An Economic Evaluation of the Ricecheck Extension Program in NSW

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Abstract
Ricecheck, an extension program for rice developed by the NSW Department of Primary Industries, is based on eight best management practice recommendations ("key checks") considered essential for achieving high yields. The program comprises grower meetings and field days. The Ricecheck recommendations provide information on the impact of the best management practices on crop yields and farm profitability. In this paper, the economic benefits from Ricecheck to the rice farmers are measured. An economic evaluation indicates that there has been a high economic return on the funds invested in developing and adopting Ricecheck.

Keywords: rice; extension; checks; yield; economic; evaluation

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1. Introduction

In the 1980s, increasing costs placed pressure on rice farmers, farm advisors and researchers to find ways to improve yields to enable farmers to remain viable. In 1985-86, to assist with identifying the causes for the limited yield increases on farms, and to evaluate whether there should be a similar package of best management practices for rice as was being developed for irrigated wheat, a field study of commercial rice crops was conducted in the Finley-Jerilderie area of NSW. The study observed that only a few rice growers were able to achieve a consistently high yield. It was observed that there was a gap between the yields of "top" and "bottom" farmers.

The study also observed that the widely accepted transfer of technology model of research ➔ knowledge ➔ transfer ➔ adoption ➔ diffusion that was being followed by district advisory staff for rice was too slow in the dispersal and adoption of a new technology and in creating change. It was a one-way model where advisory staff were being used to transfer information to the growers. Most of the extension programs were very much focused on addressing factors one at a time rather than using a systems approach recognising the interaction between key inputs influencing production. Further, the study found that most farmers and extension advisors did not monitor their crops between sowing and harvest. There was a general lack of awareness among farmers about the management practices which contributed most to crop production (Lacy 1998).

There was a need for a fresh integrated approach that would also help to promote best management practices, to identify and address issues important for improving yield, financial viability of the rice farms and development of the rice industry.

Based on the recommendations of the initial study and following a similar program for irrigated wheat, a new extension program called "Ricecheck" was developed in 1985. The program was developed first for rice growers of the Finley district and later adapted to the whole rice industry.

Relatively few attempts have been made to measure the contribution of extension in promoting and disseminating the findings of new research and its likely impact on the rate and extent of adoption of a new technology or practice in agriculture. In measuring returns to research and development investments in agriculture, the contribution of extension is often included as a part of the research contribution. In southern NSW, the NSW DPI advisory staff have played a significant role in the development and growth of rice farming particularly by identifying and promoting best management practices through the Ricecheck program. An attempt was made to measure economic, social and environmental consequences of implementing the Ricecheck program (Singh *et al.* 2005).

In this paper, the economic analysis is reported. The main objectives of this study of the impact of Ricecheck were:

- To measure the potential economic benefits from the Ricecheck program to the rice farmers
- To estimate costs involved in developing, promoting and adopting the program
- To estimate the extent and rate of adoption of the new program
- To evaluate and compare these benefits with the costs of the Ricecheck program

The focus of this evaluation was on the economic effects of the adoption of best management practices recommended by the Ricecheck program which result in productivity gains at the farm level. There are also significant environmental and social impacts associated with the Ricecheck program (see Singh *et al.* 2005), but in this paper we have not attempted to place an economic value on them.

The Ricecheck program is outlined in section 2 of this paper, where the system of checks used are described. The benefits to farmers are estimated and the extent of adoption is assessed. The economic evaluation of Ricecheck is outlined in section 3. The results of the analysis and the implications are discussed in the final section, and some conclusions are drawn.

2. The Ricecheck Program

2.1 Key Check Recommendations

The "Ricecheck approach" to extension involves direct farmer participation (Lacy 1998). The approach involves farmers in learning and sharing knowledge with fellow farmers and researchers, with extension workers play a pivotal role to facilitate this learning process. Instead of measuring the results from top yielding research plots, this approach measured the results from the top-yielding farmer paddocks. Initially eight key factors called "Key checks" linked to yield were then identified from farmer paddocks.

The major highlight from the results of the initial analysis of different factors responsible for increasing rice yields was that there was no single factor which consistently produced high yields. Increased yields only arise by ensuring that all the key factors are carried out correctly. The key check recommendations are, as far as possible, simple and objective, providing numbers that can be measured and compared. The rice extension and research staff working together revise the recommendations on these checks each year.

Initially the key checks focussed only on yield. Since environmental and grain quality issues have become very important and are intertwined with yield, four extra checks relating to these issues have been added in recent years. At present, there is a ninth productivity check (phosphorus application). All factors identified were combined together in a total management package, which is still available to farmers as the *Ricecheck Recommendation*s booklet (for example, see Lacy *et al*. 2004).

However, the data available over the period since 1985 relate to 8 key checks. Therefore in this analysis we have focussed on the 8 key checks that have been in wide use over that period. The eight key checks included in Ricecheck for the analysis undertaken here are shown in Table 1. A more detailed description of the criteria for meeting each of these checks is included in Singh *et al*. (2005).

Table 1: Eight Key Checks included in Ricecheck Analysis

Key Checks
1. Field layout
2. Sowing time
3. Crop establishment
4. Crop protection
5. Pre-flood nitrogen
6. Panicle Initiation nitrogen
7. Panicle Initiation date
8. Water management

Analysis of the yield response to implementing the Ricecheck program has shown that the more checks adopted, the higher the yield is likely to be. Further, if all the key checks are achieved, a farmer would be able to achieve high yields of all varieties of rice relative to their potential yields.

2.2 Adoption of Ricecheck

The Ricecheck approach was first tested on the rice farms in the Finley district in the Murray Valley in 1986. It later spread to the Murrumbidgee Irrigation and Coleambally Irrigation Areas in 1987.

In aiming to assist the learning of farmers, extension and research staff, Ricecheck program uses a wide range of learning methods to help to improve understanding of rice growing systems and constraints. A critical element of the operation of Ricecheck is the use of small discussion groups where farmers can both learn and give feedback on the Ricecheck management package. These farmers' discussion groups have played a key part in the delivery of the Ricecheck program.

