An evaluation of the economic, social and environmental impacts of the Cooperative Research Centre for Sustainable Rice Production.

This independent study was conducted by Dr Harry Nesbitt. It was commissioned by the Cooperative Research Centre for Sustainable Rice Production. February, 2003.

Harry Nesbitt
117 Heytesbury Road,
Subiaco, WA, 6008
h.nesbit@bigpond.net.au

Contents

Executive summary

This report summarises some of the impacts the Cooperative Research Centre for Sustainable Rice Production (Rice CRC) has had on achieving its objectives of contributing to the rice industry during the first five years of its life.

Specifically, the Rice CRC was assessed to see if it had:

a) generated technology that has been applied in the field,
b) resulted in technology which has impacted on the environment
c) advanced the knowledge of the scientific and general community,
d) benefited or will benefit the end users of technology economically and financially
e) generated strategically important knowledge,
f) communicated the technology effectively to stakeholders
g) effectively catered for gender specific issues
h) effectively promoted the philosophy of closer collaboration between stakeholders
i) built into the CRC, a level of sustainability of its programs

Although there were initial problems with some programs and on-going staff changes, the programs appeared to be well funded and staffed. A major proportion (71%) of the resources were spent on research with the remainder being reasonably distributed across education, commercialisation and administration. Approximately 44% of all personnel were professional researchers and 25% students.

The CRC was responsible for setting up excellent linkages, which in turn improved cooperation between sectors of research, education and industry. This was reflected in the number of projects with numerous linkages and multiple authorship of published material.

The CRC supported education through its vocational, undergraduate and post graduate programs. CRC sponsored courses resulted in over 1000 undergraduates receiving training in water management. Most (59%) of the 88 assessed CRC projects involved post graduate students or were specific education projects, indicating a strong educational bias within the centre activities.

Approximately 41% of all non administrative projects conducted research and development projects impacting on the environment. Similarly, 40% are considered to have or will contribute to improving the economics of the rice industry. A very conservative estimate of this contribution is currently $7 million per annum, but this amount can easily expand into tens or even hundreds of millions per year when CRC developed technologies are adopted or conditions change. All of the non administrative projects have or will generate information that will be useful to the scientific community in the future.

The Rice CRC was indirectly responsible for leveraging a considerable level of funds for rice based research and its existence encouraged institutions to invest in equipment and or human resources for such purposes. The level of external funding for rice based research and irrigation education is expected to expand in the future.

Technologies developed by the CRC were not considered to possess any gender bias and women in the CRC enjoyed higher levels of participation in research, research management and education than the industry in general.

Expertise was attracted from Asia and the middle east, resulting in a good representation from different ethnic groups working together on rice based research activities.

The CRC sponsored almost half of the research and support staff during the first five years of the centre's life. Retaining this level of staff activity after the CRC terminates will not be sustainable at current funding levels. External funds from other organisations will assist this process. In general, however, many of the personnel will return to work in government and industry positions. Rice based research will continue after the end of the CRC but at a lower level. The industry will miss the linkages developed by association with the CRC.

Fifteen conclusions from the study are documented in Section 6 of this report.

Acknowledgments

This report would not have been possible without the data tabulation efforts of Ms Julie Symes and Mr Gordon Hart. Their considerable effort during this process is gratefully acknowledged. Thanks also to Dr Laurie Lewin for his helpful guidance and for the patience of the program leaders, sub program leaders, project leaders, students and all other interviewees throughout the preparation of this document.

1 Introduction

1.1 The Australian Government CRC program and the CRC for Sustainable Rice Production

The goal of the Cooperative Research Centre program is to strengthen long term collaboration between research organisations and between these organisations and the users of research in order to obtain greater benefits from Australia's investment in research and development (Mercer and Stocker, 1998). At it's inception in 1990, the program was particularly interested in strengthening linkages between industry, research organisations, educational institutions and government agencies (www.crc.gov.au). The CRC for Sustainable Rice Production (from here on termed as the Rice CRC) is an unincorporated joint venture established in 1997 with a mission to "increase the economic, environmental and social sustainability of the Australian rice industry and enhance its international competitiveness through both strategic and tactical research and implementation of practical, cost effective programs". Its partners represent industry, research organisations, educational institutions and government agencies as follows:

Ricegrowers' Co-operative Limited (RCL)
Commonwealth Scientific and Research Organisation (CSIRO)
Rural Industries Research and Development Cooperation (RIRDC)
Charles Sturt University (CSU)
The University of Sydney (UniSyd)
NSW Department of Land and Water Conservation (DLWC)
New South Wales Agriculture (NSWAg)

Funding for the operation of the CRC is provided by the Australian Government, Department of Industry, Science and Tourism through the CRC program, the above CRC partners plus other organisations.

The Rice CRC manages its activities through five research and education programs plus a management component. The five research organisations are as follows:

a) Sustainability of natural resources in rice based cropping systems.
b) Sustainable production systems
c) Genetic improvement for sustainable production
d) Product and process development
e) Education, skills development and technology transfer.

The programs are further divided into sub programs and under the sub programs fall individual projects. The programs, sub programs and projects all have leaders through which reporting is made to the CRC director who provides overall leadership and management. Final reporting of the CRC's achievements is made to the board of directors after approval from the management committee. The management committee is made up of the CRC

director, program leaders and representatives of other collaborative parties not represented as program leaders.

1.2 CRC monitoring and reporting

Each program has a series of milestones it endeavors to reach during the 7 year funding period. These are reported to the director on a frequent basis and documented annually in the Cooperative Research Centre for Sustainable Rice Production Annual Report (Rice CRC Annual Reports). The overall performance of the Rice CRC is also reported in the annual report using a series of performance indicators. The performance indicators fall under the titles of: a) Cooperative Arrangements, b) Research and Researchers, c) Education and Training d) Application of Research and e) Management and Budget. In most cases, the measured performance indicators report the number of opportunities or level of development but does not indicate the degree of impact the projects, sub programs or programs are having on the overall objectives of the Rice CRC. The objectives of the Rice CRC are articulated as follows:

The CRC aims to increase the contribution the rice industry makes to the national economy and the general welfare of Australians by:

Generating knowledge to improve the sustainability of the natural resources and the systems used to produce rice,

Developing germplasm which will be the basis of a sustainable increase in rice yields and quality,

Developing a more strategic base for rice research in Australia, and,

Formally linking key agencies involved in rice research, education and extension and focusing their effort on a common purpose.

