An Assessment of the Economic, Environmental and Social Impacts of the Ricecheck Program

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Abstract
Ricecheck, a best management practices extension program for rice production in Australia, was developed by the NSW Department of Primary Industries advisory staff, Finley, in 1986. The program is based on eight best management practice recommendations called 'Key Checks' that are considered essential for achieving high yields. Economic analysis of the program reveals that there are significant financial, social and environment benefits from the adoption of the program. The results further reveal that the funds invested since 1986 by both NSW Department of Primary Industries and the Rural Industries Research and Development Corporation have been sound investments.

Keywords: rice; extension; economic; evaluation; Australia

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Executive Summary

Ricecheck is an extension program developed in the 1980s by the NSW Department of Primary Industries (NSW DPI) to improve productivity through improved crop management in the rice industry. The Ricecheck program is based on monitoring crops and setting key benchmarks (or "checks") based on the highest yielding rice crops. After analysing many factors involved in achieving high rice yields, a set of eight "Key checks" was developed to provide a basis for growers to achieve higher yields. The Ricecheck program involves farmers following Best Management Practices, monitoring their rice crops and keeping detailed records to determine the key checks achieved. The program comprises grower discussion group meetings, field days, pre-season meetings for farmers and broad Ricecheck recommendations to provide information on the best management practices and their impact on crop yields and farm profitability.

The more key management checks each crop achieves the higher the expected yield. The checks are such that they are often difficult to achieve, even when the grower manages the crop to try to achieve the checks, as some factors are outside the control of the farmer.

Ricecheck has been adopted across the rice industry, although formal involvement with full record-keeping has only reached a peak of around 20% of rice crops in any one year. It also helped to improve the knowledge and skills of many farmers who have left the program after joining it for a few years. Some other growers are aware of Ricecheck given its significance in rice production and widespread application and access to the Ricecheck Recommendation booklet distributed to each farmer every year. As a result, many growers utilise its approach without being formally involved in the Ricecheck program. Thus, farmers receive benefits ranging from 20% to 100% of those from full adoption, depending upon their level of participation.

Farmers adopting Ricecheck spend a significant amount of time (and some resources) implementing Ricecheck. They spend time in attending discussion group meetings, monitoring crops and in record-keeping, as well as providing additional inputs to meet some key checks. The time involved in adoption is included in the analysis, and is estimated to have a total annual cost of $294,000 per year, on average.

An economic analysis was undertaken within a benefit cost framework to measure the return on the investments in the Ricecheck program. The basis for evaluating the benefits of Ricecheck was to determine the difference in the yield levels that were associated with the observed level of key checks achieved through the Ricecheck program with the equivalent levels of management that would have been achieved in the absence of Ricecheck. Estimates were made of the industry knowledge that would have been available and the extent to which it would have been used by rice growers had Ricecheck not existed. That level of achievement would have increased over time as management information and technologies were improved even without Ricecheck, and because rice research and extension programs would have continued even if there had been no Ricecheck program,. Thus, achieving a given number of checks with Ricecheck provided lower benefits at the end of the period than it did at the start of the period.

The present value of the investment in Ricecheck over the period from 1986 to 2002 is $3.8 million (in real 2002 dollars). Over two-thirds of this has been an in-kind contribution from

NSW DPI staff, with 29% cash investment by Rural Industries Research Development Corporation (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, averaged in real 2002 dollars per year from 1986 to 2002, is estimated to have provided a return of $18.00.

There is no obvious way to attribute the benefits separately between NSW DPI and RIRDC, so it is assumed that they share the benefits in the same proportion that they share investment costs. Thus, both achieve the same benefit-cost ratio of 18.0 on their respective investments.

Many of the on-farm economic benefits identified have social and environmental implications. To the extent that these impacts are associated with the improved economic welfare of the farm, they are incorporated into the economic benefits measured. However, this study has also identified some of the on and off-farm social and environmental benefits from the Ricecheck program that have not been incorporated into the economic evaluation. Increases in income from rice and on-farm investments are likely to have flow on effects on the regional economy, help develop social capital and enhance the cohesiveness of local community activities. In addition, the participatory approach employed in Ricecheck has also improved human capital by helping farmers to develop their managerial, marketing and decision-making skills.

There are also some environmental outcomes of Ricecheck, as the improved management incorporated into Ricecheck is likely to result in improvements in parameters such as deep drainage/seepage, surface runoff, downstream pollution, and greenhouse gas emissions. In this study, no value has been attributed to these benefits.

The benefits of Ricecheck have flowed to both industry and the community. Industry captures a larger share of the quantified economic benefits of the program than does the community, while the community has captured the majority of the unmeasured environmental and social benefits.

1. Introduction

1.1 Introduction

NSW DPI invests about $160 million per year in research, extension and education activities making it the largest provider of research and development services within the New South Wales government sector[1]. The opportunity cost of these investments is the benefits to the people of New South Wales were they used in other areas such as health and education. Hence it is important that the Department can demonstrate that it uses these resources in ways that enhance the welfare of the people of New South Wales.

Since 2003 the Department has had a more systematic process of evaluating the economic, social and environmental impacts of its major programs of investment in research, extension and education. Several areas of investment are evaluated each year so that a significant proportion of the Department's portfolio will be evaluated on a regular basis.

A summary of the five evaluations conducted in 2003 can be found in Mullen (2004) which is available on the web at: http://www.agric.nsw.gov.au/reader/10550. Detailed reports on each of the evaluations can also be found published as Economics Research Reports at this site.

In 2005, evaluations are being undertaken in the following areas:

- The Ricecheck extension program;
- The fox control program;
- The use of genetic markers in cereal breeding;
- The beef quality CRC program;
- Conservation farming in central and southern NSW;
- Aquaculture research and development in NSW.

This evaluation process serves a number of purposes including the external requirement for accountability in the way NSW DPI uses the scientific resources in its care.

This evaluation process can also be used within the NSW DPI to assist in allocating resources to areas likely to have high payoffs and to assist in designing research and extension projects that have clearly defined objectives consistent with the role of a public institution like the NSW DPI. Working through this formal benefit cost framework gives those involved – economists, research and advisory officers and program managers, a greater appreciation of the paths by which, and the extent to which, research and extension activities are likely to have an impact at the farm level and hence lead to better projects. Part of this process is a greater understanding of other trends in the industry and of the extent to which 'the market' is failing to deliver outcomes sought by the industry or by the community.

We explicitly consider environmental and social impacts of agricultural activities. Advocates of this process argue that these environmental and social impacts provide a rationale for continued government funding of the NSW DPI's activities albeit with a different focus.

It is important to recognize that the measures of economic performance used in these evaluations already capture some environmental and social impacts. Measures of farm or industry profit reflect the impact of changed environmental conditions on yields and input

[1] NSW Department of Primary Industries was formed on July 1 2004 through an amalgamation of NSW Agriculture, NSW Fisheries, State Forests of NSW and the NSW Department of Mineral Resources.

costs but not on off-farm impacts. Similarly, the measures of profit change used in this suite of evaluations are really measures of changes in industry profit, not just farm profit. Industry profit is shared between not only farmers, but inputs suppliers, processors and consumers, some of whom live in rural communities.

We would have liked to have been able to value all economic, environmental and social impacts and relate these to the investments made, but generally we were only successful in valuing some of these impacts because of:

- uncertainty about environmental and social impacts both now and in the future;
- uncertainty about the value of environmental and social resources both now and in the future;
- limited resources to undertake these evaluations.

Our approach has been to first describe qualitatively the economic, social and environmental impacts of the actual or proposed investment. We also describe the rationale for government investment from a market failure viewpoint which seeks to identify the characteristics of the investment resulting in farmers individually or collectively underinvesting in the areas under consideration. We examine the share of public and private funding in the investment and compare this to a qualitative assessment of whether the benefits from the investment flow largely to farmers or largely to the community. Note this assessment of the relative shares of benefits flowing to farmers and the community and the link to the source of funding is a highly subjective one, unlikely to be the subject of unanimous agreement.

We then attempt to quantify as many impacts as practicable to arrive at common measures of economic performance such as a benefit cost ratio. There are insights to be gained from persevering with an empirical benefit costs analysis even under uncertain scenarios, particularly with respect to understanding the relative importance of key parameters, such as the rate and extent of adoption of technology, the on-farm impacts, and the size of the investment and its time path.

However in assessing these alternative investments we must always bear in mind that some impacts, often the environmental and social impacts on the community, are not quantified and hence judgments are necessarily based on a subjective weighting of quantified industry economic benefits against unquantified environmental and social impacts.

A key step is to identify not only the expected impact on an industry of the investment, the ‘with technology’ scenario, but just as importantly, how the industry would continue to develop without the investment by NSW DPI, the ‘without technology’ scenario. Rarely is the ‘without technology’ scenario a no-change scenario because there are usually other sources of similar technologies leading to ongoing productivity growth. The need to identify appropriate ‘with’ and ‘without’ scenarios applies equally strongly to environmental and social impacts as to economic impacts. In assessing the ‘with’ and ‘without’ technology scenarios, key outputs from research and extension activities and communication strategies used are described to give credence to claims about the contribution of NSW DPI and to assumptions about the rate and extent of adoption of the technology.

