Sustainability - healthy paddocks lead to full plates

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Summary. A farming system in central New South Wales was assessed in terms of its productivity, stability and sustainability. The productivity of wheat, canola and grazing enterprises was examined; stresses to the farming system and measures to overcome them were identified. A nutrient balance sheet indicated inputs of nitrogen to the system were greater than outputs in farm produce. There were, however, major losses of potassium and sulphur. An analysis of energy usage indicated an energy ratio of 7.0 in a year of high grain production. with an energy output per labour unit of about 5 million MJ. The degradation of bio-physical resources and declining economic viability were seen as major threats to sustainability.

Introduction

Most Australian agricultural systems are relatively simple compared with natural ecosystems. Agricultural systems invariably comprise monocultures of crops, or pastures containing relatively few sown species that are grazed by one or two animal species. Agricultural systems are managed for profit and productivity and arc usually open systems that require a range of synthetic inputs to maintain their productivity. There is an increasing concern about the impact of farming systems on the environment and our ability to maintain the productivity and profitability of these systems.

The objective of the study reported in this paper was to assess the sustainability of farming systems at the farm level by monitoring the productivity of the system over time and identifying threats to that productivity (3, 7).

Description of a case study farm

This study is based on a 64.0 ha property situated 35 km south-west of Cowra. The land is undulating and receives a mean annual rainfall of 638 mm. The farming system involves cropping in rotation with pastures, which are grazed by sheep for wool and prime lamb production.

The goals of the owner are:

- to farm the property in a manner that maintains or enhances its productivity;
- to maintain financial viability; and
- to retain ownership and be responsible for all management decisions.

Soils

The two major soil types - red-brown earths (Dr 2.12) and yellow solodic soils (Dy 3.42), occupied similar areas of the farm. The former generally occupy the higher parts of the landscape with the latter on the lower slopes and valley floors. Saline springs and seepages commonly occur at the interface of the two soil types.

Climate

On average, rain falls in all months of the year, but is usually only effective in the months of April to October inclusive. Summer rainfall is very erratic and often intense, but it can benefit the growth of lucerne. *Medicago saliva,* and phalaris, *Phalaris aquatica,* pastures. The mean growing season rainfall is 420 mm.

Land use and enterprises

150 ha of the yellow solodic soils are considered unsuitable for cropping due to poor drainage and salinity. This area has been sown to pastures of phalaris and strawberry clover, *Trifolium fragiferum.* The remaining 490 ha are generally farmed on a ten-year rotation comprising five years of pastures followed by five years of cropping. The pastures arc based on subterranean clover, *Tripburn subterraneum,* and lucerne. The crop rotation is commonly:

Year I Oats/canola

Year 2 Wheat

Year 3 Grain legumes (field peas/lupins) or oil-seeds (canola or linseed)

Year 4 Wheat

Year 5 Triticale/linseed undersown with pasture legumes

The selection of crops in the rotation is influenced by anticipated market prices. bio-physical restraints and management factors.

The pastures and crop residues are utilised by sheep, for wool and prime lamb production. On average. 1.300 Border Leicester x Merino ewes mated to Dorset rams, and 1.800 Merino wethers are carried. This is equivalent to 6,500 d.s.e. about 10 d.s.e./ha for the whole farm or 16 d.s.e./ha of pasture.

Productivity, stability and sustainability of the farming system

Average wheat yields were only available for a nine-year period, commencing with the 1983 growing season. Field pea and canola yields were available from 1987 and 1988 respectively. These yields are shown in Table I. along with a five-year rolling mean yield for wheat.

Table I. Average crop yields (t/ha) and growing season rainfall (mm) for the case study farm.

Crops	1983	1984	1985	1986	1987	1988	1989	1990	1991	Mean
Wheat	2.8	2.2	2.8	2.6	2.8	2.8	3.3	2.6	5.0	3.0
Field peas	—	—	—	—	1.3	1.5	2.0	1.5	2.2	1.7
Canola	—	—	—	—	—	2.0	1.8	1.5	1.5	1.7
Wheat 5 year rolling mean	—	—	—	—	2.6	2.6	2.9	2.8	3.3	
Apr-Oct rainfall	—	460	376	400	270	416	413	664	331	420

The mean wheat yield over the nine years was 3.0 t/ha, which related to a water use efficiency (WUE) of 10 kg/ha/mm of growing season rainfall less 110mm water loss (evaporation, drainage) compared to a potential of 20 kg/ha/mm (4). Waterlogging of soils associated with above average rainfall in winter and early spring is considered to be a major factor limiting yield in some years. The stability in yield appeared relatively high with a co-efficient of variation of 21%. There appeared to be a slight increase in average wheat yields over the nine-year period.

The mean WUE of field peas and canola was only 5-6 kg/ha/mm of effective growing season rainfall (A-O minus 110 mm) compared to a potential of 15kg/ha (4).

Stocking rates were used to assess animal production. The rate of 16 d.s.e./ha of pasture compares more than favourably with the potential of 15.6 d.s.e./ha based on 1.5 d.s.e./25 mm of annual rainfall above 250 mm (4).

