Farm Modelling for Interactive Multidisciplinary Planning of Small Grain Production Systems in the Western Cape, South Africa

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Contributed paper presented at the 55th Annual Conference of the Australian Agricultural and Resource Economics Society

At

Melbourne,

February 08-11, 2011

Abstract

Subject matter research has made many contributions to small grain production in the Western Cape province of South Africa, but much of this focuses on single commodities and is undertaken within conventional disciplinary boundaries (e.g. soil science, genetics, economics). The result is that the solutions offered often have knock-on effects that are not properly accounted for by researchers.

Expert group discussions, as a research method, are 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, multi-period whole-farm simulation 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.

In this study, 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 IRR (internal rate of return on capital investment) and affordability in terms of expected cash flow. The homogeneous areas identified were Koeberg/Wellington, the Middle Swartland and the Rooi Karoo, the Goue Rûens, Middle Rûens and Heidelberg Vlakte. 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.

Key words: whole-farm modelling, expert group discussions,

1. Introduction

The Swartland and Southern Cape areas contribute 87% of the wheat produced in the Western Cape and employ 27% of the regular agricultural workforce of the Western Cape (The Directorate: Agricultural Statistics, 2007:10; Punt, 2007; SAGIS, 2008:1-3 and Statistics SA, 2002). Following the abolishment of protectionist legislation in 1996, wheat production decreased, with barley, canola, oats and triticale gaining in relative importance (Edwards & Leibrandt, 1998:246). The increase in variety of the product mix and the 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. 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. Having to cope with biophysical and socio-economic systems puts producers in a decision-making environment that is more multidimensional, less controllable, more hazardous, more complex, and less standardised than industrial production systems (Cros et al., 2004:25 and Petherham & Clark, 1998:102). Due to the cost-price squeeze, the profit margins of producers are constantly under pressure, and therefore, there is a need for farm management research to generate relevant information and identify ways to improve profitability.

Within this complex environment, research in agriculture is conducted, aimed either at improving technology or generating information (Byerlee and Tripp, 1988:141 and Pannell, 1999:126). Technical research is mostly concerned with technical improvement, while economic and farm management research is concerned with generating information. In grain production, technical research is conducted within subject disciplines such as agronomy, soils science, plant protection, pathology, entomology, economics or farm management. This research has made many contributions to the industry; however, the knock-on effects are often not accounted for by researchers. The main challenge for research in farm management is generating relevant information for decision makers (Norman and Matlon, 2000:25 and McCown and Parton, 2006:163). This requires that the complex nature of the farm system is accommodated and that creativity is stimulated, which is required to identify ways to enhance farm profitability. 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.

2. Support tools for generating ideas to enhance farm profitability

Dealing with the complexity and multifaceted nature of the farm requires a systems approach. Within systems literature, multidisciplinary group discussions as a research tool are well documented in operations and farm management studies (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).

Knowledge itself can be divided into three distinct levels: lay knowledge, gained in everyday life; scientific knowledge gained by studying real life scenarios in a rigorous and systematic manner in search of truth; and meta-scientific knowledge, based on the critical reflection on scientific methods (Gadner et al, 2004:5 and Mouton, 2008). The importance of striving for truthful knowledge has led to specialisation and the development of academic disciplines, which often grow discrete from each other and inhibit cross-disciplinary communication (Malcolm, 1990:47-48 and Mouton, 2008). Examples of scientific disciplines related to grain production include agricultural economics, agronomy, soil science, plant pathology, entomology and animal science. In South Africa, agricultural research has traditionally been further compartmentalised by commodities (e.g., wheat industry, wool industry, barley industry, etc.).

