FINANCIAL FEASIBILITY ANALYSIS OF ALTERNATIVE CROP ROTATION SYSTEMS UNDER CENTER PIVOT IRRIGATION IN THE SOUTHERN FREE STATE AREA CONSIDERING PRICE, PRODUCTION AND FINANCIAL RISKS

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Samevatting

'n Ontleding van die finansiële uitvoerbaarheid van alternatiewe gewaswisselboustelsels onder spilpuntbesproeiing in die Suid-Vrystaat substreek met inagneming van prys-, produksie- en finansiële risiko

Veertien tipiese gewaswisselboustelsels is oor 'n periode van 10 jaar ekonomies geëvalueer. Die gewaswisselboustelsels sluit koring, laatmielies, droëbone, lusern, sojabone, katoen en grondbone in en maak voorsiening vir verskillende persentasies van grondbenutting. 'n Prosedure is ontwikkel om prysverdelings vir die tersaaklike gewasse te genereer. Die gewasopbrengsverdelings is met behulp van die PUTU-simulasiemodel met 11 jaar se weerdata gegenereer. Twee 60-hektaar spilpuntstelsels op sandgrond is in die ontleding gebruik. Die jaarlikse nabelasting kontantvloei is vir die 14 wisselboustelsels vir twee statiese pomphoogtes en drie skuld/bate-verhoudings oor 'n periode van 10 jaar beraam. Slegs twee gewaswisselboustelsels is uitvoerbaar vir boere met 'n 70 persent skuld/bate-verhouding. Indien die skuld/bate-verhouding na 50 persent verbeter, is 'n verdere vier wisselboustelsels uitvoerbaar. Al die stelsels is finansieel uitvoerbaar indien die skuld/bate-verhouding 20 persent is.

Abstract

Fourteen typical crop rotation systems were evaluated over a period of 10 years. The irrigation systems were used to irrigate 60 ha of sandy soils. Various degrees of double cropping were considered. A procedure was followed to generate distributions of prices for the relevant crops. The crop yield distributions were generated by the PUTU-simulation model. The annual after-tax cash flow was calculated for the different crop rotation systems for each year of the ten year period for two static pumping heights and three different equity ratios. The results indicate that all crop rotation systems are infeasible for a 30/70 equity ratio for positive pumping heights. For a 80/20 equity ratio 14 crop rotation systems are feasible.

1. Introduction

The central theme of this study is the economics of crop rotation systems in the area below the P.K. le Roux Dam. The analysis of crop rotation systems requires a multi-disciplinary approach where economical agronomical, soil, meteorological and engineering aspects ought to be considered. Few studies on crop rotation systems take due consideration of all relevant aspects (Wilson and Eidman, 1981; Gill, 1988; Grobbelaar, 1985; De Klerk, 1986; Niksch, 1988; and Meiring, 1989). Meiring (1989) developed a scientific procedure to evaluate the economic profitability and financial feasibility of alternative centre pivot investments for a wheat/maize/cotton crop rotation system, taking into account risk. What is needed now is to apply this procedure in evaluating alternative crop rotation systems under centre pivot irrigation.

The purpose of this study was to evaluate the financial feasibility of fourteen crop rotation systems under centre pivot irrigation in the Southern Free State subregion, taking into account production, price and financial risks.

2. Procedure

The point of departure in the procedures is that the economic profitability and financial feasibility analyses of the crop rotation systems are separated. The two main variables in the analyses are crop rotation systems and debt/asset ratios of the farmers, taking into account realistic irrigation scheduling practices, irrigation systems design and soil water capacities. The analysis is done for a farm of 120 hectares. The basic steps of the procedure are subsequently described.

2.1 Crop yields and gross water requirements

The lack of comparable and accurate information on crop yields and corresponding gross water applications over a lengthy period necessitated that these values had to be simulated. Data on crops, soils and climate are used to validate and calibrate a PUTU crop growth simulation model, P9MZAB3, for this area (De Jager, 1990). The BEWAB irrigation scheduling model is used to determine the irrigation scheduling of the crops (Bennie *et al.*, 1988). The calibrated PUTU model is then used to generate crop yields and gross water applications for wheat, late maize, cotton, peanuts, drybeans, lucerne and soyabeans for a period of eleven consecutive years. By having crop yields simulated provision is made for production risk.