In 2004, approximately 40 Ricecheck discussion groups were being run by seven District Agronomists, and there were about 780 farmers who at some time attended these discussion groups during 2004 (Singh *et al.* 2005). Since the membership of discussion groups is voluntary, it can vary by up-to 50%, depending upon the clash of farmers' time with other activities in a particular year. Many of these groups have been running for 18 years and continue to function productively. The momentum for the success of Ricecheck and the discussion groups has come from having a focus on the key checks linked to yield. In the discussion groups, the farmers are encouraged to participate in the program through a number of learning steps – observing, measuring, recording, interpreting and acting. This has led to improvements in farmers' knowledge, learning and management skills. This also allows them to influence changes to the Ricecheck management package and the key checks, and to develop "ownership" of the program.

The number of crops and checks achieved in the Ricecheck system each year since 1986 is shown in Table 2 (data on a regional basis are available in Singh *et al.* 2005). From an initial level of 30 crops in 1986, the number of crops grown by farmers using the Ricecheck system grew rapidly to reach 746 in 1995, before declining to 573 in 1998, and then increasing to 823 in 2001. The number of crops using Ricecheck varied with the total area under rice, timing of the announcement and level of water allocations, prices of rice, prices of other crops relative to rice, farmer interest, perceived usefulness and occasional gaps in Departmental staffing servicing the delivery of Ricecheck.

Table 2: Number of Crops and Key Checks Achieved, 1986 to 2002

	Number of key checks achieved										
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	*Total*	*Average*
1986	1	2	4	5	7	6	3	1	0	*30*	*3.8*
1987	1	3	9	11	13	8	5	2	0	*53*	*3.7*
1988	2	6	17	22	25	17	10	4	0	*105*	*3.7*
1989	3	11	29	39	42	28	17	7	1	*178*	*3.7*
1990	5	16	42	55	59	38	24	10	1	*251*	*3.7*
1991	6	21	51	69	76	50	32	14	2	*319*	*3.7*
1992	7	25	60	82	93	61	39	17	2	*387*	*3.7*
1993	8	31	73	99	112	74	48	20	3	*466*	*3.7*
1994	9	36	85	116	131	86	56	24	3	*546*	*3.7*
1995	2	10	50	98	188	164	163	61	10	*746*	*4.6*
1996	2	12	58	120	150	167	102	39	9	*659*	*4.4*
1997	0	22	61	125	156	149	100	23	0	*636*	*4.2*
1998	0	1	13	55	122	163	145	63	11	*573*	*5.1*
1999	0	4	25	69	154	166	129	49	7	*603*	*4.8*
2000	2	8	49	129	163	199	128	42	9	*729*	*4.5*
2001	0	6	19	87	188	254	174	82	13	*823*	*4.9*
2002	0	4	61	85	175	147	71	23	5	*571*	*4.3*

Even with good management and knowledge, the checks proved difficult to achieve; for example in 2002, 65 (11%) out of 571 crops could only achieve 1 or 2 checks, and only 5 (0.9%) achieved all 8 checks (Table 2). On average, the number of checks achieved for crops in Ricecheck between 1986 and 2002 was 4.1 checks, or 52% of the 8 known checks.

Even growers who are consistent members of the Ricecheck discussion groups do not find it a simple task to achieve particular checks for their crops in some years. There are a number of reasons why the key checks are not achieved in particular crops each year (see Singh *et al.* 2005 for more details). They include:

- Several key checks have “black and white” adoption criteria, where almost meeting the criteria is counted as having no value;
- Several factors, such as water allocations, are outside the farmer’s control;
- Some checks have been refined over time and are consequently harder to achieve;
- A reliance on the NIR tissue test rather than alternative technologies;
- Some checks , such as sowing date and panicle initiation date, are linked, so missing one check means that the other check cannot be achieved;
- Some checks, such as water depth are less important in some environments or years than in others.

The Ricecheck program annually publishes a booklet of the Ricecheck recommendations and a copy is sent to each rice grower every year. Some growers follow those recommendations without necessarily becoming part of a Ricecheck discussion group or recording the detailed information for their crops. Further, District Agronomists also promote the recommendations of the Ricecheck program during one to one and preseason meetings with farmers, through the media and field days.

There are benefits to those who partially adopt this program or follow the recommendations based on the information given in the book which also needed to be considered to measure the full impact of the program.

Since 1986, many farmers are regular members of these discussion groups and are taking full benefit from the program. There are some others who join a group but leave after a few years. Although this helps them to improve their skills and knowledge about the significance of different key check recommendations in achieving higher yields, the Ricecheck program continually updates the regular members of the discussion groups about changes in key checks and other technologies over time. Irregular members or those who have never joined any discussion group may not be able to take advantage of such improvements in the key check recommendations and other technologies, which may result in them achieving lower yields than the regular attendees.

2.3 Value of Ricecheck to Growers

When growers adopt Ricecheck, for each check achieved the expected level of yield increases. Although there can be seasonal differences, and differences between regions, the accumulated data from the Ricecheck database provides a measure of the benefits (in terms of yield increases) from the adoption of the different numbers of checks (Table 3).

Table 3: Expected Yields from Achieving Different Number of Checks

Number of checks	Average yield obtained (t/ha)	Smoothed yield (t/ha)	Benefits[a] of checks (t/ha)	Marginal benefits[b] of checks (t/ha)
0	8.70	8.70	0.00	0.000
1	8.70	8.88	0.18	0.175
2	8.60	9.05	0.35	0.175
3	9.00	9.23	0.53	0.175
4	9.40	9.40	0.70	0.175
5	9.50	9.58	0.88	0.175
6	9.90	9.75	1.05	0.175
7	9.90	9.93	1.23	0.175
8	10.10	10.10	1.40	0.175

[a] Benefits compared to adopting no checks

[b] Additional benefits from adopting an additional check

The Ricecheck database contains the yields obtained from each crop and the number of checks achieved for that crop. The raw data from the database indicates that (in column 2) the yields from achieving 2 checks were lower than from those achieving no checks or one check. However the nature of the checks is such that adding an extra check would not lead to a yield reduction. This irregularity is clearly an anomaly, resulting from sampling error in the crops analysed. Therefore, the yields were smoothed linearly (column 3) to ensure consistency in the analysis.

