-making is that people are typically not completely rational. The role of the scientific method is to lead to good decision-making in a complex, turbulent and often messy world, as described in Section 1.2.

The contributions of quantitative methods in decision-making are:

- To guide decision-making by establishing quantitative and scientific discipline and to establish general objectives and goals,
- To aid decision-making when quantitative methods do not deliver an answer but do provide a number of pointers or planning schedules that reflects the way operations need to be carried out or indicate the importance of specific factors,
- To automate decision-making when a set of decision-making rules and observable indicators that accurately simulate problems that influence operations has been developed. As long as the problem does not change, a computer model can 'make' decisions such as those involving stock and inventory levels, where computers can 'place orders' with suppliers when stocks are below certain levels (Aubry et al., 1997:47 and Gallagher & Watson, 1980:6-9).

In modern agriculture, quantitative methods are widely employed by researchers, planners and service providers to assess the performance of industries and specific areas, within these industries, and to justify support and intervention strategies by government. Researchers and producers employ quantitative, scientific methods to communicate issues and implications to policy makers (Dorward et al., 1997:248).

The efficiency of specific quantitative methods depends on some general requirements, as follows:

- The applicability of the specific technique employed must be determined by the critical assumptions of the technique,
- The employer of the technique must be capable of implementing it, and

- The clients receiving the results, who are not always the same as those using the technique, must be able to understand and utilise the information (Rehman & Dorward, 1984:178).

2.5 Whole-farm systems models

The word model has various meanings, but in essence, it is a description or analogy used for helping to visualise something that usually cannot be observed directly (Daellenbach & McNickle, 2005:81). The context within which the object of enquiry for this study is embedded allows for the identification of a narrow area of interest, the profitability of a typical Western Cape wheat farm. The modelling of this identifiable narrow area of interest is referred to as systems modelling. A system model is thus a representation of all the essential parts of a system.

In the literature, modelling is defined as:

- "Building a representation of a system" (Strauss, 2005:12),
- Developing and validating representations of the real world (Mouton, 2008),
- The conceptualisation of an abstract system of relationships into something more familiar (Breimyer, 1991:246).

Modelling is typically used in studies that aim at developing and validating accurate representations of the real world, in this instance a real-world farm. Models allow for the evaluation of possible outcomes. By manipulating the parameters and inputs of the model, research questions of a descriptive, causal and predictive nature can be addressed (Brenner & Werker, 2007:229; 2008; Steward, 1993:13 and White, 1971:294). Models can usually be constructed in such a way that expected or modelled results can be compared with actual data or knowledge.

The development of modelling rested on two factors. The first factor was the social notion that the natural world could be not only scientifically explained but also scientifically managed. The second factor was the technological advancement and development of the computer (McCown, 2002:12-14). Computer models are particularly useful for exploring hypothetical systems. Models can quantitatively compare alternative management options in terms of established criteria and known risks. Models can also be applied in designing improvements on existing systems (Attonaty et al., 1999:158 and Robson, 1994:18).

In agriculture, computer models are widely used as planning or exploration tools in fields such as agricultural economics, farm management, crop management and livestock production (Glen, 1987:642-653). Models influence producer decision-making directly, by providing information that producers need, or indirectly, by influencing the farm policy framework (Meinke et al., 2001:495). The justification for models as research tools in agricultural systems is their practical use. The key to useful models is relative simplicity, which can be obtained by setting well-defined objectives. The pre-occupation of systems researchers with simulation and model building, with less attention to applications, may lead to either limited practical use or suspicion among producers who do not understand the principle or function of the model (Doyle, 1990:89-112).

2.5.1 Approaches to modelling

This section describes various approaches to modelling farm systems which should be based on the research problem and research questions. The modelling approach is determined by the purpose of the model; in other words the question the model needs to answer. The essence of economics as a social science lies in the distinction between what 'does' happen and what would be 'preferred' to happen. This distinction is made by following a specific approach that can be either normative or positive (Strauss, 2005:17).

A normative approach describes what is believed 'ought to be'. Normative models are thus prescriptive in nature. Normative statements depend on value judgements, which are formed by cultural, philosophical and religious systems and beliefs. Therefore, normative questions cannot be answered solely by relying on empirical facts. In terms of modelling, optimisation models are typically defined as normative; as such models aim to indicate a best or optimal solution. For example, mathematical programming models are mathematical relationships, expressed by equations that can be 'solved' to return a 'best' or 'optimal' solution. Typically, normative models are not calibrated to historical data. In the construction of such models, basic knowledge of the system being modelled is sufficient. The construction of normative models often starts with the decision rule of the decision maker and aims at a utility maximisation goal (Buysse et al., 2007:74). Examples of quantitative methods based on a normative approach include mathematical programming, mathematical statistics, production functions, input-output analyses and network analyses (Csáki, 1976:22). The uses of normative models include:

- Prescription of solutions,
- Prediction of consequences,
- Demonstration of sensitivity, and
- Solution of systems of equations (Buysse et al., 2007:74).

The disadvantage of normative models is that they lack the ability to compare alternative predicted consequences to the current or referenced situation. The validity of the system model lies in its ability to reproduce the observed accurately. Normative models mostly lack a calibration mechanism because of their core focus on optimisation and not on describing facts. A further disadvantage of the normative approach is that it often causes a narrow focus on the specific problem at hand, based on production economic theory, and sometimes does not consider alternatives (Malcolm 1990:33).

A positive statement, on the other hand, is concerned with ‘what is’, ‘what was’ or ‘what will be’. The term positive statement is deduced from the fact that the model reproduces observed data or situations. Positive models are seen as descriptive in nature and are not interested in the issue of desirability (Nijkamp & Van den Bergh, 1997:190 and Shakun, 1972:369). Positive statements can be proved correct or incorrect by empirical evidence. A positive approach is based on a non-optimising approach to system simulation. Positive models explain the influence of externalities and options, implemented by decision makers, on a system. Positive models describe observable situations; therefore, positive models are seen as empirically reliable (Buysse et al., 2007:76).

Positive farm simulation models are built on statistical descriptions of historically proven interrelationships. They are used to measure the ‘likely’ outcome of specific variables (Strauss, 2005:18 and Kerselaers et al., 2007:672). Positive models are not solved but ‘run’ to assess the influence of specific variables or parameters on predetermined criteria, for instance, profitability. They are seen as ‘free-form’ models. Free-form models are not dependent on sophisticated mathematical or statistical formulas. Their sophistication lies in the correct description of the system’s structure, which requires allowance for a large amount of interrelations and parameters. This does however necessitate a thorough study and understanding of the system being modelled. The modeller needs to understand and comprehend the facets and interrelations of the system, and include the correct parameters.

Some of the disadvantages of a positive approach to modelling include:

- No single solution is reached with a positive approach, which may be interpreted as a lack of purpose (Malcolm, 1990:32),
- The researcher often decides on the parameters and options to be simulated, which can lead to subjectivity,
- The model construction and validation exercise can be time consuming and expensive,
- The simulation of individual farms is often not practical enough (Strauss, 2005:18), and
- Data availability is often not sufficient, resulting in the need for additional and sometimes ad hoc assumptions (Buysse et al., 2007:77).

2.5.2 Categories of quantitative models

Based on the specific research objective, a type of model should be selected that is suited to the purpose of the research and the specific problem. The types of models discussed in this chapter are based on one category of systems models. Various methods of classifying systems models are used in the literature. Models are classified according to the objective, the system being modelled, the underlying research approach, the time dimension, the economics of agricultural production practices and sustainability. The validity of the type and complexity of the model applied to research should be based on the level of efficiency with which the model reaches its specific aim or objective (Marks, 2007:272-273).

Typical objectives for modelling are explanation, prediction or exploration. Explanatory models would result in a set of conditions that would sufficiently explain an observed phenomenon. Prediction models do not focus on understanding the necessity of the interrelatedness of the underlying variables, but only on the outcome. Exploration models aim at identifying alternative strategies. Exploration models focus on the sensitivity of the model to a specific variable or mix of variables and are interested in conditions that will change the outcome (Hengsdijk et al., 1998:383 and Kleindorfer et al., 1998:1098). Csáki (1976:108) bases model classification on objectivity and distinguishes between production models, budgeting models, simulation models and enterprise simulation. Dorward et al. (1997:242-243) distinguish between conventional management tools and decision-making tools. Conventional management tools include budgeting models such as enterprise, whole-farm, capital, partial, and cash-flow budgets while decision-making models includes the range of models based on linear programming.

Models used in farm simulation are generally classified in terms of the type of the system being modelled and/or the purpose of the model (Strauss, 2005:14). The following types of models are identified: deterministic (used to simulate specific outcomes based on a specific set of inputs and not incorporating risk) and stochastic (models containing a random number of variables and relationships) (Lien, 2003:403; Peart et al., 1985:110-113 and Richardson, 2003:2).

A distinction can also be made between simulation models and optimisation models (Cros et al., 2004:29). Optimisation models use relatively simple strategies to develop an optimisation approach and search for the ‘best possible’ outcome according to well-defined numerical criteria (Rae, 1970:40). Simulation models focus on the modelling of the structure and interrelationships of biophysical- and financial systems.

Four categories of empirical modelling methods are distinguished, based on agricultural production economics and sustainability:

- Econometric models,
- Optimisation models,
- Simulation models and
- Accounting models (Weersink et al., 2002:131-133).

Econometric models are statistical representations of farm-level systems, focusing on input demand and output supply, are derived from duality theory. Optimisation models and simulation models are systems of equations designed to replicate farm-level activities related to production, marketing, financing etc. The difference between optimisation models and simulation models is that the former involves the specification of a behavioural function such as profit maximisation. Accounting models use farm level-budgets (partial budgets, enterprise budgets, whole-farm budgets and cash-flow budgets) to assess farm-level activities, usually based on some profitability indicator.

2.6 Quantitative methods often used in farm management research

It is important for farmers, researchers, extension officers and policy makers to understand the financial impact of technical changes to the farm system. Physical simulation of a farm is not practical, and most farm-specific case studies are not representative; therefore, computerised whole-farm models are used to assess the complex issues involved in farming and their impact on farming. The multifaceted nature of the whole farm necessitates the use of multidisciplinary teams to accommodate the variety of expertise necessary for accurate assessment of whole-farm issues.

Models themselves do not generate new information; they only facilitate the processing of information. In multidisciplinary discussion groups, models serve as tools to facilitate discussions and generate new discussion points. The role of the model would thus be to provide an accurate description of the structure and interrelationships of the system being studied. This facilitation allows researchers to determine the financial outcome of various strategies and changes in exogenous factors.

The types of models utilised in farm management range from conventional budgeting methods to a range of decision models, which are based on statistical and mathematical equations aimed at optimising resource allocation to reach a predetermined goal. The four more commonly utilised models are estimation models, linear programming models, simulation models and the budgeting models (Weersink et al., 2002:131-133). Each of these methods will be discussed, with a special focus on their functioning, their uses in agricultural economics and the main advantages and disadvantages of each method. The most important consideration in selecting a modelling method is that the method should match the requirements of the specific research problem.

2.6.1 Estimation models

Estimation models statistically evaluate economical and technical relationships by some form of regression analyses, or by analyses of variance or correlation (Debertin & Pagoulatos, 1992:1). The foundation of estimation models is embedded in econometrics. The use of estimation models began in the 1930s in the USA after the realisation of the limitations of production economic theory for farm management, which stemmed from gaps in the formal economic literature (Malcolm, 1990:39). The first applications of production economic and econometric methods were the estimation of production functions. In essence, a production function is a quantitative relationship between inputs and outputs. Production functions are descriptions of physical relationships and describe the production possibilities available to producers (Dillon & Hardaker, 1984:103). The role of the production function in estimation is to forecast future values of a dependent variable by using historical data to estimate the relationship between dependent and independent variables (Winston, 2004:1275).

Estimation and forecasting are based on the foundations of regression and correlation, which are mathematical and statistical methods for describing the relationship between the dependent and independent variables (Winston, 2004:1275; Bradford & Johnson, 1953:121-152 and Goetz, 1965:251). From an economic efficiency point of view, and to identify optimal input levels, economists are interested in the part of the production function where each input has a diminishing, but positive marginal production output (Dillon & Hardaker, 1984:104). The fit between the variables is expressed in terms of a correlation, which can be linear or non-linear. Numerous algebraic equations, such as single-variable equations, Cobb-Douglas functions, quadratic functions and hyperbolic functions are used in deriving production functions (Heady & Dillon, 1966: 73-83).

A vast body of literature exists on the use of econometric and estimation models employed in agriculture. The first papers in the *American Journal of Agricultural Economics* implementing single equation models were published in 1923, while the first publication featuring simultaneous equation models was published in 1953. In 1990, of all articles published in the *American Journal of Agricultural Economics,* 21.74 percent of models used single equation econometric methods and 41.3 percent of models used simultaneous equation methods (Debertin & Pagoulatos, 1992:3-5).

In agriculture, estimation and production models provide basic scientific knowledge and, more importantly, they provide a formalised way of making decisions (Longworth & Menz, 1980:8). Initially, econometric research was designed to provide point estimates for crop and livestock outputs from data sufficient for deriving input-output regression curves (Heady & Dillon, 1966:2). Scientific advances led an increasing number of physical and biological scientists adopting econometric and production-function concepts. In the natural sciences, production functions are commonly employed in research on fertilisation, irrigation, livestock feeding, biological functions, cultivation methods, labour utilisation and other processes.

Agricultural economists employ production functions at farm level for farm planning, estimating resource productivity, analysing experimental results and analysing sample data from groups of farms. At an industry level, econometric models are often used for marketing planning. The typical outputs of econometrics and production functions include production elasticity; sum of elasticity; adjusted coefficient and multiple determination; sample means of inputs and outputs; average product; opportunity cost, marginal product to opportunity cost ratio; and break-even analyses (Dillon & Hardaker, 1984:103; Malcolm, 1990:40; Heady & Dillon, 1966:9-30 & 585-593; Plantinga et al., 1999:813 and Zellner, 1999:742).

Econometric and production function analyses have a number of general limitations regarding their applicability as clear-cut guides in decision-making. Statistical methods are usually more concerned with a superficial than a significant structure. Understanding the fundamentals of a system's structures requires a thorough understanding of, and familiarity with the issue being studied, which is not a requirement for econometric models (Good, 1983:288). Econometric production functions, contrary to the main goal of farm management, which is continual improvement of efficiency, assumes specific and constant levels of efficiency for resources (Malcolm, 1990:40). Limitations of the use of production functions in farm management are caused by:

- The effects of year-to-year differences in climatic influences on resource productivity,
- Production functions are generally of a short-term nature, while farming goals and objectives are mostly long-term orientated,
- The limitations of applying static and other specific concepts to farming, which is inherently dynamic,
- Farm households, more often than not, have different and multiple objectives in stead of one single profit maximisation objective (Jarret, 1957:75), and
- Farm managers deal with vast quantities of data from different levels and sources (Brenner & Werker, 2007:229).

2.6.2 Linear programming models

The key role of management is to make decisions regarding the most effective utilisation of limited resources. Mathematical programming is a field of study that is concerned with finding the best or optimal way of using limited resources to achieve the objectives of an individual or business (Ragsdale, 2001:16). Within the field of mathematical programming, linear programming is one of the most commonly utilised normative techniques developed to 'solve' optimisation problems with linear objective functions and constraints (Botes et al., 1996:166; Cros et al., 2004:29; Ragsdale, 2001:20 and Shakun, 1972:369). In agricultural, linear programming involves the selection and optimal combination of crop and livestock activities that maximizes a specified goal, which is consistent with specific constraints (Dillon & Hardaker, 1984:63 and Redelinghuis et al., 1989:214). Linear programming is a deterministic method of analyses for choosing the optimal or most efficient course of action from a range of predetermined alternatives. Linear programming is about satisfying various criteria simultaneously by using mathematical methods (Gallagher & Watson, 1980:153). The method of linear programming is best understood when considering the prerequisites of linear programming, which include:

- A single objective which, can be either maximisation or minimisation, that can be obtained by optimal resource allocation,
- Maximisation or minimisation is always subjective in relation to certain restrictions,
- The objective function and constraints are always proportional to the production level,
- Contributions of individual products are additive, which means that the whole is always equal to the sum of the parts,
- Divisibility, which means that fractional allocations of products are possible,
- Non-negativity, which means that negative numbers cannot be produced (Davis et al., 1986:101), and
- All functions and constraints are in linear relationships (Daellenbach & McNickle, 2005:365).

Various adaptations were made to linear programming to allow for solving equations that do not adhere to the above-mentioned characteristics. Developments include integer linear programming and the accommodation of non-linear functions (Ragsdale, 2001:230, 238). These developments advanced the ability of programming methods to cope with complex problems. Numerous examples of applications of linear programming, integer programming and non-linear programming models exist. In crop research, programming methods are employed in studies and fields such as fertilisation, chemical applications, soil moisture and fertility, disease levels, cropping systems, harvesting systems and capital invested for crop production systems. In livestock research, optimisation models are used for diet formulation, ration formulation, feeding policies, livestock production on pasture, breeding and replacement studies, production unit planning and waste disposal (Daellenbach & McNickle, 2005:365-366; Gallagher & Watson, 1980:159; Glen, 1987:644-645 and Goetz, 1965:331).

The major advantage of optimisation models is that a best or optimal option is identified (Weersink et al., 2002:133). In farm management, programming methods are widely employed in production planning, finance planning and marketing planning, with applications in tactical planning, including at a strategic planning level (Burton et al., 1979:576 and Keating & McCown, 2001:565). The major contribution of programming models is, however, in research rather than farm planning or decision-making (Malcolm, 1990:41). Producers often have more than one objective, while standard budget models are more easily adaptable. The technique lacks the quick adaptability required in this study to support interactive planning.

In terms of farm decision-making, a number of limitations exist regarding the practical use of programming methods. The most important of these limiting factors is that it is relatively complex, costly, information intensive and time-consuming. Often the alternatives available to management are already limited due to other constraints (Malcolm, 1990:42). In the rain-fed grain production areas of the Western Cape, for instance, the number of crops that can be produced is limited due to climatic and crop characteristics. The producers thus already know the options and can make decisions on simple gross margin budgeting methods. Furthermore, the role of various crops in the crop rotation system may not be based on a single objective like profit maximisation. Other disadvantages of programming methods include:

- The narrow focus on optimisation often disregards the range of combinations that are available with roughly the same margins but with different technical requirements, cash-flows, gearing ratios, etc.,
- The technical proficiency of a specific option often contributes more to the net margin than choosing the right combination,
- Maximising gross margin is short term and may differ from the other longer term goals of producers,
- Making programming techniques more realistic is a complex procedure that is often not operational or economical enough to be implemented by producers (Dillon & Hardaker, 1984:67; Malcolm, 1990:42-43 and Pannell, 1996:374),
- Mostly, programming models are not easily adaptable.

2.6.3 Simulation models

Simulation is defined as a form of experimentation, the objective of which is to represent or reproduce the relationships between real-world objects. The aim of simulation is to predict the likely response of these objects within the specific system (Gallagher & Watson, 1980:489; Nance & Sargent, 2002:163 and Strauss, 2005:12). Simulation is normally undertaken by mathematical models, but can also be based on other quantitative methods. The simulation method is general in the sense that it is not limited to a category of the problem or a specific method (Gallagher & Watson, 1980:490). Through simulation, researchers and decision makers have at their disposal a 'laboratory' technique to evaluate systems with the help of modern computer technology (Daellenbach & McNickle, 2005:463-464). The main advantage of simulation is that outcomes of different variables can be evaluated without actual observation of the outcome within the physical system. The physical system is therefore not disrupted. It also allows for the time-efficient and cost-saving evaluation of numerous alternative possibilities or combinations.

The components of simulation models include:

- Assumptions consisting of definitions and premises that set the boundaries for the model in terms of time, area, farming type, management quality and potential, and
- Implications connected to the assumptions by known interrelationships and dependencies (Brenner & Werker, 2007:228).

By 'running' the model, the implications of the set of assumptions are determined. Data is used in both components to formulate the assumptions and to test the implications. The same data can however not be used for both formulation and testing, as it will lead to a self-evident model.

The main advantages of simulation models as a research and decision-making tool include:

- Their ability to deal with a wide range of questions,
- Their ease of use and the variety of circumstances to which they can be applied,
- This might be the only method applicable to situations that cannot be observed,
- They allow for experimentation without using real systems and thus disrupting them,
- They can be applied to situations that cannot be 'solved' mathematically,
- Expected results are obtained in a much shorter time than it would take to collect survey data,
- They contribute to effective management and decision-making in that they require thorough understanding of the issue at hand before simulation (Redelinghuis et al., 1989:415), and

- Using simulations models supports a trial-and-error learning process by allowing rapid exploration of alternative management strategies at almost no cost (Cros et al., 2004:29).

The use of simulation methods in agriculture began in the late 1960s, motivated by the need to integrate research results. This need was caused by the fragmentation that resulted from specialisation in research (Wright & Dent, 1969:145). In agriculture, simulation models allow for detailed farm-level specifications and considerations within flexible structures (Weersink et al., 2002:133). Simulation models can provide 'new' information on the impact of factors in the decision-making environment in which producers operate on the farm, which reduces uncertainty. Simulation models can thus provide choices that serve as a platform where farm-level decision-making can take place. Historically, simulation models that are perceived by producers as accurate quickly tend to grab the attention of policy makers in agriculture (Keating & McCown, 2001:563).

Simulation is utilised in various specific situations in agriculture, such as crop growth modelling, yield models, crop response models, livestock growth models and livestock replacements models. In agricultural economics, deterministic and stochastic simulation models are widely used, depending on the type of system being modelled. Stochastic models contain random variables and relationships; the outputs of stochastic models are random elements or probability distributions. Deterministic models do not incorporate risk in the form of random variables, but as fixed values and relationships. Deterministic models simulate specific outcomes, given a set of specific inputs (Lust et al., 2009: 11 and Strauss, 2005:15).

A major disadvantage of simulation models is that, in their theoretical development, they can allow for so many conditions and variables that dialog between scientists and producers may be weakened. Consequently the compiler needs to explain the working of the model and the role of experts sufficiently. Another complaint against simulation models is that by nature they are not optimisation models, which mean that there is no guarantee that a best option will be identified (Weersink et al., 2002:133). Another disadvantage of simulation models is that the human behaviour factor is difficult to simulate and incorporate in models, especially in financial models, and is normally ignored. Validating simulation models can become a deep philosophical debate caught between objectivism and relativism (Kleindorfer et al., 1998:1096). The validity of simulation modelling as a tool is based on sufficient structure to provide stability and a means to validate the model itself. A balance needs to be found between keeping within the method of scientific inquiry while still allowing for enough freedom to stimulate innovativeness and creativity (Mihram, 1972:18).

2.6.4 Budgeting models

Budgeting is perhaps the most widely used method of financial planning. Budgeting, as a non-optimising method evaluates plans in physical and financial terms. The popularity of budgets stems from their simplicity of use and the fact that they aid in the heuristic approach to decision-making, rather than imposing an analytical framework on the decision maker (Rehman & Dorward, 1984:181). Budgets are often used as comparable quantitative techniques and play an important role in benchmarking. The development of computer technology introduced a dimension to budgeting methods that allowed budgets to be used as dynamic planning and decision-making tools. In this sense, budgets can now also be classified as simulation models that are based on accounting principles and methods, rather than purely on mathematics (Pannell, 1996:374). Used with caution alongside other holistic methods, budgets can be useful tools in assessing needs, aiding planning and undertaking participatory research and decision-making (Dorward et al., 1997:249).

Budgeting methods have been employed since the inception of agricultural economics and extension. During that time standard accounting methods were employed to generate comparable information for analyses and to serve as benchmark information (Malcolm, 1990:35). Throughout the development of other sophisticated quantitative methods in farm management, common budgeting approaches have been present and continually used. However, budgeting was considered straight forward and practical, and did not warrant much attention in academic literature (Malcolm, 1990:35).

Whole-farm budget models are in essence simulation models, normally developed using spreadsheet programmes. Within spreadsheet programs complex and sophisticated calculations and relationships can be expressed in a relatively simple way. The sophistication of budget models lies in their ability to allow for detail, adaptability and user-friendliness (Keating & McCown, 2001:557).The main contributions of budgets as participatory research tools are:

- Budgets can be developed to be based on and quantify resources other than financial ones,
- Budgets can usually be explained to participants and role players at any level of education (they are thus not restricted to users with high levels of education),
- Although budgets normally do not contain complex mathematical equations, they can accommodate a large number of variables and relationships, especially in the cases of break-even, partial, capital and whole-farm budgets,

- Performance indicators or criteria can be decided on by participants. (Dorward et al., 1997:250).

Whole-farm budgets are drawn up to show the anticipated consequences, in terms of selected criteria, proposed farm plans, parameters and policy options. Whole-farm budgets incorporate physical as well as financial parameters and usually produce profitability criteria such as net farm income or cash flow (Dillon & Hardaker, 1984:70). Some of the other quantitative techniques focus on optimising the whole farm gross margin. Whole-farm budgeting, however, quantifies and subtracts overhead and fixed costs to return a net farm income value. Net farm income is commonly used for a financial comparison of farming units. With some adaptation, whole-farm models may also be extended over time to calculate returns on capital invested and to calculate profitability indicators such as the Internal Rate of Return on capital investment (IRR) or Net Present Value (NPV).

The limitations of budget models are similar to those of simulation models. The most important criticism is their lack of an optimisation goal, or the possibility of their not returning a 'best' solution. Budgeting as a simulation technique requires a thorough understanding of the system being modelled, because the sophistication of the whole-farm budget lies within the number of relationships that can accurately be accommodated. The requirement of an intensive understanding of the system being modelled may also be an advantage if met successfully, as it increases trust in the model and method among other shareholders and participants. Often, validation of the model, rather than focusing on the essence of the problem, can become a philosophical debate, especially within expert discussions groups. To negate the validation problem, participants can be consulted from the early stages of the model's construction.

Despite criticism toward budgeting in farm management and agricultural economics, it is continually used in research and decision-making. The reason for this continual use may lie in the fact that whole-farm budgets allow for a sufficiently comprehensive view of farming problems in sufficient interdisciplinary depth to enable sound judgement about farm management actions. The argument is that it is better to roughly solve the whole problem or issue than to elaborately solve a part of the problem extremely well (Malcolm, 1990:48).

2.7 Requirements of different quantitative methods

The requirements of this research project on the quantitative method that will be implemented are discussed in Section 2.3. Table 2.1 shows how well each method is expected to cope with the requirements of this type of research project.

Table 2.1: The ability of the different modelling techniques to cope with the requirements of the model in this research project

	Modelling method			
Requirement	**Estimation models**	**Mathematical programming**	**Simulation models**	**Budgeting models**
Cope with complexity	No	No	Yes	Yes
Accommodate non-financial parameters	Yes	Limited	Yes	Yes
Quick return of results	No	Limited	Yes	Yes
User-friendly in terms of understanding	No	No	No	Yes
Allowing for large amounts of inputs and variables	No	No	Yes	Yes
Whole-farm perspective	No	Yes	Yes	Yes
Accommodating long-term financial evaluation	No	No	Limited	Yes

The key requirement of this study is examining the whole-farm profitability and the impact of factors that influence whole-farm profitability. Budgeting models can efficiently accommodate a large number of variables and evaluate the impact of factors that influence farm-level profitability. Most important, budgeting models can enhance the participation of experts within workgroups by being user-friendly and immediately showing the financial impacts of suggestions on farm level profitability immediately. The validity of the outputs of the models and the research project depends on the inputs of experts.

2.8 Conclusions

The approach of using creativity to identify ways to enhance profitability depends on the use of a pool of expert knowledge. Expert group discussions are required to bring together knowledge that may already exist but which may have become fragmented due to specialisation within different disciplines. Assessment of the farm system, which is multifaceted in nature, requires bringing together inputs from various expert disciplines. Another reason for the use of expert group discussions is the collective identification of ways of improving the profitability of grain farming.

The characteristics and dynamics of group discussions present an ideal situation for creative thinking. Creative thinking is necessary to identify ways of improving the profitability of grain production. Creative thinking among individuals is encouraged when they are confronted with alternative perspectives of looking at things. This could stimulate inventive and innovative thinking. However, the participants in the group need to be carefully selected, as the knowledge and experience that individuals bring to the group discussions ultimately determines their contributions. Two expert group methods that are in use were explored. The Delphi Method depends on the anonymity of participants, and communication occurs via questionnaires. In this research project, creativity among participants needs to be encouraged to generate new ideas for improving farm-level profitability. Creativity is stimulated specifically through direct interaction. Idealised design is used to stimulate creativity by doing away with all boundaries and designing a company from a zero base. In agriculture, there are a number of physical-biological factors and processes that could limit the use of a pure idealised design method. Expert group discussions, where experts from related fields in grain production are in direct dialog, stimulates creativity.

Quantitative methods used in research and decision-making cannot replace human judgement, but can enhance decision-making by scientifically comparing different alternatives. This chapter explored some of the quantitative methods used in agricultural economics and farm management. The four methods most commonly used in agricultural economics were explored.

The modelling approach can be positive where the aim is description of the system. A normative approach is followed where an object function is added; in other words the primary question is what ought to happen. Within each approach, various types of models exist, classified according to certain criteria. Models classified in terms of objective can include explanation-, prediction- or exploration varieties. Other typical criteria include the system being modelled, the underlying research approach, time, and the economics of agricultural production practices and sustainability.

Four categories of modelling methods are distinguished, based on the relationship between agricultural production economics and sustainability. Econometric models are statistical representations of farm-level systems that relate input demand and output supply information. Optimisation models replicate farm-level activities related to production and involve the specification of a behavioural function like profit maximisation. Simulation models are systems of equations designed to represent or reproduce the relationships between real-world objects to predict the likely response of these objects in the specific system. Accounting models use farm-level budgets (partial budgets, enterprise budgets, whole-farm budgets and cash-flow budgets) to assess farm-level activities, normally in terms of some profitability indicator.

Simulation modelling based on accounting principles, or budgeting, is best suited for this specific research project, as it allows for the evaluation of various factors affecting the long-term profitability of the whole farm. The most important characteristic of whole-farm budgeting is that the method is relatively simple, despite its ability to capture a vast number of variables. This is important when incorporating the inputs of producers and scientists who may not be from an agricultural economics background.

Chapter 3

Design and implementation of a method for capturing complexity and enhancing creativity

3.1 Introduction

Chapter 2 describes how creativity can be enhanced in group discussions. Various quantitative methods that deal with complexity have also been discussed. The whole-farm system is a complex object of enquiry, and identifying and evaluating strategies to enhance whole-farm profitability require inventive and innovative thinking. Chapter 3 describes how the proposed methods can be used in combination to examine the profitability of the whole-farm system and to promote creative thinking toward improving whole-farm productivity and profitability.

Chapter 3 starts by describing the design of the method that was used to develop the budget models with the input of a group of experts. The budget model had to be user-friendly and adaptable to support the group discussions effectively. The model was constructed in three phases. During each phase, the inputs of experts played an important role. The remainder of the chapter focuses on how the experts were identified and how the research was conducted to utilise the inputs of the various experts at the various stages of research.

The differences among the grain production areas of the Western Cape necessitated the delineation of the province into relatively homogeneous grain production areas. The homogeneous areas are described in terms of physical characteristics such as climate, soil and terrain. The characteristics of each homogeneous area and the resulting applicable grain production practices required were captured in a typical farm model for each homogeneous area. Chapter 3 ends with a description of the development of typical farm models, with a special focus on the principles that form the basis of the construction and use of the models.

3.2 Description of the model's design, and use, and role of group discussions

It was established in Chapter 2 that the assessment of a multifaceted object, such as a farm, depends on combining lay and scientific knowledge. The reason for this is to generate trustworthy and valid information regarding the financial performance of farming in each homogeneous grain production area of the Western Cape. Establishing feasible options for improving whole-farm profitability logically requires a description of the current financial situation in which producers find themselves. Describing the current financial situation can be achieved by doing a survey and generating information to describe the average or median investment, income and cost structures. However, a survey would only serve as a diagnostic tool. A whole-farm budget model can capture the complexity of the whole farm, which is a combination of physical-biological factors and socio-economic factors, expressed in financial terms. The budget model requires validating the model itself, which is done by the expert group discussions. The validated model can then be used for the second part of the research, which aims at identifying strategies that could improve the profitability of the whole farm.

Figure 3.1 presents the research design in terms of the three different levels of knowledge and indicates the sources of the relevant knowledge utilised in the study. During all the phases of the model's construction, validation and utilisation, the knowledge of various experts involved in various domains of farming were utilised. Producers as the decision makers were included as an integral part of the research process. The main contribution of this project is to establish a process to support strategy development, and hence the use of models and group discussions in Phase Three of Figure 3.1.

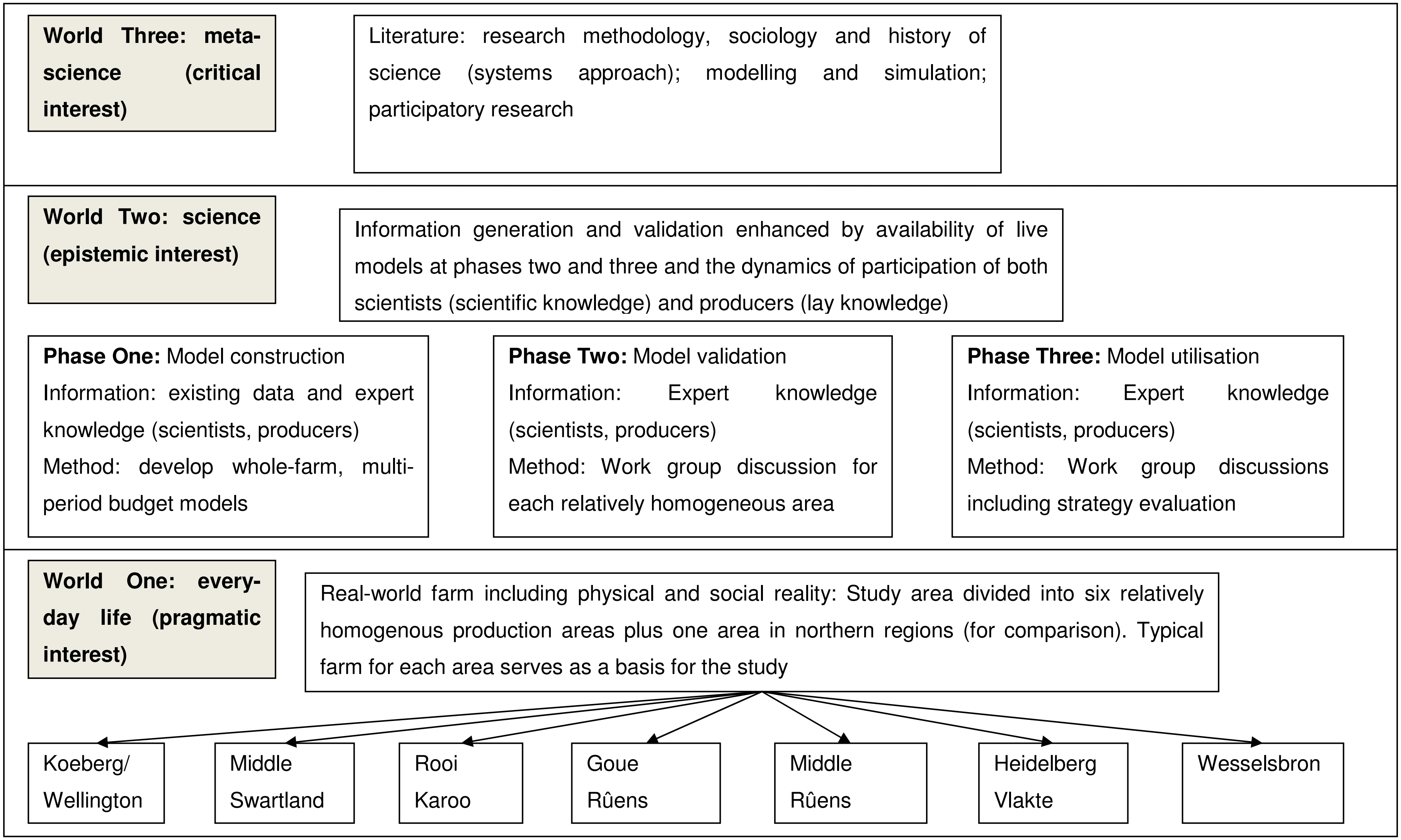

Figure 3.1: Schematic presentation of the method, and the various techniques, tools, information and people involved

This research project consisted of three distinct phases, embedded in World Two, the first of which was the model's construction phase. The theoretical foundations, such as systems concepts, modelling and simulation, and participatory research are founded in the world of the meta-science. Such knowledge is incorporated through literature overviews, as were described in Chapter 2. During the model's construction phase, the relatively homogeneous areas were identified and described. The model's construction also included a definition and description of the typical farm for each relatively homogeneous area described in physical-biological and socio-economic terms. The whole-farm, multi-period budget models, which describe the typical farm in financial terms, were the result of the model's construction phase. The aims of the models are, firstly, to describe the current financial situation of the typical grain farm and, secondly, to serve as a method for evaluating various strategies to increase the profitability of the typical farm.

