Analysing the Benefits of Growing Crops after Rice in the Rice Growing Areas in Australia

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1. Introduction

The Murrumbidgee Irrigation Area (MIA), the Coleambally Irrigation Area (CIA), and the Murray Valley (MV) constitute the major Australian rice growing areas and are located in southern east Australia. According to the Ricegrowers' Association of Australia Inc. (2002), the annual value of production of rice was $357 million in 2001 and the industry generates more than $500 million from value-added exports annually, allowing these rice growing areas to play a significant role in the Australian economy.

The rice growing areas are also among the areas where the sustainability of irrigated agriculture is under threat from rising watertables, soil salinity and other environmental consequences. The depth to watertables in more than 70 per cent of the MIA (MIA L&WMP, 1998), around 35 per cent of the CIA (CICL, 2001), and around 60 per cent of the MV (Murray Irrigation, 2001) is now around two metres from the soil surface. With the current land use practices, around 20 to 30 per cent of regions such as the MIA could become moderately salinised in the next 30 years due to rising watertables (Humphreys et al., 2001). Water leaching and run-off from rice-based farms form further problems.

Paddocks are flood-irrigated during rice growing period between November to March. Although irrigation water is released prior to rice harvest, much of the water is retained by the soil even after rice harvest. The soil then slowly drains this water along with the added winter rainwater into the watertable beyond the root zone. This wet soil profile has the potential to become an extra economic resource for rice-based farms whenever it can be used to grow another crop during winter straight after rice.

Growing winter crops immediately after rice harvest may reduce the amount of water drainage into watertables on rice-based farms. Successful adoption of this potentially attractive option seems to depend on good weather and rootzone water conditions, good drainage and timeliness in the rice harvesting, stubble burning, and winter crop sowing operations. Among the constraints for adding crops after rice are too much rain or waterlogging for the winter crop to survive, problems with stubble burn, pests, weeds, and unsuitable machinery leading to a high risk of crop failure (Humphreys and Bhuiyan, 2001).

As one of the strategies to overcome the problems of rising watertables in rice growing areas, the Rice CRC is conducting Project 1205 “Quantifying and Maximising the Benefits of Crops after Rice”, henceforward referred to as Project 1205. Project 1205 aims at determining the constraints and the success factors for rice growers to produce winter crops and pastures after rice, and at measuring the impacts of this practice on environmental and economic sustainability. In particular, the project aims to measure the effects of growing wheat after rice on the productivity and water use efficiency of the rice-wheat cropping system.

The objectives of this economic analysis of project 1205 are:

- To identify the common crop rotations in the main Australian rice-based farming systems, both with and without crops after rice;
- To estimate the potential financial benefits of growing crops after rice;
- To identify the economic benefits to the community from reduced accessions to groundwater; and
- To compare returns with the costs to the CRC and its partners of developing and extending this technology.

To measure the likely financial and economic benefits of growing crops after rice, the study relied heavily on the results from Humphreys et al. (2001).

2. Background

The MIA, CIA and MV are located along and in between the Murrumbidgee River and the Murray River in southern west NSW, Australia. The steady growth in the total area for rice growing is shown in Table 1. In summer 2001, the total area for rice growing was 184,382 ha (Lewin, 2002). The total area of land used in rice based rotations is about 510,000 ha. Today, rice is the most profitable and reliable crop on the large area farms in the rice belt of Australia.

Table 1: Area under Rice

Year	Area (ha)	Year	Area (ha)	Year	Area (ha)
1925	64	1971	38,574	1997	166,042
1931	8,198	1981	101,153	1998	139,902
1941	9,966	1991	84,686	1999	150,673
1951	14,928	1995	131,740	2000	131,584
1961	18,635	1996	149,475	2001	184,382

Source: Lewin (2002).

Rice cultivation in the MIA, CIA, and MV has brought both prosperity as well as problems. Before the introduction of rice farming in the 1920's, watertables in almost all of the MIA, for example, were 20 metres below the surface. In 2000/2001 the ground watertables in around 85% of the MIA were within the 2m depth. Waterlogging and soil salinity ads further problems to agriculture in the MIA, CIA and MV. Unless the situation is amended, waterlogging and salinity costs to agriculture in the MIA and Districts, for example, are expected to mount to $11.4 and $26.2 million respectively over the next 30 years (Land & Water Management Plan, 1998).

