rural R&D CORPORATIONS

Submission

Public support for science and innovation research study

Prepared for the Productivity Commission

September 2006

Australian Government

Cotton Research and Development Corporation

Grains Research and Development Corporation

Fisheries Research and Development Corporation

Forest and Wood Products Research and Development Corporation

Land & Water Australia

Rural Industries Research and Development Corporation

Sugar Research and Development Corporation

Grape and Wine Research and Development Corporation

DAIRY AUSTRALIA
Delivering for the dairy industry

mla
MEAT & LIVESTOCK AUSTRALIA

australian wool innovation limited

AUSTRALIAN EGG CORPORATION LIMITED

Australian Pork

HAL
Know-how for Horticulture™

Australian Government

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7/09/ 2006

Commissioner Mike Woods
Science and Innovation Study
Productivity Commission
PO Box 80
Belconnen ACT 2616
Australia

Dear Commissioner Woods,

As Chair of the Rural Research and Development Corporation Council of Chairs, I am pleased to tender to you, on behalf of the Council, our submission to the Productivity Commission's Science and Innovation Inquiry into *'Public Support for Science and Innovation'*.

The Council of Chairs' submission to the inquiry attempts to address the terms of reference with respect to rural research and development (R&D), namely:

- the economic impact of public support for Australian rural R&D, science and innovation
- the adequacy of arrangements to benchmark related outcomes
- identification of impediments to the effective functioning of Australia's innovation system
- examination of decision making principles and program design elements which influence Australia's rural R&D and innovation system, and guide the allocation of funding; and
- the broader social and environmental impacts of public support for Australian rural R&D, science and innovation.

In response to recognition of its contribution to Australia's economic and social prosperity, the Australian Government has identified science and innovation as one of its strategic priorities. The Government has provided significant support for science and innovation and funding now exceeds $5 billion per annum.

The Council has tendered this submission to you as a reference for the inquiry in relation to the large contribution of rural R&D, science and innovation to the productivity of the agricultural, forestry and fishing sector through time and the Australian economy more broadly, and Australian society at large.

Ultimately, the returns to rural R&D, science and innovation expenditure are a prerequisite to the continuing competitiveness of Australia's agricultural industry on the world stage, while also playing an important role in the improvement of Australia's standard of living.

Yours sincerely,

Terry Enright
Chair of the Council of Rural Research and Development Corporations' Chairs

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Executive Summary

Rural research and development corporations (RRDCs) take a leading strategic role in planning, investing in and managing Research and Development (R&D) for their respective industries. They strive to deliver high rates of return on R&D investment by influencing the full range of interactions along the innovation chain.

The investments made by RRDCs are both accountable and transparent. RRDCs are required to conduct their activities in accordance with strategic R&D plans and annual operational plans that take account of the R&D needs of end-users and other stakeholders. In many instances primary producers regularly vote on the level of the levy they pay.

The RRDCs invest in industry R&D. They provide strategic leadership to industry R&D activity while stimulating industry interest in R&D activity and outcomes. They take a proactive role in identifying and filling gaps in the agriculture research effort and are also responsible for facilitating the dissemination, adoption and commercialisation of research results.

There are 15 RDCs operating in Australian agriculture. 13 of the RDCs have been established to operate within specific industries. However none of the RDCs operate in isolation as most primary production enterprises are based on a number of common scientific principles. In many instances a primary producer may contribute levies to one or two RDCs and receive information and innovation from three, four or more.

The commercial operating nature of the RDCs expands the level of resources available for R&D, improves the efficiency with which R&D moneys are spent and directs R&D funding to high payoff areas. In 2004/05, the RRDCs invested $511 million, of which about 60% was funded by industry.

In the 1995 Industry Commission review of R&D several unique characteristics of rural industries were cited as justification for collective action (levy funded R&D) and matching funds from Government, they were:

- the non-rival nature of agricultural production;
- large intra and inter industry spillovers
- spillovers to the community beyond those that occurred from investments that can be justified by industry on the private benefits they generate; and
- the large number of small businesses that comprised the sector and the apparent robustness of the family farm as an economic unit.