1.3 Impact study objective

This study will evaluate the progress the Rice CRC has made towards making an impact on improving the economic, environmental and social sustainability of the Australian rice industry. It will focus on the degree to which the CRC has achieved its objectives during the first five and a half years of operation and look at potential for increased impact over the final one and a half years and beyond. Emphasis will be placed on whether the projects and programs contributed to a sustainable rice based industry by evaluating if they:

a) generated technology that has been applied in the field,
b) resulted in technology which has impacted on the environment
c) advanced the knowledge of the scientific and general community,
d) benefited or will benefit the end users of technology economically and financially
e) generated strategically important knowledge,
f) communicated the technology effectively to stakeholders
g) effectively catered for gender and ethnic specific issues
h) effectively promoted the philosophy of closer collaboration between stakeholders
i) built into the CRC, a level of sustainability of its programs

1.4 Impact study methodology

This study was conducted over a three week period in February, 2003. It was primarily a desk study using information reported in Rice CRC Annual Reports and other publications. All projects were initially ranked in order of research application, environmental impact, education, economic impact and whether the techniques developed during the studies contributed to further scientific endeavours. All program leaders were subsequently interviewed, as were most sub program and project leaders to discuss the ranking and progress made in each area of interest. The researchers were also interviewed on their perception of communication, gender, linkages and CRC program sustainability. In addition, progress within the rice CRC was discussed with representatives from the three irrigation companies (Colleambally [CIA], Murray [MI] and Murrumbidgee [MIA]), the RCL, Ricegrowers' Association (RGA) members, students, extension personnel and farming community.

No attempt was made at completing an extra economic study of the outcomes of the CRC, although figures are included in one table which could point economists in areas where future studies may be made when time is available. This report presents first the inputs and outputs of the CRC before discussing some of it's impacts and the sustainability of the CRC programs.

2.0 Inputs

The Rice CRC received cash inputs exceeding $12 million from its funding partners over the period from commencement in 1997 to the end of the 2002 financial year (Table 1). In-kind contributions were approximately $36 million over the same period. The total is considerably more than the original budgeted amount for the first five years ($37.7 million) due to increased in-kind payments from partners. The CRC has 2 more years from mid 2002 to spend the remaining budget.

Seventy one percent of the current expenditure has been consumed on research and the remainder was evenly distributed over education, commercialisation/technology transfer and administration with a small amount being spent on external communications. The distribution of staff follows a similar pattern to the finances, with most personnel being involved in research activities (Table 1). When personnel time was spread across institutions or programs, 44% of all personnel worked as professional researchers and 25% were students. Approximately 48% of the CRC personnel were funded by the CRC, 16% by NSWAg, 12% by RCL, 11% by CSIRO and to a lesser extent by the remaining organisations (Table 2).

Table 1 Personnel and financial support to CRC (1997-2002)

Program	Resource usage			
Total	$ Cash (1) ('000s)	$ In-kind ('000s)	Contributed Staff (2)	Cash Funded Staff (2)
Research	8,037	26,437	100	88
Education	2,338	2,406	8	12
External Communications	347	0	0	4
Commercialisation/tech transfer	71	4,621	16	2
Administration	1,579	2,377	8	16
TOTAL	12,372	35,841	132	122

(1) Cash from all sources, including CRC program
(2) Person years of professional staff

About 25% of the professional research staff worked on projects in Program 1, 17% on Program 2, 20% in Program 3, 11% in Program 4 and the 22% in Program 5. Post graduate student representation was reasonably spread across Programs 1-3 (12, 17, 16 students respectively) with three conducting studies in Program 4 and 2 in Program 5. (To be discussed further in Section 3.3). Some programs suffered heavy staff turnover in the first few years and Project 4 faced some difficulties overcoming the company recruitment policy regarding hiring new personnel. Overall, however, the projects were well funded and staffed.

Table 2 Source of personnel (1997-2002)

a) By organisation (Research and support staff)

Source	CRC	NSWAg	RCL	CSIRO	Other	CSU	DLWC	Syd Uni	TOTAL
Number of person years	122	40	30	27	12	11	7	5	254

b) By research program

	Total years for professional researchers	Total years for tech support staff	Total years for post grad students	TOTAL
Program 1	37	25	17	79
Program 2	25	16	31	72
Program 3	29	12	24	65
Program 4	16	27	8	51
Program 5	32	9	3	44
Program 6	8	16	0	24
TOTAL	147	105	83	335

3.0 Outputs and Outcomes

Collaborative research links between industry, research organisations, education institutions and government agencies are represented in the rice CRC through the RCL (industry), research organisations and providers include CSIRO and RIRDC, government organisations through NSWAg, DLWC and educational institutions include CSU and UniSyd.

Performance indicators to the success of the Rice CRC assigned during the contract process fall under a) Cooperative arrangements, b) Research and researchers, c) Education and training, d) Application of research and e) Good management and budget.

3.1 Cooperative arrangements

The Rice CRC provided the opportunity for different organisations to work together. The level of interaction between projects was extremely high when formal linkages were assessed. Of those reporting in the 2001/2002 Rice CRC Annual Report, most projects had at least 2 or more formal collaborating agencies (Table 3). In addition, a number of informal relationships existed which are not included in the list. For example the two projects reporting to be operating without linkages were postgraduate student studies which relied on a series of interactions with farmers, and ecology groups. Researchers comment that, because of the CRC, they make more effort to work with other organisations and the participatory approach has enhanced the application of their studies.

Table 3 Collaborating agencies. Projects with linkages.

No. of linkages	None	1	2	3	4	5	6	7 or more
No. of projects	2	14	10	8	6	3	3	6

3.2 Research and researchers.

Researchers are evaluated by the number of publications and papers they have released, the number of techniques patented, by the level of communication of this information and on the application of the technology they developed.

Personnel working with the Rice CRC published 41 papers in refereed journals during the five years up to the end of June, 2002 (Table 4). This number may expand over the final two and a half years of the project to rival the 265 refereed papers published by the Cooperative Research Centre for Legumes in Mediterranean Agriculture (CLIMA) during their 7 year contract (Abadi et al 2001). Rice CRC personnel communicated their research results more effectively at conferences and workshops (87 papers and proceedings) than with refereed contributions and were involved with the production of a number of technical reports and trade magazine articles (Table 4). The large number of non refereed publications indicated the CRC members were communicating the results of their research thoroughly. Almost all of the publications were released by Programs 1 and 2 (Table 5). This may be a reflection of the

percentage of basic research conducted by Program 3, applied commercially sensitive work conducted by the RCL in Program 4 and the educational nature of Program 5. About a quarter of all publications were authored by one person, 10% of whom were students and 17% women (Table 6). The remainder were co-authored by up to six authors or more. More than half of the publications had 3 or more authors reflecting the complex collaborative nature of some projects.

Four patents had been awarded for CRC generated techniques by mid 2002 (Table 4). One of these is being considered for commercialisation by a large industrial company. Other patents are in the pipeline. However, the expense of lodging a patent is discouraging more to be submitted.