A separate model was constructed for each homogeneous area, due to the specific and unique nature of the farms in the various relatively homogeneous areas. The typical farm for each homogeneous area differs from others in terms of size, crop rotation systems, yield potential, capital investment, machinery replacement policy, input levels, and fixed cost structure. Each area has its specific challenges confronting the grain producer, which contribute to the uniqueness of the areas. All of these factors are discussed further from Section 3.4 onwards.

Phase Two consisted of validation the model's which was achieved through various workgroup discussions consisting of experts from various related fields. A workgroup discussion was held for each homogeneous area in the Western Cape, with time allocated for explaining, evaluating, adapting and validating the model for each homogeneous area. The outcome of this exercise was to assess the budgeting method and the models for their ability to accurately describe the current financial performance of the typical grain farm.

Six iterations of model validation took place, allowing for a thorough discussion for each homogeneous area. Participants were encouraged to highlight and discuss the specific and unique issues and problems for each specific area. The success of the discussions depends on active participation and contribution of specialists. Each participant brings specific and unique contributions in the form of experience or knowledge to the discussions. The simultaneous consideration of discussion points from various domains of specialised knowledge relating to a specific issue forced participants to acknowledge and consider various options and opinions, which often fell outside of the individual's normal field of expertise. This added validity to the information generated by the whole group.

During the model's utilisation phase, they were used within the workgroup discussions to evaluate the impact of various proposed strategies on whole-farm profitability. All suggestions were critically evaluated by scientists and producers. Factors that were perceived to be most influential regarding the impact on profitability were also identified by the expert group. The workgroup was challenged to keep suggested changes to the farm system within recommended sustainability parameters. The model's utilisation phase delivered various feasible suggestions and options expected to improve farm-level profitability. The main advantage of supporting creative thinking by the expert group discussion through using the model was that suggested changes to the farming system could immediately be evaluated financially to determine whether the suggested change justified further exploration.

3.2.1 Incorporation of expert knowledge in the model's construction phase

Critical evaluation of the financial performance of a dry-land grain production farm requires in-depth discussions and validation of the aspects shown in Figure 3.1. Experts from various fields were required to establish and quantify the factors and interrelationships of the farm system.

One of the prerequisites of the use of simulation methods, and especially budgeting, is a thorough understanding of the object of the study, in this instance the typical farm. The incorporation of producers and scientists in the model's construction process ensured that the farm was accurately simulated. The main contributions of producers - experts in real-world knowledge - were the physical description of the typical farm and the rotation systems, and the identification of factors that are especially influential with regard to farm-level profitability. The producers could also establish the sequence of events on the farm, which determined the mechanisation requirements.

Scientists from various disciplines, such as agronomy, soil science, entomology, plant-pathology and mechanisation, were consulted while the models were being constructed. Scientists are able to describe the input-output relationships accurately and quantify the expected sensitivity of certain variables on whole-farm output. The main contribution of scientists was the establishment of norms regarding input/output relationships. During the model's construction phase, the scientists also helped to establish the sustainability of crop rotation systems. For example, the effect of black-stem in canola limits canola production to once in four years on a particular field. This explanation saved time during the group discussions as it provided a valid reason for not including canola more regularly in the crop rotation system.

3.2.2 The selection of participants in the multi-perspective group discussions

Exploratory research is one of the primary reasons for the use of multi-disciplinary group discussions. Section 2.2.2 described the way knowledge is created within group discussions, where different perspectives stimulate creative thinking and help verbalise new ideas. Experts are challenged with issues where they need to rely on their knowledge and experience to generate new information. With the aim of promoting individual and group creativity, two factors require attention. The first factor is an environment that consistently challenges the individual's current perception, which could enhance inventive and innovative thinking, which in turn, depends on interaction with other experts. The other factor is combining the appropriate intellectual resources as the basis for creativity.

An important reason for having appropriate representation within the group is to prevent group bias. If, for instance, all group members are from a farming background, a biased opinion about certain issues can be expected. The group discussion process depends on the variety of expertise among participants and their active participation in the discussions. The dimensions of the farm system dictate which disciplines should be represented.

The process of selecting appropriate group participants was mostly guided by the fields of expertise required at the discussions or consultations. For this purpose the group discussions included experts and researchers from the fields of agronomy, crop protection, plant pathology, soil science, agricultural economics, agri-business, agricultural mechanisation and production. The first group discussion aimed at identifying the homogeneous areas and physical properties of the typical farms. For these group discussions, climatologists and an expert on GIS (geographical information systems) were included.

The specific individuals representing each scientific discipline were selected, by identifying the foremost-recognised researcher within that specific field within the Western Cape. The producers were identified through the local agribusinesses in the grain producing areas of the Western Cape. The representatives of the local agribusinesses identified the ideal producers for each of the homogeneous areas, based on active participation in producer study groups, industry information days, competitions and research. The role of the various participants will be discussed next.

3.2.2.1 The role of the chairperson

The chairperson's core role included balancing the focus of the discussions on the relevant issues and stimulating innovative and creative discussions. Providing an early and accurate description of the focus of the discussion, in this instance the typical farm via the budget model, prevents a diagnostic exercise in model validation as opposed to developing innovative and acceptable interventions (Janssen & Goldsworthy, 1996:276).

A thorough understanding of the research requirements and goals, as well as sufficient experience in chairing group discussions was thus required. Identification of an appropriate individual to chair the discussions was based on two criteria. The first criterion was a thorough understanding of the project and the relevant issues. This would ensure that a balance could be maintained between, on the one hand, establishing the validity of the method and the model by reaching consensus on the farm structure and results and, on the other hand, innovative and creative discussions aimed at improving whole-farm profitability. The second criterion that would contribute to the efficacy of the chairperson was that he or she would be well known in the Western Cape and specifically in the grain industry. Participants would thus feel at ease to share relatively sensitive information.

Some of the more prominent dangers that could restrict the effectiveness of group discussions, which should be managed by a chairperson include:

- The hasty formulation of preconceived ideas and a disregard others' ideas,
- The 'central tendency' effect where participants follow and defend a central line of thought,
- The influence of dominant personalities, which could pressure other members to conform,
- The often-dominating effect of superfluous and irrelevant information (Kenis, 1995:4).

3.2.2.2 The role of scientists

Scientists from various fields such as agronomy, soil science, entomology, plant pathology, pasture management and animal science participated in the group discussions. At the first workgroup discussion, meteorologists and a Geographical Information Systems (GIS) expert were also part of the group discussions. As could be expected, the contribution of the scientists was mostly of a technical nature and was important in terms of quantifying suggestions. Suggestions made by economists or producers where the technical implications could be quantified by scientists included:

- Yield effects of specific cultivation practices,

- Input levels for crops for specific areas, within specific crop rotation systems and especially for crops not currently produced in a specific area (e.g. Indian mustard in the Rooi Karoo area),
- Field capacities for various machines and implements,
- The yield and input effects on crops of previous crops in the crop-rotation systems,
- Labour requirements and other overhead expenses, and
- The feasibility of changes to crop rotation systems and livestock enterprises, and the incorporation of new crops.

The scientists played a pertinent role in establishing the relationship between yield and rainfall, which forms the basis of the incorporation of climatic risk. Most of the scientists, by the nature of their research and exposure to industry, also thoroughly understand the industries and whole farm situations. They were thus already well equipped to understand the farm situation and limitations to possible alternative strategies.

3.2.2.3 Agricultural extension officers from agribusinesses

The strength of the agricultural extension officers from local agribusinesses is their exposure to broader industry-level issues, as well as their exposure to a broad variety of farm situations. These individuals are mostly technical advisers to producers, which means that they are exposed to a wide variety of specific problems, challenges and production methods. They are also ideally positioned to participate in the construction of typical farm models as they normally have access to, or manage, producer study-group data.

The agribusiness extension officers contribute toward identifying critical issues, describing limitations to suggested strategies from an industry level, and describing and identifying the homogeneous areas and typical farms. Their exposure to a variety of farming situations also allowed them to identify and express the dangers that certain proposals might have had. For example, the farm-level profitability of the Middle Swartland area reacts positively to more cash crops incorporated in the crop rotation system. The present danger and problems with weed resistance to herbicides, however, necessitates a break in the cultivation cycle to allow for alternative methods of weed control, such as mechanical control or grazing.

3.2.2.4 The role of producers

The strength of the producers is their practical knowledge and expertise with the farm system, as they are the practitioners of farm management. Producers thus contribute lay knowledge. The main contributions of the producers concerned the practical implications of suggested strategies made by other participants. For instance, the effect of alterations to crop rotation systems on the mechanisation and overhead cost requirements of the total farm were instantly quantified by producers. The producers also supplied information on the crop rotation systems initially used in the models. Their expertise showed, as their arguments for specific crop rotation systems and the inclusion of crops at specific stages of the crop rotation system were always well motivated. Most of the participating producers had some agricultural education, either at college level or at university level. This further enhanced their ability to relate practice to scientific principles.

The producers' awareness of issues surrounding sustainability and environmentally friendly production methods contributed to the structure of the models and production methods. The producers further contributed by identifying feasible alternatives and strategies for improving whole-farm profitability. Examples of such alternatives included cost-effective methods to implement minimum tillage at a fraction of the costs of newly bought planters and equipment, the combination of activities such as certain insect and disease spray activities, effective methods of increasing the livestock enterprise and managing overhead costs. Some of the strategic options described in Chapter 4 were suggested by producers.

The producers further contributed toward describing the relatively homogeneous areas and the structure of the typical farm for each area. Unique problems and challenges to each area were described mainly by the producers, providing challenges for the rest of the participants to solve.

3.2.2.5 The role of agricultural economists

The main contribution of the agricultural economists was their quantification of suggested improvements to the farm system in financial terms. Suggestions made by other participants had to be expressed in financial terms for the farm models to calculate the expected effect on profitability. The first phase of the research, namely, model construction, was conducted by agricultural economists, who were able to translate physical-biological and socio-economic data and inputs into financial data. The agricultural economists' understanding of the relative contribution of specific variables to profitability helped the groups to focus on these variables. These variables included capital investment requirements, age of machinery, interest rates, investment to cultivated area relationships, crop yields and fixed costs. Economists can also create greater awareness to the affect of off-farm issues because of their wider understanding of economic, environmental and social issues that impact at the farm level. Such issues include policy issues, international trends, social responsibility, market trends, costs of land, machinery costs and hidden costs, such as provision for replacements of livestock and machinery.

3.3 Relatively homogeneous grain production areas in the Western Cape

The first step towards constructing farm models that producers can generally relate to involved identifying relatively homogeneous production areas. The variation in climate, terrain and soil necessitated that the total production area of the Western Cape be divided into smaller, more homogeneous areas. The expert groups were used to validate these homogeneous areas. The areas were specified by consulting the literature and visiting various experts before the group discussions took place (ARC Small Grains Institute, 2003:*i.*; Barnard, 2007; Haasbroek, 2007; Lusse, 2007; Van Eeden, 2000:22 and Wallace, 2007). In principle, it was decided to decrease the size of the homogeneous areas to allow for higher homogeneity, especially in the Southern Cape.

3.3.1 Definition and identification of homogeneous grain production areas

Relatively homogeneous production areas were used to distinguish the areas. In identifying the homogeneous production areas, other characteristics were included, such as farming practices, typical crop rotation systems, typical machine replacement policies and affiliations to agribusinesses. The Western Cape, in terms of grain production, can be divided into the Swartland and the Southern Cape regions. The Swartland region covers the area from Durbanville, north to Eendekuil, and from the West coast to the Groot Winterhoek mountains, to the East. The Southern Cape stretches from Botrivier to Riversdal, between the coastline and the Sonderend and Langeberg mountain ranges. Within each region, three homogeneous areas were identified. In the Swartland, the three areas are Koeberg/Wellington, the Middle Swartland and the Rooi Karoo. The three areas in the Southern Cape are the Goue Rûens, the Middle Rûens and the Heidelberg Vlakte area. The geographical locations of these areas are indicated in Annexure B.

The description of the homogeneous areas was presented and discussed in Workgroup Discussion One (Annexure A). In preparing work for this session, the areas were identified with the help of a number of individual producers and representatives from the local agribusinesses. Data from farm study groups and data from the agribusinesses were used to initially identify the areas. During the model's construction phase, producers and scientists were involved in validating the delineation of the areas.

One other area was included in the research project, the Wesselsbron area in the Northern Free State, which served as a comparison for the Western Cape producing grain areas. The Northern Free State area was not included in the workshops to determine strategies for the areas, because it served only to compare certain factors, like machinery usage, yields, distance from the markets (effect of the transport differential) and climatic risk.

3.3.2 Climatic characteristics

An important distinction that needs to be made between the homogeneous areas is based on total annual rainfall and rainfall dispersion throughout the season. The impact of rainfall and rainfall dispersion on crop performance is established in this section. Good, average and poor years based on rainfall and rainfall dispersion were defined, and a typical prevalence of such years over the longer term was established. This prevalence of good, average and poor years represents yield risk in the models.

3.3.2.1 Rainfall and rainfall distribution

The availability of sufficient moisture during the crucial plant growth phases is the most influential factor that determines crop yields. Sufficient moisture availability is determined by the balance between precipitation and evaporation/transpiration, which is mostly influenced by heat and wind. In the Western Cape, wheat yields are 85 percent correlated to rainfall (Parkendorf, 2007). A relationship comprising a yield increase of 5 kg per ha for every 1 mm increase in rainfall above a minimum average annual rainfall of 110 mm is shown by Australian models (Hardy, 2007).

From a climatology point of view, the factors that influence rainfall in the winter rainfall areas are complex and numerous and include global weather patterns, upper-level atmospheric circulation, oceanic variability and sea temperature. The characteristics of the land that also impact on rainfall includes height above sea level, the distance from the coastline, and natural barriers like mountain ranges (Xoplaki et al., 2004:63-64 and Valero et al., 2004:310). The result is extremely high inter-annual variability of precipitation, making it impossible to detect long-term trends and patterns accurately. If trends cannot be identified, predicting the future occurrence of wet and dry seasons is highly risky.

The Swartland area has a high concentration of rainfall in the winter. More than 80 percent of the total annual rainfall is concentrated between March and October. The area is classified as temperate with dry, warm to hot summers. The Southern Cape is categorised as temperate with warm summers, but without a specific dry season (Peel et al., 2007:467). Rainfall for the Southern Cape is more dispersed. The Goue Rûens area typically receives 70 percent of its rain in winter and 30 percent of its rain in summer. Towards the Heidelberg Vlakte the summer to winter rainfall dispersion is closer to 60 percent:40 percent. (Cerfonteyn, 2007; Wallace, 2007 and Workshop discussion [Annexure A]).

Total rainfall for the season is not as important as the dispersion of precipitation during the growing season. Various examples were presented during the workshop discussions of relatively low yields obtained per hectare, despite relatively high total seasonal rainfall, due to high concentration in specific months (and vice versa.) The 2003 season is an example where relatively low total rainfall, but during the critical stages of plant growth, led to relatively high yields. Normally the canola yield is more susceptible to lower rainfall than wheat. The 2006 season in the Southern Cape was extraordinary, when higher than expected yields were attained for canola compared to wheat. Lower rainfall areas are more susceptible to rainfall risk than the higher rainfall areas.

During the workshop discussion it was established that there is currently no model for winter grains used in South Africa that predicts yields for small grains based on physiological and physical parameters. This is probably due to the complexity of predicting rainfall and crop yields among a variety of factors.

3.3.2.2 The prevalence of good, average and poor yields and associated crop yields

To accommodate crop yield risk in the models, the prevalence of good, average and poor years needed to be identified. For this purpose, daily and weekly rainfall information for each area, obtained from local weather stations, was compared with yield data from the silo intakes to try to establish the amount of good, average and poor production seasons and their dispersion over a 10-year period. Various factors impeded this approach. One of these factors includes poor correspondence between silo throughput and total yield. This is due to producers utilising other means of marketing their products. There is inadequate rainfall time-series data for all areas. In some cases, rainfall data is available for more than 20 years, but some weather stations have only been operating for seven years or less. In the end, the prevalence of good, average and poor years for each area was established based on workgroup consensus.

The workgroup agreed that a trend in the sequence of wet and dry years could not be predicted, which is in accordance with the literature (refer to Section 3.3.2). A definite distinction can however be made between good, average and poor years as determined by rainfall and rainfall dispersion. The budget model runs over a twenty-year calculation period, which means that the number of good, average and poor years will have an impact on the profitability of the farm, especially the expected cash flow. The definition for each is as follows:

- A good year is when the rain falls at exactly the right times in relation to the water requirements of the crops. This means sufficient rain for planting, with good follow up rain that increases throughout the growing season and peaks during seed filling, and then decreases towards harvesting time.
- An average year would mean sufficient total rainfall for the year. It deviates from a good year in that rainfall may be late for planting, of falls mostly during planting and then level off towards seed fill, or there may be too much rain towards harvesting time.
- A poor year would entail receiving sufficient rain, but too late for planting, followed by a decrease in rainfall through the crucial growing phases or a concentration of rainfall at harvest time. A poor year can also be caused by a drought.

The workgroup allocated typical yields for each crop according to the above-mentioned definitions. Table 3.1 shows expected yields for good, average and poor years along with their frequencies for wheat, barley and canola for each homogeneous area. The prevalence of good, average and poor years out of ten years for each region gives a good indication of the production risks involved in crop production.

For the Wesselsbron area, wheat and maize are the main crops cultivated. The Wesselsbron area is a summer rainfall area and is classified as temperate with dry winters and warm to hot summers (Peel et al., 2007:467). The Wesselsbron area is also characterised by deep soils, up to 150 cm, with high water storage capacity. The way producers utilise this soil and climatic characteristics to counter the dry winters is by fallowing fields during the summer to allow for water level build up. This water is sufficient for the planting phase and lasts almost up to the seed fill phase (Botha, 2007). At planting time, producers thus have an indication of the availability of water for, at least, part of the growing season, which decreases production risk.

Table 3.1: Expected yields and associated prevalence of good, average and poor yield years for wheat, barley and canola

Area/Year	Wheat		Barley		Canola		Grazing capacity
	Yield (t/ha)	In 10 Years	Yield (t/ha)	In 10 years	Yield (t/ha)	In 10 years	Ewes/ha pasture
Swartland:							
Koeberg/Wellington							2.5
Good	4,1	3	-	-	2,0	3	
Average	3,5	6	-	-	1,5	5	
Poor	2,5	1	-	-	1,0	2	
Middle Swartland							2.1
Good	3,0	2	-	-	1,8	2	
Average	2,4	7	-	-	1,4	6	
Poor	1,8	1	-	-	0,8	2	
Rooi Karoo							2.0
Good	2,0	1	-	-	1,5	1	
Average	1,5	5	-	-	1,0	4	
Poor	0,7	4	-	-	0,5	5	
Southern Cape							
Goue Rûens							2.8
Good	3,5	4	3,3	4	1,6	3	
Average	2,9	5	2,7	5	1,3	3	
Poor	2,3	1	2,1	1	1,0	4	
Middle Rûens							3.0
Good	2,5	3	2,5	3	1,5	3	
Average	2,2	5	2,2	5	1,2	3	
Poor	1,8	2	1,8	2	0,8	4	
Heidelberg Vlakte							2.0
Good	2,4	2	2,4	2	1,4	2	
Average	2,0	4	1,8	4	1,1	4	
Poor	1,5	4	1,5	4	0,8	4	

For the Wesselsbron area, the crop yield variation between years is less because producers base planting decisions on some certainty. Fallowing fields throughout a summer within an established crop rotation system restricts producers in terms of areas available for planting. Only two thirds of the available productive land is used in any one specific season; the other third is mostly utilised for grazing for livestock. Table 3.2 shows the yields for wheat and maize for the Wesselsbron area.

Table 3.2 Wheat and maize yields for the Wesselsbron production area

Crop:	Yield (t/ha)	In 10 years
Wheat		
Good year	3.5	3
Average year	2.9	6
Poor year	2.3	1
Maize		
Good year	5.0	4
Average year	4.0	5
Poor year	3.0	1
Grazing capacity (ewes per ha pasture)	**1.5**	

3.3.2.3 Livestock carrying capacity of pasture

Livestock enterprises are important components in all of the production areas. Livestock was brought into the cropping system for diversification, enhancement of profitability and the utilisation of land resources that are unsuited to crop production. In some areas, the implementation of a grazing phase breaks the life cycles of diseases and pests. It also presents alternative methods for weed control. Annual income from livestock is not influenced by annual rainfall distribution to the same extent that it influences cash crop yields. The grazing capacity of pasture in the models was expressed in terms of ewes per hectare. This principle standardises and simplifies the discussions. Tables 3.1 and 3.2 include grazing capacity for all the homogeneous farming areas.

3.3.3 Terrain and soil description of the homogeneous areas

Dry-land grain production in the winter rainfall areas of the Western Cape depends mainly on climate and soil. Section 3.3.2 describes the effect of rainfall and rainfall dispersion on the crop performance of each area. Table 3.3 contains a description of the terrain and soil characteristics for areas in the Swartland region. The characteristic that stands out is that soil in this region is mainly shallow or at the most medium-deep. Deep soils are usually sandy. The importance of this fact is the restricted water retention capacity of the soil. This means that irregular rainfall over the production season will likely lead to crop yield losses.

Table 3.3: Land and soil description for homogeneous areas in the Swartland

	Koeberg/Wellington	Middle Swartland	Rooi Karoo
Size of area	71 936 ha	369 868 ha	377 158 ha
Description of terrain:	Relatively flat, drainage problems	Rolling plains, gradients moderate, low-lying areas poorly drained	Rolling plains, gradients moderate
Description of soils:	Medium-deep, wet duplex soils; Medium-deep soils on shale, sandstone or granite; Medium-deep, wet, saline alluvial soils	Medium-deep duplex soils; medium deep soils on shale, sandstone or granite; Medium-deep, well-drained red soils; Red, dry and structured sands	Poorly drained, medium-deep to deep yellow and white sand; Dry red structured sands, shallow red or yellow sand, and medium-deep saline alluvial soils
Most common soil profiles:	Kroonstad, Estcourt, Pinedene, Glenrosa, Swartland, Westleigh, Dundee, Fernwood, Lamotte and Constantia	Kroonstad, Estcourt, Glenrosa, Swartland, Hutton, Clovelly, Sterkspruit, Fernwood, Lamotte and Constantia	Fernwood, Lamotte, Constantia, Hutton, Kroonstad, Clovelly, Swartland, Sterk-spruit, Oakleaf, Westleigh and Dundee

Source: Western Cape Department of Agriculture. 1989. Opbrengsnorme en Produksietegnieke vir Aangepaste Akkerbou- en Weidingsgewasse en Veevertakkings onder Droëlandtoestande in die Wes- en Suid-Kaapland. Burger report, Elsenburg.

Table 3.4 contains terrain and soil descriptions for areas of the Southern Cape region. It is important to notice that the soils are mostly shallow. The steep gradients, especially in the Goue Rûens, which is the high potential area, necessitate the use of heavier machinery for planting, soil preparation, spraying and harvesting.

Table 3.4: Land and soil description for homogeneous areas in the Southern Cape

	Goue Rûens	Middle Rûens	Heidelberg Vlakte
Size of area	86 724 ha	46 386 ha	43 715 ha
Description of terrain:	Undulating areas, steep gradients influence mechanisation needs	Undulating, gradients moderate in relation to Goue Rûens	Flat area relative to the other areas in the Southern Cape
Description of soils:	Shallow soil on shale or granite; Shallow, dry, non-red, structured and/or duplex soil; Dry red, structured duplex soil; Deep well-drained alluvial soils.	Shallow soil on shale or granite; Shallow, dry, non-red, structured and/or duplex soil; Dry, red, structured duplex soil; Deep well-drained alluvial soils; Low-lying wet saline duplex or structured soils	Shallow soil on shale or granite; Shallow, dry, non-red, structured and/or duplex soil; Medium-deep soils on shale, sandstone or granite
Most common soil profiles:	Glenrosa, Mispah, Swartland, Sterkspruit, Valsrivier, Oakleaf and Dundee.	Glenrosa, Mispah, Swartland, Sterkspruit, Valsrivier, Oakleaf Dundee and Katspruit.	Mispah, Glenrosa, Swartland, Estcourt Sterkspruit, Glenrosa, Kroonstad, and Pinedene.

Source: Western Cape Department of Agriculture. 1989. Opbrengsnorme en Produksietegnieke vir Aangepaste Akkerbou- en Weidingsgewasse en Veevertakkings onder Droëlandtoestande in die Wes- en Suid-Kaapland. Burger report, Elsenburg.

The Wesselsbron area consists mainly of deep sandy and loamy soils with a high water retention capacity, with only slight gradients. The cultivation methods to take advantage of the deep soils were discussed in Section 3.3.2.2.

3.3.4 Crop rotation systems

Crop rotations systems are employed to enhance sustainable land use. The advantages of crop rotation are well known and include the following:

- Enhanced soil fertility due to nitrogen fixing, of for instance, legumes such as alfalfa and medics (Wasserman, 1995:1-3),

- Yields of successive crops are positively affected; for instance, wheat yield increases when planted after canola, medics or lupines, as opposed to wheat planted after wheat (Hardy, 2007),

- Protection of crops by the break in diseases, insect and weeds life cycles, which also allows pests' natural enemies the opportunity to attack them,

- Certain chemicals can be used in combination with certain crops. In this regard, weed resistance to herbicides is an especially sensitive and growing problem (Cairns, 2007; Cummings, 2007 and Pieterse, 2007),

- Financial performance can also be enhanced as risk can be decreased, while the profitability of the whole farm can be increased (Hoffmann, 2001:82),

- Stabilisation of the farm's cash flow especially with the incorporation of a livestock enterprise, and

- Utilisation of expensive mechanisation is dispersed over a longer period, which brings down investment requirement as well as overhead and fixed costs.

The crops that can be included in a crop rotation system depend on two factors. The first is the crop growing potential determined by the climate, terrain and soils. The second factor is the availability of a well-functioning market for the product. The crops used in the crop rotation systems were discussed as part of the workgroup discussions and are as follows:

- Wheat production is part of most systems on each of the typical farms. Wheat is produced mainly for human consumption in the form of bread, pasta and confectionary. On a limited number of farms in the Swartland, wheat monoculture is still being practiced. Two consecutive wheat productions somewhere in a crop rotation system is however still a common production practice in the Koeberg/Wellington area as well as the Middle Swartland.
- Barley is grown in the Southern Cape, especially in the Goue Rûens and Middle Rûens. Barley is utilised as malt barley or for animal feed. The malt barley industry is well established. The characteristics of barley within a crop rotation system are the same as for wheat. Due to high temperatures in late winter and spring in the Swartland, the quality of

barley produced there is not high enough for brewing; therefore, barley does not feature as a crop in the Swartland.

- Canola is an oilseed crop and part of the *Brassica* family. Due to the prevalence of black-stem, production of canola is limited to only once in four years on a particular field. In a crop rotation system, canola has a positive effect on the subsequent wheat crop yield (a 22 percent increase can be expected). Input levels in terms of fertilisation and chemicals are lower for wheat produced after canola than for wheat after wheat or other grains. During the canola phase, as a broad-leaf crop, different herbicides can be applied compared with a grain phase. This limits the build-up of resistance from weeds to specific chemicals. The canola market is well developed and canola is utilised, in the form of edible oil, for human consumption, and for the animal feed market.
- Lupine has a high protein content and is utilised for animal feed or directly for grazing. Lupine is a legume with the characteristic of nitrogen fixing, which contribute to higher yields for successive crops in the crop rotation system.
- Oats is used mostly for animal feed in the form of direct grazing or silage. There is a market for oats in the cereals industry, but this market is relatively limited in size (De Lange, 2007). Oats as a grain crop in crop rotation systems behaves in the same way as other grains.
- Triticale is utilised solely for animal feed and is mostly used on farms for their livestock enterprises. The limited demand for triticale means that the price for triticale is derived from the price of feed-grade maize. Triticale is currently being investigated as a potential input in bio-ethanol production. Triticale has the advantage of being more resistant to various diseases than wheat, possibly due to current limited plantings (Botes, 2007). Triticale fetches higher yields than wheat does in marginal sandy soils.
- Medics is part of the clover family and is used for pasture in the Swartland area. Medics re-establishes itself if properly managed. Medics results in higher yields for subsequent cultivation of wheat (due to nitrogen fixing) in a crop rotation system. A broad-leaf phase is ideal for breaking life cycles in various diseases, weeds and pests. It is well adapted to the Swartland, as the dry and warm summers are not suitable for alfalfa production. Medics is not well adapted to sandy soils and soils with a high alkalinity.
- Alfalfa is a perennial legume pasture crop with a nitrogen fixing capability. The fact that alfalfa requires rain all year limits its use to the Southern Cape area (refer to Section 4.4.3). Alfalfa is normally grazed directly, but it is baled when good rains allow good yields.
- Maize is a summer grain crop and is produced for both human consumption and animal feed. Maize is the most produced grain in South Africa and the market for maize is well developed, and trade contracts on the SAFEX futures market. Of the areas covered by this study, maize is produced only in the Wesselsbron area

The specific cropping system employed in each area is described in Chapter 4. Chapter 4 also include a description of a typical farm that was identified for each relatively homogenous area with the help of various experts.

3.4 The budget model

The financial performance of the typical farm is influenced by various factors. The factors that directly or indirectly influence prices and quantities of outputs and inputs are the most influential in terms of their effect on profitability. Some factors can, to some extent, be managed or influenced by management. Other exogenous factors are completely beyond the influence of individuals or even groups of producers. These factors are typically determined in the market- and macro environments. They impact on the farm in the form of input prices, product prices and crop yields. The potential impact of these factors on the profitability of the typical farm needed to be established. This was done by the developing whole-farm, multi-period budget models.

The purpose of developing the budget model for each homogeneous area was twofold. Firstly, the models were used to determine the current financial position of the typical farm for each homogeneous area. Secondly the models were used to measure the impact of proposals by the expert groups in terms of established financial criteria. Because the models immediately calculated the financial impact of suggestions, this added another dimension to the group discussions, which enhanced creative thinking.

To establish the current financial position of each farm, the complexity of the farm needed to be captured. The factors and interrelationships that influence and determine profitability were incorporated in such a way that these factors could be manipulated and could instantly show the financial impact on the entire farm. Whole-farm, multi-period budget models were developed for each area. Budgets allow for the incorporation of large numbers of variables, which allow for accurate reflection of the factors and interrelationships that influence the financial performance of the total farm. The models consist of various sets of data and calculations that are interconnected and are based on standard accounting principles and methods.

Numerous adaptations in terms of farm size, crop rotation system, input costs, interrelationships, investment, replacement of machinery, price levels and own versus borrowed capital can be accommodated in a spreadsheet budget model. The model was developed to be able to take into account all the factors and functions illustrated in Figure 2.1. Spreadsheet programs, through the range of functions available, enable incorporation of a wide range of parameters, interrelationships and inputs. The number of variables that can be incorporated is limited only by the expertise and creativity of the modeller. It must be stressed again that whole-farm modelling requires a thorough understanding of the whole-farm system, and thus requires extensive preparation.

The components of the calculation model are shown in Figure 3.2. It illustrates the input component, calculation component and output component of the budget model. Each component consists of various parts.

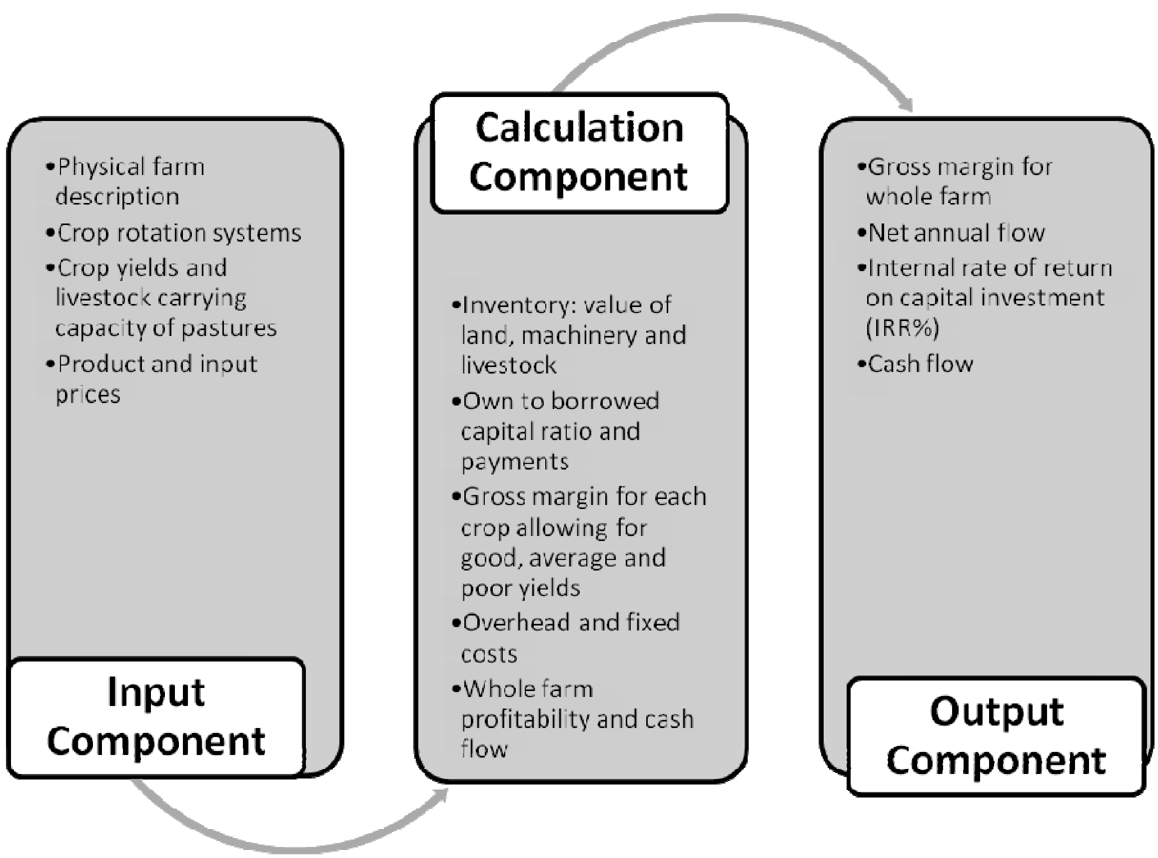

Figure 3.2: A graphic representation of the components of the whole-farm, multi-period budget model

3.4.1 The input component

The input component consists of the description of the physical farm description, land use patterns, crop rotation systems, yield assumptions, input prices and output prices. All of these factors can be adapted, which will immediate impact on the output component.