2.2 Crop price distributions

The price variability of late maize, wheat, drybeans and lucerne was taken into account by generating a distribution of 33 prices for each crop.

2.3 Cost estimation

The fixed, variable and marginal irrigation costs of the centre pivot systems on sandy soils with a positive pumping height (Sarel Hayward area) and a negative pumping height (Ramah area) are estimated with a computerised method (Meiring, 1989). The investment in land and other machinery equipment is also estimated. Crop budgets are developed for all seven crops. Successively a distribution of net margins for each crop can be calculated by selecting prices and yields at random from the respective price and yield distributions. The crop net margins are then determined for each year of the ten year period. For the consideration of production and price risk a distribution of twenty net margins of the crops are determined by repeating the process of selecting price and yields twenty times for each year.

2.4 Crop rotation systems

Based on economic, agronomical and practical principles fourteen crop rotation systems with different degrees of double cropping are developed and analysed. The notations of the 14 crop rotation systems are as follows:

60W/60S	(200)
60W/60LM/60W/60S	(200)
45W/45LM/15P	(175)
60W/60S/60C	(150)
45W/45LM/15P/60C	(137,5)
30W/30LM/30L	(200)
30W/30LM/30C/30L	(175)
60W/60LM	(200)
60W/45LM/15D	(200)
60W/60LM/60C	(150)
60W/45LM/15D/60C	(150)
30W/30S/30L	(200)
30W/30S/30W/30LM/30L	(200)
30W/30S/30C/30L	(175)

where W = wheat, LM = late maize, C = cotton, P = peanuts, D = drybeans, S = soyabeans and L = lucerne. The degree of double cropping (%) is expressed in parenthesis and the number of hectares planted is 60, 45, 30 or 15.

2.5 Economic Profitability

For each crop rotation system an annual net margin is estimated by randomly selecting crop price/yield combinations. The net present value for each crop rotation system is then calculated by discounting the net margins over a period of ten years. The procedure of estimating NPV is repeated twenty times to take risk into account. The average NPV/investment ratio indicates the relative profitability of the crop rotation systems.

2.6 Financial feasibility

The purpose of the financial feasibility analysis is to determine whether the crop rotation systems will generate sufficient cash income to meet all financial obligations timely. Three debt/asset ratios were identified by Meiring and Oosthuizen (1991) for farmers in the research area. Debt/asset ratios of 70, 50 and 20 per cent were used to reflect financial risk. The long, medium and short term debt are respectively 35; 25 and 40 per cent for all three groups.

A decision rule was formulated to determine whether a crop rotation system is feasible or not. A year is considered a deficit year when 10 or more out of 20 repetitions of the net cash flow estimations are negative. When one or more deficit years occur over the ten year period the particular crop rotation system is then considered infeasible.

Equation (1) is used to calculate the surplus or deficit after-tax net cash flow (ATNCF) of the crop rotation systems:

$$ATNCF_t = ATCI_t - ATCC_t \qquad (1)$$

where:
$ATNCF_t$ = annual after-tax net cash flow in year t,
$ATCI_t$ = annual total after-tax net cash income in year t and
$ATCC_t$ = annual total after-tax cash costs in year t.

The equation of the annual total after-tax net cash income ($ATCI_t$) for the farm is shown in equation (2):

$$ATCI_t = (BTNCI_{at} \times S_a) \times (1 - T) \qquad (2)$$

where:
BTNCI = annual before-tax net cash income from crop a in year t,
S = size of land section planted to crop a,
T = marginal tax rate (%),
t = year 1 to 10 and
a = crop 1 to 4.