Table 4 Publications and patents by year (1997-2002)

Year	1997-98	1998-99	1999-00	2000-01	2001-02	Total
Refereed journals		8	11	9	13	41
Books and book chapters		2			1	3
Published conference papers	4	12	10	18	21	61
Workshop proceedings	1		12		14	26
Technical reports	1	2	7	13	16	38
Trade magazines			3	7	9	19
Published theses					3	3
Patents		1		1	2	4
						195

Table 5 Publications and patents by at least one CRC author, by program

Year	Prog 1	Prog 2	Prog 3	Prog 4	Prog 5	Prog 6	Total
Refereed publications	15	19	3	4	2		41
Books and book chapters	1	2					3
Published conference papers	28	29		3		1	61
Workshop proceedings	24	2					26
Technical reports	29	8	1				38
Trade magazines	9	8	1	1			19
Published theses	3						3
Patents	3		1				4
Total	112	68	6	8	2	1	195

Table 6 Rice CRC publications by number and gender of authors

Number of authors per publication	1	2	3	4	5	6 or more	Total
Number of CRC publications	46	35	52	35	13	14	195
% including students	10	6	31	36	69	14	13
% including women authors	17	36	44	55	77	86	23
% of all 195 publications	24	17	28	17	7	7	100

The level of communication between the CRC researchers and stakeholders can be measured by their interaction with other researchers, commercial interests and farmers. The Rice CRC's interaction with other researchers, the RCL and irrigation companies was through the exchange of published work and workshops as mentioned above. Communication with farmers directly was generally on a first hand basis with various projects plus through the distribution of the CRC Rice Newsletter which is distributed to all 2000 rice farmers (Table 7). In addition, farmers could access CRC information through the CRC website, at field days and other meetings (Table 7).

Table 7 Communication of CRC material with farmers

	No. growers (approx)
Rice CRC newsletter "Rice Update" goes out to all growers with Sunrice mailout	2,000
Murrumbidgee Farm Fair	200
Henty Field Days	100
Program meetings (mainly Program 1)	10
CRC Symposium	15
Annual Rice Field Day	250-350
Individual rice field days at various locations	350-450
RRDC meetings	20
Farmers collaborating with trials:-	
Information is also conveyed to growers through RRDC representatives who disseminate information at their own Branch meetings (7 branches)	210
Programs 1 & 2	50-70
Program 4 - all growers	2,000
Project 5204 - direct collaboration	10
Project 5204 - indirect collaboration	50
Sub-Program 5.1 involves up to 50% of growers	1,000
Growers have access to CRC website directly and linked through the RGA website	500
Growers are also made aware of CRC research through the RGA newsletter	2,000

3.3 Education and Training

A total of 50 post graduate students enrolled during the period from 1997 and 2002 (Table 8). Most of the students studied at CSU and USyd with supervisors closely associated with the CRC. Drop out rates were on par with the universities general enrolment. Twelve students researched problems in Program 1, 17 in Program 2, 16 in Program 3, 3 in Program 4 and 2 in Program 5 (Table 9). Almost half (46%) of post graduates were women (Table 10). A number of undergraduate students were also trained in cereal production by CRC sponsored lecturers (Table 11). A total of 1060 received training over the four year period leading up to 2002. These courses provided the students with exposure to rice based farming systems. Some students were selected from these courses for post graduate awards.

Table 8 No. CRC post graduate students enrolled (Total of 50 students)

University	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03*
CSU	5	11	11	14	16	10
USyd	1	5	9	9	8	4
UNSW	0	1	2	2	2	0
UQ	0	2	2	2	3	1
ANU	0	0	2	2	2	1
UTS	0	0	0	2	4	1
Umelb	0	0	1	1	0	0

Does not include summer students (3 months term).
***** as at 31/1/03

Table 9 Thesis topic by CRC Sub-Program

Sub-Program No.	Sub-Program Title	No. of theses
1.2	Net recharge management	2
1.3	Surface drainage management	3
1.4	Groundwater management at the regional scale	7
2.1	Managing soil chemical, physical and biological properties to achieve yield and environmental	1
2.2	Crop management in relation to environmental	4
2.3	Mineral nutrition and grain quality	4
2.4	Sustainable crop protection	8
3.2	Tolerance to abiotic and biotic stress	8
3.3	Enhancing the technology base for rice	2
3.4	Breeding for quality attributes	6
4.3	Quality assurance systems and post-harvest pest management	1
4.5	New rice-based foods	2
5.2	Extension and information technology methods	2
	Total	50

Table 10 Student enrolment by gender (1997-98 to 2002-03*)

University	Hons		MSc		PhD	
	Total Women	Total Men	Total Women	Total Men	Total Women	Total Men
CSU	3	2		1	10	6
Usyd	2	1	1	1	3	7
UNSW						2
UQ				2		1
ANU						2
UTS			3	2		
Umelb	1					
Total	6	3	4	5	13	17

*Data for 2002-03 only as at 31/1/03.

Table 11 Number of undergraduate students involved in CRC sponsored courses

Year	1999/2000	2000/2001	2001/2002	Total
Number	571	153	336	1060

3.4 Application of Research

Developed technology was applied by researchers and extension personnel, irrigation companies, RCL and farmers. The degree by which the technology was used and the level of its effectiveness is discussed in detail in Section 4 below.

3.5 Budget

The budget is expected to expand over the seven year period by approximately $15.5 million, mostly due to an increase in in-kind contributions from partners. All partners increased their contributions to above the agreed amount at the end of June, 2002, with NSWAg providing a considerable extra amount. These over payments are reflective of the positive nature the partners perceive the contribution of the CRC.

4.0 Impact

4.1 Impact by project and program

The number of projects administered by the CRC at evaluation (February, 2003) numbered 88. These projects included components of research, education and administration.

Of these, 21 projects were in Program 1, 20 in Program 2, 19 in Program 3, 8 in Program 4, 18 in Program 5 and 2 projects in the administration Program 6. Across the CRC, fifteen projects were purely administration or capital improvement and two had just commenced. Thus, 17 of the 88 projects were not assessed as directly contributing to the number of activities in research or education.

All Rice CRC projects active in 2002/2003 were listed in Appendix 1 and evaluated whether they had significantly contributed to the CRC in terms of the following categories.

a) Generated technology that had been implemented in the field at the time of assessment (Column A). Effective technologies included those used by research personnel, irrigation companies, manufacturing or other industry or by farmers.

b) Generated technology that has or could significantly impact on the environment (Column B). Included in this category were projects that monitored changes in the environment (eg water tables and salinity), actively reduced pollution (eg bioremediation of pesticides), altered soil fertility (eg mineral requirements) or those that were designed to reduce health hazards (eg sustainable fumigation practices) or improve biodiversity in rice fields (eg frog habitats).

c) Advanced the knowledge of the scientific and general community directly through education (Column C). These were projects with a major involvement of post graduate students or were projects specialising in education. Many of Program 5 activities fall in the latter category. All research based projects are expected to report and/or extend the results of their studies and these activities are reported elsewhere.

d) Benefited or will benefit the end users of technology economically or financially (Column D). End users are considered as being farmers (eg a farmer who is able to reduce water costs or increase yields), irrigation companies (eg reduce the cost of water or cost of monitoring), manufacturers or processors (eg a reduction in milling costs or development of new products), or scientific procedure users (eg a reduction in the cost of a breeding program).

e) Developed techniques or technology which directly assisted the scientific community to conduct future research (Column E). Some projects were more successful in developing innovative techniques than others. However, it is considered that future researchers will utilise the knowledge from these studies in the design of further research programs.

A summary of the impacts detailed in Appendix 1 is presented in Table 12.