The focus of this evaluation is the Ricecheck Program, which is an extension program designed to increase the rate and extent of adoption of efficient technologies, practices and input use in the rice industry, many of which were developed in research programs undertaken by NSW DPI. There were a number of reasons for evaluating Ricecheck. The rice

industry is an important industry in NSW in which NSW DPI makes significant investments in research and extension activities. In addition Ricecheck has long been seen as a model for successful extension programs and we were interested both in confirming that Ricecheck has been a profitable investment for NSW DPI and also in identifying reasons for the success of the Program and the nature of the benefits that have flowed from it.

1.2 Background to the Development of the Ricecheck Program

The Australian rice industry experienced only limited increases in yield up to the 1970s. Even with the existing yields levels, rice growing was highly profitable compared to other irrigated crops. Hence little attention was being paid to the adoption of best management practices to further improve yield, reduce losses or lower production costs. A sharp increase in the area sown to rice, and increased production of rice on "leaky" soils in the 1970s resulted in serious problems of rising water tables, water-logging and soil salinity. To address these issues, restrictions were imposed on further expansion of the area under rice production by local irrigation authorities. 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, 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. The study observed that only a few rice growers were able to achieve a consistently high yield. It was observed that there was 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. Without checking the crop, it is difficult to identify the factors causing losses from the wide range of potential causes such as weeds, pests, establishment, nutrition or moisture. The recording and identification of the factors responsible for the increase or decrease in yields were missing. 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 like the one developed for wheat that would help to bring farmers, extension specialists and researchers together. It would also help to promote best management practices and 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 in the Finley district and later adapted to the whole rice industry.

1.3 Economic, Social and Environmental Assessment of Ricecheck

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 NSW, most of the extension advice is provided by the NSW DPI advisory staff. In southern NSW, the extension advisors 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. It was, therefore, considered worthwhile to measurethe economic, social and environmental consequences of implementing the Ricecheck program.

More specifically, the main objectives of this study of the impact of Ricecheck were:

- To measure the potential economic benefits from the Ricecheck program to rice farmers
- To identify social and environmental benefits
- To identify the distribution of benefits between the community and the industry
- 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. While we have been able to identify these impacts qualitatively, we have not attempted to place an economic value on them.

1.4 Outline of This Report

The Ricecheck program is outlined in section 2, where the system of checks used is 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 social and environmental outcomes of the Ricecheck program are discussed in section 4. The results of the analysis and 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). Farmers learn and share knowledge with fellow farmers and researchers, with extension workers playing a pivotal role in facilitating this learning process. Instead of measuring the results from top yielding research plots, this approach measured the results from the top-yielding farmer paddocks. The key factors or checks linked to yield were then identified from farmer paddocks. The study showed that the higher the number of checks adopted, the higher the yield would be.

The new approach proved to be a better alternative to the 'transfer of technology' model that was being used as the basis for extension previously in the rice industry. The change was from a one-way communication flow to a multiple-flow model with flow from farmers to farmers, farmers to extension officers and researchers, and vice versa.

Key differences between the traditional extension approach that was common in the early 1980s and the new Ricecheck approach developed for rice farmers are presented in Table 2.1.

Table 2.1: Key Differences between Traditional Extension and the Ricecheck Approach

Traditional Extension	Ricecheck Approach
• Solve one factor at a time • Single factor information • "Motherhood" recommendations • No recognition of farmers as researchers • One way communication: research-extension-farmers (top down) • No paddock checking • No benchmarks • Little use of adult education principles • No facilitation • Few learning tools • Lack of target setting	• Solve all factors – integrated approach • Information packages • Objective recommendations • Recognise farmers as researchers • Two way communication: research-extension-farmers (bottom up) • Paddock checking • Set Benchmarks to aim for • Wide use of adult education principles • Facilitation practised • Range of learning tools • Target setting

Source: Lacy (1998)

The major highlight from the results of the initial analysis of factors responsible for increasing rice yields was that there was no single factor which consistently produced high yields. Increased yields only arise by ensuring all the key factors are carried out correctly. 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).

The key parameters identified as essential for achieving high yields were called "Key checks". 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, extra checks relating to these issues have been added in recent years.

Checking and measuring a range of farmers' crops, the study initially identified seven key recommendations that were linked to high yields and/or productivity. That set was later increased to eight checks. At present, there is a ninth productivity check (phosphorus application) and four checks that address quality and environmental issues (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 2.2. A more detailed description of the criteria for meeting each of these checks is included in Appendix A.

Table 2.2: 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. The target yield range for different rice varieties, based on current technology, variety, and seasonal conditions, is shown in the Table 2.3.

Table 2.3: Expected Target Yield of Rice Varieties under Ricecheck Management, 2004

Varieties	Expected target yield range
Amaroo, Quest, Reiziq, Illabong	10.0 to 12.0 t / ha
Langi, Doongara, Opus	9.5 to 11.5 t / ha
Kyeema, Jarrah	8.5 to 10 t / ha

Source: Lacy *et al.* (2004)

While, in general, a well designed benchmarking program may lead to improved financial performance of farms, it cannot be presumed that for every farmer meeting each check gives a net benefit. This can only be achieved by applying marginal principles where the cost of increments in yield are compared to benefits. Typically this requires a detailed knowledge of

the rice response function which rarely available and certainly not for individual farms (for example see Malcolm 1990). Therefore, the analysis undertaken in this study is based on the average gains that can be achieved across a group of farms, rather than the impacts on individual farms.

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 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 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 (Table 2.4), and there were about 780 farmers who at some time attended these discussion groups during 2004. The attendance can vary by 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.

Table 2.4: Discussion Groups in Each Rice-Growing District, 2004

District	Number of groups	Number of farmers
Murray irrigation area		
Barham	7	140
Finley	8	200
Deniliquin	7	105
Murrumbidgee irrigation area		
Yanco	5	50
Hay	1	15
Griffith	6	120
Coleambally irrigation area		
Coleambally	6	150
Total	**40**	**780**

The number of crops and checks achieved in the Ricecheck system each year since 1986 is shown in Table 2.5 (data on a regional basis are available in Appendix B). 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.

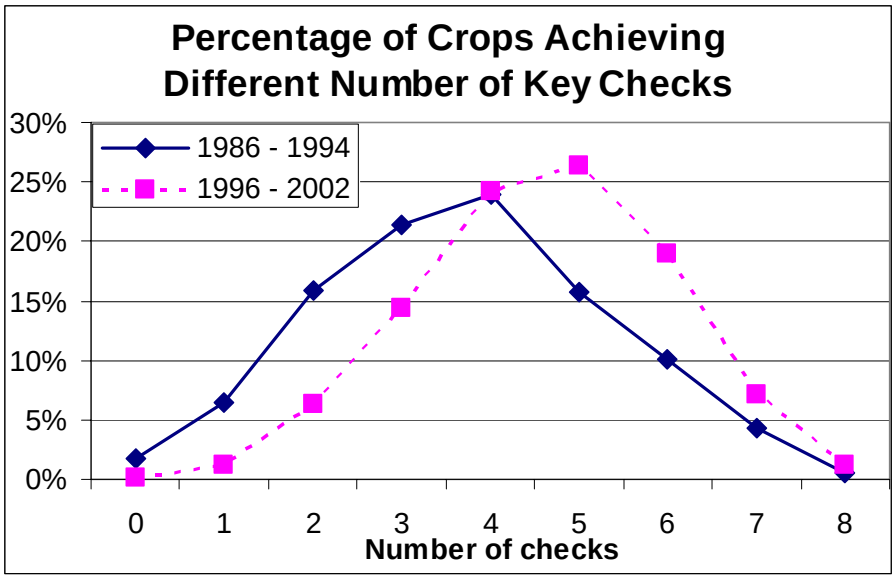
Table 2.5: Number of Crops and Key Checks Achieved, 1986 to 2002

	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*

The extent to which farmers have been able to achieve the checks has also changed over time. This is illustrated in Figure 2.1, where the frequency of checks achieved from 1986 to 1994 is compared to those achieved in 1995 to 2004. Clearly, there has been an increase in the frequency of checks being achieved in the second period. While in the years to 1995, 20% of crops achieved 2 or fewer checks, 44% achieved 3 or 4 checks, and 36% achieved 5 or more, from 1996 onwards only 8% achieved 2 or fewer, 38% 3 or 4, and 54% achieved 5 checks or more. Therefore, as time passed, growers involved in Ricecheck became better at achieving the checks.

However, even with good management and knowledge, the checks proved difficult to achieve; for example even 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 2.5). 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.

Figure 2.1: Percentage of Crops Achieving Different Number of Key Checks



Even growers who are consistent members of 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. They include:

(a) "*Black and white" adoption criteria:* When check adoption has been analysed, there has been no allowance for any error or blurring at each end of the window. For example the sowing date window for the variety Amaroo for the Murrumbidgee Valley is between 1 October and 20 October, and if a crop is sown on 21 October it fails the check. In reality there would be no significant yield difference from a day's delay.

(b) Factors outside farmer control: Conservative water allocation announcements at the start of irrigation seasons often result in farmer indecision on whether there is enough water to grow rice at the recommended sowing times. Often mid or late October announcements signal significant rises in water allocations, which trigger farmers to sow rice although it is well past the sowing date for meeting the check. As a second example, seasonal temperature differences up to panicle initiation can alter nitrogen mineralisation and resultant nitrogen uptake by 30-40 kg N/ha. Hence a hotter season can increase nitrogen uptake by 40 kg N/ha, producing a crop outside the nitrogen uptake check window, while an average season for the same crop would result in lower nitrogen uptake and adoption of the check.

