REFEREED ARTICLE

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Facilitating small grain production system innovation in the Western Cape, South Africa

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ABSTRACT

The profitability of current grain production practices is under pressure, while alternatives are limited due to the nature of the physical/biological environment of the Western Cape of South Africa. The search for ways to enhance the profitability of grain production systems requires the incorporation of expert knowledge and the stimulating of creative thinking, focused on generating ideas that could alter the whole-farm system. Expert knowledge may already exist, but could have become disunited due to disciplinary specialisation. Within multidisciplinary group discussions, knowledge is pooled, and due to the dynamics of group discussions, creative thinking is naturally stimulated. Whole-farm multi-period budget models – parameterised to quickly show the impacts of suggestions to the farm system – are used in group discussions, not only to save time by quickly identifying feasible suggestions, but also to stimulate creativity by immediately confronting experts with the financial implications of suggestions. This method of combining budget modelling and group discussions was used to generate area-specific alternatives that could improve whole-farm profitability in six different production areas in the Western Cape.

KEYWORDS: creative thinking; whole-farm systems; multidisciplinary group discussions; grain production

1. Introduction

Relatively low returns on investment and the volatility of commodity prices force grain producers in the Western Cape of South Africa to constantly seek improvements or alternatives to current farming practices. The low 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 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 current 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 among consumers of environmental responsibility, which adds an ecological dimension to the producer's goals (McCown *et al.* 2006).

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, ultimately, in financial terms. For instance, an alteration to a crop rotation system could have significant ripple effects on the whole farm.

Research in agriculture focus either on improving technology or on generating information (Pannell 1999). Fields such as agronomy, entomology, plant pathology, soil science and genetics are mainly concerned with technological improvement, while agricultural economics focuses on information (Byerlee and Tripp 1988). Research in farm management mainly focuses on generating knowledge that is adaptable and relevant in principle (McCown 2002), while the specific need of producers is for practical knowledge applicable to specific situations (McCown, Brennan *et al.* 2006). For management purposes, producers desire information on what the expected outcome of a decision or scenario would be. This requires of academics in farm management to provide a tool to define the expected outcome, and together with farmers, apply logic to reach a decision (Malcolm 1990; Pannell *et al.* 2000).

To generate possibilities for enhancing profitability of grain production systems requires the merging of expert knowledge. This paper aims to show the value of bringing a multidisciplinary group of experts face to face with a management model to generate valuable decision-making knowledge for researchers and producers. The challenge is to accurately capture and measure the knock-on effects caused by suggested changes to the farm system.

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2. Multidisciplinary group discussions

Before deregulation of agricultural marketing in 1996 the Wheat Board was particularly powerful under the policy of food self-sufficiency which contributed to a shift towards wheat production from other grain crops (National Agricultural Marketing Council (NAMC) 1999; Kleynhans *et al.* 2008). Continuous wheat production was subsequently adopted by producers in many areas of the Western Cape. After deregulation the relative importance of wheat to crops such as barley, oats and canola consequently decreased (Edwards and Leibrandt 1998). The following factors further contribute to the complex nature of the small grain farming system: the diversity of crops and livestock; the implementation of new technology; the role and contribution of livestock; the multiple interactions and interrelatedness among crops; various diseases, pest and weed problems; constantly changing product and input prices; awareness about sustainability; uncertainty about commodity markets; political issues regarding land reform and labour wages and the increasing uncertainty of weather patterns due to global warming. The farm system is thus characterised by complexity, consisting of a growing number of parts and relationships (Flood and Carson 1988; Checkland 1993). This complexity and continuous expansion of the external environment increasingly requires the incorporation of human interaction in management decision-making within a systems approach (Ison *et al.* 1996; Jackson 2006; Leleur 2008). The systems approach is well developed and documented, but is possibly underutilised in practice (Ackoff 1974; Severence 2001; Hammond 2003). A research method that accommodates and supports a systems approach is multidisciplinary group discussions. As a method or technique for generating information and knowledge, it started in the military during World War II and evolved to become widely used in operations management and farm management (Linstone and Turoff 1975; Whyte 1989; Doll and Francis 1992; Fildes and Ranyard 1997; Calheiros *et al.* 2000; Colin and Crawford 2000; Van Eeden 2000; Haggar *et al.* 2001; Jabbar *et al.* 2001; Hoffmann and Laubscher 2002). Farm management research, which by definition is multifaceted, relies on the use of a pool of knowledge from various disciplines (Hoffmann and Laubscher 2002; Bullock *et al.* 2007).