While rural industries have undergone some structural change since the Industry Commission's report, these unique characteristics remain in place.

Thus there are two main arguments for Government contributing to the RDCs, they are:

- to provide an incentive to for industry to increase expenditure on rural R&D; and
- to generate investments in areas that generate a public good that would be underinvested in by primary producers.

The points above are not concurrent but rather are cumulative.

In addition to these points the contribution to the RDCs from Government must also been seen in the context of broader industry R&D support. At present there are tax concessions of between 125 percent and 175 percent for certain types of R&D expenditure for other sectors of the economy. Rural industries forego this tax concession in return for receiving matching funding through the RDCs.

Comprehensive reviews of existing economic literature regarding the private returns to R&D, undertaken by authors such as Dowrick (2003) and Salter and Martin (2000), confirm the existence of significant spillovers of knowledge from the firms that perform the R&D, to other firms within the same industry and the economy more broadly.

In terms of science and innovation policy, the RRDCs:

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- Play a unique role in the innovation system in Australia by coordinating the efforts of government, industry and research institutions:
    - this role extends over the long-term, unlike that of the Cooperative Research Centres that have a 5 to 7 year focus on a particular subject area;
- Provide the institutional framework that is able to marry the objectives of government with those of industry within R&D programs:
    - the RRDC model is a world-leading approach to the integration of private benefit and public good outcomes; and
- Have become central to the ongoing support of rural science, both in terms of funding and the delivery of R&D outcomes, particularly as State agriculture institutions lose funding and their role in extension services:
    - this support of the science base is important for the generation of new ideas in Australia, as well as adaptation of overseas innovation to Australian circumstances.

In terms of economic, social and environmental returns to the nation, the RRDCs:

- Are the model for addressing significant market failures that lead to under-investment by industry in both private benefit and public good R&D;
- Address the under-investment. Not only are the acknowledged significant direct benefits of rural R&D able to be captured, but also the extensive spillovers that flow beyond rural Australia to the general community. Economic studies of agriculture R&D suggest average social[1] internal rates of return of around 64% per annum, of which only 34% are returns to the investing industry;
- Are delivering improvements to rural industry productivity which has important implications for the ongoing viability of rural communities; and
- Represent excellence in terms of the management of R&D resources and delivery of outcomes.

A significant impediment to better outcomes in rural R&D is the loss of R&D and adoption capacity in the innovation system. The number of quality scientists available to carry out the programs that industry and government commission through the RRDCs is of particular concern.

[1] The average social rate of return is the total measurable benefit to R&D that results in increased output (GDP). The social rate of return does not include other non-measurable or intangible benefits that do not result in output improvements.

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1. Introduction

The Council of Rural Research and Development Corporations Chairs (CRRDCC, The Chairs or The Council) welcomes this opportunity to make a submission to the Productivity Commission's study on *Public Support for Science and Innovation*.

1.1. Advantages of the rural RDC model

Rural research and development corporations (RRDCs) take a leading role in planning, investing in and managing R&D for their respective industries. In terms of R&D investment planning, RRDCS are required to conduct their activities in accordance with strategic R&D plans and annual operational plans that take account of the R&D needs of end-users and other stakeholders. Furthermore, the Primary Industries and Energy Research and Development Act (PIERD Act) require the RRDCs to treat R&D as an investment in economic, environmental and social benefits to their respective industries and the community more broadly.

Prior to 1997, all RRDCs were established by regulation under the PEIRD Act. However, the RRDC model today is a mix of statutory and industry owned companies. The statutory RDCs are responsible to their members under the PIERD Act, while the industry-owned companies are responsible to their share holders under the *Corporations Act* (2001) and have contractual arrangements (Statutory Funding Agreements (SFAs)) with the Australian Government to plan, fund and disseminate R&D in a manner consistent with the objectives of the original RRDC model.