(c) Checks changed over time so harder to achieve: The initial plant establishment check was 150-300 plants/m^2. Ricecheck results showed higher yields from plant establishment of 200-300 plants/m^2, so the check was changed. This has made adoption more difficult. As a second example, the optimum nitrogen plant level check was initially based on shoot numbers/m^2 at panicle initiation. Hence only one parameter needed to be satisfied. In the late 1980s, the NIR nitrogen test was developed to provide more objective ratings, and made the check harder to achieve. In the late 1990s, shoot

nitrogen was replaced by fresh weight and NIR analysis, again making the check harder to achieve.

(d) Reliance on the NIR Tissue test: Although the change from shoot nitrogen to fresh weight is a more accurate measure of crop nitrogen, extra labour effort is needed to measure fresh weight, and so is a barrier to many farmers carrying out the test. The NIR Tissue test crop data form has been designed to record information for crop nitrogen and Ricecheck. Hence any issues or advancements in technology leading to reduced use of the NIR test automatically reduce the potential number of Ricecheck records captured. Local agribusiness agronomists are being encouraged to increase the number of crops NIR Tissue tested.

(e) Some checks difficult to achieve: Farmer surveys conducted in the Finley district from 1995 to 2000 showed there were 25 different factors affecting rice establishment, *i.e.* the plant number check. A number of these related to seasonal weather conditions. In a warm, no-wind start to a season, adoption of this check is relatively easy, but in colder windy starts check plant numbers are difficult to achieve.

(f) Linked checks: Sowing date is linked to panicle initiation date. Hence if a farmer chooses to sow late and not adopt the check it is likely that the panicle initiation check will also not be adopted either. Although bank height check adoption is good, crops with low banks are unlikely to be able to achieve the early pollen microspore check. Crops with poor establishment are more likely to have poorer weed control since the rice crop biomass provides less competition to weeds and there is more reliance on chemical weed control.

(g) Check importance: Temperatures in the Murrumbidgee Valley are higher than in the Murray Valley. Cold affects rice yields 4 years out of 10 in the former compared to 6 years out of 10 in the latter. Hence microspore water depth adoption to reduce cold damage tends to be better in the Murray Valley than Murrumbidgee Valley because it is a more important check in their valley.

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 Rice 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 be considered in measuring the full impact of the program.

The Ricecheck program and the discussion groups have been running 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 2.6).

Table 2.6: Expected Yields from Achieving Different Number of Key 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 2.6 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 report 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. 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 time spent at group meetings and field days related to Ricecheck, crop monitoring activities and formal record-keeping. Farmers who adopted Ricecheck informally (see section 3.5.5 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 section 3.5.5 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. In the first two years of the program, the record-keeping was undertaken by Departmental officers rather than farmers (see Appendix E2 for details of annual labour inputs by farmers).

Table 2.7: 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	0.0	1.0
- Total hours	*8.7*	*5.7*	*3.0*
Total value of farmer time[b]	**$218**	**$143**	**$75**

[a] See section 3.6.5 for explanation

[b] Valued at $25 per hour

In addition, the adoption of key checks involved extra expenditure on inputs such as seeds, fertilisers, chemicals for plant protection, 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 in Appendix C, following discussions with rice industry research and extension officers, and are summarised in Table 2.8 for an average rice crop of 30 hectares. 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 costs 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.

Table 2.8: Additional Costs of Adopting Ricecheck Recommendations for an Average Rice Crop

Operation	**Check cost ($/ha)**
Harvesting cost $/t	$3.94
Extra seed cost (@ 40 kg/ha)	$8.80
Additional aerial sowing cost	$7.33
Cost of raising bank height (20 years)	$0.88
Cost of reforming banks	$0.93
Changing concrete stops (20 years)	$1.19
Tissue testing	$4.57
Laser levelling for 20 years	$12.50
Total extra costs for 8 checks	*$40.14*
Cost per check	**$5.02**

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 (see Appendix D) 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 (Appendix E1), the total labour input from Departmental staff is estimated to average 461 person-weeks per year. The value of the average labour input since 1986 was $153,000 per year (in 2002 dollars) (Table 3.1), ranging from $42,000 in 1986 to $177,000 in 1996 (see Appendix E1 for more details).

Operating costs incurred by Ricecheck other than labour costs, involved the costs of printing the Ricecheck forms, printing the annual *Ricecheck Recommendations* booklet (Lacy *et al.*

2004), and travel costs for the extension officers. In addition, from 1992-93 onwards, an annual fee of $5,000 has been required for programming to establish and maintain the database for Ricecheck. These costs are shown in Table 3.1, and have averaged approximately $10,000 per year.

The annual R&D investment in Ricecheck is shown in Table 3.1 as varying from $43,900 in the first year to a peak of $190,020 in 1996, and an annual average of $162,927 throughout the period since 1986. Of those R&D funds, 71% have been contributed by NSW DPI and 29% by the Rural Industries Research and Development Corporation (RIRDC). The total investment (in nominal dollars) has been $2.77 million, almost 94% of which has been labour costs.

Table 3.1: 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

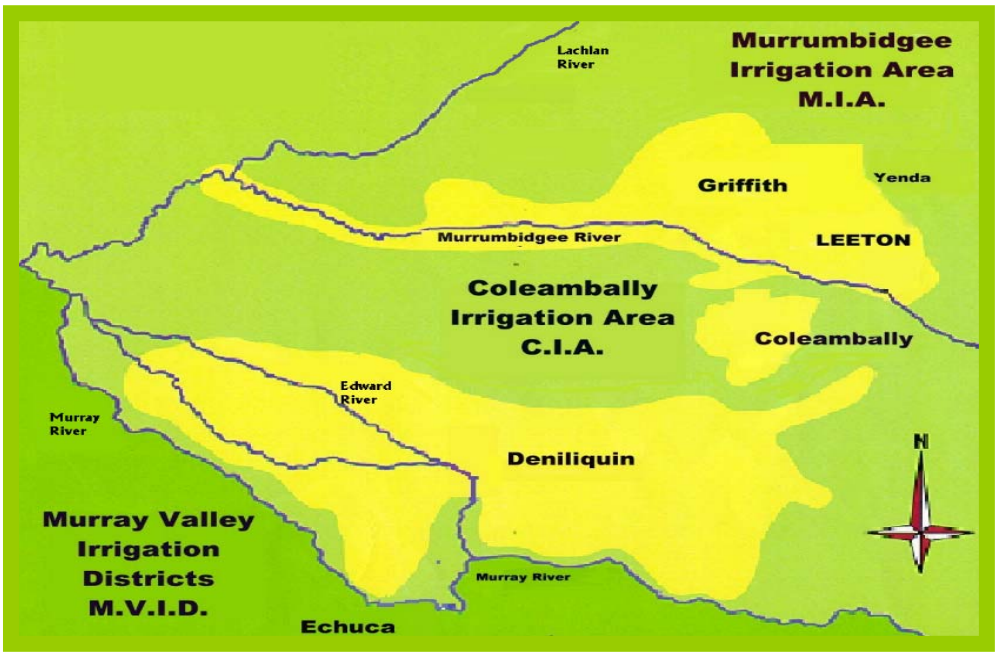
3.3 Analysis of Benefits

The NSW rice industry is located in four irrigation districts, namely the Murrumbidgee Irrigation Area (MIA), the Coleambally Irrigation Area (CIA), the Western Murray Valley (WMV) and the Eastern Murray Valley (EMV). The location of these regions is shown in Figure 3.1.

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

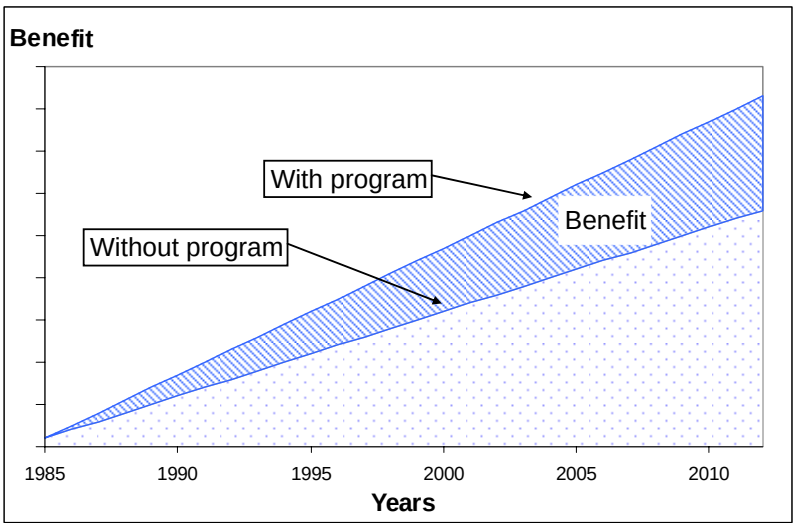
Ricecheck. In the analysis in this study, all regions are aggregated into the NSW rice industry for the estimation of benefits.

Figure 3.1: Rice-growing Areas and Production Regions



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. In Figure 3.2, the R&D that would have taken place without Ricecheck is included in the "without program" line, and the "with program" line shows the total benefits of the adoption of the key checks through Ricecheck. Thus, the benefits from the Ricecheck program are determined as the difference between the situation with Ricecheck and that which would have occurred without Ricecheck.