3.4.1.1 Physical description of the typical farm

The aim of using a typical farm is to represent a farm with physical parameters to which producers in a particular area can relate. The physical and financial extent of the typical farm for each area was established in three phases. The first phase consisted of an initial description of the farm in physical terms. Producer study-group information, obtained from the local agribusinesses, was used for this exercise, to establish typical farm sizes, land use patterns, machinery and equipment layouts, overhead and fixed cost structures and labour employment. The producer study-group data have mostly been converted into averages, which can be misleading, due to the effect of outliers. From the study-group information, the mode for each of the aforementioned aspects was established. The mode is the point around which data is most heavily concentrated and that is closest to the definition for a typical farm. This method was used to establish the physical extent of the typical farm described in terms of farm size, land ownership, land use pattern, mechanisation infrastructure, livestock replacement policy and overhead and fixed costs.

The systems nature of a farm demands that the relationships between physical-biological and socio-economic factors be incorporated into the model. For example, interrelationships between factors such as farm size and the mechanisation layout and livestock enterprises should be captured by the model. The model would then automatically be able to adapt mechanisation requirements to changes in farm size. A statistical calculation was thus used only to establish the initial farm sizes that were presented during the group discussions. In the model, the interrelationships were captured with various calculations. Another reason why validation of the typical farm described was required was because participants in producer study groups often do not represent a true reflection of the whole population, but rather the top third or top half of the population.

After the budget model was developed and before the first group discussion took place, the model was tested. This involved visits to individual producers and the representatives from the agribusinesses in each area, to test the model for accuracy. The typical farm was 'tested' for accuracy of relating the financial implications of assumptions, parameters and inputs. During the expert group discussions, the physical extent of the typical farm was established through consensus.

3.4.1.2 Farm description

The first important assumption in the typical farm model for each area was the size of the total farm. Within the model, farm size forms the basis that determines numerous other factors. Factors that depend on and change with a change in farm size include cultivated area, land utilisation, mechanisation requirements, investment in fixed improvements, investment in land, number of permanent labourers required, as well as the other fixed costs.

Other physical parameters that influence the financial performance of the typical farm include land ownership, land usability and land utilisation. Total land consists of rented land and own land. Rented land influences the factor cost component of the model. Own land and the assumed own-to-borrowed capital ratio determine the payment required, which impacts on the expected cash flow. All farms include an uncultivated part, which, for example, includes riverbeds, roads, buildings, steep inclinations, sandy soils and rocky fields.

Land utilisation indicates the number of hectares on which each crop is cultivated and depends on the total cultivated area and the crop rotation system. In the model, the crop rotation system can be manipulated to incorporate other crops or other sequences of crops. Through a series of 'DSUM' formulas, the model automatically adjusts the number of hectares under each crop with changes to crop rotation systems.

3.4.1.3 Financial description of the farm

The farm's financial description expresses the physical extent of the farm in financial terms. It is presented in the form of an inventory or asset register. It calculates the sum of the investment requirement for all assets. It contains values for all items. Items in the inventory include land, fixed improvements, machinery, equipment and livestock. All these factors are connected and dependent on the farm size, and are automatically adjusted if farm size is altered. The assumptions regarding the relationships between land and moveable items were based on the field capacities of machines and the livestock carrying capacity of pasture. All the assumptions were validated during the group discussions. All the assumptions and parameters in the model can also be adjusted. Some of the proposals the workgroup came up with required alterations only to the assumed values e.g., the efficiency of tractor usage or the carrying capacity of livestock were manipulated to test for their effect on profitability.

3.4.1.4 Data on input and output prices

Lists of prices for all production factors, including machinery and directly allocated inputs like seed, fertilisers, chemicals and fuel, were accommodated in the model. These lists are in the form of data tables, from which items can easily be selected by various spreadsheet functions. The budget model is set up to select the prices in the data tables. These tables provide prices and quantities for calculations in the enterprise budgets and inventory, as well as calculations of fixed and overhead costs.

The data tables typically consist of the units in which products are sold, the unit prices, typical or recommended application levels and a calculated value per hectare. Prices can thus be updated, or new products can easily be included. In the budget models, 2005-2007, three-year average prices were used throughout. The data tables are incorporated into the model so that prices for alternative products or items can be selected quickly and group discussions are not interrupted in order to look for data elsewhere. The prevention of interruptions enhances the continuity and thus the focus and creativity of the discussions.

Seed costs depend on seed prices and the seeding densities for each crop. Seeding densities vary significantly from area to area, depending on expected yield, cultivation method and technology. Both seed price and seeding density are instantly adaptable. The three-year average seed prices were obtained from SANSOR (Goldschagg, 2007) and the agribusinesses that supply seed to the producers. An extensive variety of wheat cultivars is available. The work group decided that a single price of seed for each crop be should used in the models. The three-year average price for the most commonly used cultivars was agreed. In practice, producers keep some of the grain harvested to use as seed for planting the next crop. A 30 percent own seed ratio was decided on by the work-groups, which was taken into account in calculating the seed price at the opportunity cost for which it could have been sold. The seed prices for maize and wheat for the Wesselsbron area were based on producer study-group results from the area (Botha, 2007). Table 3.5 shows the quantity of seed used per hectare in the Western Cape and Wesselsbron, based on the planting densities as decided on by the work-groups. In the model for each typical farm, the seeding density and the price per kilogram of seed are separated, which allows for easier manipulation by the work group.

Table 3.5: Seeding densities for various crops planted on the typical farm for each homogeneous area

	Seeding density for various crops (kg/ha)						
Area	**Wheat**	**Barley**	**Canola**	**Oats**	**Lupine**	**Triticale**	**Maize**
Koeberg/Wellington	100	-	5	90	80	-	-
Middle Swartland	85	-	4.5	60	80	85	-
Rooi Karoo	85	-	-	60	80	85	-
Goue Rûens	90	70	4	70	80	90	-
Middle Rûens	70	50	4	60	80	85	-
Heidelberg Vlakte	85	95	4.5	60	80	85	-
Wesselsbron	30	-	-	-	-	-	6.4

Table 3.6 illustrates the fertilisation costs for each crop produced in the Koeberg/Wellington area. Nitrogen is applied twice during the production cycle, once at planting and once as top dressing after about six weeks into the growing season.

Table 3.6: Fertiliser costs for Koeberg/Wellington as an illustration of fertiliser costs as discussed at workshops

	Wheat/ Wheat	**Wheat/ Canola**	**Canola**	**Wheat/ medics**	**Oats**	**Lupines**	**Medics**
	Kg/ha	Kg/ha	Kg/ha	Kg/ha	Kg/ha	Kg/ha	Kg/ha
Nitrogen: Planting	30.00	30.00	30.00	30.00	30.00	10.00	0.00
Nitrogen: Top dressing	80.00	80.00	50.00	60.00	50.00	0.00	0.00
Phosphorus	20.00	20.00	15.00	20.00	0.00	20.00	0.00
Potassium	10.00	10.00	10.00	10.00	0.00	0.00	0.00
Cost (R/ha)	**1 274.06**	**1 274.06**	**947.68**	**1 105.13**	**675.69**	**376.45**	**0.00**
Price for fertiliser components: R/kg							
Nitrogen	R8.45						
Phosphorus	R14.60						
Potassium	R5.30						

A wide variety of specific fertilisers, which essentially consists of a combination of nitrogen (N), phosphorus (P) and potassium (K), are available on the market. The prices of these three fertiliser components were determined with the help of representatives of the local agribusinesses that supply fertilisers to producers. The price and the indicated amount of N, P and K that different mixes consist of is shown by a basket of commonly used fertiliser products, which was used to calculate the value of each component (Bruwer, 2007; Burger, 2007; Laubsher 2007 and Lusse 2007). The quantity of N, P and K applied for each crop were discussed and manipulated during the workgroup discussions.

The variety of weeds, diseases and pests combined with the variety of chemical products available for the control of each is vast. All possible combinations of products available were incorporated into the model to allow producers to select the appropriate product from the list. The nature of weeds, pests and diseases dictates that some problems occur over a wide area while others may only manifest in small areas, even individual fields on a specific farm. Producers will also use different brand names within the same group of chemicals or other groups of chemicals over time. This is done to prevent the build-up of resistance to a specific chemical. It was decided at the workshops to use typical study group costs for herbicides, pesticide and insecticides as the input costs for each crop in each homogeneous area. These costs were discussed and calibrated during the workgroup discussions, and served to simplify the discussions. No differentiation was made between the chemical costs incurred during good, average and poor years. The producers follow a prevention-first policy regarding the possible outbreak of weeds, pests and deceases. The natural scientists mentioned that, technically, marginally lower costs during poor years could be expected. Poor rainfall should also inhibit the growth of weeds and diseases. The safety-first option that the producers suggested was however included into the calculations.

Regarding calculating and incorporating running costs of machinery, two separate sheets were developed, an activity cost sheet and a data sheet. The data sheet includes the complete database of the *Guide to Machinery Costs* (2005, 2006 and 2007). Each item is allocated a code that is used as reference number for ‘LOOKUP functions in the spreadsheet program. The activity sheet calculates the total running cost for each activity, combining the costs of the implement set, which consists of a tractor and an implement. Any combination of tractor and implement can be selected from the database for which an activity cost per hectare is calculated. The activity is then allocated an activity code. These codes can then be selected in the enterprise budgets to calculate the non-directly allocated costs per hectare for each crop.

3.4.2. The calculation component

The calculation component consists of the various calculations and interconnections that relate and connect the various input parts to generate valid outputs in the form of profitability criteria. Standard and established accounting principles are applied to ensure the validity of the model.
The total investment in mechanisation depends on the number, size and age of machines and equipment. The mechanisation requirement can be calculated. Factors included in the calculation are the area that needs to be cultivated, the time available for the activity, and the capacity of the machine and implement set. This method would however not necessarily present a typical mechanisation layout for each area. The typical mechanisation layout, in terms of sizes, the number and age of machines, and amount and age of equipment were established through consultation with various experts and validated at the group discussions. The most expensive machinery and equipment is required for planting, including preparing the soil and harvesting.

3.4.2.1 Inventory

The role of the inventory is to calculate the expected capital requirement for the whole farm. The capital requirement is in essence a financial quantification of the sum of all assets required to farm sustainably. Capital items include land, fixed improvements, machinery, equipment and livestock. The investment in land, determined by farm size and the price of land, is the biggest contributor to capital requirements for all areas. On the recommendation of the expert group, fixed improvements were included with the land price.

The prices for new items were obtained from the *Guide to Machinery Costs* (2005, 2006 and 2007). The number of machines and pieces of equipment for each typical farm was determined by the group of experts. The norm, proposed by the *Guide to Machinery Costs*, for replacing machinery items is 12 years. In various instances, like the Middle Rûens, Middle Swartland and Rooi Karoo, producers do not replace machinery and equipment according to a recommended schedule. Machinery items are often replaced after 15 years or longer. The reasons for this are the financial positions in which producers find themselves, which often do not allow for replacing expensive items, as well as the relatively low annual utilisation rate of machines in the Western Cape. The *Guide to Machinery Costs* bases annual machine use on 1000 hours per annum. In most instances, machines in the Western Cape are used for 300 to 350 hours per annum (Rautenbach, 2007).

In some instances, prices were adapted as recommended by the expert group. Differences between prices listed in the *Guide to Machinery Costs* and retail prices in the Western Cape were established and adjusted accordingly. Examples of adaptations that were made include the price for combine harvesters and no-till planters. The price of combine harvesters was too low according to the *Guide to Machinery Costs.* The reason for this was possibly that the quoted price excluded the head with cutters and a pickup. A price difference of R300 000 for some of the combine harvesters was identified (Rankin, 2007; Rautenbach, 2007 and Van Niekerk, 2007). Cost estimates on no-till planters are not available in the *Guide to Machinery Costs*. Hence, the cost estimates for these implements were created in the data tables using the same method employed in the *Guide to Machinery Costs* for calculating the salvage value and the maintenance and repair costs of equipment. The new no-till planters cost R26 000 per tine based on 2007 values (Rautenbach, 2007). For future use of the models, prices or the whole data set can be updated easily, which will automatically update the budget model.

Investment in livestock is determined by herd size and herd composition. Herd size is calculated by the model using the area allocated to pasture and grazing capacity. Herd composition is calculated by making assumptions concerning the ram to ewe ratio, and the ewe replacement policy. The values of rams, ewes, replacement ewes and lambs were obtained from various experts and were validated during the group discussions.

3.4.2.2 Gross production value and gross margin

For each homogeneous area, a separate enterprise budget was compiled for every crop included in the crop rotation system. The price data included in the enterprise budgets were selected from the aforementioned data tables. The work group discussed only the amount of input per hectare for the individual crops. For each crop, three separate budgets were compiled, one each for good, average and poor yields. In the multi-period budget, each year was indicated as good, average or poor. The model selects the gross margin for the whole-farm budget according to the type of year, which is multiplied by the number of hectares planted under a specific crop. The enterprise budgets include, on a per hectare basis, production value, directly allocated variable costs and non-directly allocated variable costs.

The sequence of good, average and poor years for the next twenty years (the budget period) is, by definition, completely unpredictable (refer to Section 3.3.2.1). To apply a method to selecting the sequence of poor, average, and good years historical rainfall distribution patterns obtained from weather stations were used. Where data from weather stations was insufficient, rainfall data obtained from producers that kept records of rainfall were used. Any other sequence with the specified number of good, average and poor years however, would be just as likely. The chosen evaluation criterion for measuring whole-farm profitability is the internal rate of return on capital investment (IRR); therefore, good years, with higher yields and subsequent higher cash-inflow, earlier or later in the evaluation period will influence the IRR. This is caused by the number of periods over which each amount is discounted. Good years earlier in the evaluation period are discounted over a shorter period, causing a positive influence on the IRR.

The models for each area were run according to various alternative sequences for good average and poor yield years. The sequence was kept constant, but each of the twenty iterations started with a different year one. Twenty different possible sequences were thus evaluated in terms of effect on IRR. For all 20 iterations for each typical farm, the average IRR, maximum IRR, minimum IRR and median IRR are shown in Table 3.7. This exercise was done only to allow for alternative sequences of good, average and poor years. It should be borne in mind that the 20-year cycles selected were in any event only a random twenty year period in the farms' existence, and not necessarily the first 20 years of the total existence of the farm.

Table 3.7: Current, average-, maximum-, minimum-, and median IRRs for 20 different sequences of good, average and poor grain yields determined by rainfall

	IRR (%)				
Area	**Current**	**Average**	**Maximum**	**Minimum**	**Median**
Koeberg/Wellington	5.67%	5.69%	5.81%	5.59%	5.69%
Middle Swartland	4.20%	4.30%	4.50%	4.19%	4.29%
Rooi Karoo	3.05%	3.05%	3.39%	2.78%	3.05%
Goue Rûens	5.63%	5.78%	6.00%	5.55%	5.77%
Middle Rûens	1.05%	1.04%	1.10%	0.94%	1.05%
Heidelberg Vlakte	3.21%	3.16%	3.23%	3.08%	3.16%
Wesselsbron	5.97%	5.88%	6.37%	5.37%	5.88%

3.4.2.3 Overhead and fixed costs

Overhead and fixed costs were determined by the information provided by the producer study groups. The overhead and fixed costs for each area were verified during group discussions. The owner's remuneration is included as a fixed cost in the models. Fixed and overhead costs typically include permanent labour, licences, insurance, water scheme levies, fuel and maintenance on general farm vehicles, maintenance on fixed improvements, banking costs, accountant's fees, electricity, communication costs, administration costs and provision for diverse costs.

3.4.3 The output component

The output of the models includes a calculation of whole-farm profitability expressed as an IRR (internal rate of return on capital investment) and a NPV (net present value). The cash flow measures the affordability of the borrowed capital amount in terms of cash flow.

3.4.3.1 Profitability

The budget models were based on a 20-year calculation period. The main reason for the long period was to capture the nature of the crop rotation systems, some of which run over a 14-year period. Another important reason was to allow for the replacement of machinery and equipment. The 20-year calculation period reflects only a random period in the life of a farm to allow for comparable evaluation. Three-year average prices for all inputs, products as well as land prices were used in the models. The calculations were thus based on 2005, 2006 and 2007 average prices.

The principal aims of the models are to establish the current financial positions of the typical farms for each homogeneous area and to examine the relative financial impacts of various changes on profitability. All calculations are based on constant prices. The effect of inflation is captured in the use of real interest rates for all cash flows and financial profitability calculations. The multi-period budget for each area is presented in Annexure E.

The model calculates the gross margin for each crop by 'looking up' the gross margins according to good, average or poor yields per hectare and multiplying them by the total number of hectares for that specific crop. The total number of hectares for each crop is determined by the crop rotation system and the total cultivated area. By a series of selective-sum formulas, the total area under each crop is calculated. The gross margin for the total farm is the sum of the gross margins for all crops.

The annual fixed and overhead costs remain the same over the calculation period. These costs are typical for each homogeneous area, and were determined with the help of study-group data and verified during the workshops. Capital expenditure is calculated on the information in the inventory or asset register, which is determined by the farm's physical description. Replacement of machinery and equipment is based on the life and age at the beginning of the calculation period and the life of the machines. The salvage value of an item of machinery and equipment is subtracted from the price of the new item.

The capital-flow budget calculates the net flow of funds, which is gross margin, minus overhead and fixed costs, minus capital expenditure. The annual net flow of funds over the 20-year period is used to calculate profitability. The profitability for each typical farm was measured in terms of Net Present Value (NPV) and Internal Rate of Return on capital investment (IRR). The NPV and IRR are closely related. By definition, the IRR is the rate that when used as an interest rate would return a zero NPV. The NPV measures the present value of future cash flow. The IRR measures the growth that the cash flow generates, as a return on the initial investment. The NPV and IRR are ideal criteria if different projects or options, which start at different times, run over different periods, or have different capital investments, need to be compared to one another. In this instance, the financial implications of various changes to the parameters and assumptions can be established. The impact of different strategies on whole-farm profitability can be measured by the IRR while the size of the initial investment affects the NPV result.

3.4.3.2 Affordability: ratio of own to borrowed finance, and cash flow budget

The affordability of the investment is measured in terms of a cash flow analyses to establish the effect of borrowed capital and interest. The IRR calculation incorporates the size of the required investment and the income generated from that investment. The cash flow budget includes cash items only. The impact of interest payments on the farm's bank balance can be established. As constant prices are used in the models, the three-year average nominal interest rate needed to be converted to a real interest rate. The real interest rate is used in calculating the interest received or paid on the bank balance. The real interest rate is calculated using the following formula:
Real interest rate = {[(1+nominal interest rate) / (1+inflation rate)]-1} %.

The cash flow budget typically calculates the breakeven-year or indicates periods of positive and negative cash flow. Thereby, the affordability of borrowed capital and the replacement of mechanisation items can be established.

3.5 Conclusions

The methods employed in this project are aimed at reaching two goals. The first is to establish the current financial position of grain production in the Western Cape. The second is to identify strategies to improve profitability at a farm level. The farm is a complex and multi-faceted object of enquiry. The study of such a complex system requires and depends on incorporating expert knowledge. Chapter 3 describes the roles and practical implementation of both the expert groups and the budget model. The design and components of each method are especially important.

The research was conducted in three distinct phases, namely model construction, model validation and model utilisation. Simulation modelling requires a thorough understanding of the system being modelled. To gain insight into the farm system, expert knowledge was incorporated from the start of the model's construction phase. While constructing the model, this consisted of individual consultations with various experts. The models were also tested with farmers and representatives from local agribusinesses before the group discussions.

The role of the models is twofold. Firstly, they serve to assess the current financial situation of the typical farm for each homogeneous area. Secondly, various proposed strategies can be examined for their impact on farm profitability. The model is simply a tool that can measure and quantify the farm's performance based on standard accounting principles. The validity of the information generated by the model depends on the accuracy of the inputs entered into the model. In this instance, a group of experts was used to validate the information.

The expert groups comprised participants from various scientific disciplines as well as producers and extension officers from local agribusinesses. The unique contribution of each participant results in discussion topics being viewed from different perspectives. The validity of critical issues is established by reaching consensus within the expert groups. The exposure to different perspectives also contributes to creative thinking. The models served to examine the financial impact of suggestions, made within the expert group, aimed at improving whole farm profitability.

The variation in climate, terrain and soil in the Western Cape necessitates the area being subdivided into smaller, more homogeneous, areas. Within the regions of the Swartland and Southern Cape, six relatively homogeneous areas were identified. In the Swartland, the Koeberg/Wellington, Middle Swartland and Rooi Karoo areas were identified. In the Southern Cape, the Goue Rûens, Middle Rûens and Heidelberg Vlakte were identified. To serve as basis for comparison the Wesselsbron area in the northern, summer-rainfall, grain producing region was identified. Rainfall and rainfall dispersion were identified as the most influential factors that determine crop yields. For each area, good, average and poor years, based on total rainfall and rainfall dispersion were defined and allotted an expected yield. The prevalence of these good, average and poor years over the 20-year budget period represents crop yield risk in the models.

For each homogeneous area a typical farm model was developed. The extents of the typical farms were validated during the group discussions. Standard accounting principles, which maintain the validity of the model, were applied throughout the modelling process. The models consist of three components, an input component, a calculation component and an output component. The input component consists of the assumptions, parameters and prices that determine the financial extent and performance of the typical farm. The investment requirements, income and costs depend on the physical extent of the typical farm. The contributing factors are farm size, land ownership, land use, crop rotation systems, crop yields, input levels, mechanisation layouts and overhead and fixed costs. All these factors were identified by consulting various experts and were validated during the group discussions.

The calculation component consists of a serious of simple mathematical equations, based on standard accounting principles, which use the inputs to calculate profitability. The inputs are mostly of a physical-biological nature while the outputs are in financial terms. Enterprise budgets are used to calculate gross production value and gross margin from physical and financial parameters. For each crop an enterprise budget for good, average and poor years was developed. For the typical farm for each homogeneous area, the overhead and fixed costs were determined, based on study group information and validated during the group discussions.

The output component consists of an IRR and NPV calculation, which measures expected profitability. Both these outputs are generally accepted criteria for measuring the performance of a capital investment project over the long term. A multi-period budget model was developed for each area to calculate the expected profitability of the typical farm. The expected financial performance of each typical farm, based on currently valid assumptions, can thus be established.

Chapter 4 presents the current financial performance of each typical farm calculated by the models using the inputs from the discussion groups. The financial implications of changes in certain inputs and parameters are examined. Various strategies suggested by the expert groups are described, and the expected impact of each proposed strategy on whole-farm profitability for each typical farm is shown.

Chapter 4

Typical farm models for small grain producers in South Africa

4.1 Introduction

The way in which the financial performance of the typical farm was determined and the model validated is described in Chapter 3. The financial performance of the farming operation was calculated by using multi-period whole-farm budget models. The extent of the typical farms and models' parameters were established by consulting experts, in individual consultations followed by group discussions.

Chapter 4 includes the description of the typical farms identified through using expert groups and various experts with indigenous knowledge of the areas. These experts were mostly extension officers from the local agribusinesses that worked within the farming community, and producers. The extent of each typical farm was validated during the group discussions. Chapter 4 starts with a short description of the typical farm as a research tool.

4.2 The typical farm as an evaluation tool for whole-farm profitability

A tool that can be used to assess farm profitability and to determine the effect of variations in a range of variables on farm-level profitability is the typical farm. In this instance, a typical farm model for each homogeneous area is required. The use of typical farm models means that the models cannot be applied directly to a specific farm. Typical farm information is not directly applicable to providing direct managerial guidance. The typical farm model does however allow for evaluation and comparison of the effect of various managerial decisions and options. Typical farm models are mostly used for measuring major managerial implications (Blackie & Dent, 1974:166). An advantage of using typical farm models is that it is a cost and time efficient research method compared to surveys.

The typical or representative farm model cannot accurately reflect internal managerial problems for individual farms. Even small farms are complex and unique, and on no two farms will exactly the same factors affect profitability in precisely the same way. The impact of trends, strategies and policy options on whole-farm profitability can be assessed by using a typical farm. A typical farm model only remains typical as long as the general assumptions about available technology, market access and management are valid (Carter, 1965:1452).

Typical farm models were first used in the 1930s in the USA. Their first recognisable advantage was the shift in focus away from the traditional production-cost approach towards a whole-farm approach. The whole-farm approach provides a more reliable basis for assessing the potential impact of variables on which to base policies and programmes. At first, the concept of the typical farm was defined in terms of 'normality'. The idea was to avoid good or poor farms in terms of management quality, profitability, size, access to markets and life expectancy (Carter, 1965:1449). Later descriptions of the typical farm were based on existing enterprises, practices and environmental factors. Feuz and Skold (1991:44) define a typical farm as 'a model farm in a frequency distribution of farms in the same universe'.

The inputs of producers and other stakeholders were incorporated in the process of establishing and modelling the typical farm. Producers could therefore relate to the farm model during the model validation and model use phases. The typical farm model is sterile of personal information pertaining to specific farms, and this enhanced participation during the group discussions. The typical farm description in terms of size, crop rotation system, yield, investment, mechanisation and cost structure, in all cases, was developed together with producers and/or field agents from agribusinesses in the various areas. The first part of the group discussions on the specific areas was aimed at validating the typical farm model.

4.3. The physical extent of each typical farm

Table 4.1: Farm size, own to rented land ratio and land prices for the typical farm for each homogeneous area

Area	Typical farm size (ha)	Own to rented land ratio		Own to rented land (ha)		Land price R/ha
		Own land	Rented land	Own land	Rented land	
Koeberg/Wellington	1 400	80%	20%	1 120	280	R13 500
Middle Swartland	1 000	100%	-	1 000	-	R8 000
Rooi Karoo	980	100%	-	980	-	R4 000
Goue Rûens	2 500	80%	20%	2 000	500	R9 000
Middle Rûens	1 600	70%	30%	1 120	480	R 6 000
Heidelberg Vlakte	1 600	70%	30%	1 120	480	R 6 000
Wesselsbron	1 365	100%	-	1 365	-	R6 000

The typical farm size for each area as decided by the expert groups is shown in Table 4.1. In most areas, the farm enterprise includes rented land. Table 4.1 shows the own-to-rented land ratio as well as the three-year average land prices for each area.

Table 4.2 Cultivatable land for the typical farm for each homogeneous area

Area	Percentage cultivatable land	Cultivatable land (ha)
Koeberg/Wellington	92%	1 288
Middle Swartland	95%	950
Rooi Karoo	90%	882
Goue Rûens	90%	2 250
Middle Rûens	94%	1 504
Heidelberg Vlakte	90%	1 440
Wesselsbron	95%	1 297

On every farm, there are areas that are non-cultivatable sandy areas, riverbeds, roads, steep slopes, wet areas, areas used for housing and buildings and saline areas. The typical percentages of non-cultivatable and completely cultivatable areas per typical farm in each production area are shown in Table 4.2.

Land ownership, land utilisation and land prices were validated during the workgroup discussions. The farm sizes and land-use patterns that were used to construct the models were obtained prior to the group discussions, from producer study-groups information, supplied by representatives from the local agribusinesses (Bruwer, 2007; Burger, 2007; Haasbroek, 2007; Laubser, 2007; Laubsher, 2007; and Lusse, 2007).

4.4. Land utilisation

Table 4.3: Land use patterns for typical farms for each of the homogeneous areas of the Swartland

Area	**Crops**	**% of usable land**	**Ha under crop**
Koeberg/Wellington	Wheat after wheat	13%	161
	Wheat after canola/lupines	15%	187
	Wheat after medics	33%	419
	Canola after wheat	8%	97
	Medics	26%	335
	Oats (pasture)	6%	77
	Lupines	1%	13
Middle Swartland	Wheat after wheat	30%	285
	Wheat after canola/lupines	6%	57
	Wheat after medics	13%	124
	Canola after wheat	6%	57
	Medics	13%	124
	Oats (pasture)	6%	57
	Wheat after oats or fallow	10%	95
	Lupines	6%	57
	Fallow	10%	95
Rooi Karoo	Wheat after fallow	40%	353
	Triticale as pasture	40%	353
	Oats	10%	88
	Wheat after wheat	10%	88

The area on which each crop is produced annually is determined by the total cultivated area per typical farm and the crop rotation system. An assumption was made that the farm could be divided into fields according to the crop rotation system. In other words, all camps within a specific system are assumed to be the same size. Table 4.3 shows the area under each crop in percentages and actual sizes for the Swartland areas. Table 4.4 shows the land use patterns for the Southern Cape areas. Table 4.5 shows the land use pattern for the typical farm in the Wesselsbron area.

Table 4.4: Land use patterns for typical farms for each of the homogeneous areas of the Southern Cape

Area	Crops	% of usable land	Ha allocated to crop
Goue Rûens	Wheat	19%	421
	Barley	22%	491
	Canola	8%	179
	Oats	3%	69
	Lupines	3%	64
	Alfalfa pasture	46%	1026
Middle Rûens	Wheat	17%	260
	Barley	19%	285
	Canola	11%	160
	Triticale	2%	25
	Oats	3%	50
	Alfalfa pasture	48%	725
Heidelberg Vlakte	Wheat	24%	347
	Barley	10%	137
	Canola	10%	137
	Oats	5%	65
	Oats/alfalfa pasture	52%	753

Table 4.5: Land use pattern for typical farm of the Wesselsbron area

Crops	% of usable land	Ha allocated to crop
Wheat	33%	432
Maize	33%	432
Fallow	33%	432

4.5 Investment requirement

The inventory for the typical farm for each relatively homogenous area is presented in Annexure C. In the Western Cape, the prices of farm-land range from R13 500/ha for the Koeberg/Wellington area to R4 000/ha for the Rooi Karoo area. The typical farm sizes also contribute significantly to total investment requirements. The total farm size of the Goue Rûens, combined with the relatively high land price results in a high investment requirement for land. In the Southern Cape, the investment in livestock is high due to the opportunities presented by the cultivation of alfalfa.

4.6 Gross production value

The gross production value of the whole farm is the sum of the gross production values all of the individual enterprises. The gross production value is the quantity of output multiplied by the price per output unit. Table 4.6 shows the three-year average farm-gate prices, for the various crops and livestock products, that were used.

Table 4.6 Product prices for crops and livestock products (average: 2005-2007)

Product	Unit	Price per unit (R)
Wheat	Ton	1 353
Wheat (Wesselsbron)	Ton	1 550
Barley	Ton	1 540
Canola	Ton	2 250
Lupine	Ton	1 250
Oats	Ton	850
Triticale	Ton	850
Maize (Wesselsbron)	Ton	1 150
Meat (lamb)	Kg	23
Meat (ewes)	Kg	18
Wool	Kg	30

- The difference in wheat price between the Wesselsbron area and the Western Cape is caused by the difference in the transport differential.

Table 4.7: Total gross production value for typical farms for good, average and poor years as determined by rainfall

Area	Gross production value for the whole farm and per hectare					
	Good year		Average year		Poor year	
	R/farm	R/ha	R/farm	R/ha	R/farm	R/ha
Koeberg/Wellington	6 163 591	4 515	5 101 227	3 737	4 038 863	2 959
Middle Swartland	3 260 000	3 260	2 717 767	2 718	2 152 734	2 153
Rooi Karoo	2 073 523	2 116	1 609 671	1 643	1 212 083	1 237
Goue Rûens	7 692 939	3 077	6 736 520	2 695	5 780 102	2 312
Middle Rûens	4 058 677	2 537	3 708 478	2 318	3 248 649	2 030
Heidelberg Vlakte	3 752 706	2 345	3 375 560	2 111	2 935 872	1 835
Wesselsbron	6 163 591	4 515	5 101 227	3 737	4 038 863	2 959

The area planted under each crop for each typical farm is shown in Section 4.4. The expected crop yields are shown in Section 3.3.2.2. The models incorporate the increased yields automatically in the calculations. The gross production values for the typical farms for good, average and poor rainfall years are shown in Table 4.7.

A significant advantage of crop rotation is the positive effect some crops bring about for the subsequent crop on a specific field. During the preparation phase and the workshops two positive yield effects were identified that were incorporated into the model:

- A 22 percent yield increase for wheat that is preceded by canola, and
- A 25 percent increase in yield for wheat preceded by legumes including medics, lupines and alfalfa.

4.7 Variable costs

An enterprise budget, making provision for good, average and poor years, was compiled for each crop. Table 4.8 and Figure 4.1 show the relative contributions of various cost items to total variable costs for each area.

Table 4.8: The contributions of various inputs to total farm variable costs

	Seed	Fertiliser	Chemicals	Fuel	Maintenance	Other
Koeberg/Wellington	6.6%	39.8%	16.4%	13.5%	10.2%	13.6%
Middle Swartland	7.5%	36.7%	14.6%	15.2%	13.3%	12.8%
Rooi Karoo	13.1%	26.7%	3.1%	22.1%	20.6%	14.4%
Goue Rûens	8.1%	37.8%	20.8%	10.1%	10.6%	12.6%
Middle Rûens	6.3%	30.2%	17.4%	14.8%	14.4%	17.0%
Heidelberg Vlakte	11.4%	27.5%	21.7%	14.9%	14.2%	10.4%
Wesselsbron	4.7%	28.7%	13.5%	12.0%	12.8%	28.2%

The difference in variable costs between good, average and poor years for the same crop lies only in the silo costs, which are determined by the yield. Variable costs typically include seed costs, fertilisation costs, chemical costs, transport costs, contactors costs, crop insurance costs and silo costs. During the budget construction phase, the variables costs were obtained from producer study-group information. The quantities of inputs were discussed and validated at the group discussions.

Other variable costs include marketing costs, silo handling fees, levies, and livestock production costs. Variable costs in the livestock enterprises include feed costs, vaccinations, veterinarian costs, dosages, mineral licks and shearing contract work. The high ‘other cost’ component of the Wesselsbron area is caused by insurance costs typical of that area. Fertiliser costs are, in all instances, the highest contributor to total variable costs.

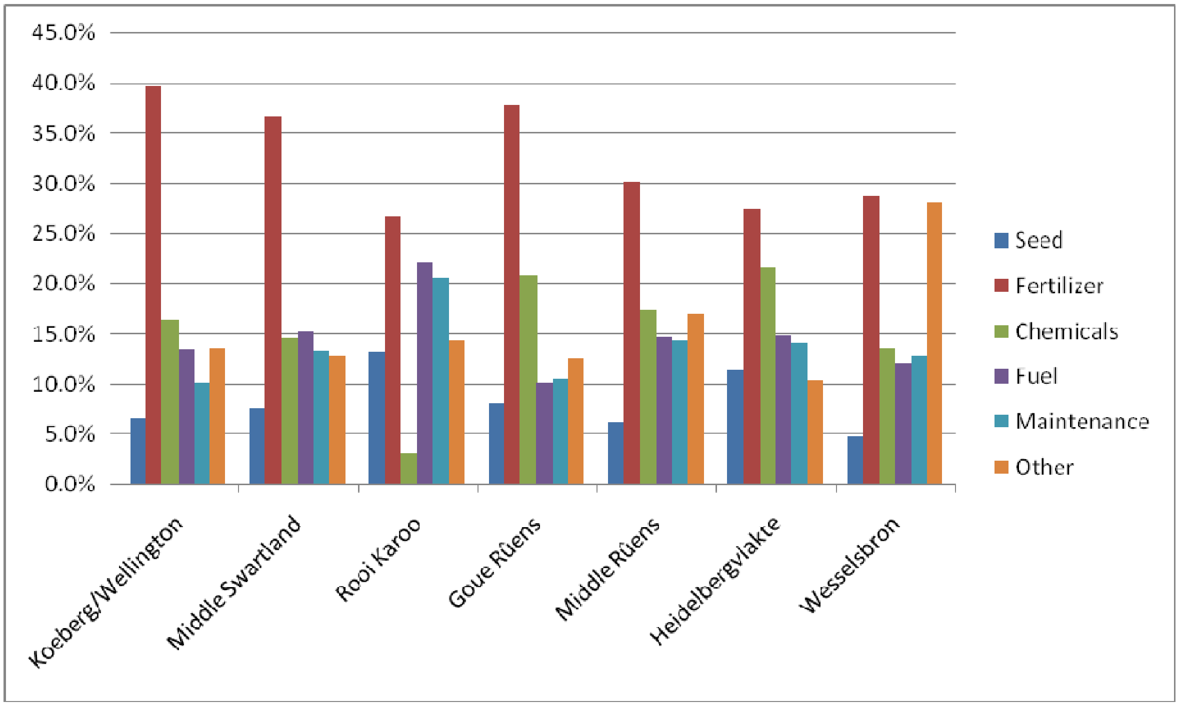

Figure 4.1: Graphic illustration of the contribution of various inputs to total farm variable costs

Minimum tillage and no-till practices have various positive effects on soil sustainability and enhancement. However, these practices rely on the chemical control of weeds, which increase chemical costs. Figure 4.1 shows the relatively high chemical control cost of the Heidelberg Vlakte area where no-till and minimum-till cultivation are already common practices. The policy of stretching the lifetime of machinery and equipment, as is done in the Rooi Karoo area, decreases the required investment in machinery (refer to Section 4.5) but increases the maintenance costs of machinery component.