These smoothed data in Table 3 imply that rice yields can be increased from an average of 8.70 t/ha progressively as checks are achieved, reaching an average of 10.10 t/ha when all 8 checks are achieved, with each additional check giving additional yield of 0.175 t/ha. However, during the period of the analysis, potential rice yields have increased for a number of reasons other than the Ricecheck Program, including the use of higher-yielding varieties. The analysis undertaken for this paper does not imply that yield levels have not increased from other sources, but merely that the benefit from adopting additional checks has remained constant throughout the period.

The approach of considering the total number of checks achieved as the key indicator, rather than the achievement of particular individual checks, implies that each of the checks is equally important in determining yield levels. While this could be challenged, the limited resources available for this study and the nature of the data in the database precluded any analysis of the value of achieving individual checks without substantial analytical resources beyond the scope of this study. Therefore, in the analysis presented here, the implicit assumption is that each of the checks has equal weight, and any combinations of, say three, checks would give the same expected yield level.

2.4 Costs of Adopting Ricecheck

In adopting Ricecheck, farmers have to make several commitments of their time and resources. The input of farmers' time was estimated at 8.7 hours per crop, comprising of time spent at group meetings and field days related to Ricecheck, crop monitoring activities and formal record-keeping (Table 4). Farmers who adopted Ricecheck informally (see below), without keeping formal records, were assumed to also spend time at meetings and field days and the same time on crop monitoring, but not the time on record-keeping. Those who were defined as "awareness adopters" (also see below) were estimated to spend time gaining awareness only. The farmers' time was valued at a basic rate of $25 per hour, and was valued at $218, $143 and $75 per crop for full adopters, informal adopters and awareness adopters, respectively.

Table 4: Farmers' Labour in Adoption of Ricecheck Recommendations

	Hours per Crop		
	Full[a] adopters	**Informal[a] adopters**	**Awareness[a] adopters**
Discussions groups	2.7	2.7	0.0
Crop monitoring	2.0	2.0	2.0
Meetings	1.0	1.0	0.0
Record-keeping	3.0	0.0	0.0
Reading Ricecheck Booklet	0	0	1.0
- Total hours	*8.7*	*5.7*	*3.0*
Total value of farmer time[b]	**$218**	**$143**	**$75**

[a] See below for explanation

[b] Valued at $25 per hour

In addition, the adoption of key checks involved extra expenditure on inputs such as seeds, , chemicals for plant protection, sowing, harvesting of additional rice yield or farm improvements like land-forming or raising bank height. These costs need to be considered while measuring the net benefits from the increased yield.

The additional costs of achieving the different checks are estimated following discussions with rice industry research and extension officers for an average rice crop of 30 hectares (more details are given in Singh *et al.* 2005). Some of the checks require adjustments to timing of operations, and have no direct additional costs. Others, where plant densities are required, need increased seeding rates for most farmers. Similarly, where tissue testing for nitrogen is undertaken, the costs of the testing are included. Other costs involve structural changes to farm layout, such as laser levelling and bank height, both of which are estimated to provide benefits for 20 years. In those cases, the

annual costs for rice are converted to a per hectare basis. Where the benefits from laser levelling are shared between different crops, an estimate of the proportion of value to rice (50% in the case of laser levelling) is included. As the adoption of the checks leads to increased yields, the harvest costs for the additional yield is also included. On this basis, the total cost of adopting all eight checks is estimated as $40.14 per hectare, or an average of $5.02 per check. In the analysis, for each check achieved, costs of $5.02 per hectare are deducted from the gross benefits of adoption.

Any cost involved in the purchase and use of heavy machinery / implements and the employment of casual labour during peak periods to enable a farmer to complete different operations on time and achieve different checks have not been considered in this analysis.

3. Economic Assessment of the Ricecheck Program

3.1 Methodology for Evaluation

In evaluating an extension program, it is often difficult to identify separately the benefits from research and extension activities involved. In a situation where the extension program is aimed at delivering research findings to farmers, a common approach is to evaluate the extension program as speeding up the rate of adoption of the technology.

Ricecheck has been in part a research process as well as an extension program. The participatory nature of Ricecheck has meant that the best management practices in the highest-yielding farmer crops were identified in collaboration with farmers rather than solely being based on researcher trials. These best management practices ("key checks") were specified to enable farmers to benchmark their own practices against best management. Therefore, we have used a more complex approach in this evaluation. We have identified the benefits of adopting the key checks of the Ricecheck program, as well as estimating the progress that would have occurred without the Ricecheck program. Because of the farmer involvement, the cost of farmers' labour is a significant element in the adoption of Ricecheck, and these costs are included as adoption costs in this analysis.

To evaluate returns to the investment on the Ricecheck program, the study first measures the crop scale benefits and costs from the adoption of the Ricecheck recommendations and then drawing these impacts into a benefit cost framework measures returns to the research, development and extension investments on the program. Ricecheck is essentially an extension program but we have included the time spent by staff in developing and improving the program over many years.

The crop level benefits are estimated for different levels of adoption of Ricecheck, taking into account the lags involved in the development and rate and extent of adoption of the program over the accounting period. The study measures the returns to the investment in research, development and extension, taking into account both in-kind and cash expenditure on the program.

3.2 R&D Investment in Ricecheck

The R&D investment in Ricecheck includes the direct expenditure by the Rural Industries Research and Development Corporation (RIRDC) and the in-kind contributions from the extension and research staff of the NSW DPI in the development and promotion of the Ricecheck program over the study period. All costs are considered in estimating the total costs, and are expressed in 2002 dollars, using the GDP deflator.

The labour input for departmental officers was estimated on the basis of days per year for departmental officers and the labour costs (including salary and on-costs) in 2002 were then applied to those inputs to give the cost of those inputs in constant 2002 dollars. On that basis (see Singh *et al.* 2005), the total labour input from Departmental staff is estimated to average 374 person-weeks per year. The value of the average labour input since 1986 was $153,000 per year (in 2002 dollars) (Table 5), ranging from $42,000 in 1986 to $177,000 in 1996.