Figure 3.2: Benefits from Ricecheck Program



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 2.5, 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 3.2), 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 3.2). 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.

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 Appendix F.

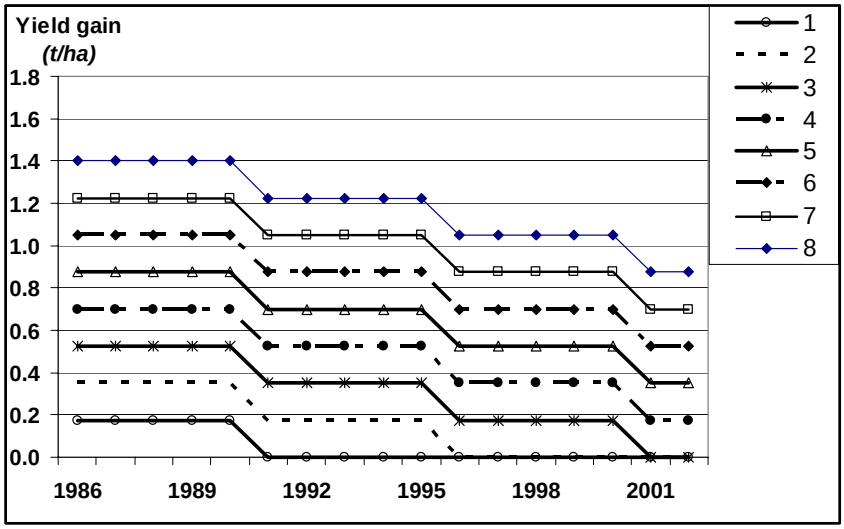
Table 3.2: Number of Key Checks Achieved without Ricecheck

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 2.6

Over time, the benefits of achieving a set number of checks with Ricecheck decline, as the "without Ricecheck" baseline is increased. For lower number of checks achieved, there may be no benefits from Ricecheck, if that level (or higher) would have been achievable without Ricecheck. The benefits of achieving each number of checks over the period of the analysis are shown in Figure 3.3.

Figure 3.3: 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. For example:

(a) Key check on water management: Evidence on the importance of deep water for rice production came from both research and the information in the Ricecheck database. Prior to the development and implementation of Ricecheck, research had been undertaken to measure the impact of deep standing water for protecting rice crops from cold damage. Although recommendations were made for using deep water to protect the rice crops from cold damage at microspore, the evidence of the impact of deep water on crop yields, reasons for the very low level of adoption of deep water and the issues involved in the adoption of deep water came from the Ricecheck program. After checking farmers' crop production records and closely monitoring the selected crops, it was found that only those farmers having a water depth of 20 to 25 cm were able to achieve good yields. This helped to develop more precise recommendations incorporating additional information provided by the Ricecheck program.

(b) Plant number or plant density: Prior to the Ricecheck program, even after applying the recommended seed rates, most farmers could not achieve high yields. After closely monitoring the crops and analysing the records of the selected crops through the Ricecheck database, it was found that plant density per unit area was either too low or not uniform across the paddock. Factors responsible for not achieving the required plant density were identified and were incorporated in the recommendations for a uniform establishment of crop to achieve high yields.

(c) Nitrogen management: Research being carried out at Yanco was recommending only one application of nitrogen. However, Ricecheck observations gave an impetus to research suggesting the benefits of split treatment. Similarly, the analyses of the Ricecheck database showed wide variations into the availability of nitrogen to the plant, and led to research that improved the NIR Tissue test.

In this analysis, we were not able 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 (Table 3.3) in the area sown to rice 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 (Table 3.3). 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.

Table 3.3: Rice Area and Prices Used in Analysis

Year ending	Area sown to rice ('000 ha)	Nominal Price ($/t)	Constant Price ($/t) (2002 dollars)
1986	104	$144	$267
1987	93	$149	$252
1988	104	$203	$319
1989	100	$190	$279
1990	110	$162	$221
1991	85	$198	$256
1992	123	$172	$218
1993	123	$209	$262
1994	133	$276	$340
1995	129	$246	$293
1996	150	$250	$287
1997	166	$227	$257
1998	140	$222	$251
1999	151	$224	$250
2000	132	$242	$263
2001	184	$200	$205
2002	147	$250	$250

Source: Sunrice, Leeton (2004)

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 DAs, 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. The nature of Ricecheck is such that farmers can adopt the program partially or in full (see, for example, Szmedra, Wetzstein and McClendon 1990).

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 farmer 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 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[2]. 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 3.4. 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 3.4. The partial adopters are assumed to achieve the same number of checks as full adopters, but to receive fewer benefits.

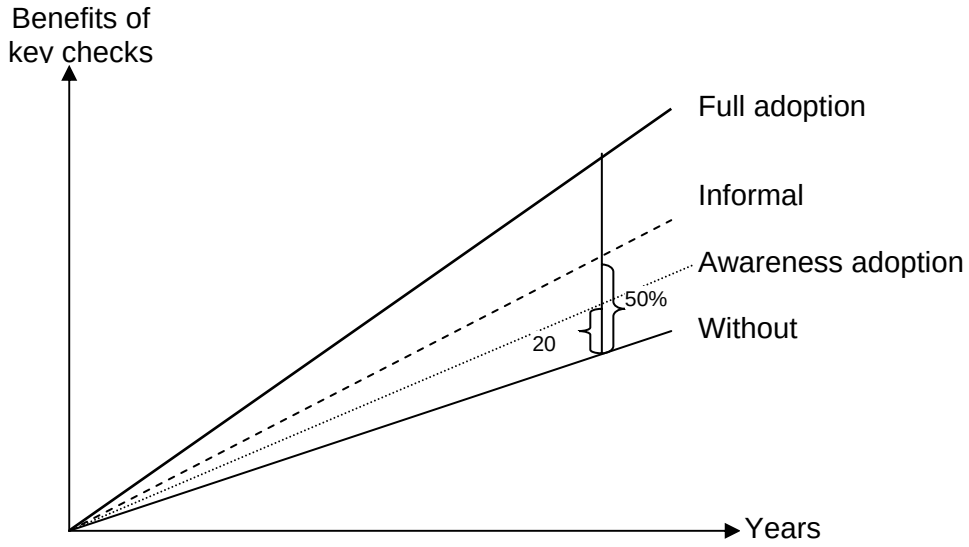
[2] The Ricecheck booklet, *Ricecheck Recommendations* (Lacy *et al.* 2004) is mailed annually to every rice grower in the industry.

Table 3.4: Assumptions Relating to Adoption and Non-Adoption

	% of known checks achieved	% of benefits of checks achieved
Without Ricecheck	41%	80%
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

Figure 3.4: Basis for Determination of Benefits of Key Checks



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[3].
- "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 recent years to 14% of crops in 2000, with an average of 52% over the period 1986 to 2002.

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 impact for the industry. The detailed steps in the estimates are shown in Appendix G.

[3] 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.

3.7.1 Estimating impacts per hectare

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 3.2, compared to the baseline without Ricecheck. As illustrated in Figure 3.2, 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 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, compared to the without-Ricecheck scenario, are shown in Table 3.5.

Table 3.5: Net Benefits from Achieving Key Checks in Ricecheck ($/ha): Full Adoption

	Number of Checks Achieved								
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1986	$0	$42	$83	$125	$167	$208	$250	$291	$333
1987	$0	$39	$78	$117	$156	$196	$235	$274	$313
1988	$0	$51	$102	$152	$203	$254	$305	$356	$407
1989	$0	$44	$88	$131	$175	$219	$263	$306	$350
1990	$0	$34	$67	$101	$134	$168	$202	$235	$269
1991	$0	$0	$40	$80	$119	$159	$199	$239	$278
1992	$0	$0	$33	$66	$99	$132	$165	$198	$232
1993	$0	$0	$41	$82	$123	$163	$204	$245	$286
1994	$0	$0	$54	$109	$163	$218	$272	$327	$381
1995	$0	$0	$46	$93	$139	$185	$231	$278	$324
1996	$0	$0	$0	$45	$90	$135	$181	$226	$271
1997	$0	$0	$0	$40	$80	$120	$160	$200	$240
1998	$0	$0	$0	$39	$78	$116	$155	$194	$233
1999	$0	$0	$0	$39	$78	$116	$155	$194	$233
2000	$0	$0	$0	$41	$82	$123	$164	$205	$247
2001	$0	$0	$0	$0	$31	$62	$93	$124	$155
2002	$0	$0	$0	$0	$39	$77	$116	$155	$193

3.7.2 Economic benefits from full adoption

The average rice crop size is estimated to be between 23 and 37 ha each year (Appendix G), 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 2.5 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 3.6). 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.

Table 3.6: 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**

3.7.3 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 2.5 above), adjusted by the size of the group of partial adopters (see 3.5.5 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 (as shown in Table 2.8) and the labour inputs also vary (Table 2.7), the total net benefits for informal adopters are lower than the full adopters (Table 3.7). 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 3.7: 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

3.7.4 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 annual cash flow of benefits and costs from the Ricecheck program are shown in Table 3.8. 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.