Multidisciplinary research methods are used to accommodate participation across disciplinary gaps (Moore et al., 2007:37 and Young, 1995:122). The role of the farm management researcher is to facilitate multidisciplinary participation by focusing the input of researchers from the natural and social sciences, and producers, who have indigenous knowledge gained through their experience of real-life problems (Bosch et al., 2007:218; Keating & McCown, 2001:556; McCown, 2001:3 McGregor et al., 2001:79 Röling & Wagemakers, 1998:10-16 and Vandermeulen & Van Huylenbroeck, 2008:352). Expert groups are ideally suited to exploratory research, as experts can rely on experience and judgement: hence, expert groups are time saving compared with other methods. The major limitations of expert group discussions as a research tool are, firstly, the presence of an influential figure may cause other group members to be hesitant to disagree, and secondly, group discussions may become an exercise in model validation rather than in problem solving or strategy development.

The requirement of this research is to identify ways to enhance profitability, which necessitates creative thinking. The height of creative thinking, as a form of behaviour in individuals, is the creative shift, which takes place when the perspectives of individuals are challenged. 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. However, the stimulation of innovative and inventive thinking also depends on recourses such as knowledge, experience and insight that the individual has and therefore can contribute to the group (Hare, 1983:156-161 and Thompson & Choi, 2006:164). It is therefore important to carefully select participants for expert group discussions.

The generation of trustworthy and relevant information is reliant on the choice of a valid method to quantify and evaluate the whole farm in financial terms. Accurately describing the typical farm in financial terms and evaluating suggested changes made by the expert group requires that the quantitative method needs to comply with two important demands:

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

For the purpose of this study, whole-farm multi-period budget models were employed. This type of modelling is essentially simulation modelling based on accounting principles. It allows for the required sophistication through the number of variables that can be accommodated in a spreadsheet program (Pannell, 1996:374). Whole-farm budget models also meet the other requirements of this research, such as:

- Accommodating the complexity of the system being modelled through the number of equations that can be accommodated in a spreadsheet program,
- Incorporating the physical and financial variables (most of the inputs of natural scientists are in physical terms),
- Incorporating a multi-period assessment, as the dynamics of the crop rotation systems need to be captured,
- Allowing for the quick evaluation of suggestions made by group members through the adaptability of the model,
- Allowing user-friendliness through the participation of members, who are not all economists and must be able to understand and trust the model outputs.

The research method entailed using whole-farm models during the group discussions to quickly evaluate the financial impact of suggestions made by participants. The models contributed three major benefits to the group discussions. Firstly, participants could quickly see the financial implications of suggestions to physical factors such as crop rotation systems, mechanisation layout, labour availability, livestock enterprises, etc. Secondly, the models played the role of presenting an alternative perspective, which contributed to creating an environment for creative thinking. Thirdly, the fact that the models showed the financial impacts of suggestions quickly allowed the group discussions to identify and discard non-viable suggestions and further refine suggestions, with positive impacts on profitability.

3. Design and implementation of the combination of expert group discussions and models

The research was carried out in three distinct phases, namely, model construction, model validation and model use. Although the research carried out was scientific, during all three phases the research process relied on input from everyday knowledge (pragmatic interest), science (epistemic interest) and meta-science (critical interest). Figure 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.

The model construction phase relied heavily on inputs from practicing farmers. One of the prerequisites of simulation is a thorough understanding of the system being modelled. Producers have the best understanding and knowledge of the current issues and problems, and operate within the farming system. During an expert group discussion, six relatively homogenous production areas were identified for the Western Cape, and for each a typical farm model was constructed. The areas identified for the Swartland region were Koeberg/Wellington, Middle Swartland and the Rooi Karoo, and for the relatively homogenous Southern Cape region, the Goue Rûens, the Middle Rûens and the Heidelberg Vlakte. One area Wesselsbron for the Northern, summer rainfall areas was included in the study, for comparison.

Phase Two consisted of validating the models, which was achieved through various workgroup discussions comprising 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.

During the model's utilisation phase, experts were used in 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 their 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.