The decline in sheep and wool prices after the collapse of the reserve price scheme has made pasture-based cropping systems in at least the MIA and the CIA less profitable compared to cropping predominantly systems. Because of these changes in the farming environment, farmers are shifting to the more profitable cereals-based cropping systems, with minimum and in some cases even without livestock and pasture activities. Further, with rising water costs and less availability of water, farmers now aim at using water on those high value crops that give better returns per ML of water used; eg, soybeans and maize in summer and wheat and canola in winter. In some of the rotations the cropping phase is so long that soil health and crop yields are under threat.

3. Methodology

The analysis uses partial budgeting to compare changes in annual costs and benefits from including wheat immediately after rice. The alternative rotations were first compared from the viewpoint of growers by summing the gross margin from one hectare of each of the rotations. Because the rotations extend over nine years period, the gross margins in years 2 to 9 have to be discounted back to year 1. The sum of the discounted gross margins over
up to 9 years is the net present value of the rotation. The discount rate used to measure the net present value was 7 percent.

A gross margin is gross returns from the crop (yield times price) less the variable costs such as seed, fertiliser, water, and fuel required to grow it. Overhead costs such as rates, permanent labour etc, which do not vary with output, are not included in gross margins. Rotations or crops can be compared using gross margins provided there is no substantial change in overhead costs between the alternatives being compared. It seems unlikely that replacing the fallow year with wheat will significantly alter overhead costs.

Net present value was used in assessing the financial values of rotations.
The NPV of a rotation is the discounted sum of the annual gross margins from the crops in the rotation. The NPV is calculated using the following formula:

$$\text{NPV} = \sum_{i=1}^{n} GMs_i \,/\, (1 + rate)^i$$

where *rate* is the rate of discount - this study used a *rate* of seven per cent – and GM_1, GM_2, …, GM_i are the respective gross margin values for years 1 to *n*, *n* being the rotation length.

The NPV of the alterative rotations cannot be compared if they differ in length (years). To overcome this problem we computed the NPV of an infinite series of each rotation using the Faustman formula (Pearse 1990). The PV of an infinite series of rotations is given by:

$$NPVI = \text{NPV} \,/\, \{1-[1/(1+i)^N]\}$$

where the denominator is the Faustman factor and is one less than the discount factor from a standard discount table (Elton et al., 1997).

4. Rotations and Their Gross Margins for MIA, CIA and MV

The rice-growing belt in Australia comprises three major irrigation areas: the MIA, CIA, and MV. These areas differ from each other in terms of farm size and cropping rotations. The study first identified typical rotations and their gross margins ‘with’ and ‘without’ ‘wheat after rice’ in each of these three areas. There has been large variation in the area under rice, and prices of rice, wheat and canola during the last few years. An average of the last five years for each of these parameters was used in the analysis. On that basis, the average total area under rice was 154,600ha, and the average prices of rice, wheat and canola used in the analysis were $208, $170, and $293 per tonne respectively. The prices of wool and lamb were the same as used in the Budget Handbook for sheep and wool.

The typical crop rotations, assumptions and data used for each area are as follow.

4.1 Crop Rotations

The MIA

- The MIA is located in the Riverina region of southern west NSW, Australia. It includes the Yanco and Mirrool Irrigation Areas, which are centred on Leeton and Griffith respectively.
- The total area suitable for rice based rotations was 172,185 ha (MIL, 2002).
- The typical farm size is 220 ha, with 200 ha used for cropping and 180 ha irrigated (Singh et al., 2002).
- The main rice-based rotations include wheat, canola and pasture. Typical cropping rotations in the MIA, that represent 89 percent the area under rice, are given in Table 3.
- Compared to the other rice growing areas, farms tend to be well established. The debt equity ratio for a farm is usually very low, with virtually no liabilities or borrowed bank loans (Singh et al., 2002).

The CIA

- The CIA is located to the south of the MIA. It is centred on Coleambally.
- The total area suitable for rice was 66,459 ha (CIL, 2002).
- The typical farm size is 212 ha, with 200 ha used for cropping and 180 ha irrigated (Singh et al., 2002).
- Compared to the other rice growing areas, farms tend to be recently established. The debt equity ratio for a farm is usually high, with high liabilities and borrowed bank loans (Singh et al., 2002). Most farmers follow more intensive cropping rotations.
- The main rice-based rotations include winter cereals and pasture. Details of the typical cropping rotations, that represent 65 percent the area under rice in the CIA, are presented in Table 3.