1.1.1. Return on investment

RRDCs strive to deliver high rates of return on R&D investment by influencing the full range of interactions along the innovation chain. Although RRDCs fund basic research, a high proportion of activity is applied R&D, in both the long and short term. This means that R&D investments are targeted and not designed to generate new knowledge for its own sake, as per basic academic research.

Aiming to maximise return on investment according to stakeholder priorities leads the RRDCS to apply significant resources to translating basic research outputs into practical and commercially viable outcomes, that is, innovation. Added advantages of the RRDC model include:

- A robust investment framework as described in Section 3.5
- The ability to actively engage with the relevant industry end-users of R&D, with regard to setting priorities, allocating resources and designing R&D programs
- Incorporation of adoption into the R&D planning phase
- Design of mechanisms to communicate R&D impacts; and
- Provision of a means for effective coordination and the ability to deal with cross-sectoral issues.

In summary, the current industry and statutory arrangements for rural R&D investment derived from the PEIRD Act involve an expertise based board with the full power to act. Recently the Uhrig Report recommended the removal of Government directors from the boards of the statutory RDCs as these appointments were seen as inconsistent with the skills based board intention of the PIERD Act.

Skills based boards remain an effective means of managing R&D investment and managing the multiple accountabilities of industry, government and the community. Furthermore, the RRDCs have been successful in employing public funds more closely with industries in order to bridge the gap between research and industry innovation (CIE, 2003).

1.2. Why have rural R&D Corporations

The purpose of the PIERD Act was to establish RDCs through which to replace the existing councils and committees responsible for administering the allocation of government R&D program funds. The established

RDCs allowed for improvements that enable the expenditure of research funds to be conducted in a more autonomous and flexible fashion.

The Government's aim in establishing the RDCs was to make agricultural R&D activity more efficient and effective, while continuing to produce results relevant to the needs of industry. The corporate form of the established RDCs is seen as the optimal administration model as a result of the operating and financial flexibility it brings.

1.2.1. The RDCs and industry

The RDCs provide strategic leadership to industry R&D activity while stimulating industry interest in R&D activity and outcomes. They take a proactive role in identifying and filling gaps in the agriculture research effort.

The commercial operating nature of the RDCs expands the level of resources available for R&D, improves the efficiency with which R&D moneys are spent and directs R&D funding to high payoff areas.

The RDCs were established such that the Commonwealth funding contributions would act as incentives for industry contributions. Up to the 0.5 percent GVA matching limit, the more funds contributed by industry, the more contributed/matched by government. Therefore, the RDC model is constructed so that Commonwealth contributions are seen as seed money which encourages further industry contributions. The RDCs therefore have a key role in both the generation and allocation of R&D expenditure.

In the absence of Commonwealth funding—the other wise case—it is likely that the level of industry investment in R&D would be lower. Evidence of this is that 11 of the 13 levy funded RDCs receive industry contributions equal to that made by the Commonwealth.

1.2.2. RDC collaboration

The effective use of networking will play a major role in assisting R&D corporations to increase their effectiveness and to encourage greater investment. RDCs are responsible for developing close liaison with each other in order to ensure informed decision making and collaboration between corporations.

1.2.3. Investment planning

Both statutory and industry owned RDCs responsibilities include the preparation of five-year strategic R&D plans in consultation with their industries and annual operational plans which are designed to focus their activities around industry endorsed objectives. RDCs are required to fund and monitor research, facilitate the dissemination, adoption and commercialisation of results of research and report annually to the Minister regarding their activities. R&D councils are accountable to their representative organisations through their annual reports and are subject to the requirements of the Audit Act.

1.2.4. Monitoring R&D activities

In addition to the initial coordination and funding of R&D activities consistent with their annual operational plans, the RDCs also monitor and evaluate those funded activities, that is, they do not play a passive role in allocating R&D monies. Evaluation of projects is undertaken against an assessment of industry needs and objectives as embodied in the strategic plans and outlined in Section 3.5.