4.8 Gross margin

The gross margin is calculated by subtracting the variable costs from the gross production value. A gross margin calculation is done for a good, average and poor years as determined by rainfall distribution for each crop included in the crop rotation system of the typical farm. Annexure D contains, as an example, the gross margin calculations for good, average and poor years for wheat production for the Koeberg/Wellington area. Similar enterprise budgets were complied for each typical farm and for each crop produced in the crop rotation system of that farm.

The gross margin for the whole farm is the sum of the gross margins for all individual enterprises. The total farm gross margin per production area is shown in Table 4.9.

Table 4.9: Total gross margin for each typical farm for good, average and poor years

Area	Gross margin for the whole farm and gross margin per hectare					
	Good year		Average year		Poor year	
	R/farm	R/ha	R/farm	R/ha	R/farm	R/ha
Koeberg/Wellington	3 052 492	2 180	2 217 041	1 584	816 803	583
Middle Swartland	1 358 738	1 359	1 212 306	1 212	666 015	666
Rooi Karoo	915 776	934	416 972	425	109 719	112
Goue Rûens	3 115 323	1 246	2 656 746	1 063	1 321 249	528
Middle Rûens	556 332	348	283 026	177	204 056	-127
Heidelberg Vlakte	3 752 706	2 345	3 375 560	2 111	2 935 872	1 835
Wesselsbron	2 771 673	2 031	1 753 496	1 285	821 401	602

Incorporating a dairy enterprise, as typical practice, in the Heidelberg Vlakte area stabilises income during average and poor years for this area.

4.9 Overhead and fixed costs

Overhead and fixed costs typically include items not dependent on production scale or the amount of output. Overhead and fixed costs include items such as permanent labour, licenses, water scheme fees and levies, electricity, communication costs, administration costs, maintenance on fixed improvements (fencing, water supply system and buildings), auditing fees, insurance on fixed improvements and the owner's remuneration. The overhead and fixed costs vary from farm to farm. During the group discussions, it was decided to use study-group information for overhead and fixed costs. The overhead and fixed costs for each typical farm are shown in Annexure E.

4.10 Profitability and cash flow

The profitability of the typical farm is measured over a 20-year period. A whole-farm multi-period budget model was used for calculating the IRR for each farm. The way in which the whole-farm budget models work is described in Section 3.4.3.1. The capital budget for each typical farm is presented in Annexure E. The expected NPV and IRR for each typical farm are shown in Table 4.10. The NPV and IRR are calculated on the net flow of funds for each typical farm. The calculation period in all instances is 20 years. For the three-year period from 2005 to 2007, the average nominal interest rate was 11.5 percent, the inflation rate 6.5 percent and the real interest rate 4.69 percent (Statistics South Africa, 2008:1 and South African Reserve Bank, 2008:1).

Table 4.10: The net present value (NPV) and internal rate of return on capital investment (IRR) for each typical farm

Area	Net present value (NPV)	Internal rate of return (IRR)
Koeberg/Wellington	R 2 681 251	5.67%
Middle Swartland	R -692 903	4.20%
Rooi Karoo	R -1 312 288	3.05%
Goue Rûens	R 3 008 647	5.63%
Middle Rûens	R -4 862 538	1.05%
Heidelberg Vlakte	R -2 385 022	3.21%
Wesselsbron	R 2 067 044	5.97%

The areas with an IRR lower than the real interest rate of 4.69 percent all returns a negative projected NPV for the 20-year calculation period. Despite the higher land prices and consequent higher investment requirement, the high-yield areas show the highest projected profitability. The Middle Rûens is expected to be worst off in terms of long-term profitability.

Annexure E shows the expected 20-year cash flow for each typical farm. Only cash items are included in the cash flow calculations. The capital items included in the inventory are thus assumed to be partly financed with borrowed capital. The borrowed capital amount generates an annual payment that influences the expected cash flow. The cash flow budget takes into account the annual cash in and outflows that would typically reflect the farm’s bank balance. In some instances, for example, the Middle Rûens, the expected cash flow shows that the replacement of expensive equipment such as harvesters or large tractors and planters cannot be afforded. In these instances, producers are required to make an even larger own capital contribution to maintain a positive cash flow.

4.11 Conclusions

One of the aims of this study was to determine the current profitability of grain production in the Western Cape. Another aim was to identify opportunities to improve the farm-level profitability of grain production. By using an expert group, the extent of the typical farm and parameters entered into the model were validated. A whole-farm multi-period budget model was developed for a typical farm identified for each homogeneous grain production area in the Western Cape. A typical farm for each relatively homogeneous area was identified with the inputs of various experts familiar with each area. The use of a typical farm is not to establish relevant information on individual farms, but rather to develop a model to which alternatives can be compared. The typical farm can thus be used to evaluate the expected impact of specific factors on farms in general. The farms were described as typical with regards to farm size, land ownership, land utilisation, investment, income and costs. The assumptions made for the typical farm for each area were presented to and validated by the discussion group session for that specific area. Based on such assumptions, and using standard accounting and budgeting principles, the expected return for each farm were calculated and expressed in terms of IRR, NPV and cash flow, as described in Chapter 3. The role of the budget models was to measure the financial performance of the typical farm and to examine the impact of certain changes on the profitability of the whole farm.

The budget models were used to establish the current financial performance of each typical farm. The capital requirement for the typical farm varies between R6 596 267 for the Rooi Karoo to R28 025 054 for the Goue Rûens. The profitability of the typical farms, measured in terms of IRR and NPV, showed that in the Western Cape, the high-yield areas of the Goue Rûens and Koeberg/Wellington are the most profitable. The expected profitability of the typical farm for the Wesselsbron area is also relatively high. The Wesselsbron area has less variance between poor and good years, with less frequent poor years, and due to the transport differential, it receives higher wheat prices.

Chapter 5

The impact of climate and price changes on the profitability of small grain farms

5.1 Introduction

The first phase of using the models, supported by typical farm models with the capacity to capture the complexity of the farm system, involved evaluating the financial implications of specific external factors. In all instances, the financial implications were compared with the current financial performance of the typical farm, as shown in Chapter 4. Firstly, the potential impact of declining crop yields due to expected climate change was evaluated. In terms of crop yields, all the areas were expected to be negatively affected by climate change. Secondly, the models were also used to measure the sensitivity of variations in input and output prices on whole-farm profitability. Both input and output prices are traditionally volatile variables. The impact of variations in the wheat prices on farm-level profitability is particularly important, as wheat is the only crop included in the crop rotation systems of each area. Changes in the cost of fuel, seed, fertilisers and chemicals are evaluated in terms of their impact on whole-farm profitability.

Investment opportunities identified in the external environment need to be assessed in terms of their impact on farm profitability. One such opportunity is the possibility of cultivating triticale to produce bio-ethanol. A farm-gate price for triticale was identified using the projected price of bio-ethanol. The farm models were used to simulate the effect of replacing some of the area under wheat with triticale, to determine the impact of farm profitability in order to get an indication of whether producers would be willing to increase triticale production at the expense of other typical crops in the crop rotation systems of the various study areas.

5.2. Decline in crop yields due to expected climate change

The expected influence of global warming on the climate in the Western Cape and its subsequent effect on crop yields were discussed at the first workshop (refer to Annexure A). The general expectation is that the entire Western Cape will become dryer, but more so in the northern and western parts of the Swartland. Not only is the rainfall expected to decrease, but minimum and maximum temperatures as well as wind speed are expected to increase. This will increase evaporation and transpiration, negating the effect of rainfall, which will cause a drop in crop yields. Wheat is a typical winter grain with a certain requirement for units of cold. A significant increase in either minimum or maximum winter temperatures is expected to contribute to lower crop yields (Agenbag, 2007). Various members of the workgroup discussions pointed out, by way of illustration, that in 2005 the total rainfall for the Swartland was adequate for normal yields, but because the temperatures were so high, the high evaporation led to water stress and relatively poor yields.

Some of the agronomists pointed out that higher temperature may lead to enhanced plant growth and consequently higher yields. There is also the danger of pollen being damaged by extremely high temperatures, due to scorching, or inhibited growth due to extremely low temperatures. The temperatures in the Southern Cape are more moderate than in the Swartland, making the Swartland more vulnerable to risks due to extremely high temperatures.

Table 5.1 shows the expected changes due to global climate change for each season in terms of rainfall and temperature. Expected best-case and worst-case scenarios are presented.

Table 5.1: Best-case and worst-case scenarios for projected rainfall and temperature changes per season

	DJF	MAM	JJA	SON	Annual
	Rainfall %				
Best case	-	-15%	-5%	-5%	-6%
Worst case	-5%	-25%	-25%	-10%	-16%
	Daily temperature °C				
Best case	+1,5	+1,25	+1,0	+1,25	+1,25
Worst case	+3,0	+2,5	+2,0	+1,5	+2,5

The frequencies of the good, average and poor years were kept constant as the prevalence of good, average and poor years was not expected to change due to climate change. The definitions for good, average and poor years were also kept the same, but the yield parameters allocated to each could shift from those presented in Section 3.1. For the Southern Cape, it was decided that barley would give roughly a 0.2 t/ha lower yield than wheat.

The workgroup decided that in terms of canola there was not enough information available to be able to establish a good indication of the effect of climate change on yields. Canola is dependent on early rains, and if the rainfall should shift to later in the growing season, the production of canola would not be viable, especially in the Swartland. The workgroup also agreed that canola is expected to be more sensitive to climatic change than wheat. Canola is sensitive to wind as it has very light seed. If any region should thus become windier, this would have a negative impact on the viability of canola production.

Table 5.2: Projected potential wheat yield changes due to expected climate change

Area/Year	**Best case**		**Worst case**	
	Yield (t/ha)	*In 10 Years	Yield (t/ha)	*In 10 years
Swartland:				
Koeberg/Wellington	**(-5%)		**(-10%)	
Good	3.89	3	3.69	3
Average	3.325	6	3.15	6
Poor	2.375	1	2.25	1
Middle Swartland	**(-10%)		**(-25%)	
Good	2.85	2	2.25	2
Average	2.28	7	1.8	7
Poor	1.71	1	1.35	1
Rooi Karoo	**(-15%)		**(-60%)	
Good	1.7	1	1.0	1
Average	1.11	5	0.72	5
Poor	0,60	4	0.4	4
Southern Cape	**Best case**		**Worst case**	
Goue Rûens	**(-5%)		**(-12%)	
Good	3.33	4	3.08	4
Average	2.76	5	2.55	5
Poor	2.19	1	1.94	1
Middle Rûens	**(-12%)		**(-30%)	
Good	2.2	3	1.75	3
Average	1.94	5	1.54	5
Poor	1.58	2	1.26	2
Heidelberg Vlakte	**(-20%)		**(-70%)	
Good	1.92	2	0.72	2
Average	1.6	4	0.6	4
Poor	1.2	4	0.45	4

- * Indicates the prevalence of good, average and poor years in every ten years
- ** Indicates the expected percentage decrease in crop yields, caused by climate change

Table 5.2 presents the projected impact that the workgroup expects the climate changes presented in Table 5.1 to have on the yields for crops in the various homogeneous areas. The summer rainfall areas in the northern part of South Africa are expected to become wetter over time.

The pronounced effect of climate change in the Southern Cape is due to the natural occurrence of the dry winter period, and a decrease in winter rainfall would accentuate this natural effect, especially towards the Heidelberg Vlakte. It was also mentioned that in cases where areas are already close to threshold values for maximum temperatures, for instance the Rooi Karoo area, a further increase in temperature can have devastating effects on the production potential of various crops. In a higher rainfall area like the Koeberg/Wellington area, the yield effect of an increase in temperature could be expected to be more moderate.

The expected effect of the best-case scenarios on the internal rate of return on capital investment (IRR) for the typical farms for the various areas is shown in Table 5.3. Only the best-case scenario was used to determine, by means of the budget model, the sensitivity of profitability to variations in wheat yields.

Table 5.3: Expected financial effect of the best-case scenario for climate change on the typical farm for each homogeneous area

Area	Internal rate of return (IRR) without climate change	Internal rate of return (IRR) for best-case scenario	Projected change in IRR
Koeberg/Wellington	5.67%	4.69%	17.3%
Middle Swartland	4.20%	3.37%	19.8%
Rooi Karoo	3.05%	1.25%	59.0%
Goue Rûens	5.63%	5.34%	5.2%
Middle Rûens	1.05%	0.29%	72.4%
Heidelberg Vlakte	3.21%	1.91%	40.5%
Wesselsbron	5.97%	5.97%	0.0%

The areas of the Rooi Karoo, Middle Rûens and Heidelberg Vlakte are expected to be the most severely affected. Profitable grain production in these areas will most probably not occur in the projected climatic environment, which will necessitate extensification of production practices into enterprises such as livestock. This will be caused by the already low IRR in relation to some of the other areas and the more severe drop in expected yields. The Goue Rûens is expected to be the least affected due to its high reliance on the livestock enterprises, which is not strongly affected by decreasing grain yields, and only a five percent drop in expected yields is anticipated. Areas relying more on grain pasture such as oats are more negatively affected, the Middle Rûens and Heidelberg Vlakte being examples.

Areas that are already classified as dry production areas, as well as areas with a high grain production component, are expected to be the most severely influenced. This expected effect is caused by the percentage of land used for wheat, whereas the areas in the Southern Cape have shifted towards a more intensive employment of livestock enterprises. The effect of dryer than normal years will thus have less of an effect on the performance of the whole farm that is diversified into livestock production.

Some strategies the workgroup identified for the agricultural sector and/or individual producers to counter the negative effects of climate change are:

- Obtain greater clarity on the yield potential for each area as a basis for planning. Areas that will be most severely affected should diversify earlier into other practices such as livestock.
- Identify farming practises that will increase the saving of soil water (e.g. no-till practices).
- Select cultivars that are more heat and drought resistant and short season growers.
- Implement a different planting date (maybe with short season growers, thus changing the cropping season, e.g. planting early in autumn and harvesting in early spring).
- Alter seed densities at planting, and
- Select different farming systems and enterprises; the whole farming objective may shift towards livestock production

It may happen that a sheep enterprise may become increasingly important and that a system allowing for pasture should be implemented or enhanced. A crop rotation system may decrease the intensity of the worst years and increase yields over time. In some areas, a no-till strategy may turn out to be unavoidable due to decreasing yields combined with lower rainfall and higher temperatures. Another factor that is increasingly important is the use of stubble and hay for extra income. In some instances a difference of R150/ha in expected gross margin was suggested by the workgroup.

5.3 The sensitivity of deviations in product and input prices on whole-farm profitability

This section concentrates on the sensitivity of farm profitability to deviations in product and input prices. Special focus is given to the price of wheat as it is the only crop included in all the production systems for all areas. The most important inputs in grain production include fertilisation, crop protection chemicals and fuel costs.

5.3.1 Output price scenarios

Deviations in any factor that influences the quantity or price of farm output will reflect in the gross production value and consequently also in the farm's profitability. Planting dates, soil moisture management, seeding density, amount of fertilisation and chemical applications can be optimised to increase yields, but rainfall and rainfall distribution were shown to have an 85 percent correlation to wheat yields in the Western Cape (Parkendorf, 2007).

Wheat is the only crop present in the crop rotation systems of the typical farms for all the production areas. Fluctuations in the wheat price were identified as an important factor that needed to be assessed for their impact on farm-level profitability. The producer wheat price for the Western Cape grain producer is determined by a number of external factors. The silo price is determined by the SAFEX price minus the transport differential between Randfontein, the delivery point of the SAFEX futures market, and the Western Cape. The producer price is calculated by subtracting the silo handling fees, levies and grading costs. The SAFEX price for wheat is determined by domestic supply and demand, stock levels and imports. South Africa is a net importer of wheat; therefore, the domestic price will be related to international wheat prices.

The SAFEX wheat price is determined by factors such as world production and world consumption, world stocks, transport and freight costs to South Africa, import taxes and duties, handling fees, transport costs from Durban to Randfontein, and the R/$ exchange rate. The international price is determined not only by stocks, and supply and demand, but also by other, less tangible factors. Some of these factors that contribute to the international wheat price are trader and consumer perceptions of issues such as food security, concerns over bio-ethanol policies, the performance of stock markets and the perceived intrinsic characteristics of wheat (Hawkins, 2008; Lemmer, 2009:40-42 and Meyer, 2008).

The three-year average transport differential between the Western Cape and Randfontein is R355/ton. The budget models were run with various wheat prices as theoretical producer prices.

The effect of variations of the wheat price on whole-farm profitability was consequently measured. The results of six theoretical wheat price scenarios are shown in Table 5.4. Each scenario represents a theoretical farm-gate price.

- Scenario 1: current three-year average wheat price of R1353/ton, as discussed at the workgroup sessions,
- Scenario 2: wheat price of R1289/ton equals the three average annual SAFEX wheat price minus the three-year average transport differential between Randfontein and the Western Cape,
- Scenario 3: wheat price of R1509/ton equals the Randfontein three-year average import parity price of hard red USA wheat minus the transport differential between Randfontein and the Western Cape,
- Scenario 4: wheat price of R1146/ton equals the Durban export parity price of hard red USA wheat,
- Scenario 5: wheat price of R1288 equals to the Randfontein import parity price of Argentinean wheat minus the transport differential between Randfontein and the Western Cape, and
- Scenario 6: wheat price of R960/ton equals the export parity price of Argentinean wheat.

Table 5.4: The IRR for each homogenous area of the Swartland, Southern Cape and Wesselsbron, for each of the wheat price scenarios

Area	IRR at various wheat prices					
	R1353/t	**R1289/t**	**R1509/t**	**R1146/t**	**R1288/t**	**R960/t**
Koeberg/Wellington	5.67%	4.88%	7.62%	3.17%	4.87%	0.99%
Middle Swartland	4.20%	3.46%	6.06%	1.84%	3.45%	-0.19%
Rooi Karoo	3.05%	2.95%	3.31%	2.71%	2.94%	2.4%
Goue Rûens	5.63%	5.30%	6.44%	4.57%	5.3%	3.63%
Middle Rûens	1.05%	0.71%	1.89%	-0.04%	0.71%	-1.00%
Heidelberg Vlakte	3.21%	2.86%	4.08%	2.09%	2.86%	1.11%
*Wesselsbron	**R1550/t**	**R1552/t**	**R1772/t**	**R1409/t**	**R1054/t**	**R868/t**
	5.97%	5.99%	8.23%	4.57%	1.18%	-0.55%

* For the same period, the average transport differential between Wesselsbron and Randfontein was R92/ton. In calculating the export parity price for the Wesselsbron area

the transport differential between Durban and Randfontein needed to be subtracted from the quoted price.

As expected, the areas where producers have diversified more into livestock production are less vulnerable to wheat price changes. The Koeberg/Wellington and Middle Swartland areas are able to take advantage of high wheat prices, but are more vulnerable to low wheat prices. The wheat price for the Wesselsbron area is higher due to the lower transport differential. This is because the area is closer to the SAFEX point of delivery at Randfontein.

Table 5.4 shows clearly that farm profitability for all areas is highly sensitive to changes in product prices. In this instance, only the wheat price was changed, and wheat is cultivated on only a part of the total farm area. The transport differential works against the producers of the Western Cape because South Africa, and specifically the Northern part of South Africa, is a net importer of wheat. The Western Cape's surplus wheat will thus be transported to Randfontein, which serves as the basis for the farm-gate price in the Western Cape. The Western Cape producers are also more directly affected by imported wheat due the transport differential, which does offer some protection for the producers in the northern production areas.

5.3.2 Input price scenarios

Fertilisers, chemicals and fuel are the main contributors to total directly allocatable costs. Fertiliser costs contributed between 27 percent and 40 percent of the total variable costs for various farms, as is shown in Table 4.8 and Figure 4.1. South Africa imports 50 percent of its total supply of fertilisers, including 100 percent of its potassium requirements. Fertiliser prices are determined by international fertiliser prices. Fertilisers used in South Africa mostly include nitrogen (N), phosphorus (P) and potassium (K). The prices of fertilisers landed and mixed in South Africa depend on variables such as supply and demand, freight and transport costs, import and export levies and taxes, international oil prices and the rand exchange rate (mostly the R/$ exchange rate, but not all base materials are bought in US dollars). The large importing companies, such as Kynoch (Yara South Africa), Nitrophoska and Omnia, try to lessen the impact of exchange rates and price hikes by placing orders at strategically optimal times. This contributes to the difficulty of correlating and quantifying the impact of one specific variable on South African fertiliser prices. The relative contribution of these factors changes constantly. Currently, the major factor driving international fertiliser prices is the demand for fertilisers in China and India (Van der Linde, 2008).The same type of factors determines the prices of crop protection chemicals, while intellectual property rights and patent rights play an important role in some of these chemicals (Mcdermotte, 2007).

Table 5.5: The impact of changes in the price of fertilisers, chemicals and fuel on the IRR of the typical farm for each area

Area	Typical farm IRR at various input prices			
	IRR typical farm	10% price increase	15% price increase	20% price increase
Koeberg/Wellington	5.67%	4.68%	4.19%	3.70%
Middle Swartland	4.20%	3.59%	3.29%	2.98%
Rooi Karoo	3.05%	2.63%	2.41%	2.20%
Goue Rûens	5.63%	4.75%	4.31%	3.87%
Middle Rûens	1.05%	0.40%	0.07%	-0.25%
Heidelberg Vlakte	3.21%	2.82%	2.62%	2.43%
Wesselsbron	5.97%	4.90%	4.37%	3.85%

The sensitivity of whole-farm profitability to increases in input prices, namely 10 percent, 15 percent and 20 percent increases in the prices of fertilisers, chemicals and fuel, was determined (see Table 5.5). Table 5.6 shows the changes in IRR caused by input price increases, with all other factors kept constant.

Table 5.6: The impact of increases in the price of fertilisers, chemicals and fuel on the IRR of the typical farm for each area

Area	Relative changes in IRR for typical farm at various input price scenarios			
	IRR typical farm	10% price increase	15% price increase	20% price increase
Koeberg/Wellington	100%	-17.46%	-26.10%	-34.74%
Middle Swartland	100%	-14.52%	-21.67%	-29.05%
Rooi Karoo	100%	-13.77%	-20.98%	-27.87%
Goue Rûens	100%	-15.63%	-23.45%	-31.26%
Middle Rûens	100%	-61.90%	-93.33%	-123.81%
Heidelberg Vlakte	100%	-12.15%	-18.38%	-24.30%
Wesselsbron	100%	-17.92%	-26.80%	-35.51%

5.4 Determining the profitability of cultivating triticale for producing bio-ethanol in the Western Cape

Interest in producing bio-ethanol has been renewed in many parts of the world because:

- It is cleaner burning than gasoline in terms of harmful gas emissions,
- It inhibits the use of fossil fuels, and
- Promotes rural diversification.

The search for alternatives to fossil fuels and especially for renewable energy sources is high on the political agendas for various leading countries (Schubert, 2006:778 and Briggs, 2001:90). Bio-diesel fuels are produced mainly from plant oils, like sunflower oil. Bio-ethanol is produced by fermentation DDGS (Distiller Dried Grain Soluble) found in grains. Although the cost of bio-fuel per litre is currently higher than that of gasoline, various countries support bio-fuel production with subsidies or tax credit systems.

South Africa does not have a well-functioning bio-fuel industry yet, due to large coal reserves and the well-developed capacity to extract liquid fuel from coal. After the sharp increase in food prices in 2007 and the blame put on bio-ethanol production for this, mainly in the USA, the South African Government put an embargo on the use of grains for bio-ethanol production. However, the possibility exists for other starch-rich grains to be utilised for this purpose. Triticale, a source of animal feed, may be used for producing bio-ethanol. Triticale has the advantage of attaining higher yields than wheat in marginal areas. A scenario was therefore developed whereby 10 percent of the area allocated to grain production was replaced with triticale, for each area, at a 10 percent higher yield than that of wheat.

A bio-fuel industry in South Africa or the Western Cape is not currently operational, which necessitated the use of a theoretical triticale price in the models. This price for triticale was derived in two ways. The first way was to start with the price of bio-ethanol and subtract the production costs to derive a price for the raw material, in this case triticale. Factors that were taken into account include the fixed costs of building the plant; costs of denaturants, enzymes, yeasts, and other production chemicals; the cost of water; labour costs; maintenance and repair costs; management and quality control costs; licences and fees; electricity; and other expenses. The extraction of alcohol from a ton of grain was then taken into account to establish a farm-gate price for grain (Lemmer, 2007 and Richardson et al., 2006:10).

Another way of determining a theoretical producer price would be to derive the price from other raw material prices. Currently the international maize price would be the benchmark price. The price of triticale for bio-ethanol production would therefore need to be derived from with the international maize price. Various experts indicated that the DDGS yield obtained from maize and triticale are equal (Agenbag, 2007; Botes, 2007 and De Lange, 2007). That meant that for the purpose of bio-ethanol production, the price of maize and triticale should be equal. Various triticale price scenarios were developed, all based on likely sources against which triticale would compete at the bio-ethanol plant. These include the SAFEX price for yellow maize plus a transport differential to the Western Cape, the Durban import parity price for maize, and the export parity price for yellow maize. Table 5.7 shows the expected effect on the IRR of various triticale price scenarios.

The model calculates the impact of a change in the crop rotation system, using a series of equations that interrelate all the physical-biological and socio-economic factors of the whole-farm system. A change in the crop rotation system influences land use patterns, which influences the inventory, because the livestock component is influenced by the pasture component. In this instance, the impact is minor because triticale stubble provides only slightly better grazing than wheat or other grains.

Table 5.7: The effect of bio-ethanol production on whole-farm profitability for various triticale price scenarios

Area	**IRR before changes**	**Triticale price**		
		***R960/ton**	****R1 002/ton**	*****R1 485/ton**
Koeberg/Wellington	5.67%	5.02%	5.30%	6.20%
Middle Swartland	4.20%	3.45%	3.52%	4.35%
Rooi Karoo	3.05%	2.56%	2.64%	3.52%
Goue Rûens	5.63%	5.47%	5.51%	6.05%
Middle Rûens	1.05%	0.93%	1.02%	2.06%
Heidelberg Vlakte	3.21%	2.29%	2.38%	3.43%

- Triticale production replacing 10% of other grains
- * Triticale price based on feed price for triticale
- ** Triticale price based on Durban export parity price of yellow maize
- *** Triticale price based on Durban import parity price of yellow maize

The movable asset component is not affected, because a grain crop is replaced with another grain crop, with the same requirements of machine capacity. In some typical farm models of areas such as Koeberg/Wellington, the Middle Swartland and the Goue Rûens, triticale is a ‘new’ crop that was not part of the original crop rotation system. In all the farm models, provision was made for triticale production, incorporating all the necessary parameters such as yields, input quantities and input prices. An enterprise budget for good, average and poor years was used for triticale, as was the case for the other grain crops. The model would thus automatically pick up the change in the crop rotation system, as well as the hectare change for each crop, and calculate the annual gross margin for each year. The impact of a change in crop rotation system on the whole-farm profitability was thus immediately calculated.

5.5 Conclusions

Certain external factors influence the profitability of grain production. Crop yields, input prices and output prices were identified as critical factors in terms of their potential effect on whole-farm profitability. A series of scenarios, at various levels of the aforementioned factors, were applied using the budget model to establish the sensitivity of farm-level profitability to changes in these factors. The model effectively captured the wider consequences of these changes in input prices, output prices and yields on the crop rotation system, investment requirements, and machinery and labour requirements. The expected impact of changes in these factors proved to be more severe in the areas that are more dependent on cash crop production. It is expected that climate change will have a negative impact on crop yields throughout the grain-producing region of the Western Cape. This effect is expected to be accentuated in the northern and western parts of the Swartland. The expected effect of yield decreases on whole-farm profitability was determined using the budget model. Profitable grain production in the Middle Swartland, Rooi Karoo, Middle Rûens and Heidelberg Vlakte is expected to come under severe pressure should climate change result in its expected impact.

The model was also used to determine the expected influence that a new business opportunity, such as triticale cultivation for the production of bio-ethanol, would have on whole-farm profitability. The adaptability of the model allows for easy-to-implement changes in crop rotation systems in order to replace various grain crops with triticale and measure the impact of this on profitability. At current prices, this presents a more profitable option in certain areas, but this depends largely on the fuel price to wheat price ratio.

Chapter 6

Strategies to enhance farm profitability

6.1 Introduction

The focus and aim of this research project was to use the models within group discussions to identify ways to improve farm level profitability and establishing a process that can be implemented aimed at generating strategies that could enhance profitability. During the expert group discussions, the participants proposed strategies aimed at improving whole-farm profitability for each homogeneous area. These strategies ranged from changes in mechanisation and livestock structure to increases in crop yields due to enhanced production efficiency. Such proposals were quickly simulated using the farm models, and the expected impact calculated in order to establish whether a suggestion was sufficiently viable to justify further development. This section presents these proposals and their expected financial implications to illustrate the effectiveness of the modus operandi of creative planning by the expert group, supported by typical farm models. The financial impact of each suggestion was measured by the whole-farm budget model while the wider ripple effects of such suggestions, especially the ecological affects, were discussed and validated by the group of experts.

The discussion on each homogenous area was started with the current crop rotation systems that were defined as typical by the expert group. The discussions also focused on possibilities to improve on the current crop rotation systems. The group discussions excelled during this phase, as the impact of various suggested changes on the balance of the whole farm and the synergies between crops were brought to the fore.

6.2 Strategies aimed at enhancement of whole farm profitability

One of the goals of this study was to identify ways to improve the profitability of grain production in the Western Cape. To achieve this, the expert groups were challenged with identifying optimum means of doing so during the group discussions. The dynamics of group discussions stimulate creative thinking, a necessary requirement for identifying innovative ideas to improve profitability. The model was used as a tool to measure and immediately show the expected financial effect of proposals on the whole farm. The experts participating in the group discussions also validated the technical feasibility of the suggestions. The suggestions and the expected financial implications thereof are described in the rest of this section.

In all instances, the systems nature of the farm enterprise dictates that all changes in parameters, assumptions, relationships and costs will impact on other parts of the system. A change in any factor that will influence the cultivated area for each crop will affect other parts of the system. These factors are, for instance, the mechanisation requirements, the size and structure of the livestock component, the farm’s gross margin, overhead costs and profitability. Changes in crop rotation system will influence the profitability of other crops in the system, the livestock component, the investment requirement in machinery, and overhead costs. In the same manner, changes to the mechanisation structure cannot be made blindly because this may mean that certain crops are excluded as possibilities for inclusion in the crop rotation system due to an overlap in time constraints. Changes to the livestock enterprise, such as intensification, have a specific impact on the management of pasture, the use of stubble, costs involved in making silage, and labour requirements. Cultivation practices impact on crop yields, mechanisation requirements and overhead costs such as labour. In all these instances, the model, by way of a series of interrelated equations, can easily accommodate the ripple effects caused by the factors identified by the expert groups. The interrelationships are either already built into the model or are identified and quantified by the expert group and are then manipulated via the model. In any event, the model quickly calculates the financial implications of any of the above-mentioned changes. The strategies that follow for each area were all identified and discussed by the expert group and then fed into the model to assess the financial implications thereof.

6.3 Koeberg/Wellington

The crop rotation system implemented in the Koeberg/Wellington area consists mainly of wheat alternated with a variety of other crops. Three systems, shown in Table 6.1, were identified that would typically be implemented in varying combinations. Wheat is produced in consecutive years to take advantage of its potential cash income. Wheat yields in the Koeberg/Wellington area are relatively high, while the wheat price, compared to the price of other cash crops, is also relatively high. The expert group mentioned that where producers diversify into a dairy enterprise, the production of oats could increase the total grain cultivation by as much as 20 percent. System Two is predominantly used and would typically comprise 65 percent of the entire cultivated area, System Three make up 30 percent and System One 5 percent. The decision regarding the extent to which each system is employed is based on soil fertility. System Two is used on the most fertile soils. Despite the high potential wheat yields, wheat, and other crops are seldom produced consecutively on the same field. This is due to the danger of weed resistance to chemical control, soil fertility and the positive yield gains obtained from crop rotation systems.

Table 6.1: Typical crop rotation system in the Koeberg/Wellington area

Year	System One	System Two	System Three
1	Wheat	Wheat	Wheat
2	Canola	Medics	Wheat
3	Wheat	Wheat	Canola
4	Lupines	Medics	Wheat
5	Wheat	Wheat	Oats
6	Canola	Wheat	Wheat
7	Wheat	Medics	Wheat
8	Lupines	Wheat	Canola
9	Wheat	Medics	Wheat
10	Canola	Wheat	Oats

Aggressive and deep soil cultivation once in four years is necessary in this area, due to soil compaction by the livestock component. This mechanical activity also provides an alternative weed control method to chemical control. The constant use of chemicals often enhances the build up of weed resistance to herbicides.

Wheat monoculture production used to be a common practice in this area. The shift to crop rotation in this area was necessitated by three factors:

- weed competition with grains, and the growing resistance of weeds to chemical control,
- disease stress on crops in monoculture systems, and
- fluctuating yields due to the above-mentioned problems led to severe cash flow risks.

In the rotation system, wheat is succeeded with a pasture or broad-leaf crop like canola or lupines. In a 10-year rotation cycle, wheat is produced once in consecutive years, to make full use of the high cash flow offered by a good wheat yield. One proposal that was accepted for implementation was consecutive wheat planting in the system.

The way in which the model accommodates the extra wheat planting in the rotation system is described here to serve as an illustration of the general working of the models. An adaptation in the crop rotation system, as is suggested in this instance, impacts on the total area under each crop. The model adds the number of hectares allocated for each crop which, using a series of DSUM formulas, are multiplied by the gross margin per hectare for each crop. In table containing the crop rotation system (similar to that shown in Table 6.1), medics is replaced with wheat by typing in *wheat* in the selected Excel spreadsheet cell. The total cultivated area planted under wheat will thus increase and the total area under medics will decrease. In the whole-farm multi-period budget, the total income from wheat will increase and that of livestock will decrease. The budget model automatically selects the type of year for wheat and uses the yield and wheat price to calculate the gross income per enterprise.

The area allocated to wheat also influences the total area under grains, which impacts on the mechanisation requirements. The inventory shows whether the total mechanisation requirements are still being met. The model uses the time limits of the activity, in this instance planting and harvesting, the capacity of the tractor and implements set, and the area that needs to be cultivated in order to calculate the requirements in terms of machine capacity. As the area under grains increases at some stage, the model will show that the current requirements exceed the available capacity. The decrease in the medics component will influence not only the income from livestock, which is also calculated using an enterprise budget, but also the inventory.

The amount of livestock is directly derived from the area under pasture. The livestock herd is calculated using certain parameters regarding the carrying capacity of pasture, the ram-to-ewe ratio, replacement policy, as well as lambing and weaning percentages. The number of livestock units and consequently the investment in livestock will thus automatically be adapted by the model if changes are made to the area allocated to pasture. Using the same method as is used for mechanisation, the model will also indicate labour shortages, which may be brought about by an increase in the livestock component. In other words, the model captures all changes to the income and cost component as well as to the investment requirement, all of which directly impact on profitability, measured in terms of IRR.

Lengthening the replacement period for machinery and equipment was one of the main suggestions made and accepted by the discussion group towards enhancing profitability. However, with this strategy, the danger exists that expensive breakdowns may occur at critical times in the production season, such as planting or harvesting time. The strategy is based on the relatively low annual use of machines in the Western Cape. The relatively shallow soils, with their low water retention capacity, necessitates that planting be done within a few weeks, mostly around eighteen days from the first sufficient rains in middle to late autumn. Harvesting is risky because of the risk of quality losses due to rain, mist or strong winds. Therefore, again, around eighteen days is the time period within which harvesting should be completed.