The focus of scientific research, led to specialisation and the development of scientific disciplines (Johan Mouton, *pers. comm.*, 2009). Discipline-based research often reinforces the fragmentation of knowledge which may already exist and counter solutions to real-world problems (Malcolm 1990; Janssen and Goldsworthy 1996). 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. Consequently, multidisciplinary research methods are used to accommodate participation across disciplinary gaps (Young 1995; Moore *et al.* 2007). Examples of scientific disciplines related to grain production include agricultural economics, resource economics, agronomy, soil science, plant pathology, entomology, labour management and animal science.

The challenge for researchers, studying the whole-farm system lies in facilitating multidisciplinary participation (Röling and Wagemakers 1998; Keating and McCown 2001; McCown 2001; Bosch *et al.* 2007). This requires integrating natural science, social science and indigenous knowledge (Young 1995; McGregor *et al.* 2001; Jeffrey 2003; Francios 2006; Vandermeulen and Van Huylenbroeck 2008). Another reason for using multidisciplinary expert group discussions is the exploratory nature of the research, which in this case is aimed at identifying ways of improving whole-farm profitability. The implication is that some of the required information does not exist at present. Experts can base their judgement of the impact of changes to the farm system on experience and knowledge. Compared to other methods, expert group discussions are more time efficient in generating information.

The most important contribution of group discussions is that it stimulates creative thinking in groups. The height of creativity is the creative shift, which happens when an individual are made aware of alternative perspectives. Creative thinking can lead to either inventive thinking, the provision of new ways of solving existing problems, or innovative thinking, the modification of approaches, based on a thorough understanding of principles (Hare 1983; Linstone 1984). As this happens naturally in group discussions it creates an ideal situation for creative thinking (Leleur 2008) and often leads to new ideas (Krueger 1994; Litosseliti 2003; Porac *et al.* 2004). When new ideas are generated, other group members can help verbalise these new ideas. Coupled with the aforementioned processes, the resources that individual members (which include knowledge, experience and insight) contribute to the group are equally important regarding the ability of group discussions to generate new ideas (Thompson and Choi 2006). This increases the importance of the correct selection of participants for group discussions.

The expert groups comprised of participants from various scientific disciplines as well as producers and extension officers from local agribusinesses. The participating scientists were selected by identifying the foremost-recognised researcher within a specific field within the Western Cape. The producers were selected based on active participation in producer study groups, industry information days, competitions and research. The chairperson's role was focusing the discussions on the relevant issues. Scientist's quantified the technical impacts, input/output relationships and sustainability impacts of suggestions on the broader system. Agricultural extension officers, from local agribusinesses, are well exposed to industry-level issues, have thorough knowledge of the area and experience of a broad variety of farm situations. The extension officers can identify critical issues; describe limitations to suggested strategies from an industry level, and describe and identify the homogeneous areas and typical farms. The strength of the producers is their practical knowledge of the farm system and relating practical implications of suggested strategies made by other participants. 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.

3. Quantifying outcomes of group discussions through financial modelling

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. Models themselves do not generate new information; they only facilitate the processing of information. 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. In multidisciplinary discussion groups, models can serve as tools to stimulate discussions and generate new discussion points by financial evaluation of possible outcomes. Modelling is typically used in studies that aim at developing and validating accurate representations of the real world, allowing research questions of a descriptive, causal and predictive nature to be addressed (Brenner & Werker 2007:229; 2008; Steward 1993:13 and White 1971:294).

The development of modelling was founded on two factors. The first factor was the social notion that the natural world could not only be scientifically explained, but also scientifically managed. The second factor was the technological advancement and development of the computer, which also allows for exploring hypothetical systems (McCown 2002). Models can quantitatively compare alternative management options in terms of established criteria and known risks and be applied to design improvements on existing systems (Robson 1994; Attonaty *et al.* 1999).

In agriculture, computer models are widely used as planning and exploration tools in fields such as agricultural economics, farm management, crop management and livestock production (Glen 1987). The justification for models as research tools in agricultural systems is their practical use. The key to useful models is their relative simplicity, which can be achieved by setting well-defined objectives. The pre-occupation of systems researchers with simulation and model building, with less attention paid to applications, may lead to either limited practical use or suspicion among producers who do not understand the functioning of the model (Doyle 1990).

During group discussions, 'live' simulations of the whole farm were used to quickly assess the financial implications of suggestions made by participants. This serves two purposes. The first lies to quickly identify suggestions that contribute positively to profitability. These suggestions can then be further discussed and refined, while suggestions with a negative effect on profitability can be discarded. Secondly the model plays the role of one of the experts and contributes an alternative, financially quantified perspective, which contributes to the stimulation of creativity during group discussions. Participants are immediately confronted by the financial implications of their suggestions (Snabe and Gröfsler 2006).