The MV

- The MV is located to the south of the CIA along the northern side of the Murray River. It includes the towns of Berrigan, Finley, Deniliquin, Wakool and Moulamein.
- The total rice suitable area was 271,369 ha (MVIL, 2002).
- The typical farm size is around 400 ha in the eastern MV and around 600 ha in the western MV, which is comparatively large (Per. comm., John Lacy).
- Compared to the other rice growing areas, farms tend to be moderately established.
- The main rice-based rotations contain wheat and pasture as well as other winter cereals. Typical rotations that account for 64 percent of the rice suitable area in the Murray Valley are given in Table 3.

4.2 Assumptions for Crop Gross Margins

The gross margin per hectare for each crop was calculated using the NSW Agriculture farm budget handbooks for sheep and wool and for southern NSW irrigated summer and winter crops (Webster, 1998; Faour, 2001; Faour and Whitworth, 2001). Some of the farming practices in these budgets were modified to more closely reflect practices in each region with assistance from agronomists and researchers including David Smith, John Lacy, Don

McCaffery, Mary-Anne Lattimore, and Geoff Duddy. In calculating the gross margins, the study used the following assumptions:

The Rice GM

- All rice is aerially sown and medium grain.
- The first rice in a rotation has 10% less nitrogen fertiliser application than in the budget handbook.
- The second rice has the same application rate as is used in the budget handbook.
- The third rice has 10% more nitrogen fertiliser application than used in the budget handbook.

The Opportunistic Wheat GM (OW)

- ASW wheat was used as the opportunistic wheat crop after rice.
- *For the MIA and CIA* this wheat crop had a yield of 4.9t/ha (early); 3.7t/ha (late); 2ML/ha of irrigation and 260kg/ha of urea, compared to a yield of 4.0t/ha, 2.90ML/ha of irrigation and 125kg/ha of urea as given in the budget handbook.
- *For the MV* this wheat crop had 3.4t/ha (early); 1.9t/ha (late) yield and no irrigation applied.

The Wheat GM (standard wheat)

- ASW wheat was considered for the analysis.
- *For the MIA and CIA*:
    - The wheat coming second after another wheat has 10% more nitrogen fertiliser application than in the budget handbook.
    - The third wheat after two previous wheats has 15% more nitrogen fertiliser application than in the budget handbook.
    - The wheat coming second after a canola has 10% more yield than in the budget handbook.
- *For the MV*:
    - The study has used the budget of the wheat coming after a long fallow.
    - The wheat coming second after another wheat uses 200 kg/ha of nitrogen fertiliser.
    - The third wheat after two previous wheats uses 250 kg/ha of nitrogen fertiliser.
    - The wheat coming second after a canola has 10% more yield than given in the budget handbook.

The Pasture GM

- Sub clover was used as in the budget handbook.
- The last year of a pasture has 50% irrigation reduction than in the budget handbook.
- *For the MV*, sub clover uses 60kg/ha of fertiliser, no insecticide or herbicide, and 2ML/ha of irrigation water, compared to 300kg/ha of fertiliser, 0.09L/ha of insecticide, 2.0L/ha of herbicide, and 5ML/ha of irrigation water in the budget handbook.

The Sheep GM

- Second cross Merino lamb was considered for this analysis.
- *For the MIA and CIA* 20 DSE/ha and 200 hd/farm were used.
- *For the MV* 10 DSE/ha and 400 hd/farm were used.

It is assumed that a farmer would earn a gross margin of $34 per hectare (@1 dse/ha) from sheep grazing natural grasses and weeds in a fallow paddock straight after the rice phase of the rotation (Per Com. Geoff Duddy and Geoff Beecher). This amount is included as income in the without scenario rotations.

Based on the assumptions mentioned above, the GMs per hectare for each crop used in this study are shown in Table 2.