Table 5: Total R&D Investment in Ricecheck, 1986 to 2002

	Labour costs	Operating costs	Total costs	RIRDC	NSW DPI
1986	$42,300	$1,600	$43,900	76%	24%
1987	$56,299	$3,200	$59,499	53%	47%
1988	$128,962	$4,800	$133,762	25%	75%
1989	$144,080	$6,400	$150,480	23%	77%
1990	$169,929	$8,000	$177,929	20%	80%
1991	$168,063	$8,000	$176,063	22%	78%
1992	$168,063	$8,000	$176,063	23%	77%
1993	$168,063	$13,000	$181,063	24%	76%
1994	$168,436	$13,000	$181,436	25%	75%
1995	$168,436	$13,000	$181,436	27%	73%
1996	$177,020	$13,000	$190,020	27%	73%
1997	$176,274	$13,000	$189,274	29%	71%
1998	$174,035	$13,000	$187,035	20%	80%
1999	$172,542	$13,000	$185,542	35%	65%
2000	$170,676	$13,000	$183,676	27%	73%
2001	$173,288	$13,000	$186,288	41%	59%
2002	$173,288	$13,000	$186,288	41%	59%
Total	**$2,599,754**	**$170,000**	**$2,769,754**	**29%**	**71%**
Average	**$152,927**	**$10,000**	**$162,927**		

Source: Details of funding proposals, and estimates by the authors

The annual R&D investment in Ricecheck is shown in Table 5 as varying from $44,000 in the first year to a peak of $190,000 in 1996, and an annual average of $163,000 throughout the period since 1986. Of those R&D funds, 71% have been contributed by NSW DPI and 29% by RIRDC. The total investment (in nominal dollars) has been $77 million, almost 94% of which has been labour costs.

3.3 Analysis of Benefits

The NSW rice industry is located in four irrigation districts, namely the Murrumbidgee Irrigation Area, the Coleambally Irrigation Area, the Western Murray Valley and the Eastern Murray Valley. There are some significant differences among these regions in terms of farm size, water allocations, level of development, area under different irrigation layouts, cropping rotations, percent area irrigated, rice area, input use, and yield, for example. However, data are not available to allow a regional analysis of the levels of benefits and rate of adoption of Ricecheck. In the analysis in this study, all regions are aggregated into the NSW rice industry for the estimation of benefits.

Not all of the benefits from improved rice research and extension are the result of Ricecheck. Had there been no Ricecheck program, there would have been continuing improvements in rice

productivity since the mid-1980s. However, those improvements would have been at a lower rate than has occurred with Ricecheck.

3.4 Defining the "Without Ricecheck" Scenario

In this section, the definition of the "without Ricecheck" scenario is outlined. Although the concept of "checks" would not have existed without the Ricecheck program, most of the activities now defined as a "check" would have been incorporated into rice production over the years in the absence of Ricecheck. For example, the nitrogen NIR test would have been developed without Ricecheck, so farmers would have been assessing their crops for nitrogen status in mid-season by the late 1990s even without Ricecheck.

Therefore following consultation with rice industry extension specialists, the 'without Ricecheck' baseline defined in terms of the number of checks the industry was likely to achieve was determined for different 5-year periods since 1986. This represents the equivalent level of learning about best management practice that would have occurred without Ricecheck. Benefits are only recorded for Ricecheck where farmers achieve a higher number of checks than this baseline.

Notice that the number of checks in the baseline 'without Ricecheck' scenario steadily increased reflecting the fact that the industry outside Ricecheck eventually learnt ways to grow better rice crops from other sources, including the increasing number of private agronomists operating in the rice industry. Ricecheck did speed up the adoption of efficient technologies but this benefit erodes as the rest of the industry catches up over time.

In determining the baseline without Ricecheck, it was apparent that knowledge of the relevant checks was not sufficient to ensure that those checks would be achieved. Farmers using Ricecheck would have been aware of all the checks from their initial introduction to Ricecheck, but many failed each year to achieve the desired number of checks. From Table 2, the overall average number of checks achieved for crops in Ricecheck was 4.1 checks, or 52% of the 8 known checks. On that basis, it would seem that, at best, growers without Ricecheck would have been only able to achieve 52% of the baseline checks. However, given the extension support provided within the Ricecheck program, it was assumed that, rather than achieving the same level of the performance of those in Ricecheck, growers without Ricecheck support achieved only 80% of the level achieved. Thus, without Ricecheck the growers were assumed to achieve 41% (i.e., 80% of 52%) of the known checks in any season. Thus (Table 6), where growers would have known of 5 checks, we assume that they would have achieved 41% of 5 checks, that is 2.1 checks, without Ricecheck. The number of checks achieved in a crop, rounded to the nearest integer, was used in the analysis (Table 6). The yield level associated with that number of checks was taken as the yield without Ricecheck, and benefits of Ricecheck are only available where yields achieved are higher than the appropriate baseline level.

Table 6: Number of Key Checks Achieved without Ricecheck

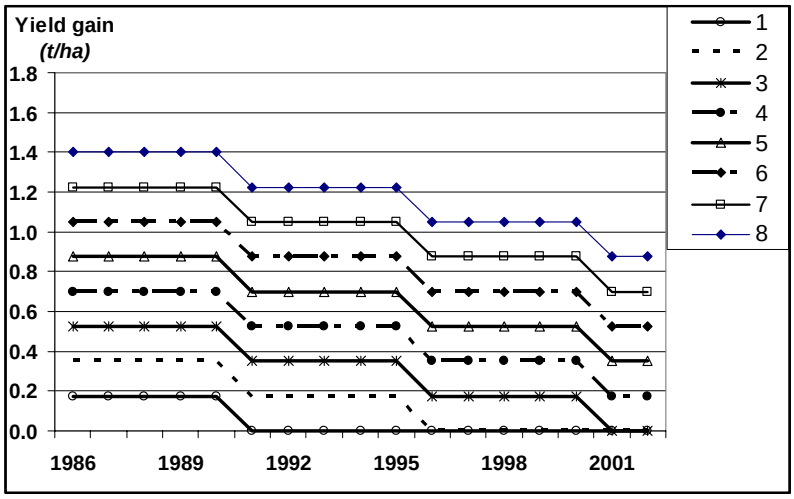
Period	No. of checks known	% known checks achieved	Checks achieved	Rounded level of checks	Expected yield[a] (t/ha)
1986 to 1990	1	41%	0.4	0	8.70
1991 to 1995	3	41%	1.2	1	8.88
1996 to 2000	5	41%	2.1	2	9.05
2001 to 2002	7	41%	2.9	3	9.23