Another suggestion was that the stocking rate for livestock could be increased to 2.8 ewes per ha of pasture, instead of 2.5, as was the figure initially used in the model. This increase is feasible due to the increased utilisation of wheat hay and alternative methods of weed control. Table 6.2 shows the affect of the various options on the expected IRR of the typical farm for the Koeberg/Wellington area. A suggestion was made by the expert group to increase the area allocated to grazing and thus increase the livestock component, but at current stocking rates. The replacement of one wheat crop in each system was suggested to make this possible. This suggestion resulted in a decrease in the expected IRR, as is shown in Table 6.2, and was therefore not explored any further.

Overcapitalisation in mechanisation is a common practice in the Koeberg/Wellington area. Surplus machinery capacity serves as a form of insurance by ensuring that harvesting can be finished in time. The other reason for the overcapitalisation in machinery is to support increases in farm size by renting additional land, a common practice in this area. The scale of the cultivated area can thus be increased without requiring added an investment in machinery. Fitting the investment in machinery to production requirements more precisely would increase profitability. This suggestion, made by agricultural economists, was not accepted as being practically feasible by other members of the expert group, based on the argument for having surplus machinery capacity available during critical periods.

Table 6.2: The influence of changes in various factors on the IRR for the Koeberg/Wellington typical farm

Scenario	**IRR %**
Status quo	5.67%
An extra wheat cultivation in the rotation system	5.89%
Longer replacement interval for machinery and equipment (20 years for harvesters and 15 years for tractors, instead of 12 years)	7.00%
Increased livestock stocking rate (2.8 instead of 2.5 ewes per ha of pasture)	6.00%
Permanently replace one wheat crop in each system with oats as pasture	5.55%

6.4 Middle Swartland

In the Middle Swartland, the structure of the crop rotation system is mostly determined by the potential performance of the livestock component. Most producers diversify into livestock as far as possible, the restricting factor being the availability of and cost of livestock with which to expand the enterprise. In some cases, medics does not perform sufficiently well to sustain a profitable livestock enterprise. Other important considerations are the policy regarding fallowing and the yield potential of canola and lupines. Good years do result in profitable wheat production, but not to the same extent as in the Koeberg/Wellington area. Producers tend to diversify more into other crops, but still try to capture the positive cash flow that results from good years.

Four systems, shown in Table 6.3, were identified by the expert group as being typical for this area. System Three is typically implemented on 40 percent of the total cultivated area. Systems One and Two are each implemented on 25 percent of the cultivated area, and System Four on 10 percent of the cultivated area. This makes wheat production relatively intensive in the Middle Swartland.

Table 6.3: Typical crop rotation systems for the Middle Swartland

Year	System One	System Two	System Three	System Four
1	Wheat	Wheat	Wheat	Triticale
2	Medics	Canola	Wheat	Fallow
3	Wheat	Wheat	Oats	Wheat
4	Medics	Lupines	Wheat	Fallow
5	Wheat	Wheat	Wheat	Triticale
6	Medics	Canola	Wheat	Fallow
7	Wheat	Wheat	Oats	Wheat
8	Medics	Lupines	Wheat	Fallow
9	Wheat	Wheat	Wheat	Triticale
10	Medics	Canola	Wheat	Fallow

Increasing the wheat-medics crop rotation system, System One, was the first strategy discussed for the Middle Swartland. The main advantages of the wheat-medics system are the stability that the livestock enterprise brings to the cash flow and the enhanced yield effect of medics on the following year's wheat crop. Various factors disallow the implementation of a wheat-medics crop rotation system on the whole-farm area. These factors include soil limitations, rainfall that often begins too late in autumn (especially in the northern parts of the Swartland) and the cost of enlarging the livestock component. According to the workgroup, it should be possible to extend the wheat-medics rotation system to approximately 60 percent of the total cultivated area of the farm.

The second strategy involved extending the age and replacement schedule of machinery and equipment. It was proposed that the replacement period be extended to 20 years for harvesters and 15 years for tractors. The producers and representatives of the agribusinesses also proposed the use of cheaper, less sophisticated and durable machinery and equipment. The mechanisation expert added that most suppliers of agricultural machinery have a lower specification version of harvester, in terms of technology, that is also cheaper; for instance harvesters without the expensive global positioning systems (GPS) can be bought.

The third strategy that was suggested by the expert group involved expanding the wheat-medics rotation and the livestock enterprise. According to the workgroup, the optimal management of medics should allow for a decrease in nitrogen fertilisation requirements for the following wheat crop. A normal practice for wheat following medics is to apply 30 kilogram N per ha at planting and another 30 kilogram N as top fertilisation approximately six weeks later. The top fertilisation can be decreased to 20 kilogram N per ha in the case of well-performing medics. Along with the added nitrogen saving advantage, the stocking rate for medics pasture can be increased to 2.5 ewes per ha of pasture, instead of the typical 2.2 ewes per ha.

Table 6.4 shows the effect of the above-mentioned strategies on the expected internal rate of return on capital investment for the typical farm of the Middle Swartland. In each instance, only the factors mentioned were altered, and all other factors and functions were kept constant.

Table 6.4: Comparison of the IRR for the typical farm for the Middle Swartland with the outcomes of different strategies suggested for increasing whole-farm profitability

Strategy option	**IRR %**
Status quo	4.2%
Shift to 60% of area utilised for wheat-medics rotation system	5.46%
Longer life expectancy for machinery, and cheaper machinery	5.35%
Higher livestock stocking rate (2.5 ewes per ha instead of 2.2) and less use of nitrogen fertiliser as top fertiliser (20kg/ha instead of 30kg/ha)	4.93%
Permanently use one wheat crop in the medic-wheat rotation system for producing feed	4.01%

Pursuing higher wheat yields, by disregarding grade, to produce feed-grade wheat, at lower prices but higher yields was suggested by the expert group. The fertiliser costs, especially nitrogen, would increase, but the crop protection chemical costs would decrease. There would be no grading, storage and insurance fees charged by local silos. Yields of up to 4 tons per hectare were suggested. A feed-grade wheat price R850/ton was used. Replacing one wheat crop in the wheat-medics system was suggested. Implementing this proposal in the model resulted in a decrease in projected IRR.

6.5 Rooi Karoo

The relatively low rainfall of the Rooi Karoo, compared to the other areas of the Swartland, limits the variety of crops available for production in crop rotation systems. The rainy season tends to start late, and the high maximum temperatures quickly work against the effect of rainfall. These factors preclude the production of canola, lupines and medics in the Rooi Karoo. The systems typically implemented in the Rooi Karoo are shown in Table 6.5.

Table 6.5: Typical crop rotation system for the Rooi Karoo area

Year	System One	System Two	System Three
1	Wheat	Fallow	Wheat
2	Fallow	Triticale	Wheat
3	Wheat	Oats	Fallow
4	Fallow	Fallow	Wheat
5	Wheat	Triticale	Wheat
6	Fallow	Oats	Fallow
7	Wheat	Fallow	Wheat
8	Fallow	Triticale	Wheat
9	Wheat	Oats	Fallow
10	Fallow	Fallow	Wheat

Producers in the Rooi Karoo area depend heavily on the utilising of livestock enterprises to counter the production risk of cash crops. As the Rooi Karoo is characterised by low rainfall, late rainfall in autumn and high maximum temperatures in autumn and spring, the performance of wheat is risky, and canola production is not feasible at all. To negate this problem, research and development should focus on heat and drought resistant cultivars and cultivars with a shorter growth period. This is a lengthy process and the area is relatively small in terms of wheat production, which means that research funding for the Rooi Karoo area will always be limited.

It was proposed during the group discussion that converting to no-till and minimum-till cultivation practices should, over time, manage soil moisture more effectively. A slight increase in yields is possible when stubble is protected and only the top soil is disturbed at planting time. This is expected to bring about an increase of five percent in the wheat yield for good and average years, but no increase for poor years.

Another proposal to increase farm profitability is lengthening the period that machinery and equipment is kept. One factor that contributes to the ability to utilise machinery over a longer period is low annual usage and the terrain and soil characteristics. Annual cultivations are kept to the minimum and include only one crop protection spray activity compared to between six and nine done in the Goue Rûens, for instance. The terrain in the area is relatively flat, which means that the power demand for tractors is relatively low. The soils have a low clay and rock content, which limits wear and tear on equipment and machinery. Harvesters, tractors and most equipment are kept longer than 20 years. Table 6.6 shows the expected effect of the suggested strategies on farm profitability.

Table 6.6: Impact of different strategies on the IRR for the typical farm for the Rooi Karoo compared with the status quo

Strategy option	**IRR %**
Status quo	3.05%
5% higher wheat yield in good and average years due to enhanced cultivation practices	3.54%
Longer life expectancy for machinery, and cheaper machinery due to less intensive utilisation of technology	5.05%

A ten percent increase in maintenance and repair costs was applied for the Rooi Karoo to accommodate the strategy of long replacement periods. It was also mentioned at the workshop that producers in the Rooi Karoo area mostly buy second-hand machinery and equipment from other areas instead of new equipment.

6.6 Goue Rûens

The main difference between the Swartland and the Southern Cape is the more even spread of rainfall throughout the year in the Southern Cape. This allows for using a perennial crop like alfalfa for pasture. Table 6.7 shows the most common crop rotation systems implemented in the Goue Rûens. The crop rotation systems for the Southern Cape run over periods of ten years and longer. All systems include alfalfa production, covering approximately half the rotation cycle. The length of the alfalfa phase is usually determined by local land conditions and management practices affecting the endurance of the crop. If productivity is maintained, alfalfa can be kept longer. The productive life of alfalfa usually ranges from five to seven years, although a dry establishment year can cause a shorter productive life. The total annual rainfall for the Goue Rûens area is relatively high, comparing well with the Koeberg/Wellington area, but is has a more even rainfall distribution, with 70 percent falling in winter and 30 percent in summer. The yield risk for this area is relatively low.

Table 6.7 Typical crop rotation systems for the Goue Rûens area

Year	System One	System Two	System Three
1	Alfalfa	Alfalfa	Alfalfa
2	Alfalfa	Alfalfa	Alfalfa
3	Alfalfa	Alfalfa	Alfalfa
4	Alfalfa	Alfalfa	Alfalfa
5	Alfalfa	Alfalfa	Alfalfa
6	Wheat	Alfalfa	Alfalfa
7	Barley	Wheat	Wheat
8	Canola	Barley	Barley
9	Wheat	Barley	Canola
10	Barley/alfalfa	Canola	Wheat
11		Wheat	Barley
12		Barley	Lupine
13		Oats/Alfalfa	Wheat
14			Barley/Alfalfa

In the last year of the cash crop phase, alfalfa is planted together with the crop planted in that year. After harvesting time, the alfalfa is already established and can be used for grazing after the first summer. The three systems are used relatively evenly in terms of land allocated to each. The shorter system, five-year alfalfa, is usually implemented on the cooler southerly facing slopes where the productive life of alfalfa is shorter. Relatively high quality malt barley is produced in the Goue Rûens area. Barley is planted in consecutive years. The second barley year produces high quality malt barley.

The most prominent issue in the Goue Rûens area is the rapid expansion of break-even farm sizes in order to remain viable. Farms sizes of 2 000 ha to 3 000 ha are slowly becoming the typical farm size for the area; however a number of farms of 800 ha in size are however still operational. The inventory for the typical 800 ha farm is also included in Annexure C and shows total capital investment requirements of R11 695 821. The total capital requirements per ha of own farm for the 800 ha farm is R18 275, and for the 2 500 ha farm they are R14 013 per ha. Table 6.8 shows the difference in expected long-term financial performance between the 800 ha and 2500 ha farms. The low profitability of the 800 ha farm will, according to the workgroup discussion, force producers to move towards hired machinery and equipment, which is not readily available, or to lease land to increase the scale of the operation.

Table 6.8: Comparison of the net present value (NPV) and internal rate of return (IRR) of the 800 ha and 2500 ha typical farms for the Goue Rûens area.

Area	Net present value (NPV)	Internal rate of return (IRR)
Goue Rûens 2 500 ha farm	R 3 008 647	5.63%
Goue Rûens 800 ha farm	R -7 047 075	-0.40%

The survival of the 800 ha farm is at risk, which forces producers on such farms to keep machinery for periods well in access of 20 years. Producers try to intensify production and ensure that high-input-cost crops are only planted on the best fields. They also try to get higher lambing and weaning percentages through precision management.

Increasing the livestock component of the typical farm was identified as an option. More hectares allocated to pasture can potentially free up some mechanisation capacity, which can be sold or rented to other producers. The current mechanisation structure for the Goue Rûens, as shown in Annexure C, has a safety margin built into it to ensure that critical activities are not endangered by mechanical breakdowns. It was suggested to scale down on the current inventory, and more specifically on the size of one of the harvesters from 201 kW to 170 kW and to replace one of the 100 kW tractors with a 70 kW tractor.

An option that was suggested, almost contradictory to the above-mentioned strategy, was that a part of the farm be used for a continuous cash crop system where only grains would be included with no pasture phase. This would enable producers to take advantage of occurrences of high grain prices. The mechanical infrastructure would be kept the same but used with fuller utilisation of the available mechanisation capacity. An important aspect that was mentioned was that, if a continuous cropping system were implemented, the input levels, especially fertilisation and herbicides costs, would have to be increased for the specific area where the system was utilised. The suggestion was that 20 percent of the farm be allocated for a continuous cash cropping system.

Relatively high and more consistent yields allow producers to replace machinery and equipment more regularly in the Goue Rûens area, resulting in a technologically more up-to-date machinery stock. Producers are thus able to take advantage of technology such as precision farming to apply fertilisers optimally. Over the longer term, this results in yield increases. A proposal was made to allow for a five percent yield increase in good and average years to allow the grain crops to exhibit these benefits.

The large farm units, and consequent scale of the farming operation, enable these producers to negotiate discounts on inputs like fertilisers and crop protection chemicals. The producers in the expert groups indicated that they receive a five percent discount above the normal cash discounts. Table 6.9 presents the effect of the above-mentioned options and strategies on the IRR of the typical farm for the Goue Rûens area.

Table 6.9: The impact of various strategies proposed for the Goue Rûens on the profitability of the typical farm

Strategy implemented	**IRR %**
Status quo	5.63%
Downscaling on mechanisation and increasing pasture utilisation	5.72%
Implementing a continuous cash cropping system on 20% of the cultivatable area of the farm	5.75%
Increasing grain yields by 5 percent for good and average years, due to technological improvements	6.31%
Effect of a 5 percent discount on the price of fertilisers and chemicals	5.96%
All harvesting done by contractors	5.41%

A shift to make use of contract harvesting, instead of investing in more harvesters, was suggested. The three-year average contracting fees is R250/ha, with the producer providing the fuel. This proposal proved to have a negative impact on expected profitability. It was speculated that the reason for this was the relatively high profit margin of the contractors. In other areas where total investment is less, and the relative contribution of a harvester to total investment is higher, this effect might be different.

6.7 Middle Rûens

The crops suitable for production in the Middle Rûens are the same as those for the Goue Rûens. In the, dryer, Middle Rûens area the livestock enterprise is more important than in the Goue Rûens area. For this reason, oats and triticale are more regularly brought into the crop rotation system. To produce feed, green oats are sometimes used as pasture. The quality of barley is not as good as it is in the Goue Rûens. The practice of producing barley for two consecutive years on the same field is thus not followed in the Middle Rûens. During the cash crop phase of the crop rotation system, canola is produced to break the life cycle of narrow leaf weeds, such as rye grass, and insects. Canola production also causes a yield increase in the succeeding grain crop. The typical crop rotation systems in the Middle Rûens are shown in Table 6.10.

Table 6.10: Typical crop rotation system for the Middle Rûens area

Year	System One	System Two	System Three
1	Alfalfa	Alfalfa	Alfalfa
2	Alfalfa	Alfalfa	Alfalfa
3	Alfalfa	Alfalfa	Alfalfa
4	Alfalfa	Alfalfa	Alfalfa
5	Alfalfa	Alfalfa	Alfalfa
6	Alfalfa	Alfalfa	Wheat
7	Oats	Wheat	Barley
8	Wheat	Barley	Canola
9	Oats	Canola	Wheat
10	Wheat	Wheat	Barley
11	Barley	Barley	Canola/Alfalfa
12	Triticale/Alfalfa	Barley/Alfalfa	

The selection of a system depends on the potential of the land. System Three would be implemented on the best soils, and cash crops like wheat and barley would be primarily produced during the cash crop phase. Feed production mostly takes place on the poorer soils. Systems implemented on these poorer soils would typically include oats, for grazing or silage, and triticale. System One would typically be implemented on the poorer soils. This is done to reduce the production risk of high-input-cost crops on the lower potential soils. A typical division of area between systems would be 40 percent each for Systems Two and Three and 20 percent for System One.

The first proposal that the expert group made for the Middle Rûens area was to increase the stocking rate of livestock from three ewes per ha of pasture to 3.5 ewes per ha pasture. In the Middle Rûens area, producers focus more on the livestock enterprise, with a more intense management approach. Intensifying management of the livestock component includes optimal lambing season selection, weaning lambs as early as possible, resting pasture at critical periods by using grain stubble fields and focusing on the management of alfalfa pasture.

The second strategy involves expanding the life span of machinery and equipment. Producers rely on their own ability to maintain and repair machines and equipment. As is the case for the Middle Swartland, producers in this area tend to invest in cheaper, less sophisticated technology and equipment. The Middle Rûens area is characterised by steep slopes, which requires more tractor power for cultivations involving soil preparation and planting. A tendency in the Middle Rûens is to invest in one large harvester rather than in two smaller ones. This is more efficient in terms of cost per hectare, but increases the risk of a breakdown in harvesting season. The same principle is applied to planters. Using larger machines decreases the number of labourers required, but they require a higher level of skill.

Producers in the Middle Rûens area are capable of marginal increases in crop yields due to the availability of new technology that allows more accurate planting and thus lower seeding density, planting depth, fertilisation levels, and enhanced management of legume pasture, resulting in increased yields for successive crops. A five percent yield increase was suggested for grain crops if optimal management could be implemented and maintained. The five percent increase would not apply to poor yield years, due to the climatic limitations.

Table 6.11 shows the expected effect of the suggested strategies on the long-term profitability expressed in terms of the IRR for the Middle Rûens. It was also suggested that the grain yield increase and the increase in the livestock stocking rate of pasture be combined. This would, however, require that provision be made to hire a manager at a cost of R180 000 per annum, which would have a negative impact on the expected IRR; this strategy was not recommended for further exploration.

Table 6.11: The impact of various suggested strategies on the IRR for the typical farm for the Middle Rûens

Strategy option	IRR %
Status quo	1.05%
5% higher yield for grain crops in good and average years due to enhanced cultivation practices	1.64%
Longer life expectancy for machinery and cheaper machinery due to utilisation of less sophisticated technology	2.99%
Increased stocking rate for livestock (3.5 ewes per ha of pasture instead of 3.0).	3.13%
Hire manager and increase stocking rate and crop yields.	0.97%

6.8 Heidelberg Vlakte

Table 6.12: Typical crop rotation systems for the Heidelberg Vlakte area

Year	System One	System Two
1	Alfalfa	Alfalfa
2	Alfalfa	Alfalfa
3	Alfalfa	Alfalfa
4	Alfalfa	Alfalfa
5	Alfalfa	Alfalfa
6	Wheat	Alfalfa
7	Wheat	Wheat
8	Barley	Barley
9	Canola	Oats
10	Wheat/Alfalfa	Wheat
11		Canola/Alfalfa

The total rainfall during the year is the most evenly distributed for the Heidelberg Vlakte area than for all the other areas. This contributes to relatively low cash crop yields because of the lack of a wet winter season. Producers typically diversify into livestock enterprises, with more land being allocated to pasture. Table 6.12 shows the systems typically used in the Heidelberg Vlakte area.

The system used on the high potential soil is System One, and System Two is used on lower potential soils. In the Heidelberg Vlakte area, the utilisation of pasture for dairy and ostrich farming is becoming increasingly important. The focus of this study is on the profitability of grain production; the profitability of dairy and ostrich enterprises, normally combined with grain production in the Heidelberg Vlakte area, is accommodated in the models by incorporating information obtained from local producers. Diversification by adding a dairy enterprise is considered typical, and was thus included in the typical farm model for this area. Producers in the Heidelberg Vlakte area have already adopted minimum-till and no-till cultivation methods.

The use of oats for either grazing or silage to increase the livestock component was proposed for the Heidelberg Vlakte area. Oats would then be utilised as animal feed and grazed at the same stocking rate as alfalfa or used as silage and contribute to increasing the livestock stocking rate of alfalfa pasture. Two livestock scenarios were therefore applied in the model, one where oats was used for direct grazing at two ewes per hectare and one where the oats is used for silage and the stocking rate is subsequently adapted from two ewes per hectare pasture to three ewes per hectare pasture. The second scenario required the addition of costly silage-making activities, which were subsequently incorporated into the model.

Table 6.13: Impact of proposed strategies on the profitability of the typical farm for the Heidelberg Vlakte

Strategy option	**IRR %**
Status quo	3.21%
Six % higher yield for grain crops in good and average years due to enhanced cultivation practices	5.88%
Using oats as pasture for livestock	3.69%
Increased stocking rate for livestock (3.0 ewes per ha pasture instead of 2.0). Due to utilisation of oats as silage for livestock	5.09%

Another suggestion made by the expert group was the assumption of increased managerial ability and intensity. According to the expert group, this could result in six percent higher crop yields and an increase in the potential stocking rate of livestock from two ewes per ha pasture to 3 ewes per hectare of pasture. Table 6.13 shows the expected effect on the suggested strategies of the long-term profitability expressed in terms of the IRR for the Heidelberg Vlakte area.

6.9 Wesselsbron

Maize and wheat are the only crops used in the crop rotation system for the Wesselsbron area. Maize is a summer cereal, which is produced during the rainy season of the northern production areas. Wheat is a winter crop produced in the dry season of the summer rainfall areas. To overcome the dry winters, fields are left to fallow during the rainy season to allow for water level build-up. Producers in the Wesselsbron area have more production certainty at planting time than producers in the Western Cape. Subsequently their production risk is also lower. The producers of the Western Cape have little potential soil moisture-level build-up capacity because of the shallow soils. The other impact of production certainty, with regard to the Wesselsbron area compared with the Western Cape, is that the planting season is potentially longer with a lower mechanisation requirement. This practice effectively means that a field is fallowed for ten months from the maize harvest to the next wheat planting. The effect on the utilisation of land is that production takes place only two out of three years, once for wheat and once for maize. During the other year, the field is fallowed. The system followed is shown in Table 6.14. Equal amounts of land are normally used for maize, wheat and fallowing.

Table 6.14: Typical system used in the Wesselsbron area

Year	System One	System Two	System Three
1	Wheat	Maize	Fallow
2	Maize	Fallow	Wheat
3	Fallow	Wheat	Maize
4	Wheat	Maize	Fallow
5	Maize	Fallow	Wheat
6	Fallow	Wheat	Maize
7	Wheat	Maize	Fallow
8	Maize	Fallow	Wheat
9	Fallow	Wheat	Maize
10	Wheat	Maize	Fallow
11	Maize	Fallow	Wheat
12	Fallow	Wheat	Maize

6.10 Conclusions

Various strategies, aimed at improving the whole-farm profitability for each area, were suggested by the groups of experts. The models were used to measure the expected impact on profitability of such suggestions. The investment in mechanisation was the most common factor focused on by the expert group. Methods and strategies to optimise the use of machines or extend the lifetime of machines were presented, all of which had a positive effect on the expected IRR. A common limitation to aggressive changes in mechanisation structure is the volatility of weather during harvesting seasons, which leads producers to overinvest in mechanisation as an insurance policy to ensure harvesting on time. Expansion of the livestock enterprise is another strategy that was repeatedly explored, but it does limit producers from taking advantage of high grain prices. Over the long term, however, it does enhance profitability and diversify risk.

The results shown and discussed in Chapter 4 illustrate the functioning of the expert group in using the typical farm budget models. The expert group made suggestions and, through dialogue and interaction with other experts, discussed and established the wider implications of such suggestions on the physical and biological characteristics of the typical farm. The budget model was used exclusively to determine whether suggestions made by the expert group would have a positive or negative impact on the profitability of the typical farm. The model can accommodate the complexity of the numerous internal interrelationships that are influenced by changes to certain parameters of the farm system, which can generate an accurate answer much quicker than is humanly possible. The models are thus used to support and add to human inventiveness and innovativeness by quickly determining and showing the impacts of suggestions. The proposed process was successfully used to generate area specific strategies aimed at enhancing farm profitability. The purpose of this research project is the identification of management options that can be implemented. The validity of such options cannot be proved statistically as these strategies will only play out in future. The hypothesis for this research project therefore cannot be statistically proved, but the fact that consensus on the financial and ecological feasibility of a suggestion is reached within a group of experts suggests that the process is valid for its purpose.

Chapter 7

Conclusions, Summary and Recommendations

7.1 Conclusions

The price-cost squeeze forces grain producers in the Western Cape to seek various ways to increase profitability, other than simply increasing efficiency. The number of feasible alternative options available to increase profitability is limited, due to the risky climatic and soil characteristics of the grain production areas in the Western Cape. Ill-considered strategies may further endanger sustainable production. Careful identification and evaluation of options that could increase profitability are thus required to enhance the financial viability of grain producers.

Research of farm-level issues in the grain industry is usually done within a specific discipline such as agronomy, soil science, entomology, plant pathology, animal science, genetics or agricultural economics. Researchers within such fields further specialise in certain areas, which leads to the compartmentalisation of research and knowledge. Such research projects, in general, do generate valid information, which contributes towards solving certain problems but often disregards wider, interrelated impacts that should be taken into account to determine priorities more effectively. An example of such research is technical research that ignores the financial implications of proposals on whole-farm profitability or economic research that disregards the technical and physical-biological considerations regarding the implementation of suggested strategies. Financial-economic research is usually of a diagnostic nature, and is usually based on time series or cross-section data to identify reasons for failure, rather than generating new ideas to lessen the price-cost squeeze.

To address the problem of the poor financial performance of grain farms necessitates that the research method meets two requirements. The first requirement is creativity, to identify ways to improve profitability in a sustainable manner. The second requirement is to calculate the financial impact of the proposed innovation on the whole-farm operation. This implies that the wider effects on interdependent components of the farm system must be captured. The calculation tool, in this case a farm model, must therefore effectively deal with the multi-faceted nature of the farm system, which consists of, and is influenced by a variety of interrelated physical-biological and socio-economic factors.

Multi-faceted farm systems require a multi-disciplinary research approach. Experts from various disciplines need to focus simultaneously on a particular issue to ensure that the ripple effects of proposed changes to the farm system are recognised. The dynamics of group discussions provide the ideal environment for the stimulation of creative thinking, as different perspectives are constantly raised and the perspectives of individuals are constantly challenged. This stimulates innovative and inventive thinking. The success of multidisciplinary group discussions depends on the knowledge and skills that each individual contributes and on the dynamics among the individuals to stimulate innovative thinking. During the group discussions each participating expert offered a high level of knowledge and experience to evaluate and verify the suggested modifications to the model. The debate during the group discussions not only generated ideas, but also validated the whole farm effect of the suggested innovations. The inclusion of experts from various fields is thus important to ensure that the best possible outcome is reached.

The stimulation of creativity and the accommodation of complexity were implemented in this research project via separate group discussions. A group discussion for each homogeneous farming area was required to accommodate the unique characteristics of each grain-producing area of the Western Cape. The groups consisted of experts from various disciplines, local producers and extension officers from local agribusinesses. The experts represented disciplines such as agronomy, soil science, entomology, plant pathology, agricultural mechanisation and agricultural economics. Each participant contributed to the group discussions an intimate knowledge of specific issues and the ability to foresee the impact of changes on the farm system or on specific components of it. The producers and extension officers added knowledge of local circumstances for each area. They often challenged the scientific perspectives of problems and shared practical knowledge. Suggestions made by the expert group were validated through dialogue and interaction with other participating experts. This also allowed for the determination of wider implications of such suggestions on the physical and biological characteristics of the typical farm.

The participating experts had to see the financial implications of their suggestions to know if they should further explore an idea, which prevented wasting time on non-viable options. The availability of the whole-farm models allowed for quick measurement of the financial impact of changes to the parameters and assumptions of the farm system, and provided a financial perspective of the proposed technical innovations. The complexity of the farm system requires that the tool used to describe the farm in financial terms be able to incorporate accurately the wide variety of factors and relationships of the whole system. This was done by simulation modelling in the form of whole-farm multi-period models. Simulation modelling allows for a vast number of factors and relationships to be connected by a series of mathematical or accounting equations. In this study, whole-farm multi-period budgets, based on accounting principles, were developed for a typical farm for each homogeneous area of the Western Cape. All the models are based on standard accounting principles and are user-friendly in that all inputs and parameters of the models can be accessed and changed with ease. All the components of a whole-farm model are interconnected; therefore, changes to any specific component will immediately show the impact on the profitability of the whole farm.

The primary research goal was to identify ways that could improve the whole-farm profitability of grain farming in the Western Cape. The group discussions, which included experts from various disciplines, combined with using whole-farm multi-period budget models in an interactive way were successfully employed to reach this goal. The hypothesis of this study is that ways to improve farm-level profitability, in a sustainable manner, can be identified, using expert group discussions focused on enhancing profitability, in combination with whole-farm multi-period budget models that show the financial implications of suggestions. This was achieved, and therefore the hypothesis can be accepted as valid. Each farm is idiosyncratic, which means that the counterfactual for this method would have to be the development of a budget model on an individual farm basis. Identifying strategies would rely on the modeller, who would not know the farm as well as the producer and the producer whose knowledge of alternatives would be limited. Information that was generated on the profitability of grain production in the Western Cape also served to support dialogue between role-players in the wheat-to-bread supply chain. This was presented and served as a discussion point during the grain debate, which took place at the annual Bredasdorp Mega Week Expo in 2008, on the contributions of the different role players in the wheat-to-bread supply chain with regard to increasing bread prices.

The following principles were derived from the development and implementation of the methods employed. These principles can serve as guidelines for the planning and development of expert group discussions supported by whole-farm budget models, which are used to identify and evaluate innovative ideas for increasing farm profitability for other farming areas, farming types and over time:

- A thorough understanding of the system being modelled is essential, which is also one of the general requirements of simulation modelling. Farms in the study area need to be visited and thoroughly discussed with producers. The participants in the expert groups, namely, producers, extension officers, representatives of input-supplying companies and representatives from companies buying farm produce are required to understand the factors and interrelationships comprising the whole-farm system.

- The financial model of the whole-farm system needs to be parameterised as far as possible. The user-friendliness of the model depends on the ease and speed with which the different components can be accessed and changed. User-friendliness is increased when the possible values of parameters are made available in tables to allow immediate access via lookup functions.
- The multi-period whole-farm model must be adaptable, user-friendly and must be able to capture the complexity of the whole-farm system in order to allow for quick assessment of proposals made by participants during the group discussions. The group discussions included numerous experts from disciplines other than agricultural economics.
- Multi-period budgeting allows for the determination of the long-term financial implications of, for instance, machinery replacement, the synergism of the crop rotation system and alterations to the crop rotation system. In this case, the model needed to capture the positive impacts of a well-planned sequence of crops in a crop rotation system. The capacity of a multi-period whole-farm model contrasts with typical gross margin analysis methods, for example, the Micro Combud budget program used by the Department of Agriculture in South Africa. This was illustrated by comparing the financial performance of a typical farm in each homogeneous area in the Western Cape, and one in the northern wheat-producing region. Multi-period budgeting allows, via calculating the IRR, for capturing of the time value of money, the direct comparison of the profitability of crop rotation systems with different crop cycle lengths, land prices, yields, and the carrying capacity of pasture.
- The successful use of a typical farm model requires that the study area be subdivided into smaller, sufficiently homogeneous farming areas, to be able to identify area-specific challenges and strategies.
- To enhance the trustworthiness of the model requires that experts from a variety of disciplines be consulted during the model development phase, the model validation phase and the model use phase. (To prevent biased results from the model, care should be taken not to use the same participants for model construction and model validation).
- The inclusion of lay knowledge from producers and extension officers from local agribusinesses contributed to the validity of the models and the practicality of the proposals.
- The success of identifying and evaluating innovative adaptations to the farm operation lies mainly in combining the multi-disciplinary expert group discussions and the multi-period whole-farm models. The fact that the financial impact of suggestions made by experts during the group discussions could be assessed quickly enabled participants to take the financial implications of their suggested innovations into account.

7.2 Summary

In Chapter 1, the contribution of the grain industry to the Western Cape economy, in terms of its contribution to the gross regional product and to employment, was highlighted. The profitability of grain production is under pressure, which has been caused mainly by the cost-price squeeze and volatile production and market conditions, experienced by producers of all agricultural commodities. Producers face a situation where they cannot simply carry on with current practices. However, their options are limited. Ill-considered changes may worsen their financial positions. The challenge for producers is therefore to create ways to improve farm-level profitability while simultaneously, in accordance with the systems approach, taking into account a wide variety of social, technical, financial and economic considerations typically present in a grain farming operation.

Most research carried out on issues related to grain farming in the Western Cape has been done within the limits of single scientific disciplines. Single disciplinary research interprets a problem from a specific perspective and is unable to recognise dimensions observable from other relevant disciplines. Various examples exist of technical research conducted on farm systems by natural scientists while neglecting the financial implications for the farm system. In the same manner, economists often neglect some critical technical aspects of the farm system. Financial research on farm systems is mostly retroactive in nature, based on the analyses of historical data. It is aimed at identifying reasons for failure and is not designed to assist in creative problem solving exercises. To overcome these potential shortcomings in farm systems research, multidisciplinary, multi-perspective research combines expert inputs from various disciplines.

This research project was focused on identifying ways to improve the farm-level profitability of grain farming in the Western Cape, which posed two main challenges. The first was to think creatively about ways to improve farm-level profitability and the second was to handle the complexity of the farm system. For both these challenges, a combination of methods, based on the systems approach, were proposed. A combination of expert group discussions and simulation modelling, based on accounting principles, was suggested to simultaneously accommodate complex interrelated factors and to stimulate creative thinking among the participants.

In the first part of Chapter 2, the role of group discussions and their contribution to scientific research was described. The systematic and rigorous manner in which scientific research is conducted to describe, explain, theorise or model real-world problems often leads to specialisation and the development of scientific disciplines within which further specialisation is also common. Specialisation thus easily causes the fragmentation of knowledge, which may already exist, and disconnectedness among researchers. Disciplines related to grain production include, for instance, agronomy, soil science, plant pathology, entomology, animal science and agricultural economics. The meaningful study of the financial performance of a grain farm relies on the effective integration of contributions from of all these disciplines simultaneously, as well as on the integration of indigenous and practical knowledge, necessitating the inclusion of producers in group discussions. Within this context, the various dimensions comprising the farm system can each be discussed in detail, as experts on the relevant dimensions are present to describe and explain the impact of changes on other, interrelated dimensions of the farm system.

A second, and in this project equally important characteristic of group discussions is that the inherent dynamics of interdisciplinary group discussions also stimulate creative thinking, because individuals realise that other perspectives exists. New ideas for improving the farming operation are created when participants are confronted with contributions from experts with other perspectives. Creativity is necessary for identifying ways of improving farm profitability, in order to deviate from simply focusing on productivity. Current risks confronting producers also need to be considered creatively. Group discussions thus present the ideal setting for actively seeking ways to improve the financial performance of grain farming.

The second part of Chapter 2 covered the development of a financial model that allows the immediate calculation of the expected impact of a suggestion on farm profitability. The main purpose of the model is to accommodate the complexity of the farm system by including as many as possible of the factors and interrelationships of the farm system in a parameterised manner. This means that all quantifiable assumptions, inputs, parameters and productivity relationships can be directly accessed and quickly changed when suggested by participants. Other purposes of these models are to measure the current profitability of the whole farm, to assess the impact of various changes to the parameters of the farm on the expected profitability, and to add a financial perspective to the group discussions of technical matters, which could further stimulate creative thinking.