Table 12 CRC impact by program

Program	Name	Project impact by program					Total no projects
		A	B	C	D	E	
Program 1	Sustainability of natural resources	11	13	8	11***	18	21
Program 2	Sustainable production systems	11^**	12^	11	11^*	19	20
Program 3	Genetic improvement of sustainable prod'n	1*	1*	11	1*	18	19
Program 4	Product and process development	5	3	4	5	8	8
Program 5	Edu, skills dev and tech transfer	1#	0	17	0	7*	18
Program 6	Administration	0	0	1	0	1	2
	Total	29	29	52	28	71	88

Total includes 15 admin, and 2 new projects

Legend

A	Resulting technology can be implemented on farmers fields or industry
B	Developed technology will impact on the environment
C	Project impacted on education
D	Developed practices resulted in financial and/or economic impacts
E	Techniques developed that impact on future research practices
*	1 potential impact if conditions arise
***	3 potential impacts if conditions arise
^	4 potential impacts if conditions arise
^*	5 potential impacts if conditions arise
^**	6 potential impacts if conditions arise
#	Extension of technologies

4.1.1 Project impact on future research activities

Close examination of the projects summarised in Table 12 reveals that 71 of the 88 projects evaluated are considered to have contributed or will contribute to the generation of knowledge stated in the CRC objectives as being "to improve the sustainability of the natural resources and the systems used to produce rice". When the 15 administration and 2 new projects are deleted from this list, 100% of research projects can be considered as making a measurable contribution to the science (Column E in Table 12). The high number of research projects (81%) in the programs is also an indicator of the low level of administration compared with research activities.

All research programs (Programs 1-4) were equally successful in the generation of knowledge (Table 12) when program size is taken into account.

4.1.2 Implementation of project technologies

Twenty four percent of all projects have already generated technologies which are being implemented in the field and a further 9% of projects have the potential of being implemented if conditions change (Column A in Table 12). Examples of changing conditions include the possibility of disease outbreaks; the commercialisation of a newly developed product of if farmers consider that the preservation of biodiversity in his rice fields becomes a matter of priority. Improved extension techniques are also being used to deliver these technologies to end users. Having a third of all CRC projects making or potentially making a direct contribution to applied technologies in the field can be considered as being a success

story. More applied technologies are expected to be released before the CRC funding is completed.

Program 3 is primarily involved in strategic research activities and as such, there has been an apparent low level of technologies being released from it. Conducting strategic research is a slow process and it is envisaged that an increasing number of applied applications will emerge from the program in the latter years of the funding period. A high percentage of the technologies developed in Programs 1,2 and 4 have already been applied and more have been developed for future implementation.

4.1.3 Projects impacting on the environment

Approximately one third of all projects (41% of non administrative projects) conducted research and developed technologies which have or will impact on the environment (Column B in Table 12). These projects help "improve the sustainability of the natural resources and the systems used to produce rice". The range of projects reflects the complexity of the rice ecosystem and the environmental direction of the programs. Almost all of the CRC's projects impacting on the environment were located in Programs 1 and 2, a reflection of their environmental bias.

Considerable impacts were made on improving strategies for the more efficient management of water (Projects 1102, 1105, 1107, 1401, 1204, 1207, 2102, 2201), optimising agronomic options for water control (Projects 1201, 2105) control of salinity (Projects 1403, 1404), a reduction in the level of pesticides in irrigation water, (Projects 1301,1302,1303,1304), soil improvement through improving the mineral balance (Projects 2106, 2302, 2303), the development of sustainable pest control techniques (Projects 2403, 2404, 2405, 2407, 2409, 3203), and the preservation of biodiversity in the environment (Project 2408).

4.1.4 Education projects

Quite a high percentage of all projects possessed a component of formal education (Column C in Table 12). Fifty two of the eighty eight projects (59%) either involved the activities of honours, masters or PhD students or were specifically designed to provide formal education courses. Most of the projects in Program 5 were involved in the latter activities. Post graduate students were very successful in developing applied technologies which could be implemented in the field. For example eleven of the twenty three projects involving students in Programs 1,2 and 4 were successful in developing applied technologies, indicating the benefits of having post graduate students in the research process. Other programs were either involved mainly in strategic research (Program 3), in education (Program 5) or administration (Program 6).

4.1.5 Economic impact of projects

It is beyond the scope of this study to complete another economic impact study of the CRC, by either estimating net present values or by conducting benefit-cost analyses of projects. Economic studies on the effects of projects on cold tolerance, growing crops after rice and valuing a test for nitrogen status in rice have already been completed and these may be updated at a later date when adoption rates improve. The initial studies indicated that a) if cold tolerance is increased by 1 degree Celsius, the economic Net Present Value (NPV) is expected to be approximately $13.1 million (Singh et al, 2002); b) the benefits of growing crops after rice has an economic NPV of between $66 million and $80 million (Faour et al 2002) and; c) implementing a Near Infra-red Reflectance (NIR) technique for estimation of nitrogen levels in rice expects a NPV of $1.5-2.0 million (Singh et al, 2002a). Such economic impacts on three of the 88 active CRC projects implies the whole centre will possess a high value in terms of returns on its investment in research.

Many projects have multiple outcomes affecting the environment, farmers incomes, monitoring practices and the development of scientific techniques. Traditional economic studies may not capture the full benefits of the program's outcomes and reflect their impacts on society as a whole. Issues that may be debated for example are "how much is land lost to agriculture through salination or high water tables worth?" or "what value is placed on a healthier environment and improved human health or on biodiversity in agriculture?" Such studies may need a common approach across all similar research activities to ensure comparisons can be made between projects. However, some evaluation should be presented in this report to provide other innovative indicative dollar values of Rice CRC generated technologies.

Major sources of current and potential income generation due to the adoption of CRC technologies is presented on a project by project basis in Table 13. Column 1 describes the Project number; column 2, the underlying problem for the rice industry as a whole; column 3 presents the % of the financial gain that can be attributed to the adoption or potential adoption of CRC technology or the % of savings achieved to date; Column 4 the value of that financial gain and some notes relating to the statements are presented in column 5. This table does not include estimations of economic damage to the environment. For example the underlying problem for Projects 1102 and 1201, is estimated by calculating the value of the water that the farmer must pay for which is currently being lost from the system. In other words, a reduction in these costs would translate into a direct increase in farmers profits. Water in these two projects and projects 1107, 1201, part of 1204, 1205, 1403, part of 2201 was valued at $20 per ML. Some farmers were paying up to $350 ML for a temporary water allocation in 2002/2003, so this is a conservative estimation of cost. To date, project 1204 has improved water use on 48 ha of saline land and brought it back into production. No cropping costs are included and the amount in column 4 is not considered as profit but a gain to the agronomic productivity of the area. This is also the case in project 2105. For project 2201, current knowledge on avoiding the effects of cold on rice yields is sufficient to reduce approximately $100,000 worth of damage per annum and cold tolerant screening techniques have now been streamlined (Projects 2201 and 2206).