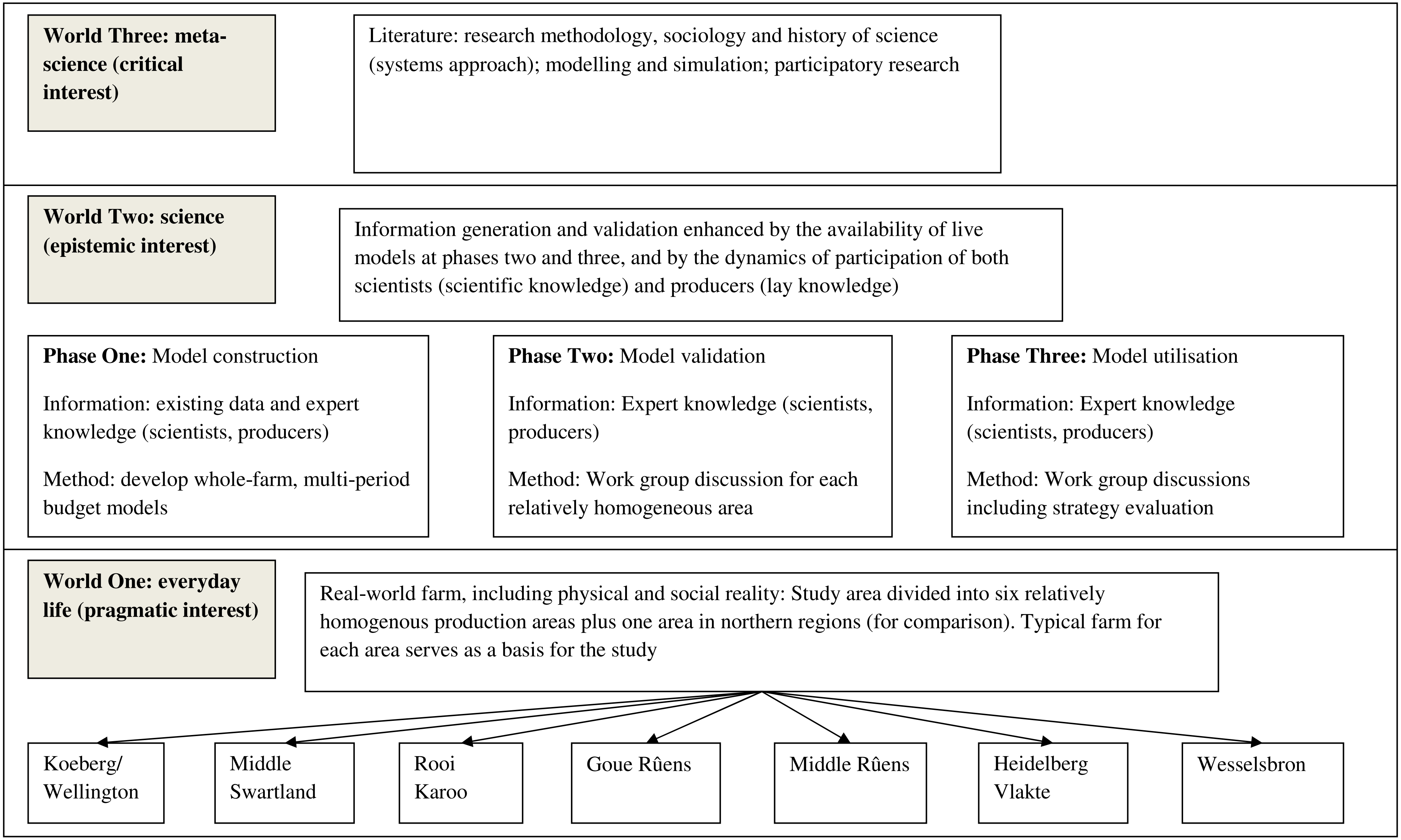

Figure 1: Schematic representation of the method, and the various techniques, tools, information and people involved