Table 3.8: Analysis of Costs and Benefits of Ricecheck Program
($'000)

	2002 dollars			Discounted / compounded		
Year ending	**Total costs**	**Total benefits**	**Net benefits**	**Total costs**	**Total benefits**	**Net benefits**
1986	59	230	171	111	431	320
1987	134	371	237	241	668	427
1988	150	1,119	968	261	1,937	1,676
1989	178	1,528	1,350	296	2,544	2,248
1990	176	1,643	1,467	282	2,631	2,349
1991	176	1,453	1,277	271	2,238	1,966
1992	181	1,771	1,590	268	2,621	2,353
1993	181	2,832	2,650	258	4,030	3,772
1994	181	4,783	4,601	248	6,545	6,297
1995	190	7,020	6,830	250	9,238	8,987
1996	189	4,277	4,087	239	5,411	5,172
1997	187	3,433	3,246	228	4,177	3,949
1998	186	3,906	3,720	217	4,569	4,352
1999	184	3,935	3,751	207	4,426	4,220
2000	186	4,367	4,181	201	4,724	4,522
2001	186	3,098	2,912	194	3,222	3,028
2002	0	1,703	1,703	0	1,703	1,703
2003	0	1,533	1,533	0	1,474	1,474
2004	0	1,363	1,363	0	1,260	1,260
2005	0	1,192	1,192	0	1,060	1,060
2006	0	1,022	1,022	0	874	874
2007	0	852	852	0	700	700
2008	0	681	681	0	538	538
2009	0	511	511	0	388	388
2010	0	341	341	0	249	249
2011	0	170	170	0	120	120
2012	0	0	0	0	0	0
	59	230	171	111	431	320

Combining the flows of costs and benefits, the analysis of the investment in Ricecheck is shown in Table 3.9. With the present value of the costs at $3.8 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 3.9: 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 the RIRDC (and its predecessors), and the time invested by rice farmers, has been a sound investment. The returns to the rice industry have been $18.00 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. There is no obvious way to attribute these benefits separately between DPI and the RIRDC. The most reasonable approach is to assume that the two organisations share the benefits in the same proportion that they share investment costs, and hence both earn benefit cost ratios of 18.0 on their respective investments.

3.9 Sensitivity Analysis

Sensitivity analysis was used to demonstrate the effects on returns of changes in discount rate, and in the rate and extent of adoption (Table 3.10). Further we examined the impact of smoothing the yield gains (Table 2.6). If the unadjusted data were used, whereby there are no gains from the first two checks adopted, but rather a small yield loss, then the returns to the program would have been markedly higher.

The results are also sensitive to the assumption about partial adoption. If only those formally and fully adopting Ricecheck obtained any benefits, then the benefit-cost ratio would have been 8.9 rather than 18.0. A benefit cost ratio of 10.8 would have been obtained if it had been assumed that the ‘without Ricecheck’ farmers achieved 52% of the checks known to them (as did the ‘with Ricecheck’ farmers) rather than the assumed rate of achievement of 41% (Table 3.2). Examination of different lengths of time over which benefits are received from Ricecheck, different costs of adopting key checks and different discount rates showed that the results are relatively insensitive to these assumptions.

The assumptions on partial adoption and without-Ricecheck scenarios, then, are the key assumptions that affect the results of the analysis. In both cases, we believe that there is strong evidence that partial adoption is indeed occurring at a significant level, and that the *process* of being involved in Ricecheck both informally and at the level of awareness, means that farmers capture benefits from Ricecheck even though they achieve fewer checks than if they were full members.

Table 3.10: Sensitivity of Results to Changing Values of Selected Parameters

	Benefit-cost ratio
Yield response smoothing	
- Response smoothed	18.0
- Unadjusted yield response	29.7
Partial adoption	
- Partial adoption included	18.0
- No partial adoption	8.9
Without-Ricecheck scenario	
- Achieve 80% of benefits of key checks (41%)	18.0
- Achieve 100% of benefits of key checks (52%)	10.8
- Achieve 60% of benefits of key checks (31%)	20.2
Length of benefits from investment to 2002	
- To 2012	18.0
- To 2002	16.2
- To 2020	19.2
Costs of adopting checks ($ per ha per check)	
- $5.02	18.0
- $6.00	16.8
- $4.00	19.2
Discount rate	
- 4% real	18.0
- 8% real	16.1
- 2% real	19.0

4. Social and Environmental Outcomes

To this point, we have focussed on the economic implications of Ricecheck. However the widespread adoption of Ricecheck has important social and environmental consequences. Some of these social and environmental consequences have been captured in our estimates of the economic impacts. Hence for example, the economic benefits from the efficiency gains associated with Ricecheck already reflect important social impacts in regional rice communities because these benefits are shared between the rice growers, rice processors and input suppliers and domestic and international consumers of Australian rice. Similarly improved environmental outcomes on farms from Ricecheck such as reduced waterlogging and salinity, are reflected in these economic impacts through their effects on yields.

However, this study has also identified some largely off-farm social and environmental benefits from the Ricecheck program that are not reflected in these estimated economic impacts. While we have attempted to identify these benefits, we have not been able to put a monetary value on them.

4.1 Social Outcomes of Ricecheck

The adoption of Ricecheck recommendations would lead to some social benefits through improvements in social capital and human capital.

4.1.1 Social capital

"Social capital" refers to the social institutions and networks at a household, local and national level that influence how people interact and how those interactions influence social and economic outcomes (Grafton and Knowles 2004). Increased local social capital has been shown to improve local economic outcomes (Knack and Keefer 1997), although Grafton and Knowles (2004) found no evidence to support the hypothesis that improved social capital measured nationally is associated with improved environmental outcomes.

For an industry such as rice, the extent to which improvements in productivity are associated with improvements with local social capital is unclear. Following Stayner and Reeve (1990), the direct impacts of the increased economic welfare of the farm sector on the health of local communities is uncertain. Because the rice industry is dominant in rice-growing regions, there are likely to be strong influences between the prosperity of the rice industry and the prosperity of the broader local communities. Thus, an increase in income and capital investment resulting directly from the Ricecheck program is likely to have a flow on effects on the regional economy, which in turn will help develop social capital in terms of creation of better health, educational, recreational, sporting facilities and business opportunities for the local community as a whole. However, other forms of investment in new technologies are likely to have similar multiplier effects.

However the manner in which the Ricecheck program is delivered means that it is likely to have larger impacts on the development of social capital than many other investments in research and extension by NSW DPI. A key component of the social capital is the cohesiveness of local community activities. Ricecheck is a program where members of the discussion groups of farmers meet on a regular basis to primarily discuss issues related to the rice production. These forums also provide opportunities for them to share ideas and discuss other important local issues as well.

The Ricecheck program has helped to bring people together and to develop faith, reliability and confidence in each other, which can provide motivation and a sense of competitiveness among members of the group to achieve better results. The cohesiveness of the community also helps to address common community issues that need a collective approach, such as salinity management and water sharing for the protection of river health.

4.1.2 Development of human capital

The participative approach followed by the Ricecheck program, which encourages rice farmers to actively and more closely work in their paddocks and to record details of operations, expenditure and performance of the crop, has helped to achieve higher yields, better quality, improved environmental outcomes and sustainable use of resources (Lacy 1998). It has also helped farmers to develop their managerial, marketing and decision-making skills. Those skills include the ability to analyse issues and to identify problems and constraints involved in achieving the desired results. Today rice farmers and farmers groups are actively associated with different research and extension projects, research and development programs and decision making bodies of different funding committees involved in development of the rice industry.

4.2 Environmental Outcomes of Ricecheck

The adoption of some of the Ricecheck recommendations such as laser levelling, the selection of soils suitable for growing rice using EM 31 technology, and early drainage of water from rice paddocks(one week) has helped reduce water use in rice from over 18 ML/ha to about 14 ML/ha. This has not only improved water use efficiency, it has also helped reduce losses of water through deep drainage. Further, this has not only helped to minimise yield losses due to water logging but has helped in tackling serious problems of rising water tables and irrigation salinity off farm as well.

Similarly, construction of strong and high banks around rice paddocks has also helped in minimising chances of lateral drainage and reduced the chances of productivity losses to the neighbouring properties or crops.

The construction of well developed supply, drainage and recycling system not only has helped to improve water use efficiency, but it also has reduced surface runoff and pesticides or nutrient residues entering regional drains (Lacy *et al.* 2004). Although many other programs and agencies are promoting the use of these technologies and practices for efficient rice production, Ricecheck has also contributed significantly in the adoption of these technologies and practices on rice farms.

The split nitrogen application strategy for rice production has helped in preventing over-fertilisation and loss of nitrogen in the form of ammonia gas, thus reducing the release of greenhouse gases into the atmosphere.

We have not attempted to measure and value these off-farm environmental gains. Nor have we attempted to value the gains to other enterprises on-farm from these environmental outcomes.

4.3 Community and Industry Outcomes from Ricecheck

The extent to which the benefits from the Ricecheck program are shared between the rice industry and the Australian community has implications for public support for rice extension. Important economic, social and environmental outcomes were identified above. Many of the economic benefits from the Ricecheck program clearly flow to producers, but some industry benefits are also likely to flow to input suppliers, processors and consumers within the rice industry. Estimates of these economic benefits are likely to include some private social and environmental outcomes.

However as we have seen there are important social and environmental outcomes from Ricecheck that spill over to the broader community and these provide a basis for some level of continuing public support.