Table 2: Gross Margins per Hectare Used for Each Crop

Crop in Rotation Sequence	Gross Margin (on farm, $/ha)		
	MIA	CIA	MV
First Year Rice	$1020	$1048	$1038
Second Year Rice	$1011	$1039	$1031
Third Year Rice	$1002	$1031	$1024
Barley			$82
Canola	$273	$256	$308
Opportunistic Wheat (OW) Early	$389	$378	$306
Opportunistic Wheat (OW) Late	$206	$195	$45
Wheat after Fallow	$376	$360	$398
Second Wheat	$371	$355	$365
Third Wheat	$368	$352	$343
Wheat after Canola	$445	$429	$463
Pasture Establishment	-$36	-$37	-$36
Pasture Maintenance	-$177	-$65	-$45
Last Year Pasture Maintenance	-$147	-$59	-$30
Sheep	$288	$165	$128
Last Year Sheep	$144	$82	$64
Sheep in fallow period after rice phase	$34	$34	$34

5. Results and Discussion

5.1 Financial Benefits from CAR

OW can only be grown in some years depending on how wet the paddock is. We have conducted the analyses for two scenarios, the first assumes that OW can be sown 1 year in two and the second assumes OW can be sown 3 years in 4 but we focus our attention on the first scenario.

The GM values were used to work out the NPVs for each rotation both with and without OW. Since the rotations considered for the analysis vary in length, the Faustman formula was used to estimate the NPV of an infinite series of rotations, NPVI, in order to allow a comparison between crop rotations of different lengths. The per-hectare financial benefits, NPVI, of early OW after rice are shown in Table 3. The table shows the NPVI of rotations without OW, with OW and the increase in NPVI. For each region an average change in NPVI was estimated by weighting the increase in NPVI for each rotation by their shares of the total area suitable for rice (also detailed in Table 3).

The financial benefits of growing early OW in the different rice growing areas are given in Table 4. The technology appears to be most profitable in the MV where the increase in NPVI was $365 per ha followed by the CIA with $336 per ha and the MIA with $ 321 per ha. The reasons that lead to high returns in the MV compared to the other regions could be the short rotation length and no pasture phase in some of the rotations considered.

Table 3: Financial Benefits of Early Opportunistic Wheat after Rice per Hectare

Early Opportunistic Wheat Rotation	Rice Area Covered (ha)	NPVI Without OW	NPVI With OW	Increase in NPVI with 50% OW	Increase in NPVI with 75% OW
MIA					
R-R-R-F-W-(W/P)-P-P-(P/R)					
R-R-R-OW-W-(W/P)-P-P-(P/R)	73179 (43%)	$7243	$7838	$298	$447
R-R-R-F-HW-C-(HW/P)-P-(P/R)					
R-R-R-OW-HW-C-(HW/P)-P-(P/R)	21523 (13%)	$7458	$8053	$298	$447
R-R-R-F-HW-HW-F					
R-R-R-OW-HW-HW-F	55860 (33%)	$8468	$9188	$360	$540
Total Area Covered by Rotations (ha)	150662 (89%)				
Weighted Average GM				$321	$481
CIA					
R-R-R-F-(HW/P)-P-P-(P/R)					
R-R-R-OW-(HW/P)-P-P-(P/R)	9969 (15%)	$7482	$8112	$315	$472
R-R-R-F-HW-HW-F					
R-R-R-OW-HW-HW-F	26584 (40%)	$8607	$9305	$349	$523
R-R-R-F-HW-C-HW-F					
R-R-R-OW-HW-C-HW-F	6646(10%)	$8249	$8879	$315	$472
Total Area Covered by Rotations (ha)	43198 (65%)				
Weighted Average GM				$336	$504
MV					
R-R-R-F-HW-HW-F					
R-R-R-OW-HW-HW-F	42291 (16%)	$8638	$9192	$277	$416
R-F-F-F					
R-OW-F-F	38767 (14%)	$4213	$5222	$505	$757
R-F-HW-F					
R-OW-HW-F	35243 (13%)	$5583	$6593	$505	$757
R-R-F-HW-C-HW-F					
R-R-OW-C-HW-B-F	21710 (8%)	$7235	$7828	$296	$445
R-R-R-F-W-(W/P)-P-(P/R)					
R-R-R-OW-W-(W/P)-P-(P/R)	13568 (5%)	$7910	$8410	$250	$375
R-F-W-C-(W/P)-P-P-(P/R)					
R-OW-W-C-(W/P)-P-P-(P/R)	21710 (8%)	$4761	$5334	$286	$429
Total Area Covered by Rotations (ha)	186822 (69%)				
Weighted Average GM				$365	$555

Where: B stands for Barley, C for Canola, F for Fallow, OW for Opportunistic Wheat, P for Pasture, R for Rice, and W for Wheat (other than the opportunistic).