Relative homogeneity was used to differentiate between the production areas studied. In identifying the homogeneous production areas, other characteristics were included, such as farming practices, typical crop rotation systems, typical machinery replacement policies and affiliations to agribusinesses. Rainfall dispersion is a more important yield-determining factor than total rainfall in the Western Cape, which has a typical Mediterranean climate. 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, include height above sea level, 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 workgroups unanimously decided that long-term rainfall trends are not identifiable for typical winter rainfall areas, but could indicate an expected prevalence of good, average and poor years, with an expected yield for various crops associated with each, as shown in Table 2. 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. Other important characteristics captured by the models include crops viable for specific areas, crop rotation systems and the use of livestock. Especially the crops that can be cultivated in each area are limited due to meteorological characteristics and soil; for instance, due to the summer drought and heat, alfalfa is not an option in the Swartland area, but because of the soil pH, the Swartland is ideal for producing medics pastures.

Wheat and canola are the only cash crops produced in all the areas, with a high variance in yield mostly due to rainfall. Barley is produced only in the Southern Cape, as the Swartland often has seed-fill problems, due to the high temperatures in late spring (De Lange, 2009). Other crops typically included in crop rotation systems are oats, which either is used as pastures or harvested for silage or used for breakfast cereal, and triticale, used for animal feed. In the Southern Cape, long rotation cycles are typical, including five to seven years of alfalfa and then five to seven years of cash crops. In the Swartland, short crop rotations, including medics as pastures, are common. In both areas, producers aim at a land utilisation ratio of about 48% pastures to 52% cash crops.

Table 2: 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	

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.

In this study, the potential impact of these factors on the profitability of the typical farm needed to be established. This was done by developing whole-farm, multi-period budget models. The components of the calculation model are shown in Figure 1, below. It illustrates the input, calculation and output components of the budget model. Each component consists of various parts.