Modelling is about developing and validating accurate representations of the real world. The main advantage of modelling is that various possible outcomes of a real-world system can be evaluated without physically disrupting the system. In agricultural economics, four main categories of empirical modelling methods are distinguished, namely, econometric models, optimisation models, simulation models and accounting models. Accounting models are mostly budgeting models, which are in essence simulation models that evaluate systems and plans in physical and financial terms. The specific requirements of this study, dictated by the research problem, were best met by budgeting models. The chosen modelling technique is the whole-farm multi-period budget model.

Chapter 3 describes three distinct phases of this study relating to the model, namely, construction, validation and use. During the model construction phase, expert knowledge was incorporated by consulting with scientists as well as producers and extension officers from various local agribusinesses to gain knowledge and insight into the farm system. A thorough understanding of the system being modelled is a prerequisite of simulation modelling. During the model's validation and use phases, group discussions were held. The multiple facets of the farm system served as the bases from which the experts that participated in the study were identified.

The diversity within the grain production areas of the Western Cape necessitated the division of the whole area into smaller, more homogeneous areas, and for each area, a typical farm was defined and simulated. The Swartland region was divided into the Koeberg/Wellington, the Middle Swartland and the Rooi Karoo areas. The Goue Rûens, the Middle Rûens and Heidelberg Vlakte were identified as being homogeneous areas within the Southern Cape region. Another area that was included in this study was the Wesselsbron area, which lies in the northern, summer-rainfall region. The important distinguishing factor among the areas is climatic characteristics, within which rainfall and rainfall dispersion were identified as being the most important factors that determine crop yields. A typical prevalence of good, average and poor years was established by the expert group, which was used to accommodate climatic risk in the model. Other physical characteristics include terrain and soil characteristics. The combination of these characteristics determines not only expected yields, but also the type of crops that can be cultivated in each area.

A typical farm model was developed for each homogeneous area and was validated with the help of an expert group as described in Chapter 4. The budget model for each typical farm consists of three main components. The first is the input component, which includes mostly physical parameters and assumptions that determine the extent of the typical farm. The parameters were, in all instances, validated by the expert groups. The second component is the calculation component, which was constructed in such a way that all interrelationships were captured by a series of financially valid equations. The third component comprises the output of the models. With the focus of the study on the whole-farm financial performance of the typical farm, the output consists of calculations of the expected whole-farm profitability, measured in terms of IRR and NPV, and expected affordability of the investment, measured by cash flow. Standard accounting principles were applied throughout the budgets. The multi-period budget and expected cash flow for each farm are shown in Annexure E.

In Chapter 5, the results that were obtained from the expert group discussions are described. The models were used to assess the financial implications of suggestions made during the group discussions. The models were also used to assess the financial implications of a number of expected risks and opportunities; for example, they were successfully used to assess the expected financial implications of variations in input and output prices, the impact of decreased crop yields due to climate change, and the impact of expanding triticale production within the crop rotation system, as a feed-stock for bio-ethanol production. The expected effects of climate change on the grain producing areas of the Western Cape are decreased crop yields, but at different levels of decrease for each area. The expected crop yield decreases were determined by an expert group discussion, which included meteorologists and a GIS expert. This exercise served as an example of the necessity of area-specific discussions, as it was shown that some areas would be more severely affected, such as the Rooi Karoo and the Heidelberg Vlakte areas. The models showed that the areas with a higher cash crop component in the crop rotation system, such as the homogeneous areas within the Swartland Region, would be more severely affected in financial terms. However, a stronger livestock component could to some extent buffer the negative impact of decreased crop yields. The same affect was picked up when the model was used to assess the impact of variations in input prices. The areas that rely more heavily on cash crop systems are more vulnerable to increasing input prices than the areas that utilise livestock to a greater extent. The most severe impact of increasing input prices is expected for the areas where the profitability is already under pressure. These areas include the Rooi Karoo, the Middle Rûens and the Heidelberg Vlakte.

A possible opportunity provided by the growing awareness around bio-fuels is that of the production of starch-rich grains for bio-ethanol. With a moratorium on the use of grains, like maize and wheat, normally consumed by humans, for bio-ethanol production, triticale was regarded as a possible viable source of starch, which would present an alternative market for triticale. If proven viable, expanded triticale production could then have a secondary benefit for Western Cape wheat producers, by limiting the regional surplus wheat production to strengthen the bargaining power of wheat producers when facing buyers. The models were used to simulate production systems for the typical farm for each homogeneous area, where some of the grain crops can be replaced with triticale in the crop rotation system. The models indicate that the inclusion of triticale at current wheat and triticale prices, derived from the petrol price, produced for bio-fuel purposes is indeed financially viable.

Chapter 6 consists of the results of the group discussions where the expert groups were challenged to identify ways to improve the profitability of grain farming in each homogeneous grain production area. The dynamics of group discussions create the ideal environment for creative thinking, as was evident on numerous occasions when a specific idea stimulated a thorough discussion on the possible impact thereof on various aspects of the farm system.

Proposals were made by the expert group, each of which was immediately run through the budget model to assess its expected impact on profitability. In most instances, suggestions revolved around the mechanisation infrastructure and the utilisation of the livestock component. For the Swartland region, an increase in the lifespan of expensive machinery and equipment increased the expected profitability level for all three areas. The suggestion to extend the lifespan of machines was based on the relatively short annual use of machines and equipment. The most notable proposals that showed a positive effect on expected profitability include adding another wheat crop in the crop rotation systems for Koeberg/Wellington area. A shift towards implementing a wheat/medics rotation system on 60 percent of the typical farm for the Middle Swartland is expected to enhance profitability significantly. Expanding the lifespan of expensive machinery, such as harvesters and planters, to twenty years showed the most positive expected impact on farm profitability for the Rooi Karoo.

For the areas of the Southern Cape region, the proposals for improving farm profitability also revolved around machinery and livestock. Technological improvements that could enhance crop yields by five percent, such as new planting material and crop protection methods, show the most significant impact in the Goue Rûens. In the Middle Rûens, the intensification of the livestock component and the subsequent increase in stocking rates show the most promising impact. An increase in the stocking rate of livestock was suggested for the Heidelberg Vlakte area, and this also shows an expected increase in profitability. For this area, oats and triticale for silage supports the carrying capacity of pasture.

The multidisciplinary, multi-perspective expert group discussions in combination with the use of budget models that immediately show the financial implications of suggestions made by the experts were successfully employed to identify and evaluate sustainable ways to increase farm profitability in each of the homogeneous areas. In various instances the models directed the discussions toward options that were financially more viable.

7.3 Recommendations

A number of recommendations are presented as an outcome of this research project. This research project illustrated the value of combining group discussions and the use of whole-farm multi-period budget models. Regarding group discussions, the inclusion of producers and extension officers was crucial to their success, both for identifying ways to improve profitability and for validating the models. A closer continuous working and research relationship between researchers from various related disciplines concerned with grain production in the Western Cape are recommended. It is also recommended that producers and extension officers are included in panels to plan research projects in order to enhance the validity of research and to ensure that the critical issues receive attention.

It is further recommended that the whole-farm budget models are used, annually or bi-annually to assess the financial implications of changes in the decision-making environment on the viability of grain production in each homogeneous grain production area. These results can be presented at farmer study-group meetings just to raise awareness regarding the expected impact of changes in external factors such as product prices, input prices, trends in yields, trends in crop rotation systems, and other cost factors, as well as of suggested innovations. This would allow producers to assess the financial implications of expected changes and to plan accordingly.

The models should be used for the identification of research needs in the industry. Research funders such as the Winter Cereal Trust, Grain SA, the National Agricultural Marketing Council (NAMC), the Protein Research Foundation and various agribusinesses can use such models to evaluate the possible financial implications of research proposals at the farm level. This could contribute to focusing research efforts and research funding on topics and issues that could really contribute to farm-level profitability, which is the main concern of producers. The models could also be used by researchers to assess the expected financial implications of their current or planned research projects.

The third area of recommendations focuses on topics for further research, following the same methodology of combining expert groups and farm modelling. A number of specific issues were identified during the group discussions that either posed problems or needed to be explored in future. The profitability of small farms in the Goue Rûens area is under severe pressure. However, there are still a number of small farms surviving. The consensus from the group was that the quality of management is the determining factor, but other unknown factors could contribute to profitability. This study dealt with the profitability of the whole farm, but with the focus on the role of wheat and other grains. A more detailed description and evaluation of livestock production enterprises may be required that focuses on fully optimising these. More profitable livestock production methods might enhance the options available to producers to increase profitability. Other factors that were mentioned as being important during the group discussions were the identification of a shorter growing season and more drought resistant cultivars, especially for the more marginal areas; the impact of land prices on whole-farm profitability; the impact of mechanisation costs; and the balance between the livestock and cash crop components of the farms. The livestock component presents numerous advantages in terms of its role in the crop rotation system, but in financial terms, it represents a period of relatively low profitability.

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Annexure A:

Attendance registers for the various multi-expert participatory workshops

Workshop 1: Climate Change Impact on small grains and discussion on relative homogeneous areas held on 29/01/2007 at JS Marais building: Stellenbosch

Members of the Small-grains Expert Group present:

Dr Guy Midgley (SANBI)

Dr Stephanie Midgley (US: Department Horticulture)

Prof Andre Agenbag (US: Department Agronomy)

Anton Kunneke (US: Spatial Analyses Unit)

Prof Theo Kleynhans (US: Department of Agricultural Economics)

Prof Johan Laubscher (US: Department of Agricultural Economics; retired)

Dr Klaus Parkendorf (Small Grains Institute)

Johan Lusse (Overberg Agri: Caledon)

Pierre Loubser (Overberg Agri: Bredasdorp)

Jannie Bruwer (SSK: Swellendam)

Attie Haasbroek (Kaap Agri: Porterville)

Dr Mark Hardy (Department of Agriculture: Western-Cape)

Sakkie Slabbert (Department of Agriculture: Moorreesburg

Willem Hoffmann (Department of Agriculture: Western-Cape)

Workshop 2: Discussion on farm level situation for the Middle Swartland and Rooi Karoo Held on 13/06/2007 at JS Marais building: Stellenbosch

Members of the Small-grains Expert Group present

Prof Andre Agenbag (US: Department Agronomy)

Prof Theo Kleynhans (US: Department of Agricultural Economics)

Prof Johan Laubscher (US: Department of Agricultural Economics; retired)

Attie Haasbroek (Kaap Agri: Porterville)

Dr Mark Hardy (Department of Agriculture: Western-Cape)

Sakkie Slabbert (Department of Agriculture: Moorreesburg)

Johan Loubser (MKB – Moorreesburg)

Jim McDermott (DuPont agricultural Chemicals)

Lukas Rautenbach (Mechanisation expert and producer)

Dr Johan Labuschagne (Soil Scientists Department of Agriculture)

Prof Altus Viljoen (US: Department Plant Pathology)

Johan Kotzé (Producer)

WG Treurnicht (Producer)

Willem Hoffmann (US: Department of agricultural Economics)

JP Louw (US: Department of agricultural Economics)

Workshop 3: Discussion on farm level situation for the Middle Rûens and Heidelberg Vlakte held on 14/06/2007 at JS Marais building: Stellenbosch

Members of the Small-grains Expert Group present

Prof Andre Agenbag (US: Department Agronomy)

Prof Theo Kleynhans (US: Department of Agricultural Economics)

Prof Johan Laubscher (US: Department of Agricultural Economics; retired)

Dr Mark Hardy (Department of Agriculture: Western-Cape)

Jim McDermott (DuPont agricultural Chemicals)

Lukas Rautenbach (Mechanisation expert and producer)

Dr Johan Labuschagne (Soil Scientists Department of Agriculture)

Jannie Bruwêr (Agronomist SSK)

Johan Lusse (Agronomist Overberg Agri)

Pierre Loubser (Agronomist Overberg Agri)

Pieter Gildenhuys (Producer)

Francios Uys (Producer)

Willem Hoffmann (US: Department of agricultural Economics)

JP Louw (US: Department of agricultural Economics)

Workshop 4: Discussion on farm level situation for the Goue Rûens held on 28/08/2007 at Welgevallen Experimental Farm Stellenbosch

Members of the Small-grains Expert Group present

Prof Andre Agenbag (US: Department Agronomy)

Prof Theo Kleynhans (US: Department of Agricultural Economics)

Prof Johan Laubscher (US: Department of Agricultural Economics; retired)

Dr Mark Hardy (Department of Agriculture: Western-Cape)

Jim McDermott (DuPont agricultural Chemicals)

Lukas Rautenbach (Mechanisation expert and producer)

Johan Lusse (Agronomist Overberg Agri)

Pierre Loubser (Agronomist Overberg Agri)

Kobus Skonken (Producer)

Francios Malherbe (Producer)

Willem Hoffmann (US: Department of agricultural Economics)

JP Louw (US: Department of agricultural Economics)

Workshop 5: Discussion on farm level situation for the Koeberg/Wellington area held on 28/08/2007 at Welgevallen Experimental: Farm Stellenbosch

Members of the Small-grains Expert Group present

Prof Andre Agenbag (US: Department Agronomy)

Prof Theo Kleynhans (US: Department of Agricultural Economics)

Prof Johan Laubscher (US: Department of Agricultural Economics; retired)

Dr Mark Hardy (Department of Agriculture: Western-Cape)

Jim McDermott (DuPont agricultural Chemicals)

Lukas Rautenbach (Mechanisation expert and producer)

Attie Haasbroek (Kaap Agri: Porterville)

Kosie Blankenberg (Producer)

Johan Steyn (Producer)

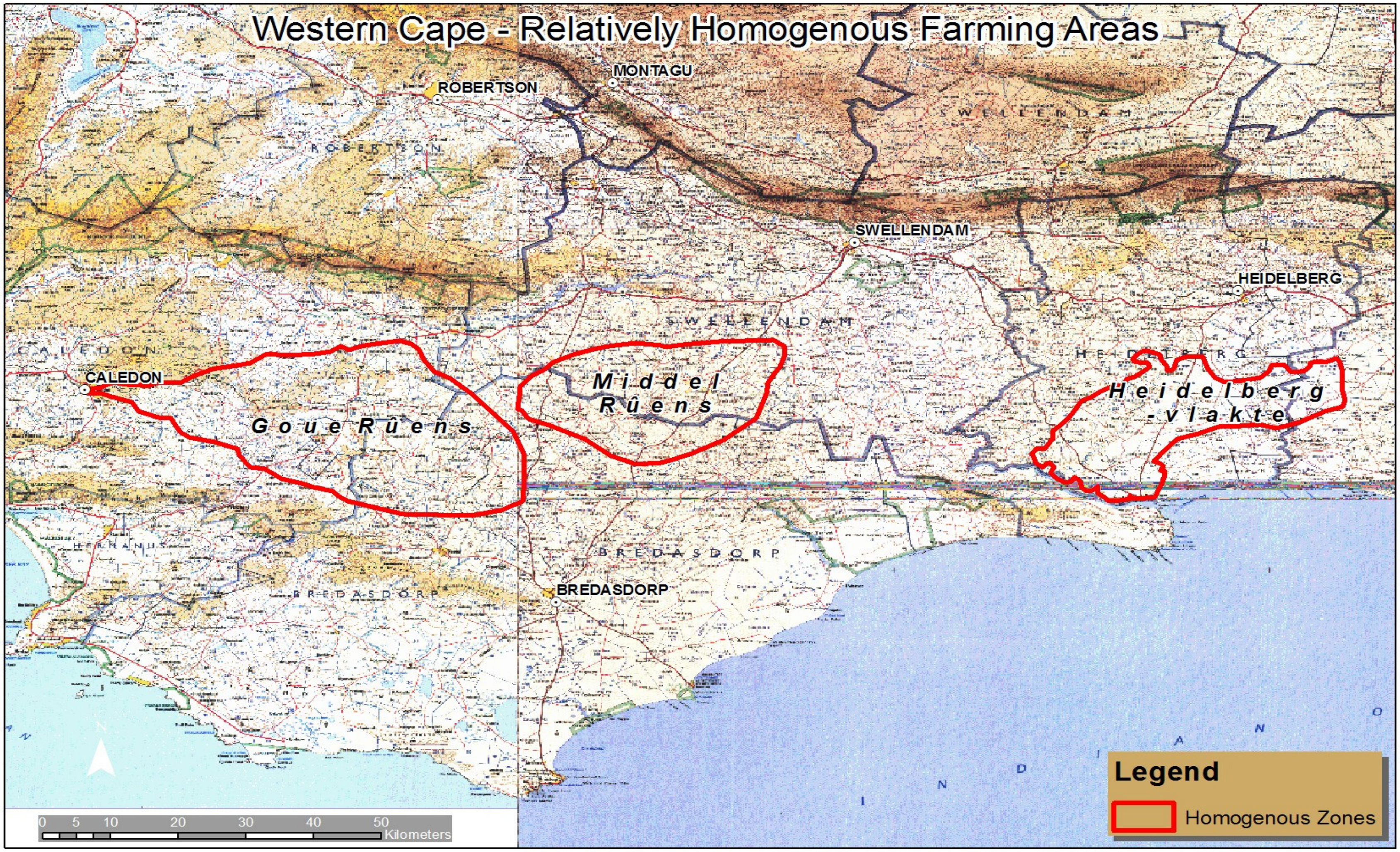
Willem Hoffmann (US: Department of agricultural Economics)

JP Louw (US: Department of agricultural Economics)

Annexure B:

Maps indicating the homogeneous areas for the Swartland and the Southern Cape


Western Cape - Relatively Homogenous Farming Areas
CITRUSDAL
Rooi Karoo
PIKETBERG
HOPEFIELD
MOORREESBURG
Middel Swartland
CERES
MALMESBURY
Wellington
WORCESTER
Koeberg
PAARL
CAPE TOWN
STELLENBOSCH
Legend
Homogenous Zones
0 5 10 20 30 40
Kilometers



Source data from Schulze, R. E. (Ed). 2006. South African Atlas of Climatology and Agrohydrology. Water Research Commission, Pretoria, RSA, WRC Report 1489/1/06.

Annexure C:

Inventories for the typical farm identified for each homogeneous area.

Koeberg/Wellington typical farm: Inventory

Item			Amount (ha)	R/item	Value
Land including fixed improvements			1400	13500	18900000
Mechanisation					
Item	**Price/new R**	**Current Age (years)**	**Expected Lifetime**	**Depreciation R**	**Value R**
Combine harvester					
124kW	900000	10	12	750000	150000
175kW	1900000	11	12	1741667	158333
Tractors					
231kW	1065391	8	12	710260.67	355130.3
120kW	544500	9	12	408375	136125
75kW	307333	8	12	204889	102444
75kW	307333	10	12	256111	51222
65kW	370000	11	12	339167	30833
Sprayer	353520	6	12	176760	176760
Fertiliser spreader	47038	11	12	43118	3920
Planter	1100000	4	12	366667	733333
Tine implements	99936	11	12	91608	8328
	49757	11	12	45611	4146
	82173	11	12	75325	6848
Trailers	68900	8	12	45933	22967
	68900	8	12	45933	22967
Front loader	64550	3	12	16138	48413
Lorry	414929	10	12	345774	69155
LDV	167857	6	24	83928	83928
	214900	2	12	35817	179083
Tools					120000
Total mechanisation					**2463936**
Livestock:			Amount	R/unit	Value
Rams			26	2000	51520
Ewes			1030	900	927360
Replacement ewes			258	800	206080
Total assets					**22548896**

Middle Swartland typical farm: Inventory

Item			**Amount (ha)**	**R/item**	**Value**
Land including fixed improvements			1000	8000	8000000
Mechanisation					
Item	**Price/new R**	**Current Age (years)**	**Expected Lifetime**	**Depreciation R**	**Value R**
Combine harvester					
124kW	688300	10	15	573583	114717
175kW	1531250	11	15	1403646	127604
Tractors					
147kW	810000	8	15	540000	270000
120kW	544500	9	12	408375	136125
75kW	307333	8	12	204889	102444
55kW	200570	10	12	167142	33428
65kW	370000	11	20	339167	30833
Sprayer	460000	6	12	230000	230000
Fertiliser spreader	94351	11	12	86488	7863
Planter	456000	4	12	152000	304000
	456000	9	12	342000	114000
Tine implements	99936	11	12	91608	8328
Trailers	68900	6	12	34450	34450
	68900	3	12	17225	51675
Front loader	64550	3	12	16138	48413
Lorry	414929	2	12	69155	345774
LDV	190815	6	24	95407.25	95407
	214900	8	12	143266.6667	71633
Tools					120000
Total mechanisation					**2246695**
Livestock:			Amount	R/unit	Value
Rams			10	2000	19855
Ewes			397	900	357390
Replacement ewes			99	800	79420
Total assets					**10703360**

Rooi Karoo typical farm: Inventory

Item			Amount (ha)	R/item	Value
Land including fixed improvements			980	4000	3920000
Mechanisation					
Item	**Price/new R**	**Current Age (years)**	**Expected Lifetime**	**Depreciation R**	**Value R**
Combine harvester 124kW	688300	10	24	286792	401508
Tractors					
120kW	544500	9	12	408375	136125
75kW	307333	8	12	204889	102444
55kW	200570	10	12	167142	33428
65kW	370000	11	12	339167	30833
Sprayer	200000	6	12	100000	100000
Fertiliser spreader	60000	11	12	55000	5000
Planter	456000	2	12	76000	380000
Trailers	41340	6	12	20670	20670
	41340	3	12	10335	31005
Front loader	64550	3	12	16137.5	48413
Lorry	124479	2	12	20746.45	103732
LDV	214900	8	12	143267	71633
Tools					120000
Total mechanisation					**1584792**
Livestock:			Amount	R/unit	Value
Rams			22	2000	44100
Ewes			882	1000	882000
Replacement ewes			221	750	165375
Total assets					**6596267**

Goue Rûens typical farm: Inventory

Item			Amount (ha)	R/item	Value
Land including fixed improvements			2000	9000	18000000
Mechanisation: Item	**Price/new R**	**Current Age (years)**	**Expected Lifetime**	**Depreciation R**	**Value R**
Combine harvester					
201kW	1900000	3	12	475000	1425000
201kW	1900000	7	12	1108333	791667
Wind mowers	261612	3	12	65403	196209
Tractors					
242kW	1396125	3	12	349031	1047094
125kW	520000	5	12	216667	303333
100kW	387703	5	12	161543	226160
100kW	387703	8	12	258469	129234
78kW	300975	10	12	250813	50163
60kW	239056	12	15	191245	47811
Sprayer	370740	4	12	123580	247160
Fertiliser spreader	47038	3	12	11760	35279
	47038	6	12	23519	23519
Planters	1116000	3	12	279000	837000
Tine implement	99936	8	12	66624	33312
Trailers	68900	6	12	34450	34450
	68900	8	12	45933	22967
Front loader	64550	3	20	9683	54868
Screen	321733	3	12	80433	241300
Water trailer	168320	4	12	56107	112213
Baler	707323	8	12	471549	235774
Wrapper	155000	8	20	62000	93000
Lorry	414929	11	12	380352	34577
LDV	190815	2	12	31802	159012
	134727	8	12	89818	44909
Tools					120000
Total mechanisation					**6529550**
Livestock			**Amount**	**R/unit**	**Value**
Rams			72	2000	143654
ewes			2873	1000	2873077
Replacement ewes			575	750	430962
Total assets:					**28025054**

Middle Rûens typical farm: Inventory

Item			(ha)	R/item	Value
Land including fixed improvements			1120	6000	6720000
Mechanisation: Item	**Price/new R**	**Current Age (years)**	**Expected Lifetime**	**Depreciation R**	**Value R**
Harvester 124kW	917447	14	20	642213	275234
Harvester 175kW	1531250	15	20	1148438	382813
Wind mowers	261612	6	20	78484	183128
	282399	10	20	141200	141200
Tractors					
78kW	300975	5	15	100325	200650
120kW	544500	4	15	145200	399300
60kW	239056	13	15	207182	19921
60kW	239056	12	15	191245	47811
49kW	201834	18	20	181651	16820
Sprayer	168320	8	10	134656	33664
Fertiliser spreader	94351	11	12	86488	7863
Planters	750000	4	12	250000	500000
Tine implement	99936	11	12	91608	8328
Trailers	68900	15	20	51675	5742
	68900	15	20	51675	5742
Front loader	64550	3	20	9683	54868
Mass trailer	200000	10	12	166667	33333
Catcher trailer	100000	10	12	83333	16667
Screen	100000	10	12	83333	16667
Water trailer	34000	15	20	42500	2833
Baler	155000	8	20	62000	93000
Wrapper	155000	8	20	62000	93000
Lorry	414929	8	10	207465	207465
LDV	190815	8	10	152652	38163
	214900	3	10	64470	150430
Tools					120000
Total mechanisation					**2961639**
Livestock			**Amount**	**R/unit**	**Value**
Rams			54	2000	108698
ewes			2174	750	1630473
Replacement ewes			543	550	298920
Total sheep					**2038091**
Total assets:					**11719730**

Heidelberg Vlakte typical farm: Inventory

Item			***Amount(ha)***	***R/item***	***Value***
Land including fixed improvements			1120	6000	6720000
Mechanisation: Item	**Price/new R**	**Current Age (years)**	**Expected Lifetime**	**Depreciation R**	**Value R**
Harvester 227kW	1668740	10	20	834370	834370
Wind mowers	261612	6	20	78484	183128
	282399	10	20	141200	141200
Tractor 152kW	632500	8	15	337333	295167
Tractor 72kW	301605	6	15	120642	180963
Tractor 60kW	239056	7	15	111559	127497
Tractor 60kW	239056	11	15	175308	63748
Tractor 49kW	201834	15	20	151376	16820
Sprayer	184000	2	10	36800	147200
Fertiliser spreader	107911	11	12	98918	8993
Planters	825000	8	12	550000	275000
Tine implement	99936	11	12	91608	8328
Trailers	68900	6	12	34450	34450
	68900	3	12	17225	51675
Front-loaders	129200	3	12	32267	96826
Mass trailer	200000	10	12	166667	33333
Catcher trailer	100000	10	12	83333	16667
Screen	100000	10	12	83333	16667
Water trailer	34000	15	12	42500	2833
Baler	155000	8	20	62000	93000
Wrapper	155000	8	20	62000	93000
Lorry	414929	2	12	69155	345774
LDV	190815	0	12	0	190815
	214900	8	12	143267	71633
Dairy					1500000
Tools					120000
Total mechanisation					**4949084**
Livestock			**Amount**	**R/unit**	**Value**
Rams			19	2000	37650
ewes			753	750	564750
Replacement ewes			188	550	103538
Cows			150	8000	1200000
Replacements calves			18	10000	180000
Total assets:					**13755022**

Wesselsbron typical farm: Inventory

Item			Amount (ha)	R/item	Value
Land including fixed improvements			1365	6000	8190000
Mechanisation: Item	**Price/new R**	**Current Age (years)**	**Expected Lifetime**	**Depreciation R**	**Value R**
Wheat harvester 201kW	1900000	3	12	475000	1425000
Wheat harvester 201kW	1900000	7	12	1108333	791667
Maize harvester 146kW	1320000	1	12	110000	1210000
Maize harvester 216kW	1561546	6	12	780773	780773
198kW	995479	3	12	248870	746609
120kW	544500	8	12	363000	181500
100kW	387703	2	12	64617	323086
75kW	307333	8	12	204889	102444
78kW	300975	7	12	175569	125406
78kW	300975	1	12	25081	275894
81kW	348456	6	12	174228	174228
74kW	316056	11	12	289718	26338
Sprayer	370740	4	12	123580	247160
Fertiliser spreader	47038	3	12	11760	35279
	47038	6	12	23519	23519
Planter: wheat	1116000	3	12	279000	837000
Planter: maize	165023	6	12	82512	82512
	165023	1	12	13752	151271
Tine implement	99936	8	12	66624	33312
Mouldboard plough	15510	2	12	2585	12925
Ripper	15480	6	12	7740	7740
Trailers	68900	6	12	34450	34450
	68900	8	12	45933	22967
Front loader	64550	3	12	16138	48413
Lorry	414929	4	12	138310	276619
LDV	190815	2	12	31802	159012
	134727	8	12	89818	44909
Tools					120000
Total mechanisation					**8300032**
Livestock:			**Amount**	**R/unit**	**Value**
Rams			16	2000	32416
Ewes			648	1000	648310
Replacement ewes			130	750	97247
Total assets					**17268004**

Scenario: Goue Rûens Typical farm (800ha): inventory

Item			**Hectares**	**R/item**	**Value**
Land and fixed improvements (own land)			640	9000	5760000
Mechanisation: Item	**Price/new R**	**Current Age (years)**	**Expected Lifetime**	**Depreciation R**	**Value R**
Harvester 210kW	1900000	3	12	475000	1425000
Wind mowers	261612	3	12	65403	196209
	282399	8	12	188266	94133
142 kW Tractor	765088	3	12	191272	573816
81kW Tractor	348456	5	12	145190	203266
81 kW Tractor	348456	5	12	145190	203266
75 kW Tractor	307333	8	12	204889	102444
Sprayer	168320	5	12	70133	98187
Screen	321733	3	12	80433	241300
Baler	707323	8	12	471549	235774
Water trailer	168320	4	12	56107	112213
Fertiliser spreader	47038	3	12	11760	35279
12m Planter	1116000	3	12	279000	837000
Tine implement	99936	8	12	66624	33312
Trailer	68900	6	12	34450	34450
Front loader	64550	3	12	16138	48413
Truck	414929	11	12	380352	34577
LDV	190815	2	12	31802	159012
	134727	8	12	89818	44909
Tools					120000
Total machinery and equipment:					4832560
Livestock			**Amount**	**R/unit**	**Value**
Rams			23	2000	45969
Ewes			919	1000	919385
Replacement ewes			184	750	137908
Total livestock:					1103262
Total assets:					**11695821**

Annexure D:

Example of Gross Margin calculation:
Gross Margin Calculation for Koeberg/Wellington area for wheat for good, average and poor years as dictated by rainfall distribution

Wheat: Good year					
Price (R/t)	1353				
Gross margin: **Item**	**Unit**	**R/unit**	**Units/ha**	**Repetitions**	**Value** **(R/ha)**
Gross income:					
Wheat	t	1353	4.1		5547.30
Total gross income:					**5547.30**
Direct-allocated costs:					
Seed : bought	kg	2.3	100		230.00
Seed: Farm produced	kg	1.353	0		0.00
Fertilisation with planting	kg				545.37
Top fertilisation	kg				675.69
Lime	t				11.40
Herbicides					420.00
Pesticides					200
Insecticides					60
Insurance (Crop)					21.50
Marketing costs					416.08
Total direct allocated costs:					**2580.03**

	R/ha		Time/	Cost
Non-directly allocated costs: **Activity**	**Fuel**	**Maintenance**	**annum**	**(R/ha)**
Soil preparation Blanton (15 tine)	77.53	40.16	1.0	117.69
Seed & fertiliser transport (10t truck)	6.82	3.54	1.0	10.36
Fertiliser spreading (3t)	11.96	13.18	1.0	25.14
6m No-till planter	105.03	77.38	1.0	182.41
Lime spreading (one in 6 years)	18.41	16.20	0.16	5.54
Load fertilisers (front loader)	0.49	0.21	1.0	0.70
Spray (18m 2000L tank)	8.01	7.55	9.0	140.02
Harvest /screen/pump	89.34	60.11	1.0	149.45
Grain transport to silo (10t truck)	55.92	29.04	1.0	84.96
LDV 2 (general management)	13.68	32.31	1.0	45.99
Total non-directly allocated costs:				**762.26**
Total variable costs:				**3342.30**
Gross margin:				**2205.00**

Wheat: Average year					
Price (R/t)	1353				
Gross margin: **Item**	**Unit**	**R/unit**	**Units/ha**	**Time /annum**	**Value (R/ha)**
Gross income:					
Wheat	t	1353	3.5	0	4735.50
Total gross income:					4735.50
Direct-allocated costs:					
Seed: bought	kg	2.3	100		230.00
Seed: farm produced	kg	1.353	0		0.00
Fertilisation with planting	kg				545.37
Top fertilisation	kg				675.69
Lime	t				11.40
Herbicides					420.00
Pesticides					200
Insecticides					60
Insurance (Crop)					18.35
Marketing costs					355.19
Total direct allocated costs:					**2516.00**

Non-directly allocated costs: **Activity**	**R/ha** **Fuel**	**Maintenance**	**Time/ annum**	**Cost (R/ha)**
Soil preparation Blanton (15 tine)	77.53	40.16	1.0	117.69
Seed & fertiliser transport (10t truck)	6.82	3.54	1.0	10.36
Fertiliser spreading (3t)	11.96	13.18	1.0	25.14
6m No-till planter	105.03	77.38	1.0	182.41
Lime spreading (one in 6 years)	18.41	16.20	0.16	5.54
Load fertilisers (front loader)	0.49	0.21	1.0	0.70
Spray (18m 2000L tank)	8.01	7.55	9.0	140.02
Harvest /screen/pump	89.34	60.11	1.0	149.45
Grain transport to silo (10t truck)	55.92	29.04	1.0	84.96
LDV 2 (general management)	13.68	32.31	1.0	45.99
Total non-directly allocated costs:				**762.26**
Total variable costs:				**3278.26**
Gross margin:				**1457.24**

Wheat: Poor year					
Price (R/t)	1353				
Gross margin: **Item**	**Unit**	**R/unit**	**Units/ha**	**Time /annum**	**Value (R/ha)**
Gross income:					
Wheat	t	1353	2.5		3382.50
Total gross income:					**3382.50**
Direct-allocated costs:					
Seed: bought	kg	2.3	100		230.00
Seed: farm produced	kg	1.353	0		0.00
Fertilisation with planting	kg				545.37
Top fertilisation	kg				675.69
Lime	t				11.40
Herbicides					420.00
Pesticides					200
Insecticides					60
Insurance (Crop)					13.11
Marketing costs					253.71
Total direct allocated costs:					**2409.27**

	R/ha		Time/	Cost
Non-directly allocated costs: **Activity**	**Fuel**	**Maintenance**	**annum**	**(R/ha)**
Soil preparation Blanton (15 tine)	77.53	40.16	1.0	117.69
Seed & fertiliser transport (10t truck)	6.82	3.54	1.0	10.36
Fertiliser spreading (3t)	11.96	13.18	1.0	25.14
6m No-till planter	105.03	77.38	1.0	182.41
Lime spreading (one in 6 years)	18.41	16.20	0.16	5.54
Load fertilisers (front loader)	0.49	0.21	1.0	0.70
Spray (18m 2000L tank)	8.01	7.55	9.0	140.02
Harvest /screen/pump	89.34	60.11	1.0	149.45
Grain transport to silo (10t truck)	55.92	29.04	1.0	84.96
LDV 2 (general management)	13.68	32.31	1.0	45.99
Total non-directly allocated costs:				**762.26**
Total variable costs:				**3171.53**
Gross margin:				**210.97**

Annexure E:

Capital flow budget for each typical farm over a 20 year calculation period

Whole farm multi period budget: Koeberg/Wellington

Year in calculation period	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Type of year for wheat and barley*	2	1	2	3	2	1	2	2	1	2
Type of year for canola and lupines*	2	1	2	3	1	2	2	1	2	3
Crop										
Wheat after wheat	234616	355006	234616	32071	234616	355006	234616	234616	355006	234616
Wheat after canola	417618	577504	417618	156091	417618	577504	417618	417618	577504	417618
Wheat after medics	889735	1215540	889735	259944	1215540	889735	889735	1215540	889735	259944
Canola	110472	212480	110472	6036	212480	110472	110472	212480	110472	6036
Medics	311776	311776	311776	311776	311776	311776	311776	311776	311776	311776
Oats (pasture or silage)	29562	29562	29562	29562	29562	29562	29562	29562	29562	29562
Wheat after oats of fallow	234616	355006	234616	32071	234616	355006	234616	234616	355006	234616
Lupines	-7563	-4381	-7563	-10745	-4381	-7563	-7563	-4381	-7563	-10745
Capital sales	0	201415	135189	45375	125877	0	29460	0	91667	5379
Gross margin total farm:	**2220831**	**3253907**	**2356020**	**862179**	**2777703**	**2621497**	**2250291**	**2651826**	**2713164**	**1488801**
Overhead and fixed costs										
Permanent labour	144000	144000	144000	144000	144000	144000	144000	144000	144000	144000
Water fees	40000	40000	40000	40000	40000	40000	40000	40000	40000	40000
Municipal taxes	6615	6615	6615	6615	6615	6615	6615	6615	6615	6615
Licences	8425	8425	8425	8425	8425	8425	8425	8425	8425	8425
Electricity	24000	24000	24000	24000	24000	24000	24000	24000	24000	24000
Banking costs	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000
Communication	23000	23000	23000	23000	23000	23000	23000	23000	23000	23000
Auditing fees	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000
Maintenance fencing	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000
Maintenance water supply	4500	4500	4500	4500	4500	4500	4500	4500	4500	4500
Owners remuneration	180000	180000	180000	180000	180000	180000	180000	180000	180000	180000
Diverse costs (4%)	18622	18622	18622	18622	18622	18622	18622	18622	18622	18622
Total overhead and fixed costs:	**484162**	**484162**	**484162**	**484162**	**484162**	**484162**	**484162**	**484162**	**484162**	**484162**

Margin above overhead and fixed costs	**1736670**	**2769745**	**1871858**	**378017**	**2293541**	**2137336**	**1766130**	**2167664**	**2229002**	**1004639**
Rented land	**154560**	**154560**	**154560**	**154560**	**154560**	**154560**	**154560**	**154560**	**154560**	**154560**
Total factor costs	**154560**	**154560**	**154560**	**154560**	**154560**	**154560**	**154560**	**154560**	**154560**	**154560**
Margin above factor cost:	**1753631**	**2786707**	**1888820**	**394979**	**2310503**	**2154297**	**1783091**	**2184626**	**2245964**	**1021601**
Capital										
Long term capital										
Land and fixed improvements	18900000	0	0	0	0	0	0	0	0	0
Intermediary capital										
Harvester 124kW	150000	0	900000	0	0	0	0	0	0	0
Harvester 175kW	158333	1900000	0	0	0	0	0	0	0	0
Tractor 231kW	355130	0	0	0	1065391	0	0	0	0	0
Tractor 120kW	136125	0	0	544500	0	0	0	0	0	0
Tractor 75kW	102444	0	0	0	307333	0	0	0	0	0
Tractor 75kW	51222	0	307333	0	0	0	0	0	0	0
Tractor 65kW	30833	370000	0	0	0	0	0	0	0	0
Sprayer	176760	0	0	0	0	0	353520	0	0	0
Fertiliser spreader	3920	47038	0	0	0	0	0	0	0	0
Planters	733333	0	0	0	0	0	0	0	1100000	0
Tine implement	8328	99936	0	0	0	0	0	0	0	0
Trailer	22967	0	0	0	68900	0	0	0	0	0
Trailer	22967	0	0	0	68900	0	0	0	0	0
Frontloaded	48413	0	0	0	0	0	0	0	0	64550
Lorry	69155	0	414929	0	0	0	0	0	0	0
LDV	83928	0	0	0	0	0	0	0	0	0
LDV	179083	0	0	0	0	0	0	0	0	0
Tools	120000									
Total intermediary capital	2452942	2416974	1622262	544500	1510524	0	353520	0	1100000	64550
Livestock	1493050									

Total capital	22845992	2416974	1622262	544500	1510524	0	353520	0	1100000	64550
Net annual flow	-21092360	369733	266558	-149521	799979	2154297	1429571	2184626	1145964	957051

IRR 5.67%

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

Cash flow:

Starting balance	0	879556	2250363	2349640	810563	838317	880413	1029913	1967184	2848139
Inflow	2220831	3253907	2356020	862179	2777703	2621497	2250291	2651826	2713164	1488801
Outflow	1351962	1910441	2285289	2411104	2760134	2590097	2113304	1738456	1866813	1532698
Flow before interest	868870	2223022	2321093	800715	828131	869717	1017400	1943283	2813535	2804241
Interest	10686	27341	28547	9848	10185	10697	12513	23900	34604	34489
Closing balance	879556	2250363	2349640	810563	838317	880413	1029913	1967184	2848139	2838731

Whole farm multi period budget: Koeberg/Wellington

Year in calculation period	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Type of year for wheat and barley*	2	1	2	3	1	2	2	1	2	2
Type of year for canola and lupines*	1	2	2	2	1	2	2	2	2	2
Crop										
Wheat after wheat	234616	355006	234616	32071	355006	234616	234616	355006	234616	234616
Wheat after canola	417618	577504	417618	156091	577504	417618	417618	577504	417618	417618
Wheat after medics	1215540	889735	889735	889735	1215540	889735	889735	889735	889735	889735
Canola	212480	110472	110472	110472	212480	110472	110472	110472	110472	110472
Medics	311776	311776	311776	311776	311776	311776	311776	311776	311776	311776
Oats (pasture or silage)	29562	29562	29562	29562	29562	29562	29562	29562	29562	29562
Wheat after oats of fallow	234616	355006	234616	32071	355006	234616	234616	355006	234616	234616
Lupines	-4381	-7563	-7563	-7563	-4381	-7563	-7563	-7563	-7563	-7563
Capital sales	17908	0	0	201415	135189	45375	125877	0	43448	0
Gross margin total farm:	**2669734**	**2621497**	**2220831**	**1755628**	**3187681**	**2266206**	**2346708**	**2621497**	**2264279**	**2220831**
Overhead and fixed costs										
Permanent labour	144000	144000	144000	144000	144000	144000	144000	144000	144000	144000
Water fees	40000	40000	40000	40000	40000	40000	40000	40000	40000	40000
Municipal taxes	6615	6615	6615	6615	6615	6615	6615	6615	6615	6615
Licences	8425	8425	8425	8425	8425	8425	8425	8425	8425	8425
Electricity	24000	24000	24000	24000	24000	24000	24000	24000	24000	24000
Banking costs	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000
Communication	23000	23000	23000	23000	23000	23000	23000	23000	23000	23000
Administration	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000
Auditing fees	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000
Maintenance fencing	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000
Maintenance water supply	4500	4500	4500	4500	4500	4500	4500	4500	4500	4500
Owners remuneration	180000	180000	180000	180000	180000	180000	180000	180000	180000	180000
Diverse costs (4%)	18622	18622	18622	18622	18622	18622	18622	18622	18622	18622

Total overhead and fixed costs:	**484162**	**484162**	**484162**	**484162**	**484162**	**484162**	**484162**	**484162**	**484162**	**484162**	
Margin above overhead and fixed costs	**2185573**	**2137336**	**1736670**	**1271467**	**2703519**	**1782045**	**1862547**	**2137336**	**1780118**	**1736670**	
Rented land	**154560**	**154560**	**154560**	**154560**	**154560**	**154560**	**154560**	**154560**	**154560**	**154560**	
Total factor costs	**154560**	**154560**	**154560**	**154560**	**154560**	**154560**	**154560**	**154560**	**154560**	**154560**	
Margin above factor cost:	**2202534**	**2154297**	**1753631**	**1288428**	**2720481**	**1799006**	**1879508**	**2154297**	**1797079**	**1753631**	
Capital											Resale value
Long term capital											
Land and fixed improvements	0	0	0	0	0	0	0	0	0	0	18900000
Intermediary capital											
Harvester 124kW	0	0	0	0	900000	0	0	0	0	0	525000
Harvester 175kW	0	0	0	1900000	0	0	0	0	0	0	950000
Tractor 231kW	0	0	0	0	0	0	1065391	0	0	0	799043
Tractor 120kW	0	0	0	0	0	544500	0	0	0	0	363000
Tractor 75kW	0	0	0	0	0	0	307333	0	0	0	230500
Tractor 75kW	0	0	0	0	307333	0	0	0	0	0	179278
Tractor 65kW	0	0	0	370000	0	0	0	0	0	0	185000
Sprayer	0	0	0	0	0	0	0	0	353520	0	324060
Fertiliser spreader	0	0	0	47038	0	0	0	0	0	0	23519
Planters	0	0	0	0	0	0	0	0	0	0	91667
Tine implement	0	0	0	99936	0	0	0	0	0	0	49968
Trailer	0	0	0	0	0	0	68900	0	0	0	51675
Trailer	0	0	0	0	0	0	68900	0	0	0	51675
Frontloaded	0	0	0	0	0	0	0	0	0	0	10758
Lorry	0	0	0	0	414929	0	0	0	0	0	242042
LDV	0	0	0	0	0	0	0	0	167857	0	328719
LDV	214900	0	0	0	0	0	0	0	0	0	53725
Tools											

Total intermediary capital	214900	0	0	2416974	1622262	544500	1510524	0	521377	0	4459629
Livestock											1493050
Total capital	214900	0	0	2416974	1622262	544500	1510524	0	521377	0	24852678
Net annual flow	1987634	2154297	1753631	-1128546	1098219	1254506	368984	2154297	1275703	26606310	

IRR

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

Cash flow:										
Starting balance	2838731	3974398	5157894	5950351	5973581	7082401	7194955	7037063	7155398	7356971
Inflow	2669734	2621497	2220831	1755628	3187681	2266206	2346708	2621497	2264279	2220831
Outflow	1582354	1500668	1500668	1804975	2164908	2241067	2590097	2590097	2152090	1777242
Flow before interest	3926111	5095228	5878057	5901004	6996353	7107540	6951566	7068463	7267587	7800560
Interest	48287	62666	72294	72576	86048	87415	85497	86935	89384	95939
Closing balance	3974398	5157894	5950351	5973581	7082401	7194955	7037063	7155398	7356971	7896499

Whole farm multi period budget: Middle Swartland

Year in calculation period	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Type of year for wheat and barley*	2	2	3	2	1	2	2	1	2	3
Type of year for canola and lupines*	2	2	3	2	1	2	2	1	2	3
Crop										
Wheat after wheat	427221	427221	214108	427221	434078	427221	427221	434078	427221	214108
Wheat after canola	127038	127038	62737	127038	188352	127038	127038	188352	127038	62737
Wheat after medics	302731	302731	164833	302731	336608	302731	302731	336608	302731	164833
Canola	8446	8446	-51663	8446	50612	8446	8446	50612	8446	-51663
Medics	88526	88526	88526	88526	88526	88526	88526	88526	88526	88526
Oats (pasture)	21473	21473	21473	21473	21473	21473	21473	21473	21473	21473
Wheat after oats	142407	142407	71369	142407	144693	142407	142407	144693	142407	71369
Lupines	12078	12078	12245	12078	12011	12078	12078	12011	12078	12245
Fallow	68097	68097	68097	68097	68097	68097	68097	68097	68097	68097
Capital sales	0	16191	16714	83375	171124	57358	44075	67500	38000	41954
Gross margin total farm:	**1198017**	**1214208**	**668440**	**1281392**	**1515572**	**1255375**	**1242092**	**1411949**	**1236017**	**693680**
Overhead and fixed costs:										
Permanent labour	144000	144000	144000	144000	144000	144000	144000	144000	144000	144000
Municipal tax	2800	2800	2800	2800	2800	2800	2800	2800	2800	2800
Licences	8425	8425	8425	8425	8425	8425	8425	8425	8425	8425
Banking fees	8000	8000	8000	8000	8000	8000	8000	8000	8000	8000
Communication	17000	17000	17000	17000	17000	17000	17000	17000	17000	17000
Administration	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000
Electricity	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000
Auditing fees	11000	11000	11000	11000	11000	11000	11000	11000	11000	11000
Maintenance fencing	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000
Maintenance water supply	4500	4500	4500	4500	4500	4500	4500	4500	4500	4500
Owners remuneration	180000	180000	180000	180000	180000	180000	180000	180000	180000	180000
Diverse costs (4%)	16109	16109	16109	16109	16109	16109	16109	16109	16109	16109

Total overhead and fixed costs	**418834**	**418834**	**418834**	**418834**	**418834**	**418834**	**418834**	**418834**	**418834**	**418834**	
Margin above overhead and fixed costs:		**779183**	**795374**	**249606**	**862558**	**1096738**	**836541**	**823258**	**993115**	**817183**	**274846**
Rent for land	0	0	0	0	0	0	0	0	0	0	
Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	
Margin above factor costs:	**779183**	**795374**	**249606**	**862558**	**1096738**	**836541**	**823258**	**993115**	**817183**	**274846**	
Capital											
Long term capital											
Land and fixed improvements	8000000	0	0	0	0	0	0	0	0	0	
Intermediary capital:											
Harvester 124kW	114717	0	0	0	0	688300	0	0	0	0	
Harvester 175kW	127604	0	0	0	1531250	0	0	0	0	0	
Tractor 147kW	270000	0	0	0	0	0	0	810000	0	0	
Tractor 120kW	136125	0	0	544500	0	0	0	0	0	0	
Tractor 75kW	102444	0	0	0	307333	0	0	0	0	0	
Tractor 55kW	33428	0	200570	0	0	0	0	0	0	0	
Tractor 65kW	30833	0	0	0	0	0	0	0	0	370000	
Sprayer	230000	0	0	0	0	0	460000	0	0	0	
Fertiliser spreader	7863	94351	0	0	0	0	0	0	0	0	
Planters	304000	0	0	0	0	0	0	0	456000	0	
Planters	114000	0	0	456000	0	0	0	0	0	0	
Tine implement	8328	99936	0	0	0	0	0	0	0	0	
Trailer	34450	0	0	0	0	0	68900	0	0	0	
Trailer	51675	0	0	0	0	0	0	0	0	68900	
Loaders	48413	0	0	0	0	0	0	0	0	64550	
Lorry	345774	0	0	0	0	0	0	0	0	0	
LDV	95407	0	0	0	0	0	0	0	0	0	
LDV	71633	0	0	0	214900	0	0	0	0	0	

Tools	120000									
Total intermediary capital	2246695	194287	200570	1000500	2053483	688300	528900	810000	456000	503450
Livestock	469120									
Total capital	10715814	194287	200570	1000500	2053483	688300	528900	810000	456000	503450
Net annual flow:	-9889313	648405	96354	-90624	-909426	195560	341676	230433	408501	-181286

IRR 4.20%

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

Cash flow:

Starting balance	0	168497	310011	-102923	-3526	284016	571931	751906	844689	760517
Inflow	1198017	1214208	668440	1281392	1515572	1255375	1242092	1411949	1236017	693680
Outflow	1031567	1076460	1076460	1181826	1231482	974409	1071252	1329429	1329429	1396103
Flow before interest	166450	306245	-98009	-3357	280565	564982	742771	834426	751277	58094
Interest	2047	3766	-4914	-168	3451	6949	9135	10263	9240	714
Closing balance	168497	310011	-102923	-3526	284016	571931	751906	844689	760517	58809

Whole farm multi period budget: Middle Swartland

Year in calculation period	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	
Type of year for wheat and barley*	1	2	2	2	1	2	2	2	2	2	
Type of year for canola and lupines*	1	2	2	2	1	2	2	2	2	2	
Crop											
Wheat after wheat	434078	427221	427221	427221	434078	427221	427221	427221	427221	427221	
Wheat after canola	188352	127038	127038	127038	188352	127038	127038	127038	127038	127038	
Wheat after medics	336608	302731	302731	302731	336608	302731	302731	302731	302731	302731	
Canola	50612	8446	8446	8446	50612	8446	8446	8446	8446	8446	
Medics	88526	88526	88526	88526	88526	88526	88526	88526	88526	88526	
Oats (pasture)	21473	21473	21473	21473	21473	21473	21473	21473	21473	21473	
Wheat after oats	144693	142407	142407	142407	144693	142407	142407	142407	142407	142407	
Lupines	12011	12078	12078	12078	12011	12078	12078	12078	12078	12078	
Fallow	68097	68097	68097	68097	68097	68097	68097	68097	68097	68097	
Capital sales	34577	0	0	16191	16714	83375	43519	0	59976	127604	
Gross margin total farm:	**1379026**	**1198017**	**1198017**	**1214208**	**1361163**	**1281392**	**1241536**	**1198017**	**1257993**	**1325621**	**1218587**
Overhead and fixed costs:											
Permanent labour	144000	144000	144000	144000	144000	144000	144000	144000	144000	144000	
Municipal tax	2800	2800	2800	2800	2800	2800	2800	2800	2800	2800	
Licences	8425	8425	8425	8425	8425	8425	8425	8425	8425	8425	
Banking fees	8000	8000	8000	8000	8000	8000	8000	8000	8000	8000	
Communication	17000	17000	17000	17000	17000	17000	17000	17000	17000	17000	
Administration	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	
Electricity	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	
Auditing fees	11000	11000	11000	11000	11000	11000	11000	11000	11000	11000	
Maintenance fencing	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000	
Maintenance water supply	4500	4500	4500	4500	4500	4500	4500	4500	4500	4500	
Owners remuneration	180000	180000	180000	180000	180000	180000	180000	180000	180000	180000	
Diverse costs (4%)	16109	16109	16109	16109	16109	16109	16109	16109	16109	16109	

Total overhead and fixed costs	**418834**	**418834**	**418834**	**418834**	**418834**	**418834**	**418834**	**418834**	**418834**	**418834**	
Margin above overhead and fixed costs:	**960192**	**779183**	**779183**	**795374**	**942329**	**862558**	**822702**	**779183**	**839159**	**906787**	
Rent for land	0	0	0	0	0	0	0	0	0	0	
Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	
Margin above factor costs:	**960192**	**779183**	**779183**	**795374**	**942329**	**862558**	**822702**	**779183**	**839159**	**906787**	
Capital											Resale value
Long term capital											
Land and fixed improvements	0	0	0	0	0	0	0	0	0	0	8000000
Intermediary capital:											
Harvester 124kW	0	0	0	0	0	0	0	0	0	0	734187
Harvester 175kW	0	0	0	0	0	0	0	0	0	1531250	1531250
Tractor 147kW	0	0	0	0	0	0	0	0	0	0	972000
Tractor 120kW	0	0	0	0	0	544500	0	0	0	0	363000
Tractor 75kW	0	0	0	0	0	0	307333	0	0	0	230500
Tractor 55kW	0	0	0	0	200570	0	0	0	0	0	116999
Tractor 65kW	0	0	0	0	0	0	0	0	0	0	555000
Sprayer	0	0	0	0	0	0	0	0	460000	0	421667
Fertiliser spreader	0	0	0	94351	0	0	0	0	0	0	47176
Planters	0	0	0	0	0	0	0	0	0	0	38000
Planters	0	0	0	0	0	456000	0	0	0	0	304000
Tine implement	0	0	0	99936	0	0	0	0	0	0	49968
Trailer	0	0	0	0	0	0	0	0	68900	0	63158
Trailer	0	0	0	0	0	0	0	0	0	0	11483
Loaders	0	0	0	0	0	0	0	0	0	0	10758
Lorry	414929	0	0	0	0	0	0	0	0	0	103732
LDV	0	0	0	0	0	0	0	0	190814.5	0	373678

LDV	0	0	0	0	0	0	214900	0	0	0	161175
Tools											
Total intermediary capital	414929	0	0	194287	200570	1000500	522233	0	719715	1531250	6087731
Livestock											469120
Total capital	414929	0	0	194287	200570	1000500	522233	0	719715	1531250	14556851
Net annual flow:	592581	826501	826501	648405	789077	-90624	347788	826501	166763	13979706	

IRR

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

Cash flow:

Starting balance	58809	-8190	-286808	-308273	-250308	-24569	114473	325611	495291	712468
Inflow	1379026	1198017	1198017	1214208	1361163	1281392	1241536	1198017	1257993	1325621
Outflow	1445634	1462940	1204763	1144291	1134251	1143741	1034355	1034355	1049473	1297001
Flow before interest	-7799	-273113	-293554	-238356	-23396	113082	321655	489274	703812	741088
Interest	-391	-13694	-14719	-11952	-1173	1391	3956	6018	8656	9115
Closing balance	-8190	-286808	-308273	-250308	-24569	114473	325611	495291	712468	750202

Whole farm multi period budget: Rooi Karoo

Year in calculation period	1	2	3	4	5	6	7	8	9	10	
Type of year for wheat and barley*	2	1	2	3	2	3	2	3	2	3	
Type of year for canola and lupines*	2	1	2	3	3	2	3	3	2	3	
Crops:											
Wheat after fallow	248858	664457	248858	-3540	248858	-3540	248858	-3540	248858	-3540	
Pasture after fallow	418969	418969	418969	418969	418969	418969	418969	418969	418969	418969	
Oats (pasture)	104742	104742	104742	104742	104742	104742	104742	104742	104742	104742	
Wheat after wheat	47439	130645	47439	-7415	47439	-7415	47439	-7415	47439	-7415	
Capital sales:	0	35833	16714	45375	43519	0	20112	0	0	8824	
Gross margin total farm:	**820008**	**1354647**	**836723**	**558131**	**863528**	**512756**	**840120**	**512756**	**820008**	**521581**	
Overhead and fixed costs:											
Permanent labour	115200	115200	115200	115200	115200	115200	115200	115200	115200	115200	
Water fees	7500	7500	7500	7500	7500	7500	7500	7500	7500	7500	
Municipal taxes	8055	8055	8055	8055	8055	8055	8055	8055	8055	8055	
Licences	7780	7780	7780	7780	7780	7780	7780	7780	7780	7780	
Banking costs	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	
Communication	23000	23000	23000	23000	23000	23000	23000	23000	23000	23000	
Administration	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	
Auditing fees	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	
Maintenance fencing	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	
Maintenance water supply	9000	9000	9000	9000	9000	9000	9000	9000	9000	9000	
Owners remuneration	180000	180000	180000	180000	180000	180000	180000	180000	180000	180000	
Diverse costs (4%)	15501	15501	15501	15501	15501	15501	15501	15501	15501	15501	
Total overhead and fixed costs:	**403036**	**403036**	**403036**	**403036**	**403036**	**403036**	**403036**	**403036**	**403036**	**403036**	
Margin above overhead and fixed costs:		**416972**	**951610**	**433686**	**155095**	**460491**	**109720**	**437084**	**109720**	**416972**	**118544**

Rented land										
Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Margin above factor costs:	**416972**	**951610**	**433686**	**155095**	**460491**	**109720**	**437084**	**109720**	**416972**	**118544**
Capital										
Long term capital										
Land and fixed improvements:	3920000	0	0	0	0	0	0	0	0	0
Intermediary capital:										
Harvester	401508	0	0	0	0	0	0	0	0	0
Tractor 120kW	136125	0	0	544500	0	0	0	0	0	0
Tractor 75kW	102444	0	0	0	307333	0	0	0	0	0
Tractor 55kW	33428	0	200570	0	0	0	0	0	0	0
Tractor 65kW	30833	370000	0	0	0	0	0	0	0	0
Sprayers	100000	0	0	0	0	0	200000	0	0	0
Fertiliser spreader	5000	60000	0	0	0	0	0	0	0	0
Planters	380000	0	0	0	0	0	0	0	0	0
Trailer	20670	0	0	0	0	0	41340	0	0	0
Trailer	31005	0	0	0	0	0	0	0	0	41340
Front loader	48413	0	0	0	0	0	0	0	0	64550
Lorry	103732	0	0	0	0	0	0	0	0	0
LDV	71633	0	0	0	214900	0	0	0	0	0
Tools	120000									
Total intermediary capital:	1584792	430000	200570	544500	522233	0	241340	0	0	105890
Livestock	1091475									
Total capital	6596267	430000	200570	544500	522233	0	241340	0	0	105890
Net annual flow	-6179295	521610	233116	-389405	-61742	109720	195744	109720	416972	12654
IRR	3.05%									

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

Cash flow:

Starting balance	0	161725	763699	802591	438104	260131	-169216	-231060	-589458	-514479
Inflow	820008	1354647	836723	558131	863528	512756	840120	512756	820008	521581
Outflow	659039	756241	801580	924665	1042717	935243	892597	847258	724173	630058
Flow before interest	160969	760130	798841	436057	258916	-162356	-221692	-565561	-493622	-622957
Interest	756	3569	3750	2047	1216	-6860	-9367	-23897	-20857	-26322
Closing balance	161725	763699	802591	438104	260131	-169216	-231060	-589458	-514479	-649279

Whole farm multi period budget: Rooi Karoo

Year in calculation period	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	
Type of year for wheat and barley*	3	2	1	2	3	2	1	2	2	3	
Type of year for canola and lupines*	3	2	1	3	2	2	3	2	3	3	
Crops:											
Wheat after fallow	-3540	248858	664457	248858	-3540	248858	664457	248858	248858	-3540	
Pasture after fallow	418969	418969	418969	418969	418969	418969	418969	418969	418969	418969	
Oats (pasture)	104742	104742	104742	104742	104742	104742	104742	104742	104742	104742	
Wheat after wheat	-7415	47439	130645	47439	-7415	47439	130645	47439	47439	-7415	
Capital sales:	48373	0	0	35833	74073	45375	43519	0	20112	0	
Gross margin total farm:	**561130**	**820008**	**1318813**	**855842**	**586829**	**865383**	**1362333**	**820008**	**840120**	**512756**	809174
Overhead and fixed costs:											
Permanent labour	115200	115200	115200	115200	115200	115200	115200	115200	115200	115200	
Water fees	7500	7500	7500	7500	7500	7500	7500	7500	7500	7500	
Municipal taxes	8055	8055	8055	8055	8055	8055	8055	8055	8055	8055	
Licences	7780	7780	7780	7780	7780	7780	7780	7780	7780	7780	
Banking costs	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	
Communication	23000	23000	23000	23000	23000	23000	23000	23000	23000	23000	
Administration	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	
Auditing fees	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	
Maintenance fencing	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	
Maintenance water supply	9000	9000	9000	9000	9000	9000	9000	9000	9000	9000	
Owners remuneration	180000	180000	180000	180000	180000	180000	180000	180000	180000	180000	
Diverse costs (4%)	15501	15501	15501	15501	15501	15501	15501	15501	15501	15501	
Total overhead and fixed costs:	**403036**	**403036**	**403036**	**403036**	**403036**	**403036**	**403036**	**403036**	**403036**	**403036**	
Margin above overhead and fixed	**158093**	**416972**	**915777**	**452805**	**183792**	**462347**	**959296**	**416972**	**437084**	**109720**	

costs:											
Rented land											
Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	
Margin above factor costs:	**158093**	**416972**	**915777**	**452805**	**183792**	**462347**	**959296**	**416972**	**437084**	**109720**	
Capital											Resale value
Long term capital											
Land and fixed improvements:	0	0	0	0	0	0	0	0	0	0	3920000
Intermediary capital:											
Harvester	0	0	0	0	688300	0	0	0	0	0	1233204
Tractor 120kW	0	0	0	0	0	544500	0	0	0	0	363000
Tractor 75kW	0	0	0	0	0	0	307333	0	0	0	230500
Tractor 55kW	0	0	0	0	200570	0	0	0	0	0	116999
Tractor 65kW	0	0	0	370000	0	0	0	0	0	0	185000
Sprayers	0	0	0	0	0	0	0	0	200000	0	183333
Fertiliser spreader	0	0	0	60000	0	0	0	0	0	0	30000
Planters	456000	0	0	0	0	0	0	0	0	0	114000
Trailer	0	0	0	0	0	0	0	0	41340	0	37895
Trailer	0	0	0	0	0	0	0	0	0	0	6890
Front loader	0	0	0	0	0	0	0	0	0	0	10758
Lorry	124479	0	0	0	0	0	0	0	0	0	31120
LDV	0	0	0	0	0	0	214900	0	0	0	161175
Tools											
Total intermediary capital:	580479	0	0	430000	888870	544500	522233	0	241340	0	2703874
Livestock											1091475
Total capital	580479	0	0	430000	888870	544500	522233	0	241340	0	7715349
Net annual flow	- 422386	416972	915777	22805	-705078	-82153	437063	416972	195744	7825069	

IRR

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

Cash flow:

	-	-								
Starting balance	649279	885316	-804649	-200693	-155060	-572351	-708472	-455437	-756951	-1005793
Inflow	561130	820008	1318813	855842	586829	865383	1362333	820008	840120	512756
Outflow	761276	706721	706721	803923	980916	972783	1090834	1090834	1048188	847258
	-	-								
Flow before interest	849425	772029	-192557	-148774	-549147	-679750	-436974	-726263	-965018	-1340295
Interest	-35891	-32621	-8136	-6286	-23203	-28722	-18464	-30687	-40775	-56632
	-	-								
Closing balance	885316	804649	-200693	-155060	-572351	-708472	-455437	-756951	-1005793	-1396927

Whole farm multi period budget: Goue Rûens

Year in calculation period	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Type of year for wheat and barley*	2	1	2	3	2	1	2	1	2	3
Type of year for canola and lupines*	2	1	2	3	2	1	2	1	2	3
Crop										
Wheat	787447	785240	787447	148106	787447	785240	787447	785240	787447	148106
Barley	731391	1045539	731391	188153	731391	1045539	731391	1045539	731391	188153
Canola	57040	153132	57040	-45369	57040	153132	57040	153132	57040	-45369
Oats	50006	87807	50006	12205	50006	87807	50006	87807	50006	12205
Lupine	-39828	-27085	-39828	-52534	-39828	-27085	-39828	-27085	-39828	-52534
Alfalfa	1070690	1070690	1070690	1070690	1070690	1070690	1070690	1070690	1070690	1070690
Capital sales	0	34577	25081	19921	116549	0	27543	75642	44922	425588
Gross margin total farm:	**2656746**	**3149901**	**2681827**	**1341171**	**2773295**	**3115323**	**2684289**	**3190965**	**2701668**	**1746838**
Annual overhead and fixed costs:										
Permanent labour	144000	144000	144000	144000	144000	144000	144000	144000	144000	144000
Water fees and levies	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000
Municipal taxes	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000
Licences	8425	8425	8425	8425	8425	8425	8425	8425	8425	8425
Bank costs	7000	7000	7000	7000	7000	7000	7000	7000	7000	7000
Communication	2400	2400	2400	2400	2400	2400	2400	2400	2400	2400
Administration	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000
Auditing fees	18700	18700	18700	18700	18700	18700	18700	18700	18700	18700
Maintenance, fencing	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000
Maintenance water system	15000	15000	15000	15000	15000	15000	15000	15000	15000	15000
Owner's remuneration	180000	180000	180000	180000	180000	180000	180000	180000	180000	180000
Diverse costs	19301	19301	19301	19301	19301	19301	19301	19301	19301	19301
Total overhead and fixed costs	**501826**	**501826**	**501826**	**501826**	**501826**	**501826**	**501826**	**501826**	**501826**	**501826**
Margin above overhead and fixed costs:	**2154920**	**2648075**	**2180001**	**839345**	**2271469**	**2613497**	**2182463**	**2689139**	**2199842**	**1245012**

Factor costs:										
Rented land										
Hired management	84000	84000	84000	84000	84000	84000	84000	84000	84000	84000
Total factors costs:	**84000**	**84000**	**84000**	**84000**	**84000**	**84000**	**84000**	**84000**	**84000**	**84000**
Margin above factor costs:	**2070920**	**2564075**	**2096001**	**755345**	**2187469**	**2529497**	**2098463**	**2605139**	**2115842**	**1161012**
Capital investment items:										
Long term:										
Land and fixed improvements:	18000000	0	0	0	0	0	0	0	0	0
Intermediate capital:										
Harvester (201 kW)	1425000	0	0	0	0	0	0	0	0	1900000
Harvester (201 kW)	791667	0	0	0	0	0	0	0	0	0
Wind mowers	196209	0	0	0	0	0	0	0	0	261612
Wind mowers	130806	0	0	0	0	0	261612	0	0	0
Tractor 242kW	1047094	0	0	0	0	0	0	0	0	1396125
Tractor 125kW	303333	0	0	0	0	0	0	520000	0	0
Tractor 100kW	226160	0	0	0	0	0	0	387703	0	0
Tractor 100kW	129234	0	0	0	387703	0	0	0	0	0
Tractor 78kW	50163	0	300975	0	0	0	0	0	0	0
Tractor 60kW	47811	0	0	239056	0	0	0	0	0	0
Sprayer	247160	0	0	0	0	0	0	0	370740	0
Screen	241300	0	0	0	0	0	0	0	0	321733
Baler	235774	0	0	0	707323	0	0	0	0	0
Water trailer	112213	0	0	0	0	0	0	0	168320	0
Fertiliser spreader	35279	0	0	0	0	0	0	0	0	47038
Planter 12m	837000	0	0	0	0	0	0	0	0	1116000
Tine implement	33312	0	0	0	99936	0	0	0	0	0
Trailers	34450	0	0	0	0	0	68900	0	0	0
Trailers	22967	0	0	0	68900	0	0	0	0	0

Loader	48413	0	0	0	0	0	0	0	0	64550
Truck	34577	414929	0	0	0	0	0	0	0	0
LDV	159012	0	0	0	0	0	0	0	0	0
LDV	44909	0	0	0	134727	0	0	0	0	0
Tools	120000									
Total intermediate capital:	6506031	414929	300975	239056	1398589	0	330512	907703	539060	5107058
Livestock:	3921750									
Total capital investment:	**28427781**	**414929**	**300975**	**239056**	**1398589**	**0**	**330512**	**907703**	**539060**	**5107058**
Net annual flow	**-26356861**	**2149146**	**1795026**	**516289**	**788880**	**2529497**	**1767951**	**1697436**	**1576782**	**-3946046**

IRR (Internal rate of return) **5.63%**

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

Cash flow:

Starting balance	0	432366	1284005	1604993	494276	479286	1461153	2050094	3029630	3460863
Inflow	2656746	3149901	2681827	1341171	2773295	3115323	2684289	3190965	2701668	1746838
Outflow	2237470	2337136	2409431	2466853	2802796	2177692	2157415	2303152	2375214	3265994
Flow before interest	419276	1245131	1556401	479311	464775	1416917	1988027	2937907	3356084	1941707
Interest	13090	38874	48592	14964	14510	44237	62067	91723	104778	60621
Closing balance	432366	1284005	1604993	494276	479286	1461153	2050094	3029630	3460863	2002328

Whole farm multi period budget: Goue Rûens

Year in calculation period	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Type of year for wheat and barley*	1	2	1	2	1	2	1	2	1	2
Type of year for canola and lupines*	1	2	1	2	1	2	1	2	1	2
Crop										
Wheat	785240	787447	785240	787447	785240	787447	785240	787447	785240	787447
Barley	1045539	731391	1045539	731391	1045539	731391	1045539	731391	1045539	731391
Canola	153132	57040	153132	57040	153132	57040	153132	57040	153132	57040
Oats	87807	50006	87807	50006	87807	50006	87807	50006	87807	50006
Lupine	-27085	-39828	-27085	-39828	-27085	-39828	-27085	-39828	-27085	-39828
Alfalfa	1070690	1070690	1070690	1070690	1070690	1070690	1070690	1070690	1070690	1070690
Capital sales	15901	0	0	34577	25081	0	116549	0	47464	75642
Gross margin total farm:	**3131225**	**2656746**	**3115323**	**2691324**	**3140405**	**2656746**	**3231872**	**2656746**	**3162787**	**2732388**
Annual overhead and fixed costs:										
Permanent labour	144000	144000	144000	144000	144000	144000	144000	144000	144000	144000
Water fees and levies	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000
Municipal taxes	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000
Licences	8425	8425	8425	8425	8425	8425	8425	8425	8425	8425
Bank costs	7000	7000	7000	7000	7000	7000	7000	7000	7000	7000
Communication	2400	2400	2400	2400	2400	2400	2400	2400	2400	2400
Administration	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000
Auditing fees	18700	18700	18700	18700	18700	18700	18700	18700	18700	18700
Maintenance, fencing	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000
Maintenance water system	15000	15000	15000	15000	15000	15000	15000	15000	15000	15000
Owner's remuneration	180000	180000	180000	180000	180000	180000	180000	180000	180000	180000
Diverse costs	19301	19301	19301	19301	19301	19301	19301	19301	19301	19301
Total overhead and fixed costs	**501826**	**501826**	**501826**	**501826**	**501826**	**501826**	**501826**	**501826**	**501826**	**501826**
Margin above overhead and fixed costs:	**2629399**	**2154920**	**2613497**	**2189498**	**2638579**	**2154920**	**2730046**	**2154920**	**2660961**	**2230562**