Table 13 Current projects generating income

Project No	Project title	Underlying problem	% due to CRC	Financial value (from CRC)	Notes
Current problems and solutions					
1102	Ground water recharge prediction	$3,000,000 pa	10	$300,000 pa	Conservative water savings. Achievable at low cost by re-planning of farms
1107	Seepage from on-farm canals	$800,000 pa	10	$80,000 pa	Conservative water savings but remedial costs are high
1201	Farm scale agronomic options	$3,000,000 pa	100	$8,000 pa	5 farmers practicing. 150 trained.
1204	Improving water use	Low productivity	100	$38,400 pa	48 ha of productivity at $800 /ha Many more farmers interested
1204	Improving water use	High water use	100	$20,000 pa	1,000 ha of rice being intermittently watered, saving 1ML/ha
1205	Crops after rice	$40,000,000	10	$5,000 pa	1 farm savings in land reforming annually. Also resurrection of saline fields
1207	GIS, net recharge management	$40,000,000 pa	10	$4,000,000	Adoption increasing with potential for 100% adoption
1403	Soil water table management	Most irrigation area	50	$500,000 pa	Irrigation companies changed management and funds to research
2102	Application of spacial data	Most irrigation area	10	$50,000 pa	200 farms currently using it to reduce fertiliser costs
2105	Crop rotations	Most irrigation area	10	$400,000 pa	Gross crop income (500ha x $800) from resurrected land
2201	Screening cold tolerant varieties	$20,000,000 pa	5	$100,000 pa	Will increase significantly when new varieties released
2201a	Screening cold tolerant varieties	$20,000,000 pa	100	$10,000 pa	Conservative annual saving during varietal selection
2206	Screening reproductive cold tolerance	$20,000,000 pa	100	$10,000 pa	Conservative annual saving during varietal selection
2302	Rice mineral requirements	Most irrigation area	10	$100,000	Use of technology will be used more frequently in future
2303	Straight head treatment	$1,000,000 pa	10	$100,000	Control through fertilisation
4101	Pre-milling grain quality	$1,000,000 pa	20	$200,000 pa	Farmers get immediate feedback, easier to dry and mill rice
4201	In-line process control	$200,000 to $m's	10	$50,000 pa	Conservative. Initial savings in $millions as mills closed
4501	New rice based food products	$50 million new product	10	$500,000 pa	Some products are not very profitable
4502	Vitamin and mineral fortification	New market	100	$420,000 pa	Process can be used for other markets
4503	New rice flour applications	New market	100	$100,000 pa	Quality control process also improves other outputs
	Total			**$7.0 million pa**	**A very conservative amount projected to expand in future**
Potential problems or solutions					
1105	Remote sensing for water balance	Monitoring water use	100	$30,000 pa	Cost of air photography which can be reduced or eliminated
1303	Bioremediation of pesticide residues	$2,000,000	5	$100,000 pa	Agricultural market in $10's of millions. All CRC technology
1304	Enzymatic remediation of pesticides	$2,000,000	10	$200,000 pa	Agricultural market in $10's of millions. All CRC technology
2106	Soil sodicity and pH	>$100,000 pa	50	$50,000 pa	Lower costs will lead to greater use of targeted sampling
2201	Screening cold tolerant varieties	$20,000,000 pa	50	$10 m pa	Potential within five years of new varieties released
2403	Sustainable pest control	5-10 % yield loss	100	$10m pa	Developed technologies prepare industry for future pest control
2407	Disease risk assessment	50% yield loss	100	$100m	Control techniques in place. Sprays may be necessary
2408	Biology of frogs	Pesticide use	100	Pesticide cost	Increasing biodiversity to control insect pests
2409	Stem diseases in rice	5-30% yield loss	100	$40m	Control techniques in place. Sprays may be necessary
3203	Blood worm resistance	$2,500,000	100	$2.5m pa	$2.5 million reduction in pesticide costs. Proving GM crop expensive

Improved pre-milling grain quality measurements (Project 4101) now mean that farmers have feedback on the quality of their grain deliveries and they can return to the farm and make appropriate adjustments to their harvesters to improve the quality of their deliveries. Costs are also reduced at the mill while drying and milling the grain. In-line processing improvements (Project 4201) and an expansion in the size of mills resulted in greater efficiency of the system resulting in considerable reductions in operating costs. Project 4201 resulted in new products being produced by RCL that were not sold in the past and the new vitamin and mineral fortification (Project 4502) plus new rice flour applications (Project 4503) are new markets which did not exist for the Australian rice industry before the CRC assisted develop the technology for its manufacture.

Technologies that were developed through the CRC include the use of enzymes to reduce pesticide residues Projects 1303 and 1304). The technology works but is not currently commercially available. Soil sodicity and pH measuring technology (Project 2106) also works but relies on policy changes and cost re-structures before implementation.

Rice disease assessment and control of new diseases (Projects 2407 and 2409) studies have the potential for saving the rice industry from large losses if the disease environment changes as it did in California 5-6 years ago. Such strategic research is necessary to reduce risk in rice based farming systems.

Studies on the biodiversity of rice fields with emphasis on the biology of frogs and other vertebrates (Project 2408) are resulting in an understanding of the level of insect pests consumed by predators. The estimated 40 billion frogs in the rice paddies could, for example, be utilised for insect control should rice farmers prefer such an approach.

It is now possible to introduce genes into the rice plant to provide bloodworm resistance (Project 3203). However, this technology will not be used until genetically modified (GM) rice is acceptable to the industry.

The total financial value of the project outputs before costs are deducted is estimated at over $7 million per annum. These are extremely conservative figures as are the value of the underlying problem. No matter how the figures are viewed, the financial contribution of the mentioned projects to the income of farmers and the industry in general is very significant. Other stated financial advantages of CRC outputs include a reduction in software costs, reductions in labour for monitoring, farm operation etc. In addition to these gains, is the level of improvement made to the environment. Technologies are also in place which have an extremely large potential for protecting the rice industry from future economic losses.

All of the technologies currently contributing to the rice economy are currently generated in Programs 1, 2 and 4. One project in Program 3 has the potential to impact on the number of pesticide applications on rice is Project 3203 with it's work on bloodworm resistance. An increase in the release of applied technologies from some programs are expected before the end of the CRC.

4.2 Overall impact of the CRC

4.2.1 Impact of the CRC on the scientific community

The results of interviews with collaborating party member scientists (CSU, UniSyd, CSIRO, NSWAg, DLWC, RIRDC and RCL) and linked organisations (CIA, MIA, MI, RGA) indicate that personnel from each organisation were, on the whole, extremely pleased to be involved with the Rice CRC. The linkages between collaborating party members and other organisations, although laborious, have proved to very productive. The high degree of collaboration is indicated by the number of linkages detailed in Table 3 and the number of multi authored publications presented in Table 6. These parties have also indicated their enthusiasm by projecting to commit an extra $15 million in cash and in-kind contributions to the CRC by the end of the funding period. In addition, collaborating scientists and organisations benefited in other ways by being involved with the CRC. The Rice CRC is credited with encouraging CSIRO to install a new laboratory at Griffith, encouraging CSIRO, Plant Industry to conduct research on rice, establishing an irrigation education unit at CSU and promoting collaboration between industry and research organisations. Most collaborating parties have also been able to generate funds from its association with the CRC. Some of the grants to these organisations are listed in Table 14 as published in the Rice CRC Annual Research Report.