Overall, improved rice productivity that comes from the Ricecheck program has benefits for industry and for the community. We have seen that there is a mix of public and industry funding for Ricecheck. There are some important environmental and social benefits that we have not been able to quantify. If overall the industry captures a larger share of the benefits of the Ricecheck program than does the community, it would be expected that industry would fund the larger share of the cost of the Ricecheck program. However, given the extent of unmeasured benefits, it is unclear how the total benefits are distributed. Institutional arrangements have been in place for many years for RIRDC and its predecessors to collect levies for funding research and development such as Ricecheck. As shown above, on average over the whole period, 71% of R&D funds have come from public sources, while 29% has come from industry.

5. Discussion and Implications

As part of a continuing process by which NSW DPI evaluates the economic, environmental and social impacts of its significant investments in research and extension, we have evaluated the Ricecheck program. The Ricecheck program is largely an extension activity rather than a research activity. As an extension program, Ricecheck differs from the research projects, in terms of the economic impacts, because its benefits are more immediate and begin from the first season of its operation. Extension programs are often seen as 'speeding up' the adoption of new technology.

While the Ricecheck program has been a significant component of the total rice extension effort over the past 20 years or so, it has not constituted the sole source of extension information in the rice industry. Thus, in this evaluation, our aim has been to evaluate Ricecheck rather than the larger rice extension effort.

The distinctive feature of the Ricecheck program is the identification of key "checks", the achievement of which is confidently expected to lead to higher rice yields. The focus of 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.

The Ricecheck program has been evaluated from 1986, when it was first introduced to farmers in the Finley district. To ensure that data could be obtained, and to avoid the difficulties facing the rice industry in more recent seasons from the lack of 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 spillover 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. 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 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 decline 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 2.7). 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 study has not considered any costs involved in buying heavy machinery and implements that may be required to complete some of the different operations on time.

The present value of the investment in Ricecheck over the period from 1986 to 2002 is $3.8 million (in real 2002 dollars). Over two-thirds of this has been in kind contribution from NSW DPI staff, with 29% 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 from 1986 to 2002 is estimated to have provided a return of $18.00.

Sensitivity analysis of the outcomes shows that, without any partial adoption, the Ricecheck program would have had a benefit-cost ratio considerably lower than 18.0 (see Table 3.10). 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.

The on-farm economic benefits we have estimated also include some social and environmental benefits to farmers and the rice industry. However, this study has also

identified some on and off-farm social and environmental benefits from the Ricecheck program that have not been incorporated into the economic evaluation.

The delivery of the Ricecheck program through discussions groups and the human capital developed though training in monitoring and evaluation of the rice crops has led to improvements in social capital, particularly at a community level. Such improvements in social capital are likely to lead to the creation of better health, educational, recreational, and business opportunities for the local community as a whole.

Environmental outcomes from Ricecheck that are of value to the community are likely to include: (a) a reduction in deep drainage/seepage, (b) a reduction in losses through surface runoff; (c) a reduction in pollution from pesticides and fertilisers and (d) a reduction in greenhouse gas emissions. Although commercial irrigation companies have taken a leading role and provided incentives to promote the use of technologies and practices for improved water use efficiency and environmental outcomes, the Ricecheck program has also contributed importantly in the adoption of these technologies and practices on rice farms.

One impact not measured in this study is the role that Ricecheck has played in developing NSW DPI's reputation within the rice industry. Industry authorities recognise that the success of the program has improved credibility of the NSW DPI extension staff working on rice, and that has helped in the increased credibility of other research on rice.

The R&D funding and in-kind inputs into the Ricecheck program were provided by NSW DPI (71%), and the RIRDC and its predecessor the Irrigation Research and Extension Committee (IREC) (29%). The benefits of Ricecheck have flowed to both industry and the community. Industry captures a larger share of the quantified economic benefits of the program than does the community, while the community has captured the majority of the unmeasured environmental and social benefits.

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.

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Appendix A: Description of Key Ricecheck Recommendations

Key Check 1: Field layout

- Develop a good field layout with a landformed, even grade between banks and well constructed banks of a minimum height of 40 cm (measured at the lowest point).

Key Check 2: Sowing time

- Sowing on time during ideal sowing window for each variety

Key Check 3: Crop establishment

- Undertake major field layout improvements (landforming and bank construction) prior to winter
- Start ground preparation (vegetation control and / or cultivations) early enough to ensure sowing on time.
- Provide a level service with enough roughness or cloddiness to suit the sowing method.
- Sow 125-150 kg seed /ha when aerial sowing and 135-170 kg seed/ha when drill sowing.

Achieve 200-300 plants/m^2 established through the permanent water to ensure uniform crop establishment over 100% of the area.

Key Check 4: Crop protection

- Prepare the field to minimise weed and snail numbers at sowing.
- Apply only registered or approved pesticides to control weeds and insect pests to prevent economic yield loss.
- Monitor herbicide resistance and implement recommended strategies.

Key Check 5: Crop nutrition - Pre-flood nitrogen

- Pre-flood nitrogen - apply sufficient nitrogen to achieve the target range nitrogen uptake at PI so that PI topdressing requirement does not exceed 60 kg N/ha.

Key Check 6: Crop nutrition - Panicle initiation nitrogen

- PI nitrogen – Topdress nitrogen based on fresh weight and NIR analysis using the Rice NIR Tissue Test and / or ‘MaNage rice’.

Key Check 7: Panicle initiation date

- Achieve PI before 10th January for each variety.

Key Check 8: Water management

- Apply shallow water (3-5 cm on the high side of each bay) during establishment and tillering.
- Achieve 10-15 cm on the high side of each bay at the panicle initiation.
- Achieve a minimum water depth of 20-25cm during early pollen microspore stage.
- Drain at the right time to ensure grains mature properly and prevent the crop haying off.

For more detailed information see the ***Ricecheck Recommendations Guide*** (Lacy *et al.* 2004).

Appendix B: Number of Key Checks Achieved by Growers

Appendix Table B.1: Murrumbidgee Valley

Murrumbidgee Irrigation Area (MIA)

Checks	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	1	0	0
1	0	0	1	1	2	3	4	6	7	3	0	1	1	0	1	1	0
2	0	1	2	4	6	9	12	16	20	10	10	8	3	9	19	3	15
3	0	1	2	4	6	9	11	15	19	25	31	21	10	18	38	29	27
4	0	1	2	4	6	9	11	15	19	53	36	17	18	33	44	45	56
5	0	1	1	2	4	5	7	10	12	35	39	23	35	43	40	65	33
6	0	1	1	2	3	5	6	8	10	37	22	27	21	31	36	35	10
7	0	0	0	1	1	2	2	3	4	3	11	6	9	4	15	24	6
8	0	0	0	0	0	0	0	0	0	0	3	0	2	0	5	2	2
Total	*0*	*5*	*9*	*18*	*28*	*41*	*55*	*74*	*92*	*167*	*152*	*103*	*99*	*138*	*199*	*204*	*149*

Coleambally Irrigation Area (CIA)

Checks	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
1	0	0	1	2	2	4	6	8	9	1	0	4	0	0	2	2	3
2	0	0	1	1	2	3	5	6	7	9	8	7	1	0	6	2	4
3	0	1	2	4	6	11	15	19	23	22	12	20	5	1	14	7	15
4	0	1	2	5	7	13	19	24	29	31	24	30	27	9	21	22	12
5	0	1	1	3	4	8	11	14	17	34	36	9	31	23	38	27	14
6	0	1	1	2	3	6	9	11	13	30	21	7	35	18	22	26	6
7	0	0	1	1	2	3	4	5	6	12	8	3	12	7	6	12	1
8	0	0	0	0	1	1	1	2	2	1	3	0	4	1	0	1	0
Total	*0*	*4*	*9*	*18*	*27*	*49*	*71*	*88*	*106*	*140*	*112*	*80*	*115*	*59*	*110*	*99*	*55*

Appendix B (continued): Number of Key Checks Achieved by Growers

Appendix Table B.2: Murray Valley

Eastern Murray Valley (EMV)

Checks	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
0	1	1	2	3	4	4	5	6	7	1	2	0	0	0	0	0	0
1	2	2	3	5	7	8	10	11	13	2	9	13	0	2	5	3	1
2	4	5	10	14	19	24	29	33	38	19	25	30	4	11	17	8	21
3	5	6	12	18	24	29	35	41	47	29	53	62	27	30	43	33	29
4	7	8	16	24	32	39	47	55	63	67	59	80	51	60	63	75	62
5	6	6	12	18	25	31	37	43	49	58	70	84	64	52	82	88	61
6	3	4	7	11	14	18	21	25	28	67	48	43	46	48	57	68	36
7	1	2	3	5	6	8	9	11	12	36	15	10	29	25	16	27	13
8	0	0	0	0	0	0	0	0	0	8	3	0	5	6	3	7	3
Total	*30*	*32*	*64*	*96*	*129*	*161*	*193*	*225*	*257*	*287*	*284*	*322*	*226*	*234*	*286*	*309*	*226*

Western Murray Valley (WMV)

Checks	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
0	0	0	0	1	1	1	1	1	1	0	0	0	0	0	0	0	0
1	0	1	2	4	5	5	5	6	7	4	3	4	0	2	0	0	0
2	0	3	5	10	15	15	15	18	20	12	15	16	5	5	7	6	21
3	0	3	7	14	20	20	20	24	27	22	24	22	13	20	34	18	14
4	0	3	5	10	15	15	15	18	20	37	31	29	26	52	35	46	45
5	0	1	2	4	6	6	6	7	8	37	22	33	33	48	39	74	39
6	0	1	1	3	4	4	4	4	5	29	11	23	43	32	13	45	19
7	0	0	1	1	2	2	2	2	2	10	5	4	13	13	5	19	3
8	0	0	0	1	1	1	1	1	1	1	0	0	0	0	1	3	0
Total	*0*	*11*	*23*	*46*	*68*	*68*	*68*	*80*	*91*	*152*	*111*	*131*	*133*	*172*	*134*	*211*	*141*