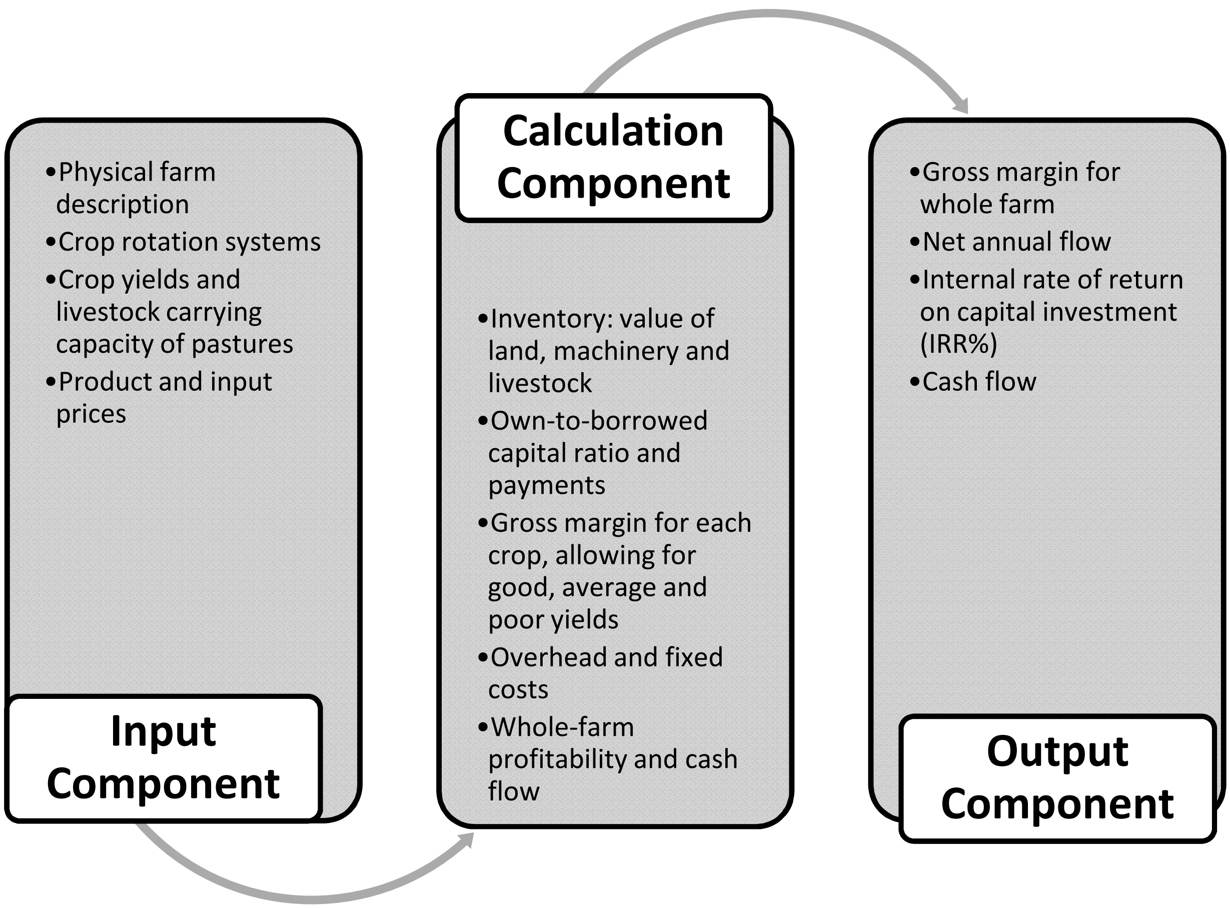

Figure 1: A graphic representation of the components of the whole-farm, multi-period budget model

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. Spreadsheet programs, through the range of functions available, enable the 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 this requires extensive preparation.

4. Identification and financial performance of the typical farm for each homogeneous area

The starting point for comparison was establishing the financial performance of the typical farm for each homogenous area, expressed in terms of standard financial criteria such as gross margin, IRR (internal rate of return on capital investment), NPV (net present value) and cash flow. The results obtained from combining expert group discussions and multi-period whole-farm budget models fell into two categories. The first was the evaluation of general exogenous factors that impact on farm profitability such as expected climate change and variability in product and input prices. The second category, and the most important output, was the identification and quantification of ways to improve farm profitability, which was done for each homogenous area, as each area had specific challenges.

Land ownership, land utilisation and land prices, as shown for each homogenous area in Table 3, 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-group information supplied by representatives of the local agribusinesses (Bruwer, 2007; Burger, 2007; Haasbroek, 2007; Laubser, 2007; Laubsher, 2007; and Lusse, 2007). Land use patterns, based on typical crop rotation systems for each area, were also identified during the group discussions. The crop rotation systems were modelled in such a way that adaptations to the sequence of crops within the systems or alternative crops could easily be accommodated. The model would then automatically, by a sequence of equations, adapt the land use pattern, area cultivated under each crop and all the margins influenced by such changes.

Table 3: 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
		Own land	Rented land	Own land	Rented land	R/ha
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

Tables 4, 5 and 6 show the various margins calculated by the models for each area. In each case, the gross production value, gross margin and net farm income is shown based on poor, average and good years, as described in Table 2. The delineation of good, average and poor was based on the past 20 years' rainfall for each area, although a repeat of the same sequence is highly unlikely. Twenty iterations were run for each area, each time shifting the starting year by one year. This was done to allow for the impact of good and poor years earlier in the calculation period to accommodate the impact of the time value of money; no serious deviations were identified in any of the areas, which may have been due to the relatively small difference between the incomes of the good, average and poor years, compared with the initial investment. The IRR for each area is also included in the tables, which is the only profitability criterion that allows for direct comparison between the areas. All the financial criteria show that the higher yield areas do better than the lower yield, higher risk areas, although the land prices in these areas were also higher. The Wesselsbron area is a summer rainfall region, which affords producers the scope of a summer and winter crop. This allows producers to use machinery more efficiently, while the lower land prices associated with the area also contribute to the higher profitability. In terms of decision-making, the producers in the summer rainfall areas also have a better indication of the availability of moisture at planting time, as their farming practices focus on the enrichment and maintenance of the soil water level.