Table 14 Grants to organisations (from Rice CRC Annual Research Report)

Name	Organisation	Project Title	Source	Amount
Tim Farrell	NSW Agriculture	Screening cold tolerance varieties of rice (2201) (PhD Student - attendance at CRC Leadership and Career Development Course)	BHERT and AusIndustry	$1,100
Wendy Quayle & Evan Christen	CSIRO Land & Water	Pesticide risk assessment for on-farm water recycling systems	Murrumbidgee Irrigation Limited	$6,500
Shahbaz Khan	CSIRO Land & Water	Groundwater model of the Murrumbidgee Irrigation Area	Murrumbidgee Irrigation Limited	Project support for 2 years
Shahbaz Khan	CSIRO Land & Water	Policy options for environmentally sustainable and economically viable cropping patterns in the Murray Valley	Murray Irrigation Limited	Project support for 2.5 years
Liz Humphreys and Shahbaz Khan	CSIRO Land & Water	Growing more rice with less water: increasing water productivity rice-based cropping systems (China, Murrumbidgee)	ACIAR	$200 k Australian component 4 years

In addition to the above list of grants, the existence of the CRC has resulted in other grants to collaborator and linked parties. These include those presented in Table 15.

Table 15 Extra grants to organisations through linkages to CRC

Name	Organisation	Project Title	Source	Amount
Liz Dennis	CSIRO	NSW centre for ag. genomics	NSW Gov't	$660,000
Shabaz Khan	CSIRO Land & Water	Management of water conservation	Murray Irrigation	$270,000
Liz Humpherys, Geoff Beecher	CSIRO Land & Water/NSW Ag	Permanent beds. India/Australia	ACIAR/RIRDC	$2 million
Matt Linnegar	RGA	Biodiversity, strategy and planning	MDBC	$80,000
Chris Blanchard	CSU	PhD students linked to CSU	Various	$400,000
Project 1105	CSIRO L&W	Extra information for hyperspacial images	NASA	$150,000 in images
Project 1105	CSIRO L&W	Extra information for hyperspacial images	Earth Observation Centre	$20,000

Information presented in these tables is not exhaustive. Their content indicates that the Rice CRC has been extremely successful leveraging its activities by attracting funds from and to other organisations to conduct work on rice based farming systems. Personnel have also received travel grants and other support for the presentation of CRC generated information.

Personnel working with collaborating parties of the CRC and those in linked organisations wholeheartedly support the existence of the CRC and consider it to have been a success to date. A few of their comments are provided in Table 16.

Table 16 Quotations from various sources about the CRC

"The CRC has had a huge impact on the level of research conducted on irrigation at CSIRO"

"Without the water quality project, we would not have the water quality laboratory"

"Having students in the research program brought different organisations together"

"The CRC opened the door for more women being in charge of programs"

"The CRC definitely started people thinking in the right direction"

"If the CRC was not there we could not have demonstrated the knowledge"

"I'm always conscious of how great it is to work in the CRC"

"The CRC has always been a comfort place where different organisations can work effectively together"

"EM31 soil surveying proven by the CRC has changed the irrigation business"

"Very happy that the CRC listens to our needs" "It's a real pity it's stopping now"

"The CRC developed the technology but also helped us extend the practices"

"I can safely say that the CRC worked"

"Some sub programs delivered the goods and we expanded our funding to research"

"Provided closer local contact"

"CRC results are changing the way we work"

"Allowed me to do 5 years of potentially useful rice based research"

"I think the whole thing as being hugely successful"

"CRC goes out of it's way to invite extension persons to its meetings"

"It's a real pity it's stopping now"

"The CRC was a little slow to get going".

"Prior to the CRC, CSIRO, Plant Industries had no commitment to research on rice"

"Other linkages developed because of CRC"

"The Rice CRC is the sort of model other CRC's should be based on"

"The CRC has looked at the whole industry and seen what to do about it"

"Commercial arrangements were laborious"

"Unfortunately the Rice CRC has not been effectively communicating it's achievements outside".

"I always thought that biodiversity conservation had a voice in the CRC"

"This is the best CRC I have been involved in". "Good opportunities for collaboration"

"CRC was good because it looked at the undergraduate level"

"Without a doubt, the CRC resulted in the formation of formal tertiary training in irrigation at CSU"

"CRC has been able to unite research effort"

"CRC has given seed funds to get things started to bring funds from other places"

"Rice CRC does not sell itself properly"

4.2.2 Impact of education and training in the CRC

4.2.2.1 Communication through scientific community

Communication between scientists and students associated with the CRC is considered to be good. The annual rice symposium, field days, CRC Newsletter and communication between the administration office and collaborators have all influenced a productive atmosphere within the CRC. Good linkages between projects have also helped. Communication between members of individual programs is judged as being variable and may have impacted on the output of personnel in one or two cases. Some programs, however, hold regular meetings and these are considered to be extremely productive.

The publication list is not extensive after 4.5 years of operation (Tables 4,5). However, preparation of publications will gather speed over the remaining 1.5 years of the project as the research projects near fruition. Existing publications appear to be well read and Rice CRC personnel are considered to have wide (in some cases international) recognition in various disciplines. This is being enhanced through their attendance at conferences and symposia.

4.2.2.2 Communication to farmers

The Rice CRC is a research organisation, not an extension agency. Therefore it's personnel cannot be expected to communicate directly with a large number of farmers. However, it is the responsibility of the CRC to ensure it remains in touch with farmers needs and the farmers are well informed about the CRC activities. Individual researchers have their own collaborator farmers and extension personnel, irrigation company personnel plus the RGA are well informed of CRC activities (Table 7). In addition, each farmer receives a copy of the CRC Newsletter through the Sunrice mailout and growers are made aware of the CRC through the RGA newsletter. Of the 30 farmers interviewed at the 2003 Rice Field Day, the level of recognition of the CRC ranged from one who had not heard of it to a group of very well informed farmers. All had heard of the EM31 work and had either used it or planned to. Some farmers recognised the technology as emerging from the Rice CRC. It is unimportant how the farmers hear of the technology, so long as it is communicated to them. From the small survey, this appears to be done effectively.

4.2.2.3 Communication outside of the farming and research communities

Interviewees overwhelming considered that the Rice CRC has not made an impact on the perception of the general community regarding the rice industry. Typical comments as quoted in Table 14 were "Rice CRC does not sell itself properly" and "Unfortunately the Rice CRC as not been effectively communicating it's achievements outside". The general public has the perception that, if they know about the Australian rice industry at all, it is considered to be wasteful of water. This perception is particularly strong during the current drought years. The CRC could improve it's impact on this attitude by increasing the level of public awareness regarding how the CRC is addressing these issues. Rural journalists in the Riverina are well aware of this problem and sympathise with the CRC and the rice industry. This makes it even

more important for the CRC to replace the communications officer and publicise the environmental attributes of the research program.