Equation 3 represents the total annual after tax cash costs ($ATCC_t$) due to debt financing:

$$ATCC_t = Cl_t + Cm_t + Il_t + Im_t + Is_t - D \qquad (3)$$

where:
Cl_t = long term capital redemption in year t,
Cm_t = medium term capital redemption in year t,
Il_t = net interest on long term loan in year t,
Im_t = net interest on medium term loan in year t,
Is_t = net interest on bank overdraft in year t plus net interest monthly account in year t and
D = depreciation tax savings in year t.

3. Results and discussion of results

The purpose of Table 1 is to rank the fourteen crop rotation systems in order of relative profitability. The profitibility criterion is net benefit/investment ratio (third column). The net benefit (column one) is the average net present value calculated from the 20 repitition of NPV for each crop rotation system. The total investment includes investment in land, irrigation system and other machinery equipment.

Table 1: Annual average net present value, investment, annual net benefit/investment ratio and the coefficient of variance for fourteen crop rotation systems, irrigated by center pivot system in the irrigation area below the P.K. le Roux Dam, 1991

Crop rotation systems	ANPV[1] (R)	I[2] (R)	ANPV/ R100I (R)	cv[3] (%)
30W/30S/30C/30L	48 677	1 006 294	4,84	5,17
30W/30LM/30C/30L	47 030	1 028 887	4,57	6,78
30W/30S/30L	44 014	1 028 887	4,28	6,59
30W/30S/30W/30LM/30L	41 742	1 048 971	3,98	6,71
30W/30LM/30L	40 483	1 048 738	3,86	7,32
45W/45LM/15P/60C	28 209	1 035 207	2,72	7,62
60W/45LM/15D/60C	27 610	1 055 291	2,62	8,60
60W/60S/60C	26 786	1 032 532	2,59	8,69
60W/60LM/60C	23 361	1 055 058	2,21	12,39
60W/45LM/15D	19 503	1 034 890	1,88	9,49
45W/45LM/15P	17 806	1 034 890	1,72	14,16
60W/60S	17 648	1 034 890	1,71	15,21
60W/60LM/60W/60S	14 005	1 041 210	1,35	17,00
60W/60LM	11 606	1 041 210	1,11	28,30

1. Annual average net present value
2. Total investment (land + mechanisation)
3. Coefficient of variance

The net benefit/investment ratios of the crop rotation systems vary between 4,84 and 1,11 per cent. The most profitable crop rotation system is 30W/30S/30C/30L. The NPV of this crop rotation system varies from R 437 674 to R 529 970.

Table 2: Annual net cash surplus or deficit for crop rotation system 30W/30S/30L with a 70/30 debt/asset ratio for twenty repetitions over a period of ten years

Year Repetition	1 (R)	2 (R)	3 (R)	4 (R)	5 (R)	6 (R)	7 (R)	8 (R)	9 (R)	10 (R)
1	-10 327	10 735	-1 254	-7 225	-3 105	-19 200	12 218	-534	19 229	-1 384
2	-11 234	29 434	12 760	16 428	17 350	-24 775	34 786	3 588	-26 128	-5 213
3	-11 897	-3 983	34 304	-23 099	-3 222	-3 149	2 072	-8 000	-5 736	13 009
4	-16 433	24 746	-30 927	27 095	15 756	-21 081	36 103	20 116	31 390	-13 825
5	2 880	-2 515	10 204	-26 560	20 892	37 481	-10 100	650	-16 599	18 029
6	17 314	9 583	12 124	35 091	6 307	12 413	17 860	-5 545	-17 473	-18 083
7	34 241	-7 510	46 126	-16 197	15 193	-14 235	29 353	44 689	-23 535	31 070
8	-10 945	-18 289	17 570	43 516	23 061	25 176	-17 857	1 949	-3 554	17 128
9	-8 685	14 783	16 273	-13 277	28 461	-422	-16 550	-6 109	-12 373	2 321
10	-683	320	-5 202	1 092	2 695	-10 241	27 531	-7 366	11 453	24 936
11	3 332	38 396	28 740	29 557	29 581	23 613	1 714	17 149	-3 461	6 517
12	-9 163	14 039	-7 962	23 008	-11 392	2 190	377	28 670	-1 933	33 866
13	29 880	-2 924	-893	-9 411	15 533	-2 112	-11 070	43 815	17 379	10 592
14	10 911	-3 816	19 227	9 505	13 116	-6 234	41 490	34 488	1 152	-4 980
15	2 809	-1 123	-6 095	22 359	12 651	30 546	11 689	8 126	13 799	1 820
16	13 348	3 826	9 906	13 273	14 820	1 754	20 647	19 853	3 642	22 846
17	-17 463	21 361	7 653	21 453	35 602	7 656	24 469	13 339	28 568	17 117
18	12 548	12 882	21 911	-6 395	19 994	-4 500	862	32 735	2 384	-962
19	-9 369	-21 064	14 777	18 415	4 711	-14 896	-3 280	36 140	17 284	-6 773
20	-8 839	29 320	-3 130	5 597	16 429	4 938	27 137	-25 197	10 091	-100
Total[4]	11	8	7	7	3	11	5	6	9	8