The corporations are also responsible for facilitating the dissemination, adoption and commercialisation of research results. This is a very important part of their function. It is through technology/information transfer that research results are put into practice and progress is made towards greater innovation and commercialisation and therefore productivity within the agriculture industry.

The Government conceived the RDC model with the expectation that these arrangements would maximise the returns to R&D investment.

1.2.5. Strategic objectives

Ultimately, the RDC model of R&D provides flexibility and autonomy to the administration of R&D funds and provides industry with a greater influence on the objectives towards which that expenditure is directed. In the

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passing of the PIERD Act, the Government considered that this was a necessary change if industry was to recognise the value of research and development expenditure and invest more in this area.

The CRRDCC's strategic objectives are to:

Promote the benefits of R&D through improved communication activity based on examples of positive and measured research outcomes;

Effectively participate in policy development; and

Demonstrate the effectiveness and quality of R&D ensuring the maximum return from stakeholder investment in R&D.

The RRDCs represented on the Council, and their corresponding income and expenditure for 2004/05, are listed in Table 1.

Table 1 **RRDCs income and expenditure (2004-05)**

	Industry contribution ($m)	Commonwealth contribution ($m)	R&D Expenditure ($m)
Rural R&D Corporation (Statutory)			
Cotton R&D Corporation	4.58	4.32	12.62
Fisheries R&D Corporation	11.20	16.90	29.06
Forest and Wood Products R&D Corporation	3.77	2.97	8.20
Grains R&D Corporation	64.19	35.74	119.53
Grape & Wine R&D Corporation	9.68	8.10	16.89
Land & Water Australia		12.50	26.27
Rural Industries R&D Corporation	2.68	14.65	21.09
Sugar R&D Corporation	5.13	4.56	8.66
Rural R&D Companies (Industry owned)			
Australian Egg Corporation	0.75	0.76	1.71
Australian Pork Limited	3.80	4.22	7.67
Australian Wool Innovation	42.84	13.51	78.49
Dairy Australia	14.53	14.53	36.11
Horticulture Australia Limited	31.63	32.91	66.92
Meat & Livestock Australia (MLA), including LiveCorp	39.04	39.04	78.08
Total	233.82	204.71	511.30

Data source: DAFF (2005)

In 2004/05, the RRDCs invested $511 million, of which about 60% was funded by industry.

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- In the remainder of this chapter, the investments of the RRDCs are placed in the context of national and Ministerial priorities, and the role of the RRDCs in the innovation chain is explained (background information on the RRDC model and its evolution can be found in Appendix 1);
- Chapter 2 provides an overview of the value of rural R&D;
- Chapter 3 provides information of the value of the RRDCs investment in R&D in the context of the national priorities, and focuses on collaboration and the decision making principles and program design strengths of the RRDCs; and
- Chapter 4 makes the case for the role of the RRDCs in managing public funds for R&D.

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1.3. RRDC priorities

1.3.1. National research and development priorities

The National Research and Development Priorities (NRDPs) covering all Australian Government resource enterprises were announced by the Prime Minister on the 5th of December 2002 and were enhanced and refined in 2003 to take greater account of the contributions of the social sciences and humanities research. The national research priorities are thematic and are underpinned by the following four main 'priority goals':

- An Environmentally Sustainable Australia;
- Promoting and Maintaining Good Health;
- Frontier Technologies for Building and Transforming Australian Industries; and
- Safeguarding Australia.

RRDC investment by each of the national priorities is shown in Table 2.