4.2.2.4 Undergraduate and post-graduate student program

The Rice CRC has sponsored the studies of 50 honours, masters, and PhD students to date (Tables 8, 10) who made up a considerable proportion (25%) of the total person years involved in the CRC (Table 2). The students' contribution to the number of publications is also significant (13% overall) with this number expected to increase in the final years of the CRC as they write up their theses. Most of the students enrolled in 2002-3 (10 students from a total of 17) were supervised from CSU (Table 8), a university with a well developed and increasingly active irrigation teaching program. They commenced studies on projects primarily in Programs 1-3 (90% of students) with the remainder spread across Programs 4 and 5 (Table 9). These figures indicate that post graduate students had a significant impact on the quantity of research conducted in the CRC and on the reporting of the results.

Undergraduate studies in irrigation at CSU have been promoted by the existence of the CRC. Seed funds of $10,000 pa resulted in the formation of a Professorship in Irrigation within the School of Agriculture. In addition, a lecturer position in horticultural irrigation is supported by funds (approximately $100,000 pa) from the Commonwealth Department of Education, Science and Technology. There are now approximately 30-40 external and 60-70 internal students attending irrigation classes each year, expanding the exposure of graduates to irrigation practices. The total number of students exposed to CRC sponsored courses is approximately 300 persons per annum expanding dramatically the impact the CRC has on graduate's perceptions of rice based farming systems.

Students graduating from irrigation courses initially find employment with irrigation service providers, irrigation companies, government agencies or possibly become farmers. Thus, the CRC has an indirect impact on farming practices in the irrigation areas through the undergraduate program. Research staff at a number of institutions are also screening students at an earlier stage of their education for training in rice research. Selection for honours studies and later, for higher degrees now occurs after scrutiny of students joining summer school training courses. This process has improved the quality of students applying for CRC scholarships plus other higher degree programs.

A large number of graduates from CRC sponsored higher degrees have remained in agricultural pursuits, many of whom remained in water related disciplines. Examples are employment with service providers (Dalgetys and Westfarmers), consulting firms (Egis Hydrology consulting), research organisations (CSRO, Land and Water), government organisations (NSW Ag; Sydney Water), irrigation companies (CIA), or continued on with further studies. The CRC sponsored education program has therefore directly impacted on the quality of personnel working in rice based farming systems.

4.2.3 Gender

4.2.3.1 Farming and farm management

Rice based farms in Australia are predominantly operated by men. It is estimated that only 1% of heads of households are women who assume responsibility for most if not all of the physical work on the farms. Women, however, are very active in the management of the farms and are responsible for most of the ordering, communication, farm accounts and farm budgeting. As such, they would have greater on-farm computer skills than most men. Approximately 5% of farmers attending field days are women and an increasing number of women are attending training courses, particularly when presentations relate to environment issues, accounting or water budgeting.

None of the technologies generated by the Rice CRC are considered to favour one gender or the other. New farm layout planning, improved water management strategies, changes in approaches to limit the effects of cold, maximising the benefits of crops following rice etc are all technologies that can be managed by either men or women. The use of CRC generated computer models will preferentially benefit computer literate farmers.

4.2.3.2 Monitoring and evaluation

The three rice related irrigation companies tend to have reasonably even staff gender balance in the natural resources area. Technologies developed through the CRC for use by the managers of water can be managed by either gender. EM31 equipment is difficult to operate for slighter bodies, but much of these measurements are contracted out to consulting companies. Grain quality measurements at delivery to the mills can be done by either men or women.

4.2.3.3 New rice products

New products successfully released after research by the CRC include vitamin fortified rice, instant cooked rice products and improved rice flour. These products are all used by men and women.

4.2.3.4 Education

CRC sponsored education projects result in a reasonably balanced impact on both gender. Undergraduate representation at CRC sponsored courses runs at 50% males and females. Forty four percent of all post graduate students were women. This is a much higher ratio than found at most universities (2-3 males/1 female).

4.2.3.5 Research

Two of the five research and education programs of the CRC are headed by women. This is a higher ratio than found at CSIRO where women hold only 10% of the research scientist and 5% of the research management positions. Approximately 13% of NSWAg

personnel are in the professional salary range (above $40,000) compared with 41% of men. Twenty four percent of the CRC contact persons list are women.

It can be concluded that there is no gender bias in the Rice CRC for either the generation or use of technology, release of products, education or research.

4.2.4 Ethnic balance

The CRC maintained a high degree of ethnic diversity within it's staff. Of the total 276 members of staff involved the research program during the first five years of operation, 22% were new Australians (Table 18). This compares with 6% of the total number of staff in NSW Agriculture whose first language spoken as a child was not English (www.agric.nsw.gov.au), 19% in the state of NSW (www.abs.gov.au) and 20.9% in Australia as a whole (www.ceoe.com.au). Many of the new Australians involved in the CRC were from Asia and the middle east where rice production is the prevalent form of agriculture.

Table 18. Ethnic origin of CRC research program staff

Ethnic origin	**Number**
Australasia	215
India/Sub-continent	20
Asia/China	17
Middle East	12
Europe	9
America's	3
Total	**276**

4.2.5 Environmental impact of the CRC

As mentioned under Section 4.1.3, almost 41% of non administrative projects of the CRC were involved with the generation of knowledge that positively impacted on the environment. This reflects the focus on developing technologies to increase natural resource efficiencies. Water tables have receded during the life of the Centre and may reflect, in part, the impact of CRC technologies on improved water management efficiencies. Considerable effort has been placed on developing systems to hold the water tables down through reductions in water losses from flooded paddies and by efficient uptake by rice and crops following rice. Indirectly these strategies are impacting on the quality of water through a reduction in the level of salt in the upper soil profile. In addition, an improvement in the understanding of the nutrient status of soils helps ensure crops don't "mine" the soils of nutrients. Bioremediation techniques have been developed which, when commercially available, will reduce the level of pesticide in on-farm and commercial spills. Technology is

also available for the control of bloodworm when the cultivation of GM rice crops are acceptable to the public. At present, the use of Bti bacteria on organic farms can impact on the yield of those farms and some organic farmers are taking interest in the use of the technology. Although not presently impacting on the environment, technologies are available for the preservation of biodiversity in the rice ecosystem when this approach becomes a priority for farmers.

4.2.6 Economic impact of the CRC

A summation of the economic impacts of projects in the CRC (Table 13) strongly indicate that the CRC has had a significant impact on the economies of rice based farming systems in Australia, the management and monitoring of irrigation water and on the cost of research. The current impact of these activities exceeds $7 million per annum and is on the increase. The potential impact could be in the $10s or $100' s of millions over time and if conditions change (Table 13).

The existence of the Rice CRC has also impacted on the level of funding of research into rice based farming systems. Some leveraging of CRC funds are mentioned in Tables 15 and 16, however, this is not a complete accounting of the increased level of funding. This level of funding may decrease when the Rice CRC finishes.