To generate information on the typical farm in financial terms and accurately simulate the expected impacts of suggested changes, the quantitative method needs to meet a number of requirements.

- Its ability to accommodate and capture complexity and accurately reflect the nature of the system being modelled (Marks 2007). 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. Performance criteria include standard profitability indicators such as IRR and NPV measured over a twenty year period. A change in, for example, input levels will instantly reflect as a relative change in profitability. The ability to cope with complexity is embedded in a detailed quantification of the factors and interrelationships that comprise the farm system.
- Producers and natural scientists will mostly contribute information of a physical-biological nature. Hence, 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 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 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, and focus on developing innovative ways of improving the problem (Janssen and Goldsworthy 1996).
- 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. The selected method needs to accommodate and accurately calculate long-term implications, such as the producer's goals, the replacement of machinery and livestock, and the benefits of crop rotation systems, in a valid way.

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. Budgeting is perhaps the most widely used method of financial planning that 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 and Dorward 1984). Budgets are often used as comparable quantitative techniques and play an important role in benchmarking (Malcolm 1990). 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 be classified as simulation models that are based on accounting principles and methods, rather than purely on mathematics (Pannell 1996). Whole-farm budget models are normally developed using spread sheet programmes which allows for the expression of complex and sophisticated calculations and relationships in a relatively simple way. The sophistication of budget models lies in their ability to allow for detail, adaptability and user-friendliness (Keating and McCown 2001).

Whole-farm budgets are drawn up to show anticipated consequences, in terms of selected criteria, proposed farm plans, parameters and policy options. These incorporate physical as well as financial parameters and usually produce profitability criteria such as net farm income or cash flow (Dillon and Hardaker 1984). 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 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 being the lack of an optimisation goal, or the possibility of them not returning a 'best' solution.

The important contributing factor in identifying and developing strategies to improve profitability and sustainability is creativity. The process thus lean on creativity generated within the group discussions and the budget models thus serve a supporting role. Suggestions can quickly be evaluated in terms of financial impact within the group discussion. This not only focuses the discussion on strategies with a positive impact, but also adds another perspective, which in turn further stimulates creativity.

4. Strategy identification and development for relatively homogeneous areas and typical farms

The variation in climate, terrain and soil necessitated that the production area of the Western Cape be divided into smaller, more homogeneous areas. Expert groups were used to validate the homogeneous areas suggested by various experts. Relatively homogeneous production areas were used to distinguish the areas, as well as characteristics 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 region. The areas were specified by consulting the literature and visiting various experts before the group discussions took place (ARC Small Grains Institute 2003; Barnard 2007; Haasbroek 2007; Parkendorf 2007; 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. Relatively homogenous areas are usually defined in terms of soil, terrain and climate. In this instance typical farm sizes, cropping systems and cultivation practices were also considered. In the Swartland, the three areas are Koeberg/ Wellington (500-750 mm/annum rainfall), the Middle Swartland (350-600 mm/annum rainfall) and the Rooi Karoo (250 -400 mm/annum rainfall). The three areas in the Southern Cape are the Goue Rûens (500–700 mm/ annum rainfall), the Middle Rûens (300-500 mm/annum rainfall) and the Heidelberg Vlakte (300-500 mm/annum rainfall). The Swartland and Southern Cape regions are shown on a map in Figures 1 and 2 which illustrate the relatively homogenous farming areas.

The correlation between rainfall and grain yields in the Western Cape is 85% (Barnard 2007; Parkendorf 2007). From a climatology point of view, the factors that influence rainfall in the winter rainfall areas include global weather patterns, upper-level atmospheric circulation, oceanic variability and sea temperature. The characteristics of the land that also impact on rainfall include height above sea level, the distance from the coastline, and natural barriers like mountain ranges (Valero *et al.* 2004; Xoplaki *et al.* 2004). 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. 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.

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. However, a distinction in terms of rainfall and rainfall dispersion can be made among good, average and poor years. 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, or falls mostly during planting and then levels off towards seed filling, 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

Figure 1: Homogeneous areas for the Swartland
(Course of M. Wallace, GIS manager, Western Cape Department of Agricultuer, Elsenburg)

concentration of rainfall during harvest. 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 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 risks involved in crop production.

