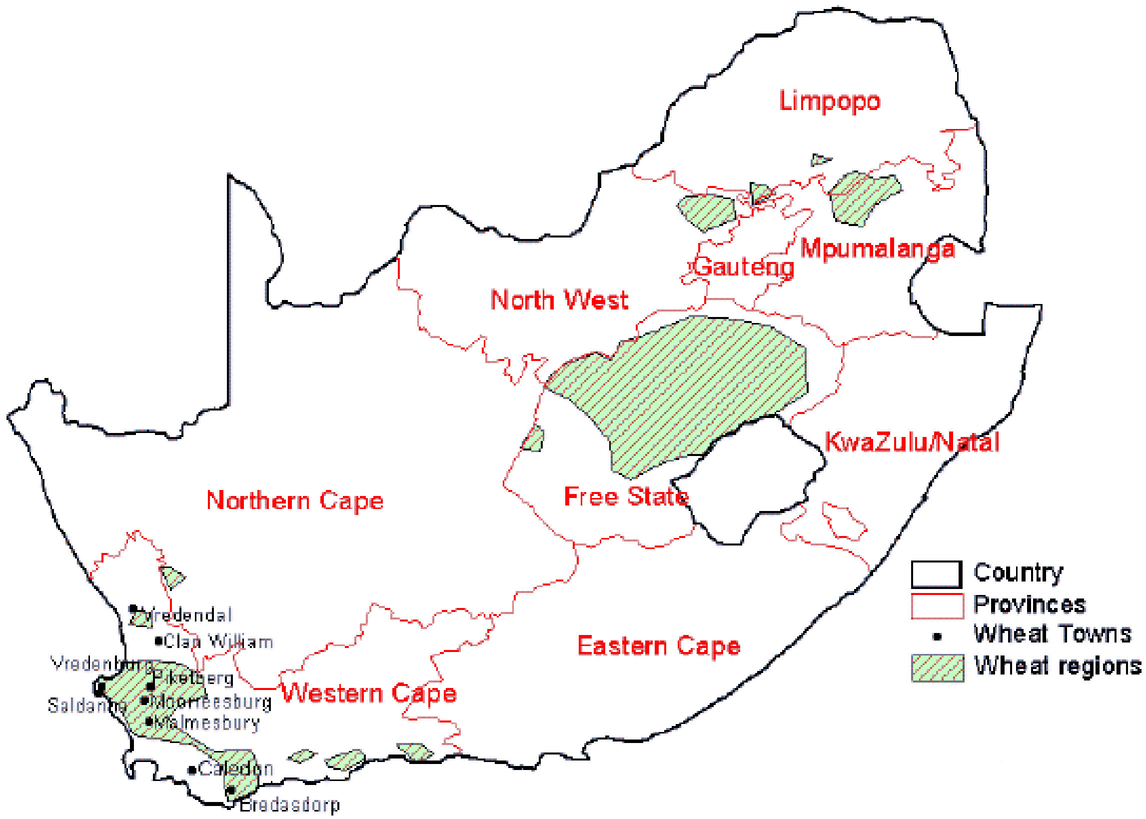
Typical farm modelling for the evaluation of zero tillage and crop rotation systems for small grains production in the Western Cape, South Africa

Hoffmann, W. & Kleynhans, TE*.

Department Agricultural Economics, University of Stellenbosch, Private Bag X1, MATIELAND, 7602, South Africa (tek1@sun.ac.za)

Rain-fed wheat production in semi-arid areas of South Africa



Background

- Income-cost pliers causes decreasing profitability
- Decreasing soil productivity, due to ploughing and monoculture, required more inputs to maintain yields
- Input prices are rising rapidly
- Most producers have already abandoned wheat monoculture and ploughing
- Financial pressure stimulates a need for more sustainable practices to address:
  - damage done to soil structure
  - low microbial status and soil carbon levels
  - increasing resistance of rye grass in wheat against selective herbicides
- Adopt lower-cost zero tillage and crop rotation
- Not just new recipe, but new paradigm which requires more insight into complex ecological system

Motivation for developing the typical farm model

- Must support a multidisciplinary expert group to assess the profitability and sustainability of crop rotation and zero tillage in small grain production systems
- Multiple perspectives to suggest improvements of the farming system
- Enhances insight into the interrelatedness of system components
- Provides coherent framework to capture the interrelatedness of the physical, biological and social components of the farming system
- Must be so user-friendly that it can show the impact of suggested changes on the profitability immediately to enhance creativity
- Must enable expert group to stop pursuing non-viable plans