Many stresses or threats to the productivity of the system were identified (Table 2). Although solutions have generally been found to these stresses, some of the solutions implemented appear to have created further stresses.

The nutrient balance sheet

Fertiliser usage plus estimates of nitrogen inputs from pasture legumes were balanced against estimated losses of nutrients through products sold from the farm (5), (Table 3).

Inputs of nitrogen are estimated to be greater than outputs, whereas potassium and sulphur arc being lost from the system in farm products. The use of nitrogen fertilisers on cereal crops has doubled in the last ten years; it is currently 16 kg N/ha. It is likely that both nitrogen and phosphorus are entering the farm waterways and the Lachlan River.

Salinity measurements made on-farm and recorded downstream in the Lachlan River (2) were 400-3,500 1..tS/cm and 280-800 1.1S/cm respectively. These are considered to be medium to high levels.

Rising water tables and increasing salinity levels of creeks are a threat to the farming system. the catchment and downstream water users.

Table 2. Farming system stresses and their solutions.

	Quantity (kg)			
	N	P	K	S
Inputs[b]				
Fertiliser	4,937	4,011	—	407
Legumes[a]	24,000			
Total Inputs	28,937	4,011	—	407
Outputs[b]				
Crops	20,901	2,808	7,353	2,206
Wool	1,750	—	250	—
Meat	3,282	285	143	285
Total Outputs	25,993	3,093	7,746	2,311
Balance	2,944	918	-7,746	-1,904

[a]Assumed input from 400 ha of pasture legumes = 60 kgN/ha/yr.
[b]No allowance has been made for losses to or gains from the environment.

Table 3. Summary of nutrient inputs and outputs from the farming system.

Stress or Threat to Productivity	Solutions implemented
	Soil resource
Low soil fertility	Use of sub-clover and phosphate fertilisers
Soil erosion	Contour banks and reduced tillage
Soil structure decline	Application of 2.5 t/ha crushed limestone/10 years
Increasing soil salinity [a]	None to date
Minimum tillage and stubble retention	
Soil acidification	
	Native vegetation
Die-back of the remaining native trees	Planting of a few shelter belts of native and exotic trees
	Weed, pest and disease threats
Grass weeds, thistles and Paterson's curse, *Echium lycopsis*	Increasing use of herbicides combined with grazing by wethers
Heliothis caterpillars in grain legume and oil-seed crops	Strategic spraying with insecticides (concern of insecticide resistance developing)
Sheep lice resistance following use of back-line insecticides	Plunge dipping carried out by contractors
	Economic resources
Declining farm returns [a]	Increased productivity and strategic marketing
Ageing farm machinery [a]	Purchase of second-hand equipment
	Human resources
Unable to afford part-time assistant	Work longer hours. Use contractors and advisors for specialist jobs
Declining skilled rural workforce	Sociological issue beyond the farm

[a]Key stresses and concerns for future sustainability both ecologically, economically and socially.

Energy usage

An inventory of all farm inputs, outputs and activities for 1991 was prepared. Energy values for these were calculated (6, 8, 9) and an energy balance sheet prepared (Table 4).

Table 4. Summary of energy inputs and outputs from the farming system in 1991.

	Total (MJ)	Proportion (%)
Inputs		
Fertiliser	486,440	33
Agro-chemicals	65,920	4
Fuel	501,500	34
Repairs and Depreciation	414,210	28
Electricity	17,082	1
Total Inputs	1,485,152	100
Outputs		
Crops	9,758,000	
Wool	300,240	
Lambs	371,020	
Total Outputs	10,429,260	

Energy Ratio (Output/Input) = 7.0. Gross energy output/labour unit on farm was estimated to be about 5 million MJ.

This on-farm Energy Ratio (ER) compares very favourably with data calculated for a highly productive farm in the UK. which was reported to have an ER of 2.1. However, it does not compare favourably with a pre-industrial farming system in New Guinea with an ER of 14.2 at the point of production and consumption (1). The energy output per labour unit on farm is very high.

In a dry season, when wheat yields are halved and no hay is made, the ER is estimated to be about 3.3. Although, this ER is relatively high by western industrialised standards, it is likely to be very much lower, possibly less than 1.0, after the energy used in transport. processing, packaging and distribution has been taken into account. The levels of energy used in our industrialised society arc key issues influencing the sustainability of production.

Conclusion

Monitoring and assessing the sustainability of farming systems is extremely complex and needs to be conducted over a far longer timeframe than in this study. A wide range of threats to the sustainability of the system were identified. In most cases, solutions were found which enabled production to be maintained. However, some solutions appeared to be the causes of new problems. There were many issues of sustainability that it was impossible to assess due to a lack of appropriate techniques, data and time. These included the impact of farming systems on the bio-physical environment, the long term efficacy of agrochemicals and the social and business implications of declining profitability.

Although it appeared that the productivity of the case study farm had been sustained over the past decade, degradation of the soil resources and low returns for farm products are seen as key threats to sustainability. Major problems appeared to be associated with inappropriate forms of land use and a heavy reliance on agrochemicals. The challenge for the future is to design ecologically sustainable farming systems that meet the food and fibre needs of society.

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