Table 4: Summary of the various margins in R/ha for the areas in the Swartland region

REGION: SWARTLAND		**YIELD VARIATION DUE TO CLIMATE**			**IRR**
AREA		**POOR**	**AVERAGE**	**GOOD**	
KOEBERG/WELLINGTON	*GPV (R/HA)	2620.40	3484.10	4023.36	
	GROSS MARGIN (R/HA)	583.43	1583.60	2180.35	
	GROSS MARGIN %	22.11%	45.45%	54.19%	
	NET FARM INCOME (R/HA)	-67.75	932.42	1529.17	5.62%
MIDDLE SWARTLAND	*GPV (R/HA)	2032.85	2609.28	3162.92	
	GROSS MARGIN (R/HA)	695.17	1394.94	1557.33	
	GROSS MARGIN %	34.20%	49.24%	53.46%	
	NET FARM INCOME (R/HA)	-34.51	665.26	827.66	4.19%
ROOI KAROO	*GPV (R/HA)	1236.82	1642.52	211.84	
	GROSS MARGIN (R/HA)	523.22	836.74	1345.73	
	GROSS MARGIN %	42.30%	50.94%	63.60%	
	NET FARM INCOME (R/HA)	44.71	358.24	867.22	2.23%

Table 5: Summary of the various margins in R/ha for the areas in the Southern Cape region

REGION: SOUTHERN CAPE		YIELD VARIATION DUE TO CLIMATE			IRR
AREA		**POOR**	**AVERAGE**	**GOOD**	
GOUE RÛENS	*GPV (R/HA)	2312.04	2694.61	3077.18	
	GROSS MARGIN (R/HA)	528.50	1062.70	1246.13	
	GROSS MARGIN %	22.86%	39.44%	40.50%	
	NET FARM INCOME (R/HA)	56.41	590.61	774.04	5.65%
MIDDLE RÛENS	*GPV (R/HA)	2030.41	2317.80	2536.67	
	GROSS MARGIN (R/HA)	460.69	765.12	935.93	
	GROSS MARGIN %	22.96%	33.01%	36.90%	
	NET FARM INCOME (R/HA)	-127.53	176.89	347.71	1.05%
HEIDELBERG VLAKTE	*GPV (R/HA)	1834.92	2109.73	2345.44	
	GROSS MARGIN (R/HA)	791.33	1060.28	1138.97	
	GROSS MARGIN %	43.13%	48.56%	50.26%	
	NET FARM INCOME (R/HA)	265.90	534.84	613.54	4.86%

Table 6: Summary of the various margins in R/ha for the areas in the Swartland region

REGION: NORTH-EAST FREE STATE		YIELD VARIATION DUE TO CLIMATE			IRR
AREA		**POOR**	**AVERAGE**	**GOOD**	
WESSELSBRON	*GPV (R/HA)	1943.63	2469.43	2995.23	
	GROSS MARGIN (R/HA)	874.39	1338.61	1842.66	
	GROSS MARGIN %	44.98%	54.21%	61.50%	
	NET FARM INCOME (R/HA)	115.72	579.94	1083.99	6.29%

Note: * = Gross Production Value

5. Results and discussion

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 also 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. Table 7 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 7: 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 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 8. 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 8: 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%

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 Figure 2. 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 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. Table 9 shows the changes in IRR caused by input price increases, with all other factors kept constant.