Table 2 **RRDC investment by national R&D priority**

	An Environmental Sustainable Australia	Promoting and Maintaining Good Health	Frontier Technologies for Australian Industry	Safeguard Australia
Rural R&D Corporation (Statutory)				
Cotton R&D Corporation (2006-07	1,533,280	1,045,320	7,780,360	31,080
Fisheries R&D Corporation	13,100,000	1,400,000	4,600,000	2,200,000
Forest and Wood Products R&D Corporation	205,561	3,659,019	3,097,934	337,480
Grains R&D Corporation (2006-07)	17,110,000	60,720,000	23,600,000	15,680,000
Grape & Wine R&D Corporation				
Land & Water Australia (2006-07)	12,465,140	6,790,700	8,550,960	1,431,200
Rural Industries R&D Corporation (2006-07)	2,380,422	15,098,349	4,976,743	402,619
Sugar R&D Corporation (2006-07)	2,985,000	3,081,000	5,690,000	226,000
Rural R&D Companies (Industry owned)				
Australian Egg Corporation	7,920	1,260,267	142,265	98,655
Australian Pork Limited (2006-07)	714,570	1,093,894	2,429,539	1,730,997
Australian Wool Innovation (2006-07)	1,780,000	32,320,000	31,410,000	4,390,000
Dairy Australia	8,995,062	22,787,492	25,186,175	2,998,354
Horticulture Australia Limited (2005-06)	6,045,974	30,531,245	20,188,124	2,254,412
Meat & Livestock Australia (MLA) including LiveCorp	20,896,000	5,563,000	51,579,000	6,760,000

Note: Unless indicated, expenditure figures represent actual 2004/05 expenditure. For those RDCs marked 2005/06 or 2006/07, these are actual 2005/06 or forecast 2006/07 expenditure.

Data source: RRDC Annual Reports.

1.3.2. Rural research priorities

Since 1994, the RRDC model has planned and executed its R&D within a strategic framework that includes priorities established by the responsible Minister and priorities identified by industry. The themes of these priorities, which are consistent with the national priorities, are shown below (Table 3).

Table 3 **National Research Priority and Rural Research Priority concordance**

National Research Priority	Rural Research Priority
An Environmentally Sustainable Australia	Sustainable Natural Resource Management
Promoting and Maintaining Good Health (Strengthening Australia's Social and Economic Fabric)	Improving Competitiveness through a Whole of Industry Approach
	Maintaining and Improving Confidence in the Integrity of Australian Agricultural, Food, Fish and Forestry Products
	Improved Trade and Market Access
Frontier Technologies for Building and Transforming Australian Industries	Use of Frontier Technologies
	Creating an Innovative Culture
Safeguarding Australia	Protecting Australia from Invasive Diseases and Pests

1.4. RRDCs and the innovation system

The innovation chain comprises the transformation of ideas into commercial and non-commercial benefits, and is therefore not just about new technology generated through R&D, but also the implementation of new ideas and innovation. The innovation chain is about developing and putting new technology and new ideas into practice, and achieving commercial, social and environmental success. Innovation can therefore improve the productive performance of a national economy, allowing for higher living standards.

The innovation system includes the institutions, incentive structures, and the abilities and competencies of all those involved that assist with, or inhibit, the innovation chain. The success of the system is a function of the strength of each of the elements and the interactions between them. The RRDCs strengthen the innovation system in Australia by:

- Being a key institution that coordinates industry and government objectives;
- Efficiently and effectively removing the disincentives associated with market failures and delivering the incentives of government funding;
- Supporting the development of scientists and R&D adoption services; and
- Providing a conduit through which each of the elements – institutions, incentives and human resources – interact for greatest national benefit.

Economic studies conducted into the economic returns from R&D have important policy-relevant findings, regarding the interaction between various elements of the innovation system, namely that:

- Business R&D is complimentary to public sector R&D, such that raising investment in one sector stimulates the productivity of the other;
- The rate at which small firms innovate is dependent on their proximity to university researchers in relevant fields; and
- A country's ability to absorb foreign technology is enhanced by investment in education and by investment in own R&D.

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The latter finding reinforces the view that in order to benefit from the global stock of world knowledge, countries need to have a well developed innovation system including well trained scientists, a technologically capable workforce and active engagement in research and development and innovation.

Stated another way, economic literature in this area leads to the conclusion that, if a country wants to take full advantage of the spillovers from international R&D and innovation, they have to spend on R&D—the free-rider approach clearly does not work (Dowrick, 2003).