Table 1: Description of selected grain production areas in the Western Cape

Rainfall	Sandveld and Rooi Karoo	Koeberg	Golden Rûens	Middle Rûens
■ Long-term average annual total rainfall	201-300 mm	410-500 mm	301-400 mm	201-300 mm
■ Rainfall distribution (% of total in winter)	75%+	80%+	65%	60%

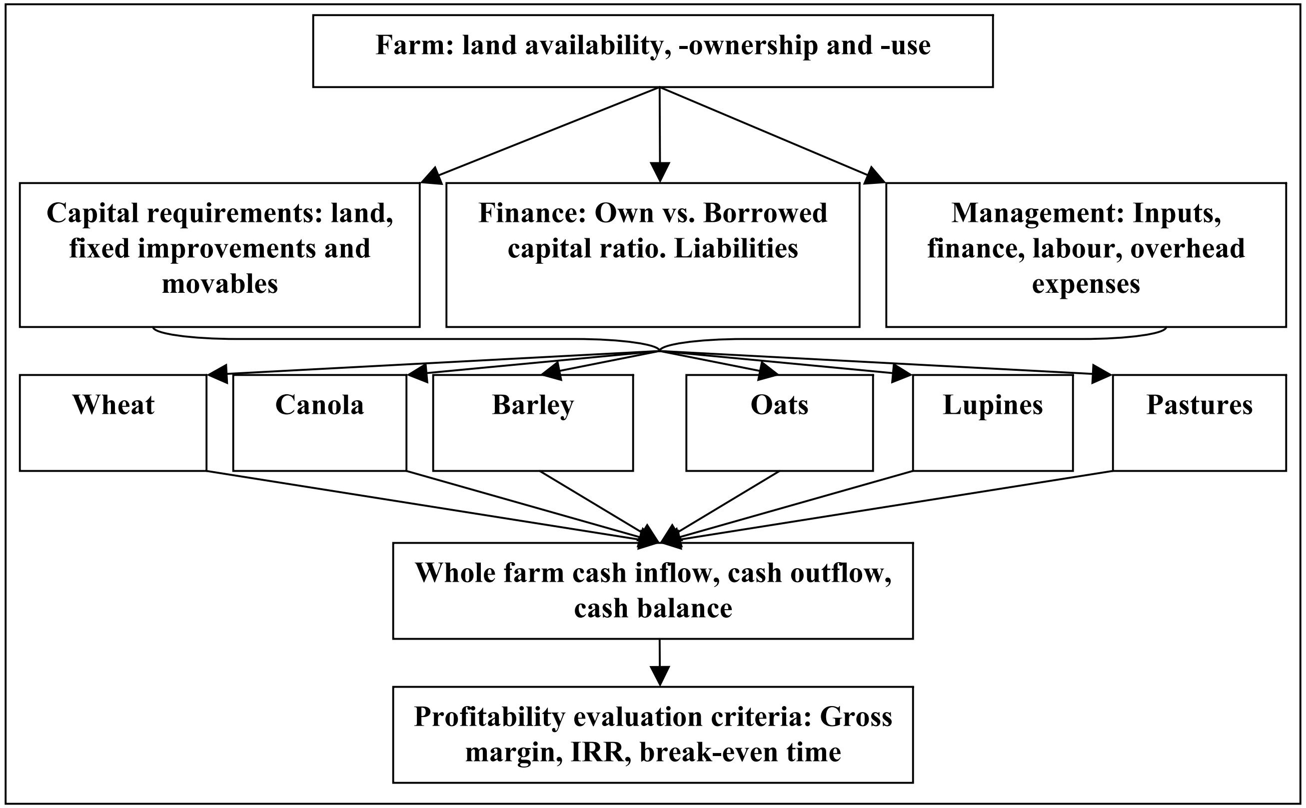
Table 2: Yield variability and expected long-term average yield per hectare

		Sandveld and Rooi Karoo	Koeberg	Golden Rûens	Middle Rûens
Yield variability (number of years out of 10)	**- Good**	1	2	3	3
	- Average	6	7	6	5
	- Poor	3	1	1	2
Expected long-term average yield per hectare (t/ha)	**- Wheat**	1.3	3.7	2.9	2.2
	- Barley	-	-	2.7	2.2
	- Oats	Grazing	Grazing	2.5	2.0
	- Canola	1.0	1.5	1.3	1.2
	- Triticale	1.3	3.7	2.9	2.2

The sequence of crops in the crop rotation system is determined by the following considerations:

- To benefit from nitrogen fixing by the previous crop (e.g. wheat following lucerne or lupins)
- To benefit from a reduction of soil pathogens during the previous crop (e.g. wheat following canola)
- To benefit from killing broadleaf weeds during a grain phase with selective herbicides (e.g. canola following wheat)
- To benefit from killing grasses during a broadleaf crop with selective herbicides (e.g. wheat following canola)

Structure of the typical-farm model



Parameters to determine the financial impact on profitability:

- Physical parameters: land availability, land ownership, land use
- Prices: land, machinery, inputs, products
- Quantities: inputs (seeding density, fertilisation levels, chemicals), yields, carrying capacity of livestock, labour, farm size and ownership (own vs rented land)
- The type and number of cultivations can be selected.
- Types and sizes of machinery and equipment (database of various sizes of tractors, harvesters and equipment is available and allows for the easy selection of items)
- External financial parameters: water levies, interest rates, handling fees at silos
- Crops and the sequence of crops
- Age and replacement schedule of machinery

Financial criteria to express the financial impact of a proposed strategy:

- Gross margins per ha and per enterprise allow comparison of the profitability of various enterprises.
- The gross margin for the whole farm indicates the margin above total variable costs.
- Net farm income: Shows return on all farming activities:
  - after allowing for variable and fixed costs
  - it allows the direct comparison of farms.
- IRR: Profitability in terms of return on investment:
  - Takes all investment and cash flow into account
  - It incorporates the time value of money
  - Allows comparison of the profitability of small grain farms with various crop rotation cycle lengths.

Results

1. Application of the farm model to determine the viability of small grain production for ethanol

- The model was used to determine the financial viability of allocating 20 percent of arable land currently used for small grains and canola production to the production of triticale as feedstock for bio-ethanol production.
- The amount of land made available for biofuel purposes is restricted for food security reasons.
- The triticale price was derived from current petrol price.
- Table 3 shows more than one crop rotation system used per typical farm per production area, necessitated by richer or poorer soils on the farm.
- It shows which rotation system is adapted and where in the crop rotation wheat was replaced by triticale.
- Table 3 also indicates whether the partial switch to triticale production delivers a higher profit or not.

Table 3: Typical crop rotation systems used in the Western Cape production areas

	Year	Rotation system 1	Rotation system 2	Rotation system 3	IRR before	IRR after
Sandveld & Rooi Karoo		(80%)*	(10%)*	(10%)*	5.41%	5.06%
	1	Wheat? Triticale	Wheat? Triticale	Oats (grazing)		
	2	Fallow (grazing)	Wheat? Triticale	Oats (grazing)		
	3	Wheat	Wheat? Triticale	Oats (grazing)		
	4	Fallow (grazing)	Wheat? Triticale	Oats (grazing)		
Koeberg	Year	(5%)	(65%)	(30%)	14.13%	14.73%
	1	Wheat	Wheat	Wheat		
	2	Canola	Medics	Wheat? Triticale		
	3	Wheat? Triticale	Wheat	Canola		
	4	Lupins	Medics	Wheat? Triticale		
	5	Wheat	Wheat	Oats		
	6	Canola	Wheat	Wheat		
	7	Wheat? Triticale	Medics	Wheat? Triticale		
	8	Lupins	Wheat	Canola		
	9	Wheat	Medics	Wheat? Triticale		
	10	Canola	Wheat	Oats		
Golden Rûens	Year	(20%)	(40%)	(40%)		
	1 - 6	Lucern	Lucern	Lucern	9.52%	10.57%
	7	Wheat	Wheat	Wheat		
	8	Barley? Triticale	Barley	Barley		
	9	Canola	Barley	Canola		
	10	Wheat	Canola	Wheat? Triticale		
	11	Barley/Lucern	Wheat? Triticale	Barley		
	12		Barley	Lupins		
	13		Oats/Lucern	Wheat? Triticale		
	14			Barley/Lucern		
Middle Rûens:	Year	(20%)	(40%)	(40%)	8.06%	9.32%
	1 - 5	Lucern	Lucern	Lucern		
	6	Lucern	Lucern	Wheat		
	7	Oats	Wheat	Barley		
	8	Wheat	Barley? Triticale	Canola		
	9	Oats	Canola	Wheat? Triticale		
	10	Wheat? Triticale	Wheat	Barley		
	11	Barley	Barley	Canola/Lucern		
	12	Triticale/Lucern	Barley/Lucern			

- Only the Sandveld area shows a lower IRR as wheat performs better in the drier areas; for the other areas the IRR of the triticale option is slightly higher.