[a] Yields based on smoothed yield data in Table 3

Yields in both the with-Ricecheck and without-Ricecheck scenarios depend on the number of checks achieved. Where no more checks are achieved than for the 'without Ricecheck' baseline in a particular year, there are no benefits from Ricecheck because the yield for both crops is the same. The benefits from achieving the different number of checks in the different periods, with the different baseline without-Ricecheck yields, are shown in Singh *et al.* (2005).

Over time, the benefits of achieving a set number of checks with Ricecheck decline, as the "without Ricecheck" baseline is increased. The benefits of achieving each number of checks over the period of the analysis are shown in Figure 1.

Figure 1: Yield Benefits of Achieving Different Numbers of Key Checks, by Year



3.5 Interrelatedness of Research and Extension

The study focuses on measuring the contribution of the Ricecheck program through the adoption of key checks. Ricecheck acts as a semi-research program that by closely monitoring crops and checking farmers' records identifies factors responsible for good or poor performance of a crop. Most of the Ricecheck recommendations are based on the findings of research into various management options. However, for some of the checks Ricecheck has taken a leading role in identifying research needs for farmers to increase crop yields through improved management practices. Therefore, it is difficult to separate the contribution of research from the benefits of the adoption of the Ricecheck program, because they are so inter-related.

For several of the key checks there have been clearly-defined feed-back linkages between Ricecheck and research activities (Singh *et al.* 2005). However, in this analysis, we do not attempt to value the enhancement given to research by these feedback processes from Ricecheck, although they have clearly been significant.

3.6 Key Assumptions and Data Used

The key assumptions in our analysis of Ricecheck are discussed in turn in the following sections.

3.6.1 Area sown to rice

The area sown to rice in NSW has generally increased throughout the period 1986 to 2002, with an average area sown of 128,000 ha. There have been considerable annual fluctuations in the area

sown to rice varying from 85,000 ha in 1991 to 184,000 ha in 2001 (Singh *et al.* 2005) due mainly to water allocations and seasonal conditions.

3.6.2 Rice prices

The price of rice used for each year was the average unit value of rice across all grades. The prices were converted to constant 2002 dollars for the analysis, using the Consumer Price Index. In 2002 dollars, rice prices fluctuated between $205 per tonne and $340 per tonne, with a mean price of $263 per tonne (Singh *et al*. 2005).

3.6.3 Accounting period

In an on-going program, it is always difficult to determine the period chosen to estimate the benefits and costs, since both will continue into the future. Because of issues related to the availability of unambiguous data, the stream of investments analysed relates to the period 1986 to 2002. That is, the evaluation being carried out is on the basis of "What if the program had been stopped at the end of the 2002 season?" It is clear that, given the participatory nature of the program, benefits would continue to accrue even after the cessation of the formal investment in the program by NSW DPI and RIRDC. We assumed that the benefits would decline linearly to zero over the next ten years after the program funding was ceased.

Thus, in this analysis, the period over which benefits of the program were accounted for was from 1986 to 2012, a total of 27 years. After 2012, it was anticipated that either this program would be replaced by a new program from future research and development, or that the rest of the industry would be achieving the same productivity as those who have adopted without Ricecheck.

3.6.4 Discounting and discount rate

Discounting and compounding was applied to ensure that people's time preference for money is appropriately accounted for in the analysis. All benefits and costs are expressed in 2002 dollars, which required past expenditures to be converted to real 2002 dollars by the GDP deflator, then compounded forward at the discount rate. All future returns and costs were discounted to 2002. These benefits and costs were discounted at a real rate of 4% per annum.

3.6.5 Adoption of Ricecheck

A range of different approaches have been followed to provide information to farmers to grow rice based on the recommendations of the Ricecheck program, including informal discussion group meetings, informal discussion group meetings with keeping records, one to one meetings with District Agronomists, field days and Ricecheck publications. As a result, the benefits of the Ricecheck recommendations to individual farmers varied depending upon their involvement and access to the different approaches. In this study, the beneficiaries have been divided into four different categories depending upon the level of involvement / adoption of the Ricecheck program:

(a) Full adopters: This group of farmers are full participants of the Ricecheck program. As members, they keep records, monitor crops and always grow rice following Ricecheck recommendations, regularly attend group meetings, other farmers meetings, field days and read the Ricecheck booklet. This group is assumed to receive 100% of the unit benefits of Ricecheck.

(b) Informal adopters: This group of farmers who are not full participants but have developed their skills and knowledge and are aware of the importance of adoption of the Ricecheck recommendations for achieving higher yields. These farmers attend meetings and field days and grow rice following Ricecheck recommendations by reading the booklet and joining discussions with farmers who are regular members of the group. This group includes former members who no longer provide records of their crops, and other farmers who have never

been formal members of Ricecheck. In this analysis, it is assumed that this group of farmers receive about 50% of the unit benefits of Ricecheck, given the level of information that they are known to receive.

(c) Partial adopters (awareness group): A third group of farmers are those who have never joined any Ricecheck farmer discussion group but who either regularly attend other farmer meetings and field days organised by the district advisory staff of the NSW DPI or who try to follow the recommendations given in the Ricecheck booklet[1]. Based on estimates from advisory staff involved in the Ricecheck program, it is assumed that this group receives 20% of the unit benefits of Ricecheck.