For each homogeneous area, a typical farm model was developed. The extents of the typical farms (farm size, land value, yields, mechanisation infrastructure and overhead cost) were validated during the group discussions. A typical farm was not developed to establish relevant information on individual farms, but rather to develop a model to which alternatives could be compared (Fuez and Skold 1991). Profitability of the typical farm is calculated over a 20-year period. A whole-farm multi-period budget model was used for calculating the IRR for each farm. To establish the current financial position of each farm, the range of factors that the farm system entails and the relationships between such factors needed to be captured. The factors

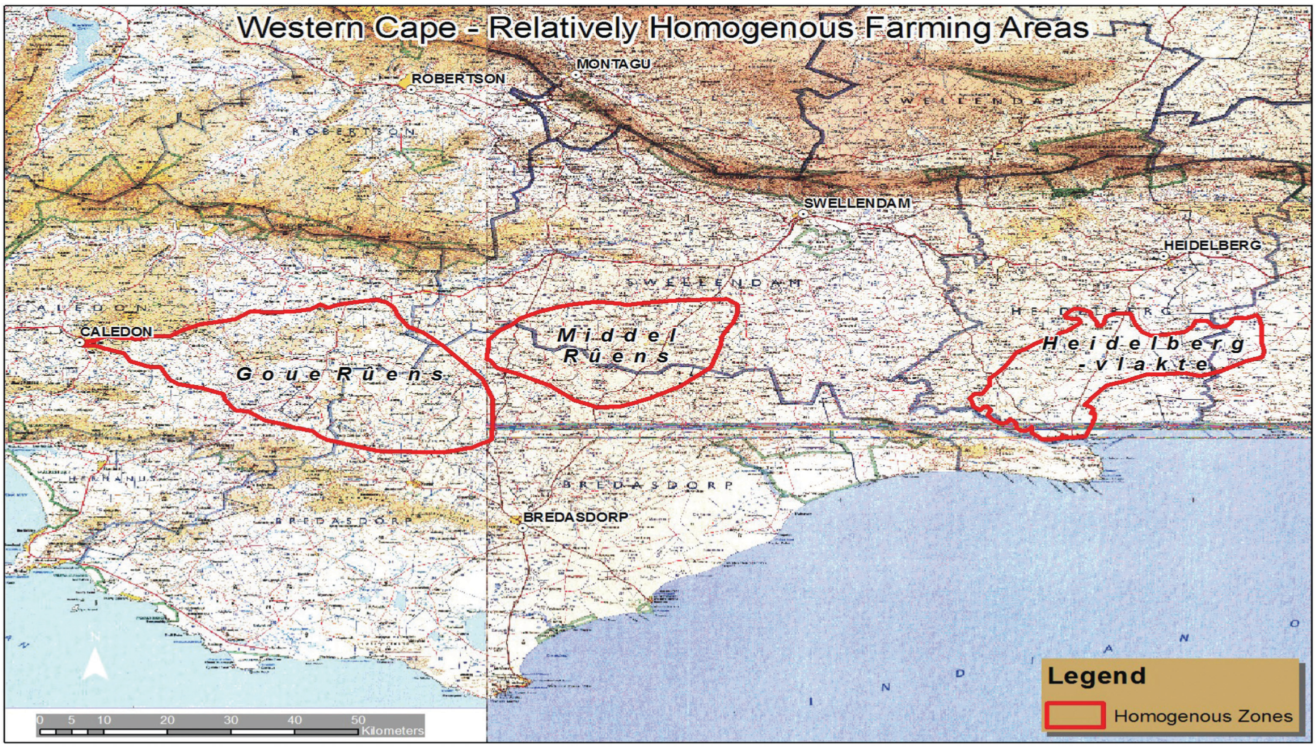

Figure 2: relative homogeneous areas for the Southern Cape
(Course of M. Wallace, GIS manager, Western Cape Department of Agricultuer, Elsenburg)

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. The variables are presented in data tables outside of the model, changes are made to such variables and run directly into

Table 1: Expected yields (and grazing capacity) 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	