5.2 Environmental benefits

There are expected to be some benefits to the broader Australian community from the 'crops after rice' technology. Wheat grown straight after rice is likely to lead to more efficient water use, thus avoiding excessive run-off and accessions to the water tables. It is estimated that growing crops after rice would lead to a 1.00 ML/ha reduction in ground water accessions. This also includes the rain water available to the crop during this period. It is hard to measure benefits of a reduction in ground water accessions. Whilst it is unlikely that spearpoints could remove all of this water, a cost of $30/ML for pumping out groundwater has been used as a surrogate measure of the benefits of reducing groundwater prior to the next crop. This includes the cost of pumping out water, the capital cost of a spearpoint, and the capital cost of a storage and drainage system for disposal of the water pumped out (Hoogers, 2002). A benefit of $30 per ha has been included at each point in the rotations when an opportunity crop of wheat is grown. This benefit was treated in the same way as crop GMs. For each rotation the present value of reduced water accessions were estimated and then converted to an NPVI using the Faustman process. A weighted average benefit was derived for each river valley where the weights were the shares of each type of rotation and assuming as above, that OW was only possible every second year. Under these assumptions the value to infinity of these reduced water accessions were $27, $29 and $39 in the MIA, CIA and MV.

6. Returns to Investment on research and development

Benefit-cost analysis has been used to compare the value of benefits arising from the new technology with the costs of developing and implementing the technology. The criteria used were the net present value of the project, (NPV) and the benefit-cost ratio (BCR). The NPV of a project is the difference between the discounted benefits and discounted costs and should be positive. For a project to be economically feasible the ratio of the present value of benefits to the present value of costs, the BCR, should be greater than one.

6.1 Estimating the Benefits of the Project.

Earlier in this paper estimates of the average increase in NPVI from the CAR technology for the three growing regions were presented. To undertake a cost – benefit analysis of the project these changes in NPVI have to be scaled up to reflect the rate and extent of adoption of the technology, lags in the development and adoption of the technology and an estimate of when the technology will become obsolete.

The benefits of project 1205 are largely in the form of a faster rate of adoption of the CAR technology. Our assumption is that without this project it would take 20 years rather than 10 for maximum rates of adoption to be attained. Under these assumptions there are no further benefits to the project after 2021.

Table 4: The Rates of Adoption of Wheat after Rice

Adoption Rate	Existing	Ending
MIA		
With project	30%	60% (after 10 years)
Without project	30%	60% (after 20 years)
CIA		
With project	30%	60% (after 10 years)
Without project	30%	60% (after 20 years)
MV		
With project	5%	30% (after 10 years)
Without project	5%	30% (after 20 years)

Table 4 shows that the current level of adoption of CAR for the MIA and CIA is approximately 30 percent and that this may increase to 60 percent under the ‘with project’ scenario in 10 years. Whereas, under the ‘without project’ scenario, the rate of adoption may increase up to 60 percent in 20 years. For the MV the current rate of adoption is only 5 percent that would increase to 30 percent in ten years time under the ‘with project’ and to 30 percent in 20 years under ‘without project’ scenario. The extent of adoption in the MV was much higher in the 1980's. During 1990's the farmers in the MV suffered heavy losses from OW due to bad weather conditions and most of these farmers stopped growing crops straight after rice.

To measure the benefits of project 1205, the information on the total rice suitable area for the rice growing year 2001/02 in the MIA, CIA and the MV was collected from the respective irrigation agencies of these districts and is detailed in Table 5.

Table 5: Total rice suitable area

Total rice suitable area in the MIA (ha)	172,185
Total rice suitable area in the CIA (ha)	66,459
Total rice suitable area in the MV (ha)	271,369

In analysing this project we have assumed that adoption of the technology would become more rapid from 2003. Under these assumptions we estimate that the present value of the gross benefits from this project amount to $5.6 m from the industry’s viewpoint. The value of the project benefits rises to $6.3m if account is taken of the reduced accessions to the watertable.