Appendix C: Estimation of Additional Costs of Adoption of Ricecheck Recommendations

No. ha in paddock	30
Yield with 8 checks	10.1
Yield with 0 checks	8.7
Average yield gain (t/ha) from each check	0.175
Average seed rate (kg/ha)	150
Additional seed for meeting check	40
Cost of tissue testing	$60
Time sampling for tissue test (hours/crop)	3
Farmer labour cost	$25

Operation	Years of life	$/paddock	$/year	$/kg	$/tonne	$/ ha	% for rice	Check cost ($/ha)
Harvesting cost $/t	1				$22.50	$3.94		$3.94
Extra seed cost (@40kg/ha)	1			$0.22		$8.80		$8.80
Additional aerial sowing cost	1					$27.50		$7.33
Cost of raising bank height	20	$520	$26.00			$0.88		$0.88
Cost of reforming banks	1					$0.93		$0.93
Changing concrete stops to stop water	20	$700	$35.00			$1.19		$1.19
Tissue testing	1	$135				$4.57		$4.57
Laser levelling for 20 years	20					$500.00	50%	$12.50
Total extra costs for 8 checks								$40.14
Cost per check								**$5.02**

Appendix D: Staff of NSW Department of Primary Industries involved in Ricecheck Program, 2004-05

Extension

- John Lacy — Technical Specialist Yanco
- May Fleming — District Agronomist Barham
- Mary-Anne Lattimore — District Agronomist Yanco
- Matt McRae — District Agronomist Finley
- Alexandra Murray — District Agronomist Deniliquin
- Kieran O'Keefe — District Agronomist Coleambally
- Andrew Schipp — District Agronomist Hay
- Rachael Whitworth — District Agronomist Griffith
- Felicity Steel — Technical Office, Finley

Research

- Laurie Lewin — Director, Rice CRC, Yanco
- Russell Reinke — Rice Breeder, Yanco
- Peter Snell — Rice Breeder, Yanco
- Geoff Beecher — Research Agronomist, Yanco
- Ranjith Subasinghe — Research Agronomist, Yanco
- Kathryn Fox — Research Agronomist, Yanco

Appendix E: Resources Invested in Ricecheck

Appendix E1: Labour Inputs for Ricecheck Program

	Year of harvest																
	1986	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
Labour input (days / year)																	
Project leader	42	38	38	37	44	39	39	39	40	40	63	61	55	51	46	53	53
District Agronomists	22	66	110	154	220	220	220	220	220	220	220	220	220	220	220	220	220
Program Leader	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
- Extension resources	*79*	*119*	*163*	*206*	*279*	*274*	*274*	*274*	*275*	*275*	*298*	*296*	*290*	*286*	*281*	*288*	*288*
Rice researchers	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
Technical Officer	20	20	220	220	220	220	220	220	220	220	220	220	220	220	220	220	220
- Total research and extension	*114*	*154*	*398*	*441*	*514*	*509*	*509*	*509*	*510*	*510*	*533*	*531*	*525*	*521*	*516*	*523*	*523*
Value of Labour Inputs ($'000 per year)																	
Project leader	$16	$14	$14	$14	$16	$15	$15	$15	$15	$15	$24	$23	$21	$19	$17	$20	$20
District Agronomists	$8	$23	$39	$54	$77	$77	$77	$77	$77	$77	$77	$77	$77	$77	$77	$77	$77
Program Leader	$6	$6	$6	$6	$6	$6	$6	$6	$6	$6	$6	$6	$6	$6	$6	$6	$6
- Extension resources	*$30*	*$44*	*$59*	*$75*	*$100*	*$98*	*$98*	*$98*	*$99*	*$99*	*$107*	*$107*	*$104*	*$103*	*$101*	*$104*	*$104*
Rice researchers	$7	$7	$7	$7	$7	$7	$7	$7	$7	$7	$7	$7	$7	$7	$7	$7	$7
Technical Officer	$6	$6	$63	$63	$63	$63	$63	$63	$63	$63	$63	$63	$63	$63	$63	$63	$63
- Total research and extension	*$42*	*$56*	*$129*	*$144*	*$170*	*$168*	*$168*	*$168*	*$168*	*$168*	*$177*	*$176*	*$174*	*$173*	*$171*	*$173*	*$173*

Appendix E: Resources Invested in Ricecheck

Appendix E2: Labour Inputs from Farmers for Ricecheck Adoption

	Year of harvest																
	1986	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
Labour Inputs (days per year)																	
Full adopters																	
Record-keeping	0.0	0.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Discussions groups	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
Crop monitoring	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Meetings	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
- Total hours per crop	*5.7*	*5.7*	*8.7*	*8.7*	*8.7*	*8.7*	*8.7*	*8.7*	*8.7*	*8.7*	*8.7*	*8.7*	*8.7*	*8.7*	*8.7*	*8.7*	*8.7*
Informal adopters																	
Record-keeping	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Discussions groups	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
Crop monitoring	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Meetings	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
- Total hours per crop	*5.7*	*5.7*	*5.7*	*5.7*	*5.7*	*5.7*	*5.7*	*5.7*	*5.7*	*5.7*	*5.7*	*5.7*	*5.7*	*5.7*	*5.7*	*5.7*	*5.7*
Awareness adopters																	
Reading Ricecheck Booklet	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Crop monitoring	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
- Total hours per crop	*3.0*	*3.0*	*3.0*	*3.0*	*3.0*	*3.0*	*3.0*	*3.0*	*3.0*	*3.0*	*3.0*	*3.0*	*3.0*	*3.0*	*3.0*	*3.0*	*3.0*
Total Farmer Inputs (days per year)																	
Full adopters	24	43	131	221	312	396	481	580	679	927	819	790	712	749	906	1,023	710
Informal adopters	49	86	171	290	409	519	630	760	889	1,215	1,073	1,036	933	982	1,187	1,340	930
Awareness adopters	26	45	90	153	215	273	332	400	468	639	565	545	491	517	625	705	489
- Total	***99***	***173***	***392***	***663***	***935***	***1,189***	***1,442***	***1,739***	***2,036***	***2,782***	***2,457***	***2,371***	***2,136***	***2,248***	***2,718***	***3,069***	***2,129***
Value of Farmer Labour Inputs ($'000 per year)																	
Full adopters	$4	$7	$23	$39	$55	$69	$84	$101	$119	$162	$143	$138	$125	$131	$159	$179	$124
Informal adopters	$9	$15	$30	$51	$71	$91	$110	$133	$156	$213	$188	$181	$163	$172	$208	$235	$163
Awareness adopters	$5	$8	$16	$27	$38	$48	$58	$70	$82	$112	$99	$95	$86	$90	$109	$123	$86
- Total	**$17**	**$30**	**$69**	**$116**	**$164**	**$208**	**$252**	**$304**	**$356**	**$487**	**$430**	**$415**	**$374**	**$393**	**$476**	**$537**	**$373**

Appendix F: Yield Gains from Ricecheck for Different Periods

Number of key checks	Smoothed yield (t/ha)	Yield without Ricecheck (t/ha)	Gains from Ricecheck (t/ha)
1986 - 1990			
0	8.70	8.70	0.00
1	8.88	8.70	0.18
2	9.05	8.70	0.35
3	9.23	8.70	0.53
4	9.40	8.70	0.70
5	9.58	8.70	0.88
6	9.75	8.70	1.05
7	9.93	8.70	1.23
8	10.10	8.70	1.40
1991 - 1995			
0	8.70	8.88	0.00
1	8.88	8.88	0.00
2	9.05	8.88	0.18
3	9.23	8.88	0.35
4	9.40	8.88	0.53
5	9.58	8.88	0.70
6	9.75	8.88	0.88
7	9.93	8.88	1.05
8	10.10	8.88	1.23
1996 - 2000			
0	8.70	9.05	0.00
1	8.88	9.05	0.00
2	9.05	9.05	0.00
3	9.23	9.05	0.18
4	9.40	9.05	0.35
5	9.58	9.05	0.53
6	9.75	9.05	0.70
7	9.93	9.05	0.88
8	10.10	9.05	1.05
2001 - 2002			
0	8.70	9.23	0.00
1	8.88	9.23	0.00
2	9.05	9.23	0.00
3	9.23	9.23	0.00
4	9.40	9.23	0.18
5	9.58	9.23	0.35
6	9.75	9.23	0.53
7	9.93	9.23	0.70
8	10.10	9.23	0.88