5.0 Sustainability

The Rice CRC is just beginning to make an impact on the sustainability of rice based farming systems in Australia. A vast improvement has already been made in amount of technology required to establish more sustainable production systems but more work will be necessary to fully realise the potential of the research done to date. The issue of whether the research effort and impacts will be sustainable after the CRC finishes at the end of June, 2004 is briefly discussed below.

5.1 Human resources development, expertise retention and attraction to research

The Rice CRC has significantly impacted on the level of vocational training, undergraduate training, post graduate training and the number of persons attracted to rice research. Over 1000 persons have received undergraduate training from CRC sponsored personnel and more than 50 persons, studied for or are in the process of completing post graduate degrees. Undergraduate degree training will continue at CSU through existing irrigation courses developed at the university with seed funds from the CRC. Courses specifically designed for rice production will need to be incorporated into irrigation courses as the CSU lecturer for rice is currently fully funded by the CRC. The number of post graduate students involved with rice production is expected to diminish.

Incorporation of research staff into participating organisations is currently underway. CSIRO, CSU, and NSWAg have taken on board some of the researchers initially employed by the CRC for specified research and training projects. At the end of February, 2003, approximately 12 of the 43 CRC employed research, training and support staff did not have affiliations with mainstream organisations and may need to seek employment elsewhere. However, the majority of current CRC assigned staff are from core and associated partners and these people will remain active in their own organisation. There is, therefore, a large degree of expertise retention in the industry. If provided with leadership and funds, many of the CRC initiated activities could continue. In many cases, as discussed in Section 4.2.1, the researchers already have funds to continue productive research projects on sustainable rice production systems. There may not be any reason for extra human resources to be attracted to research activities of the same nature unless another rice targeted research program commences.

The special feature of working with the Rice CRC was the linkages it gave to expertise in other organisations. This productive avenue of communication will be lost without a CRC structure.

5.2 Technology development and extension

Some technology developments from the CRC have already become firmly established in the rice industry. For example EM31 monitoring of soils is now a permanent feature of the CIA land classification system and is regularly used in the MIA. Technical support will need to be provided in the future and it is envisaged that this will be provided by

the NSWAg. Most other technologies will need to be developed further before release to farmers. The degree to which this will happen is solely dependent on the level of outside funding the projects have been able to acquire. Some projects are attracting extra funds, some not. Other projects are already partially incorporated into partner organisations. Breeding for cold tolerance, for example, will continue in the NSWAg rice breeding program, CSIRO will continue to research into recharge management and RCL into developing new products.

Farmer adoption of CRC released monitoring techniques has developed an interest in precision farming which will lead to a greater adoption of this practice in the rice industry. This will, in turn, place increasing pressure on research personnel to develop more efficient techniques to manage it's use.

5.3 Environmental and economic sustainability of technologies

Many of the technologies developed by the CRC have already made an impact on the environment and will continue to do so. Others have the potential to do so if the conditions arise or if alternative farming approaches are taken in the future. None of the technologies developed by the CRC and proposed for use in the field are damaging to the environment. Some of the technologies also reduce costs significantly and thus, are both environmentally and economically sustainable.

5.4 Finance

Seed funds provided by the CRC has attracted a wide range of assistance to research associated with CRC projects. A partial compilation of these funds are presented in Tables 15 and 16. This funding is not sufficient to allow a continuation of activities at the same level as the CRC currently. Research and education programs will continue at the partner organisations at a lower level.

5.5 Infrastructure

None of the CRC utilised infrastructure is owned by the CRC and will not need to be maintained after the end of the centre's life. CRC purchased equipment will be written down and transferred to the cooperating agency at the end of the term.

6.0 Conclusions

1. The Rice CRC has successfully fulfilled the goals of the Commonwealth Government CRC program.

2. The Rice CRC has generated a considerable amount of knowledge to improve the sustainability of the natural resources and the systems used to produce rice.

3. The CRC has been active improving germplasm which will form the basis of a sustainable increase in rice yields when new varieties are released.

4. The CRC developed a more strategic base for rice research in Australia.

5. The CRC has successfully focused research effort on a common purpose by linking key agencies involved in rice research, education and extension.

6. Technology generated by parties in the CRC has been successfully applied in the field.

7. Resulting technology from the CRC has positively impacted on the environment.

8. Some released technologies from the CRC are utilised by end users to improve economic efficiency.

9. The CRC has to date, successfully communicated with its immediate stakeholders.

10. The CRC has not successfully communicated its achievements to the general community.

11. Partners of the CRC have been successful in leveraging their funds to increase the level of rice based research.

12. Technologies developed by the CRC have not been gender specific.

13. The CRC has provided equal opportunity for women in it's education programs, research and management.

14. The CRC maintained a good ethnic balance of research personnel.

15. The CRC successfully inspired students to make a significant contribution to rice research.

16. Sustainability of rice based research programs is partially in place for the post CRC period.

References

Abadi A., Ewing M., and Longnecker N., (2001) An assessment of the impact of CRC investment in CLIMA, 53 p

Faour, K., Singh, R., Humphreys, L., Smith, D., and Mullen, J. (2002) Analysing the benefits of growing crops after rice in the rice growing areas in Australia. Project report. 17p

Mercer , D., and Stocker, J. (1998) Review of greater commercialisation and self funding in the Cooperative Research Centres Programme, Department of Industry, Science and Tourism, Canberra 92p

Singh, R., P., Brennan, J., Mullen, J., Farrell, T., Williams, R., Rienke, R., and Lewin, L., (2002) Economic analysis of improving cold tolerance in rice in Australia. Project report. 14p

Singh, R., P., Williams, R., Mullen, J., and Faour, K., (2002a) Valuing a test for Nitrogen status in rice. Project report. 21p

Williams, P., (2003) Investigating links between minerals in rice grain and Straighthead. Rice CRC Final Report. Project 2303. 28p

Acronyms

ACIAR	Australian Centre for International Agricultural Research
BHERT	Business and Higher Education Round Table
CIA	Colleambally Irrigation Area
CLIMA	Cooperative Research Centre for Legumes in Mediterranean Agriculture
CRC	Cooperative Research Centre
CSIRO	Commonwealth Scientific and Research Organisation
CSU	Charles Sturt University
DLWC	NSW Department of Land and Water Conservation
GM	Genetically Modified
MDBC	Murray Darling Basin Commission
MI	Murray Irrigation
MIA	Murrumbidgee Irrigation Area
NASA	National Aeronautics and Space Administration
NIR	Near Infra-red Reflectance
NPV	Net Present Value
NSWAg	New South Wales Agriculture
PhD	Doctor of Philosophy
RCL	Ricegrowers' Co-operative Limited
RGA	Ricegrowers' Association
RIRDC	Rural Industries Research and Development Cooperation
Rice CRC	CRC for Sustainable Rice Production
Rice CRC Annual Report	Cooperative Research Centre for Sustainable Rice Production Annual Report .
UniSyd	The University of Sydney