Factor costs:											
Rented land											
Hired management	84000	84000	84000	84000	84000	84000	84000	84000	84000	84000	
Total factors costs:	**84000**	**84000**	**84000**	**84000**	**84000**	**84000**	**84000**	**84000**	**84000**	**84000**	
Margin above factor costs:	**2545399**	**2070920**	**2529497**	**2105498**	**2554579**	**2070920**	**2646046**	**2070920**	**2576961**	**2146562**	
Capital investment items:											Salvage value
Long term:											
Land and fixed improvements:	0	0	0	0	0	0	0	0	0	0	18000000
Intermediate capital:											
Harvester (201 kW)	0	0	0	0	0	0	0	0	0	0	316667
Harvester (201 kW)	0	0	0	0	0	0	0	0	0	0	1583333
Wind mowers	0	0	0	0	0	0	0	0	0	0	43602
Wind mowers	0	0	0	0	0	0	0	0	261612	0	239811
Tractor 242kW	0	0	0	0	0	0	0	0	0	0	232688
Tractor 125kW	0	0	0	0	0	0	0	0	0	520000	476667
Tractor 100kW	0	0	0	0	0	0	0	0	0	387703	355394
Tractor 100kW	0	0	0	0	0	0	387703	0	0	0	290777
Tractor 78kW	0	0	0	0	300975	0	0	0	0	0	175569
Tractor 60kW	0	0	0	0	0	0	0	0	239056	0	223119
Sprayer	0	0	0	0	0	0	0	0	0	0	30895
Screen	0	0	0	0	0	0	0	0	0	0	53622
Baler	0	0	0	0	0	0	707323	0	0	0	530492
Water trailer	0	0	0	0	0	0	0	0	0	0	14027
Fertiliser spreader	0	0	0	0	0	0	0	0	0	0	7840
Planter 12m	0	0	0	0	0	0	0	0	0	0	186000
Tine implement	0	0	0	0	0	0	99936	0	0	0	74952
Trailers	0	0	0	0	0	0	0	0	68900	0	63158
Trailers	0	0	0	0	0	0	68900	0	0	0	51675

Loader	0	0	0	0	0	0	0	0	0	0	10758
Truck	0	0	0	414929	0	0	0	0	0	0	207465
LDV	190815	0	0	0	0	0	0	0	0	0	47704
LDV	0	0	0	0	0	0	134727	0	0	0	101045
Tools											
Total intermediate capital:	190815	0	0	414929	300975	0	1398589	0	569568	907703	5317259
Livestock:											3921750
Total capital investment:	**190815**	**0**	**0**	**414929**	**300975**	**0**	**1398589**	**0**	**569568**	**907703**	**27239009**
Net annual flow	**2354584**	**2070920**	**2529497**	**1690569**	**2253604**	**2070920**	**1247458**	**2070920**	**2007393**	**28477868**	

Cash flow:										
Starting balance	2002328	1878600	1343586	1489601	1233685	2623351	3604909	4863762	5568835	6779457
Inflow	3131225	2656746	3115323	2691324	3140405	2656746	3231872	2656746	3162787	2732388
Outflow	3311827	3232438	3014406	2984590	1830161	1784327	2120271	2120271	2157415	2303152
Flow before interest	1821725	1302909	1444503	1196335	2543928	3495769	4716511	5400238	6574208	7208693
Interest	56875	40677	45098	37350	79423	109139	147252	168598	205250	225059
Closing balance	1878600	1343586	1489601	1233685	2623351	3604909	4863762	5568835	6779457	7433752

Whole farm multi-period budget: Middle Rûens

Year in calculation period	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Type of year for wheat and barley*	2	1	2	3	2	1	2	1	2	3
Type of year for canola and lupines*	2	1	2	3	2	1	2	1	2	3
Crop:										
Wheat	171687	273116	171687	42235	171687	273116	171687	273116	171687	42235
Barley	162886	211994	162886	-26919	162886	211994	162886	211994	162886	-26919
Canola	126902	224896	126902	-11285	126902	224896	126902	224896	126902	-11285
Triticale	5053	11025	5053	-5786	5053	11025	5053	11025	5053	-5786
Oats	-4850	13951	-4850	-23651	-4850	13951	-4850	13951	-4850	-23651
Alfalfa	762513	762513	762513	762513	762513	762513	762513	762513	762513	762513
Capital sales	0	117797	78456	0	8333	0	21801	42990	113617	5742
Gross margin total farm:	**1224190**	**1615293**	**1302645**	**737106**	**1232523**	**1497495**	**1245991**	**1540485**	**1337806**	**742848**
Fixed and overhead costs:										
Permanent labour	201600	201600	201600	201600	201600	201600	201600	201600	201600	201600
Water fees	40000	40000	40000	40000	40000	40000	40000	40000	40000	40000
Municipal taxes	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000
Licences	8425	8425	8425	8425	8425	8425	8425	8425	8425	8425
Electricity	25000	25000	25000	25000	25000	25000	25000	25000	25000	25000
Banking costs	11000	11000	11000	11000	11000	11000	11000	11000	11000	11000
Communication	24000	24000	24000	24000	24000	24000	24000	24000	24000	24000
Administration	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000
Auditing fees	18700	18700	18700	18700	18700	18700	18700	18700	18700	18700
Maintenance: fencing	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000
Maintenance: water supply	15000	15000	15000	15000	15000	15000	15000	15000	15000	15000
Owners remuneration	180000	180000	180000	180000	180000	180000	180000	180000	180000	180000
Diverse costs (4%)	22589	22589	22589	22589	22589	22589	22589	22589	22589	22589
Total fixed and overhead costs:	**587314**	**587314**	**587314**	**587314**	**587314**	**587314**	**587314**	**587314**	**587314**	**587314**
Margin above overhead and fixed costs:	**636876**	**1027979**	**715331**	**149792**	**645209**	**910181**	**658677**	**953171**	**750492**	**155534**

Rented land	115200	115200	115200	115200	115200	115200	115200	115200	115200	115200
Total factor costs	**115200**	**115200**	**115200**	**115200**	**115200**	**115200**	**115200**	**115200**	**115200**	**115200**
Margin above factor costs:	**521676**	**912779**	**600131**	**34592**	**530009**	**794981**	**543477**	**837971**	**635292**	**40334**
Capital										
Long term capital										
Land and fixed improvements:	6720000	0	0	0	0	0	0	0	0	0
Intermediary capital:										
Harvester	76454	917447	0	0	0	0	0	0	0	0
Harvester	0	0	0	0	0	0	0	0	0	0
Wind mower	130806	0	0	0	0	0	261612	0	0	0
Wind mower	47067	0	282399	0	0	0	0	0	0	0
Tractor 78kW	175569	0	0	0	0	0	0	300975	0	0
Tractor 120kW	363000	0	0	0	0	0	0	0	544500	0
Tractor 60kW	19921	0	0	0	0	0	0	0	0	0
Tractor 60kW	0	0	0	0	0	0	0	0	0	0
Tractor 49kW	16820	201834	0	0	0	0	0	0	0	0
Sprayer	33664	0	168320	0	0	0	0	0	0	0
Fertiliser spreader	7863	94351	0	0	0	0	0	0	0	0
Planters	500000	0	0	0	0	0	0	0	750000	0
Mass trailer	33333	0	99936	0	0	0	0	0	0	0
Catcher trailer	16667	0	0	0	0	0	0	0	0	0
Screen	16667	0	200000	0	0	0	0	0	0	0
Water cart	2833	100000	0	0	0	0	0	0	0	0
Baler	72333	0	0	0	100000	0	0	0	0	0
Tine implement	8328	99936	0	0	0	0	0	0	0	0
Trailer	27560	0	0	0	0	0	0	0	68900	0
Trailer	31005	0	0	0	0	0	0	0	0	68900

Frontloaded	54868	0	0	0	0	0	0	0	0	0
Lorry	207465	0	0	0	0	0	0	0	0	0
LDV	38163	0	190815	0	0	0	0	0	0	0
LDV	150430	0	0	0	0	0	0	214900	0	0
Total intermediary capital	2030814	1413568	941470	0	100000	0	261612	515875	1363400	68900
Livestock	2038091									
Total capital	10788905	1413568	941470	0	100000	0	261612	515875	1363400	68900
Net annual flow:	-10267229	-500789	-341338	34592	430009	794981	281865	322096	-728108	-28566

IRR **1.05%**

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

Cash flow:										
Starting balance	0	250034	-406841	-927617	-1079264	-824049	-174745	-32164	155661	-743635
Inflow	1224190	1615293	1302645	737106	1232523	1497495	1245991	1540485	1337806	742848
Outflow	979890	2253923	1781825	840355	940355	840355	1101967	1356230	2203755	909255
Flow before interest	244299	-388597	-886020	-1030866	-787096	-166909	-30722	152090	-710288	-910043
Interest	5735	-18244	-41597	-48397	-36953	-7836	-1442	3570	-33347	-42725
Closing balance	250034	-406841	-927617	-1079264	-824049	-174745	-32164	155661	-743635	-952768

Whole farm multi-period budget: Middle Rûens

Year in calculation period	11	12	13	14	15	16	17	18	19	20	
Type of year for wheat and barley*	1	2	3	2	1	2	3	2	1	2	
Type of year for canola and lupines*	1	2	1	2	1	2	1	2	1	2	
Crop:											
Wheat	273116	171687	42235	171687	273116	171687	42235	171687	273116	171687	
Barley	211994	162886	-26919	162886	211994	162886	-26919	162886	211994	162886	
Canola	224896	126902	224896	126902	224896	126902	224896	126902	224896	126902	
Triticale	11025	5053	-5786	5053	11025	5053	-5786	5053	11025	5053	
Oats	13951	-4850	-23651	-4850	13951	-4850	-23651	-4850	13951	-4850	
Alfalfa	762513	762513	762513	762513	762513	762513	762513	762513	762513	762513	
Capital sales	34577	19921	177453	117797	48528	0	8333	23288	21801	25081	
Gross margin total farm:	**1532073**	**1244111**	**1150741**	**1341987**	**1546023**	**1224190**	**981621**	**1247477**	**1519296**	**1249271**	1275659
Fixed and overhead costs:											
Permanent labour	201600	201600	201600	201600	201600	201600	201600	201600	201600	201600	
Water fees	40000	40000	40000	40000	40000	40000	40000	40000	40000	40000	
Municipal taxes	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	
Licences	8425	8425	8425	8425	8425	8425	8425	8425	8425	8425	
Electricity	25000	25000	25000	25000	25000	25000	25000	25000	25000	25000	
Banking costs	11000	11000	11000	11000	11000	11000	11000	11000	11000	11000	
Communication	24000	24000	24000	24000	24000	24000	24000	24000	24000	24000	
Administration	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	
Auditing fees	18700	18700	18700	18700	18700	18700	18700	18700	18700	18700	
Maintenance: fencing	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	
Maintenance: water supply	15000	15000	15000	15000	15000	15000	15000	15000	15000	15000	
Owners remuneration	180000	180000	180000	180000	180000	180000	180000	180000	180000	180000	
Diverse costs (4%)	22589	22589	22589	22589	22589	22589	22589	22589	22589	22589	
Total fixed and overhead costs:	**587314**	**587314**	**587314**	**587314**	**587314**	**587314**	**587314**	**587314**	**587314**	**587314**	
Margin above overhead and fixed costs:	**944759**	**656797**	**563427**	**754673**	**958709**	**636876**	**394307**	**660163**	**931982**	**661957**	

Rented land	115200	115200	115200	115200	115200	115200	115200	115200	115200	115200	
Total factor costs	**115200**	**115200**	**115200**	**115200**	**115200**	**115200**	**115200**	**115200**	**115200**	**115200**	
Margin above factor costs:	**829559**	**541597**	**448227**	**639473**	**843509**	**521676**	**279107**	**544963**	**816782**	**546757**	
Capital											Resale value:
Long term capital											
Land and fixed improvements:	0	0	0	0	0	0	0	0	0	0	6720000
Intermediary capital:											
Harvester	0	0	0	917447	0	0	0	0	0	0	458724
Harvester	0	0	1531250	0	0	0	0	0	0	0	638021
Wind mower	0	0	0	0	0	0	0	0	261612	0	239811
Wind mower	0	0	0	0	282399	0	0	0	0	0	164733
Tractor 78kW	0	0	0	0	0	0	0	0	0	300975	0
Tractor 120kW	0	0	0	0	0	0	0	0	0	0	45375
Tractor 60kW	0	239056	0	0	0	0	0	0	0	0	79685
Tractor 60kW	0	0	239056	0	0	0	0	0	0	0	99607
Tractor 49kW	0	0	0	201834	0	0	0	0	0	0	100917
Sprayer	0	0	168320	0	0	0	0	0	0	0	50496
Fertiliser spreader	0	0	0	94351	0	0	0	0	0	0	47176
Planters	0	0	0	0	0	0	0	0	0	0	62500
Mass trailer	0	0	0	0	99936	0	0	0	0	0	49968
Catcher trailer	0	0	0	0	0	0	0	0	0	0	5000
Screen	0	0	0	0	200000	0	0	0	0	0	116667
Water cart	0	0	0	100000	0	0	0	0	0	0	58333
Baler	0	0	0	0	0	0	100000	0	0	0	58333
Tine implement	0	0	0	99936	0	0	0	0	0	0	49968
Trailer	0	0	0	0	0	0	0	0	0	0	99905
Trailer	0	0	0	0	0	0	0	0	0	0	103350

Frontloaded	0	0	0	0	0	0	0	64550	0	0	58095
Lorry	414929	0	0	0	0	0	0	0	0	0	643140
LDV	0	0	190815	0	0	0	0	0	0	0	57244
LDV	0	0	0	0	0	0	0	214900	0	0	-42980
Total intermediary capital	414929	239056	2129441	1413568	582335	0	100000	279450	261612	300975	3244067
Livestock											2038091
Total capital	414929	239056	2129441	1413568	582335	0	100000	279450	261612	300975	12002158
Net annual flow:	414630	302541	-1681213	-774095	261174	521676	179107	265513	555170	12247940	

IRR

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

Cash flow:

Starting balance	-952768	-707715	-568509	-2499656	-3571761	-3610326	-3377970	-3493357	-3523699	-3252209
Inflow	1532073	1244111	1150741	1341987	1546023	1224190	981621	1247477	1519296	1249271
Outflow	1255284	1079411	2969796	2253923	1422690	840355	940355	1119805	1101967	1141330
Flow before interest	-675979	-543016	-2387564	-3411593	-3448428	-3226492	-3336704	-3365685	-3106370	-3144268
Interest	-31736	-25494	-112092	-160169	-161898	-151478	-156653	-158013	-145839	-147618
Closing balance	-707715	-568509	-2499656	-3571761	-3610326	-3377970	-3493357	-3523699	-3252209	-3291886

Whole farm multi period budget: Heidelberg Vlakte

Year in calculation period	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Type of year for wheat and barley*	2	1	1	3	1	2	2	1	3	1
Type of year for canola and lupines*	2	1	1	3	1	2	2	1	3	1
Crop:										
Wheat	499392	455116	455116	283307	455116	499392	499392	455116	283307	455116
Barley	165115	220116	220116	40929	220116	165115	165115	220116	40929	220116
Canola	54505	141976	141976	-20162	141976	54505	54505	141976	-20162	141976
Oats	15390	43107	43107	17	43107	15390	15390	43107	17	43107
Alfalfa	760415	760415	760415	760415	760415	760415	760415	760415	760415	760415
Capital sales	0	17321	22046	0	117746	16820	5742	52708	35255	44588
Gross margin total farm:	**1494818**	**1638051**	**1642777**	**1064506**	**1738477**	**1511637**	**1500559**	**1673439**	**1099760**	**1665319**
Overhead and fixed costs:										
Permanent labour	230400	230400	230400	230400	230400	230400	230400	230400	230400	230400
Water fess and levies	40000	40000	40000	40000	40000	40000	40000	40000	40000	40000
Municipal taxes	3360	3360	3360	3360	3360	3360	3360	3360	3360	3360
Licences	8425	8425	8425	8425	8425	8425	8425	8425	8425	8425
Electricity	24000	24000	24000	24000	24000	24000	24000	24000	24000	24000
Banking costs	11000	11000	11000	11000	11000	11000	11000	11000	11000	11000
Communication	24000	24000	24000	24000	24000	24000	24000	24000	24000	24000
Administration	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000
Auditing fees	18700	18700	18700	18700	18700	18700	18700	18700	18700	18700
Maintenance fencing	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000
Maintenance water supply system	15000	15000	15000	15000	15000	15000	15000	15000	15000	15000
Owner's remuneration	180000	180000	180000	180000	180000	180000	180000	180000	180000	180000
Diverse costs	15835	15835	15835	15835	23035	23035	23035	23035	23035	23035
Total overhead and fixed costs	840697	840697	840697	840697	598920	598920	598920	598920	598920	598920
Margin above overhead and fixed	654121	797355	802080	223809	1139557	912717	901639	1074519	500840	1066398

costs:

Factor costs:										
Rented land	105600	105600	105600	105600	105600	105600	105600	105600	105600	105600
Hired management	0	0	0	0	0	0	0	0	0	0
Total factor costs:	105600	105600	105600	105600	105600	105600	105600	105600	105600	105600
Margin above factor costs:	548521	691755	696480	118209	1033957	807117	796039	968919	395240	960798
Capital investment:										
Long term capital items:										
Land and fixed improvements:	6720000	0	0	0	0	0	0	0	0	0
Intermediate capital items:										
Harvester (kW)	834370	0	0	0	0	0	0	0	0	0
Wind mower:	183128	0	0	0	0	0	0	0	0	0
Wind mower:	141200	0	0	0	0	0	0	0	0	0
152 kW tractor	295167	0	0	0	0	0	0	632500	0	0
72 kW tractor	180963	0	0	0	0	0	0	0	0	301605
60kW tractor	127497	0	0	0	0	0	0	0	239056	0
60kW tractor	63748	0	0	0	239056	0	0	0	0	0
49 kW tractor	16820	0	0	0	0	201834	0	0	0	0
Sprayer	147200	0	0	0	0	0	0	0	184000	0
Fertiliser spreader	8993	107911	0	0	0	0	0	0	0	0
Planters	275000	0	0	0	825000	0	0	0	0	0
Cultivation implement	8328	99936	0	0	0	0	0	0	0	0
Trailers	34450	0	0	0	0	0	68900	0	0	0
Trailers	51675	0	0	0	0	0	0	0	0	68900
Mass trailer	33333	0	64550	0	0	0	0	0	0	0
Catcher trailer	16667	0	0	0	0	0	0	0	0	0
Screen	16667	0	200000	0	0	0	0	0	0	0

Water cart	2833	0	0	0	0	0	0	0	0	100000
Baler	93000	0	0	0	100000	0	0	0	0	0
Wrapper	93000	0	0	0	34000	0	0	0	0	0
Dairy investment	1500000	0	0	0	0	0	0	0	0	0
Frontloaded	48413	0	0	0	0	0	0	0	0	64550
Lorry	345774	0	0	0	0	0	0	0	0	0
LDV	190815	0	0	0	0	0	0	0	0	0
LDV	71633	0	0	0	214900	0	0	0	0	0
Total investment in machinery	4780672	207847	264550	0	1412956	201834	68900	632500	423056	535055
Livestock	2085938									
Total capital	13586609	207847	264550	0	1412956	201834	68900	632500	423056	535055
Net annual flow:	-13038088	483908	431930	118209	-378999	605283	727139	336419	-27816	425743

IRR 3.21%

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

Cash flow:										
Starting balance	0	-314859	-229864	-194722	-491223	-1335995	-1187509	-899775	-1009387	-1513718
Inflow	1494818	1638051	1642777	1064506	1738477	1511637	1500559	1673439	1099760	1665319
Outflow	1790645	1539162	1595865	1331315	2502495	1291373	1158439	1722039	1512595	1624594
Flow before interest	-295828	-215970	-182952	-461532	-1255241	-1115731	-845389	-948375	-1422222	-1472993
Interest	-19031	-13894	-11770	-29692	-80753	-71778	-54386	-61012	-91496	-94762
Closing balance	-314859	-229864	-194722	-491223	-1335995	-1187509	-899775	-1009387	-1513718	-1567755

Whole farm multi period budget: Heidelberg Vlakte

Year in calculation period	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	
Type of year for wheat and barley*	3	2	1	3	1	3	1	2	3	2	
Type of year for canola and lupines*	3	2	1	3	1	3	1	2	3	2	
Crop:											
Wheat	283307	499392	455116	283307	455116	283307	455116	499392	283307	499392	
Barley	40929	165115	220116	40929	220116	40929	220116	165115	40929	165115	
Canola	-20162	54505	141976	-20162	141976	-20162	141976	54505	-20162	54505	
Oats	17	15390	43107	17	43107	17	43107	15390	17	15390	
Alfalfa	760415	760415	760415	760415	760415	760415	760415	760415	760415	760415	
Capital sales	197172	0	15901	17321	43847	0	97825	0	21075	19921	
Gross margin total farm:	**1261678**	**1494818**	**1636632**	**1081826**	**1664578**	**1064506**	**1718556**	**1494818**	**1085581**	**1514739**	1452354
Overhead and fixed costs:											
Permanent labour	230400	230400	230400	230400	230400	230400	230400	230400	230400	230400	
Water fess and levies	40000	40000	40000	40000	40000	40000	40000	40000	40000	40000	
Municipal taxes	3360	3360	3360	3360	3360	3360	3360	3360	3360	3360	
Licences	8425	8425	8425	8425	8425	8425	8425	8425	8425	8425	
Electricity	24000	24000	24000	24000	24000	24000	24000	24000	24000	24000	
Banking costs	11000	11000	11000	11000	11000	11000	11000	11000	11000	11000	
Communication	24000	24000	24000	24000	24000	24000	24000	24000	24000	24000	
Administration	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	
Auditing fees	18700	18700	18700	18700	18700	18700	18700	18700	18700	18700	
Maintenance fencing	16000	16000	16000	16000	16000	16000	16000	16000	16000	16000	
Maintenance water supply system	15000	15000	15000	15000	15000	15000	15000	15000	15000	15000	
Owner's remuneration	180000	180000	180000	180000	180000	180000	180000	180000	180000	180000	
Diverse costs	23035	23035	23035	23035	23035	23035	23035	23035	23035	23035	
Total overhead and fixed costs	598920	598920	598920	598920	598920	598920	598920	598920	598920	598920	
Margin above overhead and fixed	662758	895897	1037712	482906	1065657	465585	1119635	895897	486660	915819	

costs:

Factor costs:											
Rented land	105600	105600	105600	105600	105600	105600	105600	105600	105600	105600	
Hired management	0	0	0	0	0	0	0	0	0	0	
Total factor costs:	105600	105600	105600	105600	105600	105600	105600	105600	105600	105600	
Margin above factor costs:	557158	790297	932112	377306	960057	359985	1014035	790297	381060	810219	
Capital investment:											Resale value
Long term capital items:											
Land and fixed improvements:	0	0	0	0	0	0	0	0	0	0	6720000
Intermediate capital items:											
Harvester (kW)	1668740	0	0	0	0	0	0	0	0	0	2586547
Wind mower:	0	0	0	0	261612	0	0	0	0	0	457821
Wind mower:	282399	0	0	0	0	0	0	0	0	0	437718
152 kW tractor	0	0	0	0	0	0	0	0	0	0	759000
72 kW tractor	0	0	0	0	0	0	0	0	0	0	402140
60kW tractor	0	0	0	0	0	0	0	0	0	0	302804
60kW tractor	0	0	0	0	0	0	0	0	0	239056	239056
49 kW tractor	0	0	0	0	0	0	0	0	0	0	262384
Sprayer	0	0	0	0	0	0	0	0	184000	0	-18400
Fertiliser spreader	0	0	0	107911	0	0	0	0	0	0	53956
Planters	0	0	0	0	0	0	825000	0	0	0	618750
Cultivation implement	0	0	0	99936	0	0	0	0	0	0	49968
Trailers	0	0	0	0	0	0	0	0	68900	0	63158
Trailers	0	0	0	0	0	0	0	0	0	0	11483
Mass trailer	0	0	0	0	64550	0	0	0	0	0	75308
Catcher trailer	0	0	0	0	0	0	0	0	0	0	0
Screen	0	0	0	0	200000	0	0	0	0	0	116667

Water cart	0	0	0	0	0	0	0	0	0	0	58333
Baler	0	0	0	0	0	0	100000	0	0	0	58333
Wrapper	0	0	0	0	0	0	34000	0	0	0	5667
Dairy investment	0	0	0	0	0	0	0	0	0	0	100750
Frontloaded	0	0	0	0	0	0	0	0	0	0	10758
Lorry	414929	0	0	0	0	0	0	0	0	0	103732
LDV	0	0	190815	0	0	0	0	0	0	0	79506
LDV	0	0	0	0	0	0	214900	0	0	0	161175
Total investment in machinery	2366068	0	190815	207847	526162	0	1173900	0	252900	239056	6996616
Livestock											2085938
Total capital	2366068	0	190815	207847	526162	0	1173900	0	252900	239056	15802554
Net annual flow:	-1808910	790297	741297	169459	433895	359985	-159865	790297	128160	16373716	

IRR

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

Cash flow:

Starting balance	-1567755	-4003684	-3829902	-3697092	-4164365	-4380250	-4688689	-5570264	-5497264	-6124303
Inflow	1261678	1494818	1636632	1081826	1664578	1064506	1718556	1494818	1085581	1514739
Outflow	3455607	1089539	1280354	1297386	1615701	1089539	2263439	1089539	1342439	1328595
Flow before interest	-3761684	-3598406	-3473624	-3912652	-4115488	-4405284	-5233572	-5164985	-5754123	-5938159
Interest	-242000	-231496	-223469	-251713	-264762	-283405	-336691	-332279	-370180	-382020
Closing balance	-4003684	-3829902	-3697092	-4164365	-4380250	-4688689	-5570264	-5497264	-6124303	-6320179

Whole farm multi period budget: Wesselsbron

Year in calculation period	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Type of year for wheat and barley*	1	2	1	2	3	2	2	1	2	2
Type of year for canola and lupines*	2	1	2	3	2	1	2	1	2	3
Crop										
Wheat	1296807	917603	1296807	917603	598781	917603	917603	1296807	917603	917603
Maize	1913845	1295815	1913845	1295815	703484	1295815	1295815	1913845	1295815	1295815
Fallow	104225	104225	104225	104225	104225	104225	104225	104225	104225	104225
Capital sales	0	26338	0	0	96283	25081	164909	0	65472	344879
Gross margin total farm:	**3314877**	**2343980**	**3314877**	**2317642**	**1502773**	**2342724**	**2482551**	**3314877**	**2383115**	**2662521**
Overhead and fixed costs										
Permanent labour	314000	314000	314000	314000	314000	314000	314000	314000	314000	314000
Licences	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000
Bank costs	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000
Communication	35000	35000	35000	35000	35000	35000	35000	35000	35000	35000
Administration	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000
Auditing fees	25000	25000	25000	25000	25000	25000	25000	25000	25000	25000
Maintenance fencing	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000
Maintenance water	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000
Owners remuneration	180000	180000	180000	180000	180000	180000	180000	180000	180000	180000
Diverse costs (4%)	24760	24760	24760	24760	24760	24760	24760	24760	24760	24760
Total overhead and fixed costs	**643760**	**643760**	**643760**	**643760**	**643760**	**643760**	**643760**	**643760**	**643760**	**643760**
Margin above overhead and fixed costs	**2671117**	**1700220**	**2671117**	**1673882**	**859013**	**1698964**	**1838791**	**2671117**	**1739355**	**2018761**
Hired management	220000	220000	220000	220000	220000	220000	220000	220000	220000	220000
Factor costs	**220000**	**220000**	**220000**	**220000**	**220000**	**220000**	**220000**	**220000**	**220000**	**220000**
Margin above factor costs	**2451117**	**1480220**	**2451117**	**1453882**	**639013**	**1478964**	**1618791**	**2451117**	**1519355**	**1798761**

Capital										
Long term capital										
Land and fixed improvements	8190000	0	0	0	0	0	0	0	0	0
Intermediary capital										
Harvester wheat 201kW	1425000	0	0	0	0	0	0	0	0	1900000
Harvester wheat 201kW	791667	0	0	0	0	0	0	0	0	0
Harvester maize 146kW	1210000	0	0	0	0	0	0	0	0	0
Harvester maize 216kW	780773	0	0	0	0	0	1561546	0	0	0
Tractor 198kW	746609	0	0	0	0	0	0	0	0	995479
Tractor 120kW	181500	0	0	0	544500	0	0	0	0	0
Tractor 100kW	323086	0	0	0	0	0	0	0	0	0
Tractor 75kW	102444	0	0	0	307333	0	0	0	0	0
Tractor 78kW	125406	0	0	0	0	300975	0	0	0	0
Tractor 78kW	275894	0	0	0	0	0	0	0	0	0
Tractor 81kW	174228	0	0	0	0	0	348456	0	0	0
Tractor 74kW	26338	316056	0	0	0	0	0	0	0	0
Sprayer	247160	0	0	0	0	0	0	0	370740	0
Fertiliser spreader	35279	0	0	0	0	0	0	0	0	47038
Planters 12 m no till	837000	0	0	0	0	0	0	0	0	1116000
Ripper	33312	0	0	0	99936	0	0	0	0	0
Mouldboard plough	12925	0	0	0	0	0	0	0	0	0
Tine implement	7740	0	0	0	0	0	0	0	0	15480
Trailer	34450	0	0	0	0	0	68900	0	0	0
Trailer	22967	0	0	0	68900	0	0	0	0	0
Frontloaded	48413	0	0	0	0	0	0	0	0	64550
Lorry	276619	0	0	0	0	0	0	0	414929	0
LDV	159012	0	0	0	0	0	0	0	0	0
LDV	44909	0	0	0	134727	0	0	0	0	0
Tools	120000									

Total intermediary capital	8042730	316056	0	0	1155396	300975	1978902	0	785669	4138547
Livestock	777972									
Total capital	17010702	316056	0	0	1155396	300975	1978902	0	785669	4138547
Net annual flow	-14559586	1164164	2451117	1453882	-516383	1177989	-360111	2451117	733686	-2339786

IRR 5.97%

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

Cash flow:

Starting balance	0	1477661	1915762	3342088	3776458	3117479	3801129	4240683	5528206	5702160
Inflow	3314877	2343980	3314877	2317642	1502773	2342724	2482551	3314877	2383115	2662521
Outflow	1855168	1929155	1929155	1929155	2199627	1705256	2094519	2094519	2278440	2976779
Flow before interest	1459708	1892486	3301483	3730575	3079604	3754947	4189161	5461041	5632881	5387902
Interest	17953	23276	40605	45882	37876	46182	51522	67165	69279	66266
Closing balance	1477661	1915762	3342088	3776458	3117479	3801129	4240683	5528206	5702160	5454168

Whole farm multi period budget: Wesselsbron

Year in calculation period	11	12	13	14	15	16	17	18	19	20
Type of year for wheat and barley*	2	1	2	3	2	1	2	2	1	2
Type of year for canola and lupines*	1	2	1	2	1	2	1	2	1	2
Crop										
Wheat	917603	1296807	917603	598781	917603	1296807	917603	917603	1296807	917603
Maize	1295815	1913845	1295815	703484	1295815	1913845	1295815	1295815	1913845	1295815
Fallow	104225	104225	104225	104225	104225	104225	104225	104225	104225	104225
Capital sales	48210	110000	0	27631	25081	0	96283	25081	164909	0
Gross margin total farm:	**2365852**	**3424877**	**2317642**	**1434121**	**2342724**	**3314877**	**2413925**	**2342724**	**3479785**	**2317642**
Overhead and fixed costs										
Permanent labour	314000	314000	314000	314000	314000	314000	314000	314000	314000	314000
Licences	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000
Bank costs	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000
Communication	35000	35000	35000	35000	35000	35000	35000	35000	35000	35000
Administration	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000
Auditing fees	25000	25000	25000	25000	25000	25000	25000	25000	25000	25000
Maintenance fencing	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000
Maintenance water	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000
Owners remuneration	180000	180000	180000	180000	180000	180000	180000	180000	180000	180000
Diverse costs (4%)	24760	24760	24760	24760	24760	24760	24760	24760	24760	24760
Total overhead and fixed costs	**643760**	**643760**	**643760**	**643760**	**643760**	**643760**	**643760**	**643760**	**643760**	**643760**
Margin above overhead and fixed costs	**1722092**	**2781117**	**1673882**	**790361**	**1698964**	**2671117**	**1770165**	**1698964**	**2836025**	**1673882**
Hired management	220000	220000	220000	220000	220000	220000	220000	220000	220000	220000
Factor costs	**220000**	**220000**	**220000**	**220000**	**220000**	**220000**	**220000**	**220000**	**220000**	**220000**
Margin above factor costs	**1502092**	**2561117**	**1453882**	**570361**	**1478964**	**2451117**	**1550165**	**1478964**	**2616025**	**1453882**

Capital											Resale value
Long term capital											
Land and fixed improvements	0	0	0	0	0	0	0	0	0	0	8190000
Intermediary capital											
Harvester wheat 201kW	0	0	0	0	0	0	0	0	0	0	316667
Harvester wheat 201kW	0	0	0	0	0	0	0	0	0	0	1583333
Harvester maize 146kW	0	1320000	0	0	0	0	0	0	0	0	
Harvester maize 216kW	0	0	0	0	0	0	0	0	1561546	0	
Tractor 198kW	0	0	0	0	0	0	0	0	0	0	165913
Tractor 120kW	0	0	0	0	0	0	544500	0	0	0	0
Tractor 100kW	387703	0	0	0	0	0	0	0	0	0	0
Tractor 75kW	0	0	0	0	0	0	307333	0	0	0	230500
Tractor 78kW	0	0	0	0	0	0	0	300975	0	0	250813
Tractor 78kW	0	0	0	0	300975	0	0	0	0	0	200650
Tractor 81kW	0	0	0	0	0	0	0	0	348456	0	319418
Tractor 74kW	0	0	0	316056	0	0	0	0	0	0	158028
Sprayer	0	0	0	0	0	0	0	0	0	0	30895
Fertiliser spreader	0	0	0	0	0	0	0	0	0	0	7840
Planters 12 m no till	0	0	0	0	0	0	0	0	0	0	186000
Ripper	0	0	0	0	0	0	99936	0	0	0	74952
Mouldboard plough	0	0	0	15510	0	0	0	0	0	0	9306
Tine implement	0	0	0	0	0	0	0	0	0	0	20640
Trailer	0	0	0	0	0	0	0	0	68900	0	63158
Trailer	0	0	0	0	0	0	68900	0	0	0	51675
Frontloaded	0	0	0	0	0	0	0	0	0	0	10758
Lorry	0	0	0	0	0	0	0	0	0	0	34577
LDV	190815	0	0	0	0	0	0	0	0	0	47704
LDV	0	0	0	0	0	0	134727	0	0	0	101045
Tools											

Total intermediary capital	578518	1320000	0	331566	300975	0	1155396	300975	1978902	0	3863872
Livestock											777972
Total capital	578518	1320000	0	331566	300975	0	1155396	300975	1978902	0	12831844
Net annual flow	923575	1241117	1453882	238795	1177989	2451117	394770	1177989	637123	14285727	

IRR

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

Cash flow:

Starting balance	5454168	4837038	5440509	4930551	3627543	4137690	5775314	6560054	7211045	8630714
Inflow	2365852	3424877	2317642	1434121	2342724	3314877	2413925	2342724	3479785	2317642
Outflow	3041750	2887505	2887505	2781202	1882848	1747420	1708887	1779343	2164976	2094519
Flow before interest	4778270	5374410	4870647	3583470	4087419	5705147	6480352	7123434	8525855	8853837
Interest	58768	66100	59904	44073	50271	70167	79702	87611	104859	108893
Closing balance	4837038	5440509	4930551	3627543	4137690	5775314	6560054	7211045	8630714	8962730