Appendix G: Calculation of Benefits of Achieving Key Checks in Ricecheck

Checks	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Benefits from Achieving Checks (t/ha)																	
1	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
2	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
3	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53
4	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70
5	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
6	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05
7	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23
8	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40
Benefits Achieved Without Ricecheck (t/ha)																	
1	0.00	0.00	0.00	0.00	0.00	0.18	0.18	0.18	0.18	0.18	0.35	0.35	0.35	0.35	0.35	0.53	0.53
2	0.00	0.00	0.00	0.00	0.00	0.18	0.18	0.18	0.18	0.18	0.35	0.35	0.35	0.35	0.35	0.53	0.53
3	0.00	0.00	0.00	0.00	0.00	0.18	0.18	0.18	0.18	0.18	0.35	0.35	0.35	0.35	0.35	0.53	0.53
4	0.00	0.00	0.00	0.00	0.00	0.18	0.18	0.18	0.18	0.18	0.35	0.35	0.35	0.35	0.35	0.53	0.53
5	0.00	0.00	0.00	0.00	0.00	0.18	0.18	0.18	0.18	0.18	0.35	0.35	0.35	0.35	0.35	0.53	0.53
6	0.00	0.00	0.00	0.00	0.00	0.18	0.18	0.18	0.18	0.18	0.35	0.35	0.35	0.35	0.35	0.53	0.53
7	0.00	0.00	0.00	0.00	0.00	0.18	0.18	0.18	0.18	0.18	0.35	0.35	0.35	0.35	0.35	0.53	0.53
8	0.00	0.00	0.00	0.00	0.00	0.18	0.18	0.18	0.18	0.18	0.35	0.35	0.35	0.35	0.35	0.53	0.53
Net Benefits of Achieving Key Checks in Ricecheck (t/ha)																	
1	0.18	0.18	0.18	0.18	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.35	0.35	0.35	0.35	0.35	0.18	0.18	0.18	0.18	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.53	0.53	0.53	0.53	0.53	0.35	0.35	0.35	0.35	0.35	0.18	0.18	0.18	0.18	0.18	0.00	0.00
4	0.70	0.70	0.70	0.70	0.70	0.53	0.53	0.53	0.53	0.53	0.35	0.35	0.35	0.35	0.35	0.18	0.18
5	0.88	0.88	0.88	0.88	0.88	0.70	0.70	0.70	0.70	0.70	0.53	0.53	0.53	0.53	0.53	0.35	0.35
6	1.05	1.05	1.05	1.05	1.05	0.88	0.88	0.88	0.88	0.88	0.70	0.70	0.70	0.70	0.70	0.53	0.53
7	1.23	1.23	1.23	1.23	1.23	1.05	1.05	1.05	1.05	1.05	0.88	0.88	0.88	0.88	0.88	0.70	0.70
8	1.40	1.40	1.40	1.40	1.40	1.23	1.23	1.23	1.23	1.23	1.05	1.05	1.05	1.05	1.05	0.88	0.88

Appendix G (continued): Calculation of Benefits of Achieving Key Checks in Ricecheck

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Price ($/t)	$267	$252	$319	$279	$221	$256	$218	$262	$340	$293	$287	$257	$251	$250	$263	$205	$250
Value of Benefits from Crops Achieving Different Checks ($/ha)																	
1	$47	$44	$56	$49	$39	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2	$93	$88	$112	$98	$77	$45	$38	$46	$59	$51	$0	$0	$0	$0	$0	$0	$0
3	$140	$132	$168	$146	$116	$90	$76	$92	$119	$103	$50	$45	$44	$44	$46	$0	$0
4	$187	$176	$223	$195	$154	$134	$114	$138	$178	$154	$100	$90	$88	$88	$92	$36	$44
5	$233	$221	$279	$244	$193	$179	$152	$183	$238	$205	$150	$135	$132	$132	$138	$72	$87
6	$280	$265	$335	$293	$232	$224	$190	$229	$297	$256	$201	$180	$175	$175	$184	$108	$131
7	$327	$309	$391	$342	$270	$269	$229	$275	$357	$308	$251	$225	$219	$219	$231	$144	$175
8	$373	$353	$447	$390	$309	$313	$267	$321	$416	$359	$301	$270	$263	$263	$277	$180	$218
Costs of Adopting Different Checks with Ricecheck ($/ha)																	
1	$5	$5	$5	$5	$5	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2	$10	$10	$10	$10	$10	$5	$5	$5	$5	$5	$0	$0	$0	$0	$0	$0	$0
3	$15	$15	$15	$15	$15	$10	$10	$10	$10	$10	$5	$5	$5	$5	$5	$0	$0
4	$20	$20	$20	$20	$20	$15	$15	$15	$15	$15	$10	$10	$10	$10	$10	$5	$5
5	$25	$25	$25	$25	$25	$20	$20	$20	$20	$20	$15	$15	$15	$15	$15	$10	$10
6	$30	$30	$30	$30	$30	$25	$25	$25	$25	$25	$20	$20	$20	$20	$20	$15	$15
7	$35	$35	$35	$35	$35	$30	$30	$30	$30	$30	$25	$25	$25	$25	$25	$20	$20
8	$40	$40	$40	$40	$40	$35	$35	$35	$35	$35	$30	$30	$30	$30	$30	$25	$25
Net Benefit from Achieving Different Checks with Ricecheck ($/ha)																	
1	$42	$39	$51	$44	$34	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2	$83	$78	$102	$88	$67	$40	$33	$41	$54	$46	$0	$0	$0	$0	$0	$0	$0
3	$125	$117	$152	$131	$101	$80	$66	$82	$109	$93	$45	$40	$39	$39	$41	$0	$0
4	$167	$156	$203	$175	$134	$119	$99	$123	$163	$139	$90	$80	$78	$78	$82	$31	$39
5	$208	$196	$254	$219	$168	$159	$132	$163	$218	$185	$135	$120	$116	$116	$123	$62	$77
6	$250	$235	$305	$263	$202	$199	$165	$204	$272	$231	$181	$160	$155	$155	$164	$93	$116
7	$291	$274	$356	$306	$235	$239	$198	$245	$327	$278	$226	$200	$194	$194	$205	$124	$155
8	$333	$313	$407	$350	$269	$278	$232	$286	$381	$324	$271	$240	$233	$233	$247	$155	$193

Appendix G (continued): Calculation of Benefits of Achieving Key Checks in Ricecheck Benefits from Full Adoption

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Average crop size	25	26	28	27	29	23	29	29	29	28	31	33	31	32	31	37	33
Net Benefit from Achieving Different Checks with Ricecheck ($ per crop)																	
1	$1,038	$1,000	$1,426	$1,195	$976	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2	$2,076	$2,000	$2,853	$2,391	$1,953	$924	$950	$1,177	$1,587	$1,304	$0	$0	$0	$0	$0	$0	$0
3	$3,113	$2,999	$4,279	$3,586	$2,929	$1,848	$1,900	$2,354	$3,174	$2,609	$1,413	$1,327	$1,185	$1,250	$1,272	$0	$0
4	$4,151	$3,999	$5,706	$4,782	$3,905	$2,772	$2,850	$3,532	$4,760	$3,913	$2,826	$2,653	$2,371	$2,500	$2,544	$1,141	$1,260
5	$5,189	$4,999	$7,132	$5,977	$4,882	$3,696	$3,800	$4,709	$6,347	$5,218	$4,239	$3,980	$3,556	$3,749	$3,817	$2,281	$2,519
6	$6,227	$5,999	$8,559	$7,172	$5,858	$4,620	$4,750	$5,886	$7,934	$6,522	$5,652	$5,307	$4,742	$4,999	$5,089	$3,422	$3,779
7	$7,264	$6,998	$9,985	$8,368	$6,834	$5,545	$5,700	$7,063	$9,521	$7,827	$7,065	$6,633	$5,927	$6,249	$6,361	$4,562	$5,038
8	$8,302	$7,998	11,412	$9,563	$7,811	$6,469	$6,650	$8,241	11,107	$9,131	$8,477	$7,960	$7,113	$7,499	$7,633	$5,703	$6,298
Net Benefit from Achieving Different Checks with Ricecheck ($'000)																	
1	$2	$3	$9	$13	$16	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2	$9	$17	$49	$70	$82	$47	$57	$85	$135	$65	$0	$0	$0	$0	$0	$0	$0
3	$17	$33	$96	$139	$162	$127	$156	$233	$368	$256	$170	$166	$65	$86	$164	$0	$0
4	$31	$50	$143	$202	$232	$211	$265	$396	$624	$736	$424	$414	$289	$385	$415	$214	$220
5	$30	$42	$120	$165	$187	$184	$233	$347	$546	$856	$708	$593	$580	$622	$760	$579	$370
6	$20	$31	$88	$123	$141	$147	$187	$281	$444	$1,063	$576	$531	$688	$645	$651	$595	$268
7	$10	$15	$44	$61	$70	$75	$96	$144	$228	$477	$276	$153	$373	$306	$267	$374	$116
8	$0	$2	$5	$8	$10	$11	$14	$21	$33	$91	$76	$0	$78	$52	$69	$74	$31
Total	*$119*	*$194*	*$554*	*$782*	*$898*	*$802*	*$1,009*	*$1,507*	*$2,379*	*$3,544*	*$2,230*	*$1,856*	*$2,073*	*$2,097*	*$2,326*	*$1,838*	*$1,006*
Farmer time	*$4*	*$7*	*$23*	*$39*	*$55*	*$69*	*$84*	*$101*	*$119*	*$162*	*$143*	*$138*	*$125*	*$131*	*$159*	*$179*	*$124*
Total Net benefits	**$114**	**$187**	**$531**	**$743**	**$844**	**$733**	**$925**	**$1,406**	**$2,260**	**$3,382**	**$2,086**	**$1,718**	**$1,949**	**$1,966**	**$2,167**	**$1,658**	**$882**

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