4. The number of annual cash flow deficits out of 20 repetitions

Each of the five most profitable crop rotation systems include lucerne. The least profitable system is 60W/60LM. The coefficient of variance is 5,17 per cent for the most profitable crop rotation system and 28,3 per cent for the least profitable system.

The purpose of Tables 2 and 3 is to evaluate the financial feasibility of a crop rotation system. The annual net cash flow for a farmer with 70 per cent debt/asset ratio and crop rotation system 30W/30S/30L over a period of ten years is shown in Table 2. Year 1 and 6 have 10 cash flow deficits and according to the decision rule considered deficit years. Because more than one year out of ten is a deficit year the 30W/30S/30L rotation system is infeasible for farmers with a debt/asset ratio of 70 per cent.

The annual net cash surplus or deficit for all the crop rotation systems for the three different debt/asset ratios for twenty repetitions over a period of ten years is calculated as shown in Table 2 but all the tables are not presented here (Den Braanker, 1992).

The number of deficit years of the fourteen crop rotation systems for the three groups of farmers with 70, 50 and 20 per cent debt/asset ratios are shown in Table 3. Only two crop rotation systems (30W/30LM/30C/30L and 30W/30S/30C/30L) are feasible for farmers with a debt/asset ratio of 70 per cent. For ten of the crop rotation systems each year over a period of ten years is a deficit year. When the pumping height decreases with 25 meters (Ramah area) crop rotation systems 30W/30S/30L, 30W/30LM/30L and 30W/30S/30W/30LM/30L are also feasible for farmers with a debt/asset ratio of 70 per cent.

Four additional crop rotation systems become feasible when the debt/asset ratio improves to 50 per cent. For five crop rotation systems each year over a period of ten years is a deficit year. When the pumping height decreases with 25 meters crop rotation systems 60W/45LM/15D/60C and 45W/45LM/15P/60C becomes also financially feasible.

Table 3: Number of deficit years over a 10-year period for three different debt/asset ratios of respectively 20, 50 and 70 per cent for fourteen crop rotation systems, 1991

Crop rotation systems	Debt to asset ratios 20/80	50/50	70/30
60W/60S	0	10	10
60W/60LM	0	10	10
60W/60LM/60W/60S	0	10	10
60W/45LM/15D	0	10	10
45W/45LM/15P	0	10	10
60W/60LM/60C	0	9	10
60W/60S/60C	0	0	10
60W/45LM/15D/60C	0	1	10
45W/45LM/15P/60C	0	2	10
30W/30S/30L	0	0	2
30W/30LM/30L	0	0	10
30W/30S/30W/30LM/30L	0	0	6
30W/30LM/30C/30L	0	0	0
30W/30S/30C/30L	0	0	0

When the debt/asset ratio improves to 20 per cent all fourteen crop rotation systems are feasible. Although no deficit year occurs for the different crop rotation systems, cash flow deficits do occur for 60W/60LM.

Thus the financial feasibility of crop rotation systems is mainly determined by the debt/asset ratio of farmers. Production, price and financial risks are responsible for cash flow deficits.

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