(d) Non adopters: Even though all rice growers would be aware of the Ricecheck program, some growers are unable or unwilling to adopt Ricecheck recommendations because of a lack of skills, knowledge, resources, poor infrastructure, the location of the farm and social factors. This group is assumed to not receive any benefits from the program.

These assumptions are summarised in Table 7.

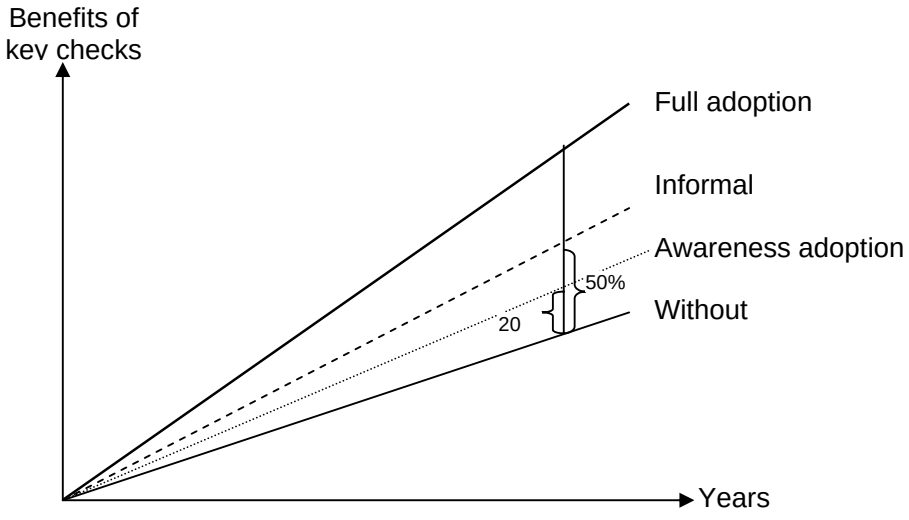
Table 7: Assumptions Relating to Adoption and Non-Adoption

	% of known checks achieved	% of benefits of checks achieved
Full adopters	52%	100%[a]
Informal adopters	52%	50%[a]
Awareness adopters	52%	20%[a]
Non-adopters	0%	0%[a]

[a] Measured as proportion of benefits additional to those without Ricecheck

The benefits of adoption are expressed as a proportion of the additional benefits obtained from adoption of Ricecheck over and above those that would have been received without Ricecheck. The basis for the determination of the benefits of key checks is illustrated in Figure 2.

Figure 2: Basis for Determination of Benefits of Key Checks



[1] The Ricecheck booklet, *Ricecheck Recommendations* (Lacy *et al.* 2004) is mailed annually to every rice grower in the industry.

In estimating the number of rice crops that fall in each category, the following assumptions are made, on the basis of the experience of advisory officers of the NSW DPI:

- "Full" adopters: The number of farmers in this group has reached a maximum of 17% of farmers in 2000, with an average of 10% over the period 1986 to 2002.
- "Informal" adopters are assumed to be twice the size of the group of full adopters[2].
- "Awareness" adopters are also assumed to be up to twice the size as the group of full adopters.
- "Non-adopters" are all other crops in each year, ranging from close to 100% in earlier years to 14% of crops in 2000.

3.7 Estimating the Benefits of Ricecheck

The benefits from Ricecheck were estimated by first estimating the unit impacts of Ricecheck per hectare, then determining the impact per crop of rice, then aggregating to measure the impact for the whole rice industry. The detailed steps in the estimates are shown in Singh *et al.*(2005).

Starting first with the group who fully adopted Ricecheck, the yield benefits from achieving the different number of checks in Ricecheck were estimated from Figure 1, compared to the baseline without Ricecheck. As illustrated in Figure 1, these benefits declined over time as the "without Ricecheck" levels increased. These yield gains were then multiplied by the average rice price each year (in constant 2002 dollars) to give estimates of the gross benefit (in dollars per ha) of achieving from one to eight of the key checks.

The costs of involvement in Ricecheck recommendations and the direct costs of adopting different numbers of checks each year are then deducted from the gross benefits of adoption to give the net benefits ($/ha) from achieving different numbers of checks each year. The net benefits are shown in Singh *et al.*(2005).

The average rice crop size is estimated to be between 23 and 37 ha each year (Singh *et al.* 2005), with an overall average between 1986 and 2002 of 29.5 ha. From these estimates, the net benefits *per crop* were calculated, and then total benefits in each year were estimated by summing over the crops achieving from one to eight checks (Table 2 above). Allowing for the value of the farmers' time in achieving Ricecheck recommendations, the total net benefits from the group of farmers adopting Ricecheck are estimated to have been $114,000 in 1986, rising to a peak of $3.38 million in 1995 (Table 8). As the area sown to rice, the price of rice and the number of crops in Ricecheck varied from year to year, the total benefits varied annually.

[2] This is based on the observation that of farmers who attend extension meetings regularly, only about one-third formally submit Ricecheck forms for their crops.

Table 8: Total Benefits from Achieving Key Checks in Ricecheck: Full Adoption
($'000, 2002 dollars)

	Number of Checks Achieved									Farmer	Net
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	***Total***	**time**	**benefit**
1986	2	9	17	31	30	20	10	0	*119*	4	**114**
1987	3	17	33	50	42	31	15	2	*194*	7	**187**
1988	9	49	96	143	120	88	44	5	*554*	23	**531**
1989	13	70	139	202	165	123	61	8	*782*	39	**743**
1990	16	82	162	232	187	141	70	10	*898*	55	**844**
1991	0	47	127	211	184	147	75	11	*802*	69	**733**
1992	0	57	156	265	233	187	96	14	*1,009*	84	**925**
1993	0	85	233	396	347	281	144	21	*1,507*	101	**1,406**
1994	0	135	368	624	546	444	228	33	*2,379*	119	**2,260**
1995	0	65	256	736	856	1063	477	91	*3,544*	162	**3,382**
1996	0	0	170	424	708	576	276	76	*2,230*	143	**2,086**
1997	0	0	166	414	593	531	153	0	*1,856*	138	**1,718**
1998	0	0	65	289	580	688	373	78	*2,073*	125	**1,949**
1999	0	0	86	385	622	645	306	52	*2,097*	131	**1,966**
2000	0	0	164	415	760	651	267	69	*2,326*	159	**2,167**
2001	0	0	0	214	579	595	374	74	*1,838*	179	**1,658**
2002	0	0	0	220	370	268	116	31	*1,006*	124	**882**