6.2 Expenditure on Research Associated with Project 1205

The analysis considered both direct expenditure by CRC on research and the in-kind contributions from the CRC partners (CSIRO and NSW Agriculture) to project 1205 over the five-year period from 1997-98 to 2001-02. All the costs were expressed in 2002 dollars after inflating expenditure in early years by the consumer price index. No direct costs for extension activities to promote this technology were considered in this analysis. It is assumed that the farmers would come to know about the new technology through rice grower's cooperative limited newsletters and through the regular extension meetings. The information on expenditure on research, both cash and in-kind is given in 2001 -02 values in Table 6.

Table 6: Cash and In-kind Expenditure on the Research Project During 1997 -2002 in 2001-02 Values

	Project Expenditure		
Year	**CRC**	**In-kind**	**Total**
1997-98	$37,800	$95,688	$133,489
1998-99	$87,935	$22,6633	$314,568
1999-00	$87,151	$234,705	$321,855
2000-01	$38,691	$141,240	$179,931
2001-02	$50,482	$51,000	$101,482
Total	**$302,060**	**$749,266**	**$1,051,325**

Expenditure by the CRC over the five years period was $302,060 (29 percent of the total expenditure) whereas the in-kind contribution was $749,266 (71 percent of the total). The total expenditure on the project was $ 1,051,325.

6.3 Benefit-Cost Analysis

The findings of the benefit cost analysis that measured returns to investment on the research project 1205 are presented in Table 7

Table 7: Results of Benefit-Cost Analysis of Project 1205

Measure	Value	
	Financial	**Economic**
Present Value of Benefits (000,$)	5561	6299
Present Value of Costs (000,$)	1051	1051
Net Present Value (000,$)	4510	5247
Benefit cost ratio	5.29	5.99

The results presented in Table 7 show that project has high level of both industry and community benefits. The anticipated financial benefits are more than five times the cost of the project and the economic benefits are almost six times the cost. The project is viable from the perspective of both the industry and the community.

6.4 Sensitivity analysis

For the MV the rate of adoption of crops after rice (CAR) was around 40 percent in the 1980’s. However, during the 1980’s and 1990’s, due to bad weather, farmers suffered losses from CAR. For this reason the existing rate of adoption of CAR in the Murray was very low compared to the MIA and CIA (Per. Com. John Lacy).

With the improved farming conditions such as, laser levelling of paddocks, the introduction of heavy machinery that helps to complete different farm operations on time, the introduction of permanent raised bed for rice-cereals based farming systems, and the development of early maturing varieties of rice, the risk of failure of opportunity cropping has reduced considerably. Therefore sensitivity analysis was done to measure the impact of growing CAR assuming the same rate of adoption in MV as used in the MIA and CIA.

Table 8: Benefits of growing CAR at different rates of adoption in the Murray Valley

	Rate of adoption in MV (Percent)			
	45		**60**	
	Financial	*Economic*	*Financial*	*Economic*
NPV of Benefits	5618	6608	6725	7970
B/C ratio	6.34	7.29	7.40	8.58

The results (Table 8) show that the NPV of benefits and the Benefit-Cost ratio increased significantly with the increase in the adoption rate of CAR in the MV.

7. Conclusions

Rice is the most important crop on broad acre farms in the south west of NSW. Although rice growing has brought prosperity to the region, its intensive cultivation has also lead to serious problems of rising water tables, water logging and irrigation salinity. In most of the rice growing areas, the water tables are around 2 meters below the surface. If unattended this would be a serious threat to irrigated agriculture in these regions with associated problems of poor water quality downstream

The Rice CRC has funded research project 1205, "Quantifying and Maximising the Benefits of Growing Crops after Rice", to encourage the growing of wheat straight after the rice phase to improve the productivity and water use efficiency of the rice wheat cropping system. The economic analysis presented here of this project indicates that growing crops after rice not only leads to more efficient use of water but also provides some financial and environmental benefits. From the industry’s viewpoint the benefit-cost ratio of the project was in the range of 5.3 to 7.3 and from the community’s viewpoint in the range of 6.0 to 8.6.

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