2. Elimination of underutilised machinery capacity and increase of livestock

- Indivisibility of combine harvesters and tractors often causes some of these items to be underutilised.
- Compare IRR of underutilised machinery capacity with IRR of full use of available machinery capacity after replacing underutilised machinery with machinery with more appropriate capacity and a lower running cost.
- Some land previously used for grain production is now available to produce oats for grazing to increase livestock production.
- Table 4 shows where wheat as a cash crop in crop rotation is replaced by oats for grazing, allowing the number of small stock units (SSU) to increase.

Table 4: Typical crop rotation systems used in the Western Cape production areas

	Year	Rotation system 1	Rotation system 2	Rotation system 3	Change in machinery capital requirements	IRR
Sand-veld & Rooi Karoo		(80%)*	(10%)*	(10%)*	Machinery total	5.41%
	1	Wheat? Oats (graze)	Wheat	Oats (graze)	R1,42? R1,42m	before
	2	Fallow (graze)	Wheat	Oats (graze)	Harvesters	?
	3	Wheat	Wheat	Oats (graze)	Keep the same	6.49%
	4	Fallow (graze)	Wheat	Oats (graze)	Tractors	after
					Replace a 75 kW with a 65 kW	
Koe-berg:	Year	(5%)	(65%)	(30%)	Machinery total	14.13%
	1	Wheat? Oats	Wheat	Wheat	R2,6 m? R2,48 m	before
	2	Canola	Medics	Wheat? Oats (graze)	Harvesters	?
	3	Wheat	Wheat	Canola	Keep 124 kW	13.42
	4	Lupins	Medics	Wheat	Replace 175 kW with	%
	5	Wheat? Oats	Wheat	Oats	124 kW	after
	6	Canola	Wheat	Wheat	Tractors	
	7	Wheat? Oats	Medics	Wheat? Oats (graze)	Replace 120 kW with	
	8	Lupins	Wheat	Canola	75 kW	
	9	Wheat? Oats	Medics	Wheat		
	10	Canola	Wheat	Oats		
Golden Rûens:	Year	(20%)	(40%)	(40%)		
	1 - 6	Lucern	Lucern	Lucern	Machinery total	9.52%
	7	Wheat	Wheat	Wheat	R7.16 m? R6.99 m	before
	8	Barley	Barley	Barley	Harvesters	?
	9	Canola	Barley	Canola	Keep 201k W	9.57%
	10	Wheat	Canola	Wheat	Replace 201 kW with	after
	11	Barley/Lucern	Wheat	Barley	75 kW	
	12		Barley	Lupins	Tractors	
	13		Oats/Lucern ?	Wheat	Replace 100 kW with	
	14			Barley/Lucern? Oats (graze)		
Middle Rûens:	Year	(20%)	(40%)	(40%)	Machinery total	8.06%
	1 - 5	Lucern	Lucern	Lucern	R3.18m? R2.97m	before
	6	Lucern	Lucern	Wheat	Harvesters	?
	7	Oats ? Oats	Wheat	Barley	Keep 124 kW	8.73%
	8	Wheat	Barley	Canola	Replace 175 kW with	after
	9	Oats? Oats (graze)	Canola	Wheat	124 kW	
	10	Wheat	Wheat	Barley	Tractors	
	11	Barley	Barley	Canola/Lucern	Replace 78 kW with	
	12	Triticale/Lucern? Oats (graze)	Barley/Lucern			

- The reduction in machinery capacity (expressed in kW) and lower capital investment is shown in the column *Change in machinery capital requirements*.
- The impact of the structural change on the IRR shows mixed results.
- The real impact will depend largely on the actual level of underutilisation of machinery.
- Producers need to be aware of the level of underutilised machinery.
- The utilisation of land freed from cash crop production for livestock production, combined with lower machinery costs, can actually deliver a better financial outcome.

Discussion and Conclusion

- Shrinking profit margins due to the cost-income pliers demand regular investigation of possible strategies to increase the efficiency and effectiveness of small grain production systems.
- A typical-farm model was constructed to determine the financial outcome of strategies to attain financial and ecological sustainability.
- Existing crop rotation and zero tillage systems contain complex input-output relationships which can only be captured by a fairly sophisticated typical-farm model.
- Wide variety of technical and financial parameters to facilitate effective interactive planning by a multidisciplinary expert group.
- The creativity of an expert group is inhibited if the model disallows easy adaptation of relevant parameters.