3.7.1 Economic benefits from partial adoption
Two forms of partial adoption are allowed for in this analysis, namely:

- Informal adoption
- Awareness adoption

The total benefits to each of these groups were estimated using the number of crops achieving the different numbers of key checks in Ricecheck each year (Table 2 above), adjusted by the size of the group of partial adopters (see above). The informal adopters account for twice as many rice farmers and receive 50% of the unit benefits. Because the direct adoption costs for each check are the same as for the full adopters and the labour inputs also vary (Table 4), the total net benefits for informal adopters are lower than the full adopters (Table 9). The awareness adopters are also twice as many rice farmers as full adopters and receive 20% of the unit benefits. The total benefits to these two groups of informal adopters of Ricecheck are estimated to have been $116,000 in 1986, rising to a peak of $3.64 million in 1995.

Table 9: Benefits from Full and Partial Adoption of Ricecheck
($'000, 2002 dollars)

		Partial Adoption			
	Full adopters	**Informal adopters**	**Awareness adopters**	**Total**	**Total benefits**
1986	$114	$96	$20	$116	$230
1987	$187	$154	$30	$184	$371
1988	$531	$469	$118	$588	$1,119
1989	$743	$642	$143	$784	$1,528
1990	$844	$693	$107	$800	$1,643
1991	$733	$610	$111	$721	$1,453
1992	$925	$745	$101	$846	$1,771
1993	$1,406	$1,189	$237	$1,426	$2,832
1994	$2,260	$2,004	$519	$2,523	$4,783
1995	$3,382	$2,947	$691	$3,638	$7,020
1996	$2,086	$1,794	$396	$2,190	$4,277
1997	$1,718	$1,442	$274	$1,715	$3,433
1998	$1,949	$1,642	$315	$1,957	$3,906
1999	$1,966	$1,654	$315	$1,969	$3,935
2000	$2,167	$1,834	$366	$2,200	$4,367
2001	$1,658	$1,305	$135	$1,440	$3,098
2002	$882	$713	$108	$821	$1,703

3.7.2 Total benefits
The total benefits (in constant 2002 dollars) are estimated to have increased from $230,000 in 1986 to a peak of $7.02 million in 1995, with an annual average over the 17-year period of $2.79 million per year. The benefits to partial adopters account for 50% of the total estimated benefits. Although the area under rice increased over time, there are fewer benefits from the project in later years because an increased number of checks would have been achieved without program. Thus, from the peak of benefits in 1995, the Ricecheck program has produced a declining level of net benefits over time.

3.8 Returns to Investment
The economic analysis was undertaken, within a benefit cost framework, to measure returns on the investments in the Ricecheck program. The criteria used were the Net Present Value of the program and the Benefit-Cost Ratio.

The analysis is carried out for the investment over the period 1986 to 2002, with benefits continuing, but declining to zero, over the following ten years to 2012. The discount rate of 4.0% (real) is used for discounting the costs and benefits to 2002.

Combining the flows of costs and benefits, the analysis of the investment in Ricecheck is shown in Table 10. With the present value of the costs at $3.7 million and the present value of the benefits at $67.8 million, the Net Present Value of the Ricecheck program is $64.0 million. The benefit-cost ratio is estimated as 18.0:1.

Table 10: Results of Benefit-Cost Analysis

Present value of costs	*($'000)*	$3,773
Present value of benefits	*($'000)*	$67,779
Net Present value	*($'000)*	$64,006
Benefit-cost ratio		18.0

These results indicate that the funds invested since 1986, by both NSW DPI and RIRDC (and its predecessors), and the time invested by rice farmers, has been a sound investment. The returns to the rice industry have been $18.0 for every dollar invested in the program (whether in cash or in kind), which is likely to have been higher than many alternative uses for those funds.

Sensitivity analysis of the outcomes shows that, without any partial adoption, the Ricecheck program would have had a benefit-cost ratio considerably lower than the values found when it is included (see Singh *et al*. 2005). Similarly, different without Ricecheck scenarios would have had a significant impact on the results of the economic analysis. However, the results tend not to be very sensitive to variations in other parameter values in the analysis.

5. Discussion and Implications

The distinctive feature of the Ricecheck program is the identification of "key checks", the achievement of which is confidently expected to lead to higher yields in rice production. The focus on the extension effort is to identify these key checks, to make farmers aware of their importance through group meetings and to encourage farmers to monitor and record their achievement of these checks.

While the origins of the "key checks" approach to extension may lie in areas other than rice, it has been in the rice industry, where the "check" approach to extension has been most advanced in Australia, and where its influence is likely to have been greatest.

In this study, the Ricecheck program has been evaluated from 1986, when it was first introduced to farmers in the Finley district. To ensure that available data could be obtained, and to avoid the recent difficulties facing the rice industry in more recent seasons with the lack of available irrigation water entitlements, the analysis was restricted to the investment up to 2002, by which time it was being used by growers across the entire rice industry. Because of the extent to which knowledge and management were influenced by Ricecheck, the benefits were estimated to continue to flow from that investment up to 2012, a further ten years. Beyond that time, it is assumed that other extension efforts would have replaced those in Ricecheck if funding did not extend beyond 2002. However, given that Ricecheck has continued since that time, the total benefits (and the total costs) will be greater than those measured in this analysis.

The Ricecheck program has clearly had a significant impact on the productivity of the rice industry since its inception in 1986. The Ricecheck program, requiring adoption of key checks, close monitoring and record-keeping of rice crops, has increased the extent to which farmers closely monitor their crops. This has had spill over impacts into other crops and into other aspects of the rice crops as well, although those benefits have not been measured in this study. The benefits that have been measured are the improved yields that follow from meeting the key checks of the

Ricecheck program. Yield increases are evident from the thousands of crops in the Ricecheck database.