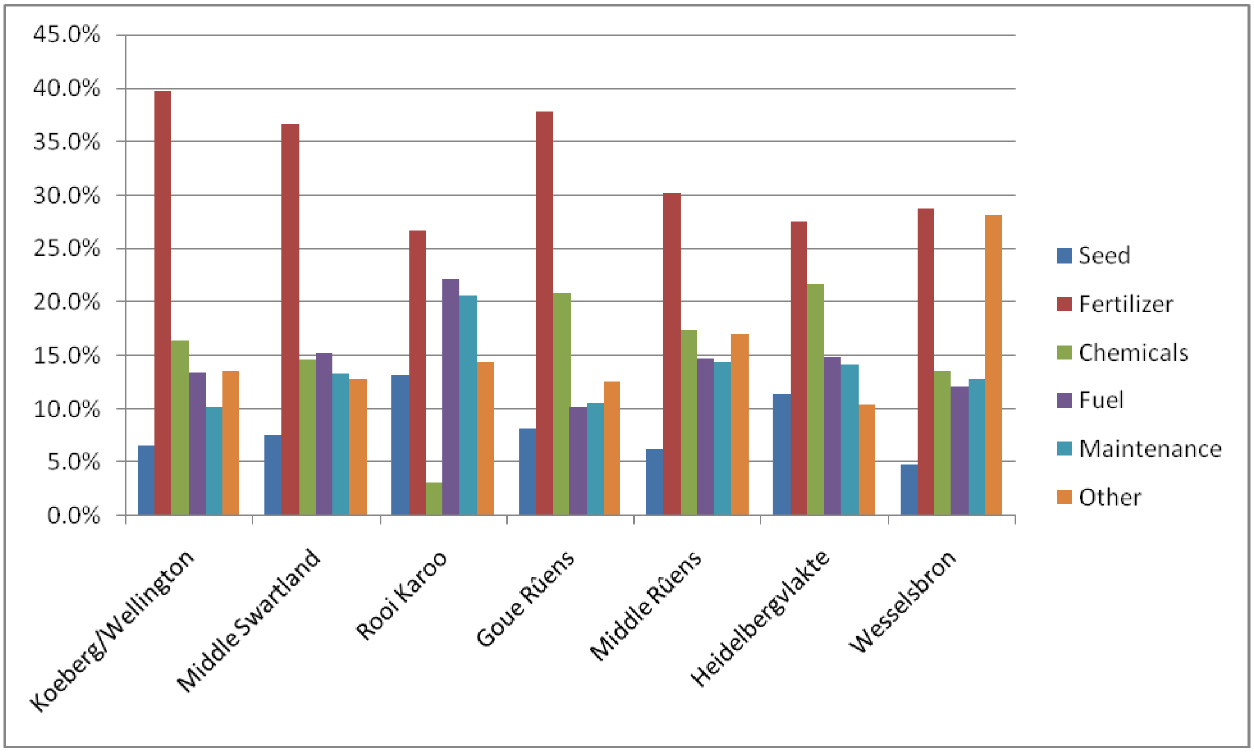

Figure 2: Graphic illustration of the contribution of various inputs to total farm variable costs

Table 9: 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%

A bio-fuel industry in South Africa is not currently operational, which necessitated the use of a theoretical triticale price in the models. This price was derived in two ways. The first way entailed starting with the price of bio-ethanol and subtracting production costs to derive a price for the raw material, in this case triticale (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 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 10: 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

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 the 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 shown for the Koeberg/Wellington area, as an example. Similar results were obtained through the group discussions for each homogeneous area. Table 11 shows the financial implications of various suggestions made by the expert group. The last option in Table 11 serves as an example of where a suggestion had a negative impact on the expected profitability, and no time was spent on refining that option.

Table 11: 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. Conclusions

The dynamics of group discussions provide the ideal environment for stimulating 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 which stimulate innovative thinking. During the group discussions, each participating expert offered a high level of knowledge and experience in evaluating and verifying 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. Within the overall aim of generating relevant information, the primary 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.

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