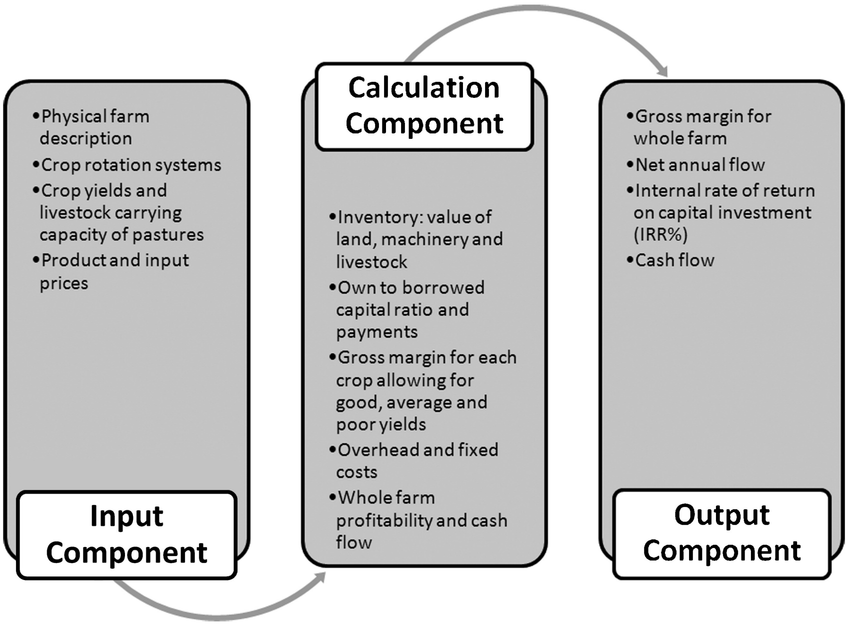

Figure 3: A graphic representation of the components of the whole-farm, multi-period budget model

the model. The whole-farm, multi-period budget models that were developed for each area consist of various sets of data and calculations that are interconnected and based on standard accounting principles and methods. These include price tables for inputs and products, input levels, yield levels, crop rotation systems and sequence of crops, running costs for machinery sets and labour use. The components of the budget model are shown in Figure 3. It illustrates the input component, calculation component and output component of the budget model. Each component consists of various interrelated parts that ultimately impacts on the calculation of whole farm profitability, measured in IRR and NPV.

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 spread sheet budget model. For the typical farm, all the factors forming part of the 'input component' as well as some of the factors of the 'calculation component' were determined from various interviews and information received from study groups, and validated during the group discussions.

Table 2 shows the expected NPV and IRR for the typical farm for each relatively homogeneous area. The areas with an IRR lower than the real interest rate of 4.69% all return 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.

One of the goals was to identify ways to improve the profitability of grain production in the Western Cape. To achieve this, the expert groups were challenged during the group discussions with identifying the optimum means of doing so. The model was used as a tool to measure and immediately show the expected financial effect of proposals on the whole farm. The experts also validated the technical feasibility of the suggestions. For instance they can point out the feasibility of a change in crop sequence in relation to impact on soil fertility, breaking of weed or pest cycles and mechanisation requirements.

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. The model is sensitive enough to show the relative impact of changes to cultivated area to other factors, such as investment requirement. 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, brought

Table 2: The net present value (NPV) and internal rate of return on capital investment (IRR) for each typical farm

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

[1]In mid-December 2013, R10 was approximately equivalent to £0.59, US$0.96 and €0.70 (www.xe.com).

Table 3: Impact of proposed strategies on the profitability of the typical farms for the Swartland area

Area	Strategy/Scenario	Profitability (IRR%)
Koeberg/Wellington	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%
Middle Swartland	Status quo	4.20%
	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%
Rooi Karoo	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%

about by, for example, the availability of new canola varieties, will influence the profitability of other crops in the system, the livestock component, the investment requirement for machinery, and overhead costs. Changes to the livestock enterprise, such as intensification, have a specific impact on the management of pasture, the use of stubble, the costs involved in making silage, and labour requirements. Cultivation practices impact on crop yields, mechanisation requirements and overhead costs, such as labour. For example a change in yield impact in a sequence the gross production value for wheat in a specific rotation system, the gross margin for wheat the gross margin for the total farm, profitability and cash flow, but also related costs such as marketing costs, transport costs and harvesting costs. The model quickly calculates the financial implications of any of the above-mentioned changes. The strategies for each area that are described in Tables 3 and 4 were all identified and discussed by the expert group and then fed into the model to assess their financial implications.

In the Swartland area, the severe summer droughts limit the options regarding pastures and crops such as barley. During the group discussions, it was established that more management effort could be invested in the livestock component, as it is currently focused mainly on wheat production. The planting and harvesting season in this area is also relatively short; therefore, effort went into the management of machinery and equipment, to extend the working life thereof. For both regions the focus fell mostly on optimising

Table 4: Impact of proposed strategies on the profitability of the typical farms for the Southern Cape region

Area	Strategy/Scenario	Profitability (IRR%)
Goue Rûens	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% for good and average years, due to technological improvements	6.31%
	Effect of a 5% discount on the price of fertilisers and chemicals	5.96%
	All harvesting done by contractors	5.41%
Middle Rûens	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%
Heidelberg Vlakte	Status quo	3.21%
	6% 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%

mechanization and the livestock component. Both these strategies showed significant improvements on expected profitability, however the way of implementation differ between areas.

5. Conclusions

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. 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 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. In most instances, suggestions revolved around the mechanisation infrastructure and the utilisation of the livestock component.

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