The awareness of the Ricecheck program is very strong, as every rice-grower receives a copy of the Ricecheck recommendations booklet each year, with the latest results and most up-to-date information and recommendations. Further, the significance of the key checks and monitoring of the crops is also highlighted and reinforced to farmers at discussion group meetings, pre season meetings, field days and informal discussions with NSW DPI extension staff. Thus industry awareness is very high, though actual formal participation in Ricecheck is relatively low, accounting for at most about 20% of the rice crops grown. There is strong evidence that the awareness of Ricecheck and the extent of its influence is greater than the direct participation in the program. The partial adoption, whether on an informal basis or because of the industry information circulated through the awareness programs, is estimated to have been substantial.

While farmers have clearly become better at meeting key checks over time, the level of information that they would have had without the Ricecheck program has also increased. The benefits have been measured not from the base of productivity that existed in 1986, but from an estimate of what information the farmers would have had on the rice-growing technologies if there had not been a Ricecheck program. It is clear that rice research and extension programs would have continued even if there had been no Ricecheck program, so an allowance is made for that increased knowledge during the period of the analysis. It is estimated that the *awareness* of the importance of key productivity parameters would have been almost the same as with Ricecheck by the year 2002. However, the extent to which farmers could *meet* those key checks would have been lower without the scrutiny and discipline required in the Ricecheck program. Nevertheless, the benefits of achieving a given number of checks through Ricecheck reduced over the period of the analysis, because of the increasing knowledge that would have been available in the absence of Ricecheck.

Another key difference between Ricecheck and many research programs is that the cost of the farmers' time in adopting those key checks is a significant input into the process. Indeed, farmers involved in Ricecheck contributed a total of $5.0 million of their time (at an annual average of $294,000) to the Ricecheck program in their districts over the period since 1986. Farmers are required to contribute 8.7 hours (valued at $218) per crop for full adoption of Ricecheck (Table 4). In addition, once they moved to achieve the key checks, they had a further investment, averaging $5.02 per hectare, to meet some of those checks such as laser levelling, increasing bank height and soil suitability testing. Thus, farmer resources are a key input to the process.

The present value of the investment in Ricecheck over the period from 1986 to 2002 is $3.7 million (in real 2002 dollars). Over two-thirds of this has been in kind contribution from NSW DPI staff, with 30% cash investment by RIRDC. The estimated present value of the benefits flowing from that investment, after allowing for adoption costs for key checks, is $67.8 million. Thus, the estimated Net Present Value of Ricecheck over the period 1986 to 2002 is $64.0 million, and the benefit-cost ratio is estimated as 18.0. Thus, every dollar invested in the Ricecheck program, averaging in real 2002 dollars per year from 1986 to 2002, is estimated to have provided a return of $18.00.

The results reveal that a benefit cost ratio of 18.0 has been achieved even with less than 20% of the farmers formally adopting the full Ricecheck program in any given year. A substantial share of the benefits we have estimated to flow from Ricecheck are those captured by the group of farmers who only utilise Ricecheck information in an informal way and hence only capture less than half the potential benefits from the program. It is apparent that any efforts to increase formal adoption of

the Ricecheck program will lead to significant benefits to farmers, industry, community and the environment.

It is, of course, difficult to extrapolate from these results to other extension programs, even to other "key check" programs. The reasons for this lie in the singular nature of the Australian rice industry. First, it is located within a relatively limited geographical area, more so than most other broadacre cropping industries. Second, the high yields from the irrigated industry mean that yield advantages from new technologies are likely to be larger in absolute or physical terms than in lower-yielding dryland crops. Third, the commonality of technologies used in different regions of the rice industry means that the total number of crops involved is likely to be larger than for extension programs for many other crops. Fourth, the "closed-loop" nature of the industry, whereby the rice processing industry is directly related to the grower and the production of rice through the Ricegrowers' Co-operative Limited (trading as SunRice) means that the industry is often less disparate and fragmented than other industries. Finally, the small size of the industry, averaging approximately 146,000 ha in the ten years to 2002, means that new technologies can be known relatively quickly among all growers, as industry figures are in close contact with a large proportion of people in the industry.

Overall, however, the success of the Ricecheck program in improving rice yields demonstrates the advantages of integrated extension and research activities. Extension activity benefits from the backing of research, and research benefits from the guidance of extension to ensure that it addresses key issues for the farmers.

References

ABARE (2004), *Australian Commodity Statistics 2004*, Australian Bureau of Agricultural and Resource Economics, Canberra.

Knack, S. and Keefer, P. (1997), "Does social capital have an economic payoff? A cross-country investigation", *Quarterly Journal of Economics*, 112(4), 1251-1288.

Lacy, J. (1994), "Ricecheck a Collaborative Learning Approach for Increasing Productivity", in *Proceedings of Temperate Rice Conference*, Vol. 1, Yanco, pp. 247-254

Lacy, J. (1998), "Learning from farmers – the check approach", in *Proceedings of the 9th Agronomy Conference*, Charles Sturt University, Wagga Wagga, pp 58-65

Lacy, J. *et al.* (2004), *2004 Ricecheck Recommendations*, NSW Department of Primary Industries and Rural Industry Research and Development Corporation, Finley.

Mullen, J.D., (2004), *Evaluations in 2003 of Five Areas of Investment by NSW Agriculture: Summary*, Economic Research Report No. 22, NSW Department of Primary Industries, Orange.

Stayner, R.A. and Reeve, I.J. (1990), *Uncoupling: Relationships between Agriculture and the Local Economies of Rural Areas in New South Wales*, TRDC Publication No. 168, The Rural Development Centre, University of New England, Armidale.

Singh, R.P., Brennan, J.P and Lacy, J. 2005, *An Assessment of the Economic, Environmental and Social Impacts of Ricecheck Extension Program in NSW*, Research Report No. 28, NSW Department of Primary Industries, Yanco. (http://www.agric.nsw.gov.au/reader/10550)