A key role of the RRDCs is to identify government and industry needs and priorities, commission research including technology development and demonstration, develop outputs to meet government and industry needs (product commercialization and market development), and foster uptake and adoption (market entry and market volume) (DAFF, 2005). The RRDCs are therefore not only intimately involved in the innovation chain due to the nature of their work, but are also an integral part of the innovation system.

The R&D commissioned by the RRDCs, and the associated generation of innovative ideas, results in outcomes that are known drivers of productivity and economic growth, in that they represent:

- Investment in physical and human capital;
- Technological advances/progress; and
- Institutions and policies consistent with efficient economic organisation.

While the R&D commissioned by the RRDCs contributes to productivity improvements primarily in the agricultural fisheries and forestry industries, they also produce economic, social and environmental spillover benefits to the community as a whole. These benefits are particularly relevant to wider Government objectives associated with rural and regional development.

While the exact contribution to the community's wellbeing from RRDC's R&D and innovation activity cannot be known, this does not mean that the contribution is not real and substantial. In the following Chapters, the contribution of RRDCs is examined using a variety of techniques including a review of:

- The contribution of the agriculture sector to GDP;
- Productivity measures for the agriculture sector through time;
- The economic literature regarding the private and social rate of return to R&D; and
- Case studies that examine specific RRDC R&D projects and review the techniques used to measure returns to project specific R&D.

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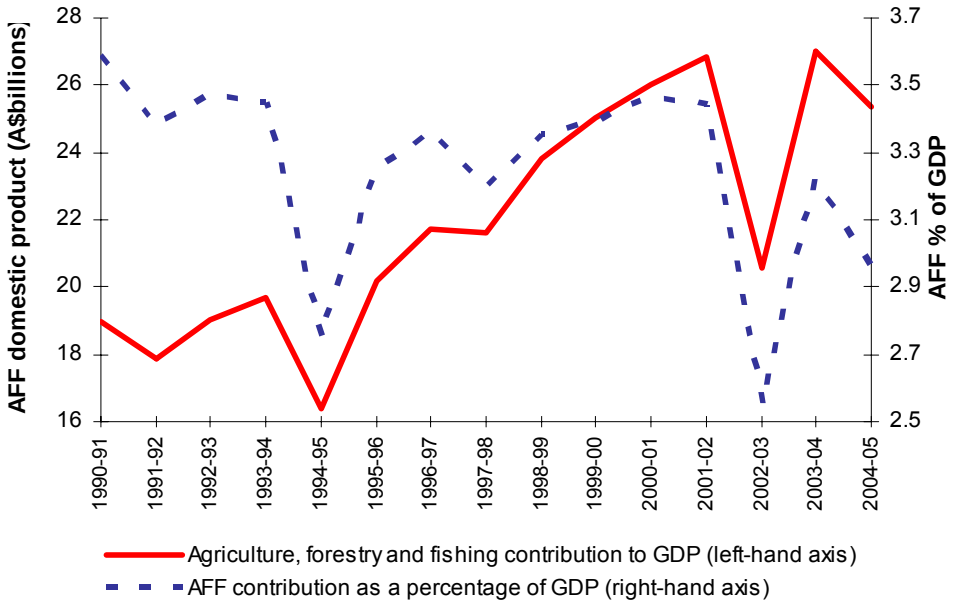
2. The Value of R&D to the Australian Economy

2.1. The AFF industry contribution to GDP

The R&D conducted by the RRDCs is primarily concerned with the Agriculture, Forestry and Fishing (AFF) sector. Over the last 15 years, AFF sector value-added has increased in real terms from $18.97 billion to $25.36 billion (in 2003-04 dollars).

During this period, the value of AFF production peaked at $27.01 billion in 2003-04. Reflecting the heavy reliance on external factors such as weather and rainfall, the sector's contribution to Australian GDP has been relatively volatile – ranging from a high of 3.59 percent in 1990-91, to a low of 2.55 percent in 2002-03 (see Figure 1 below).

Figure 1 **AFF's contribution to Australian GDP**



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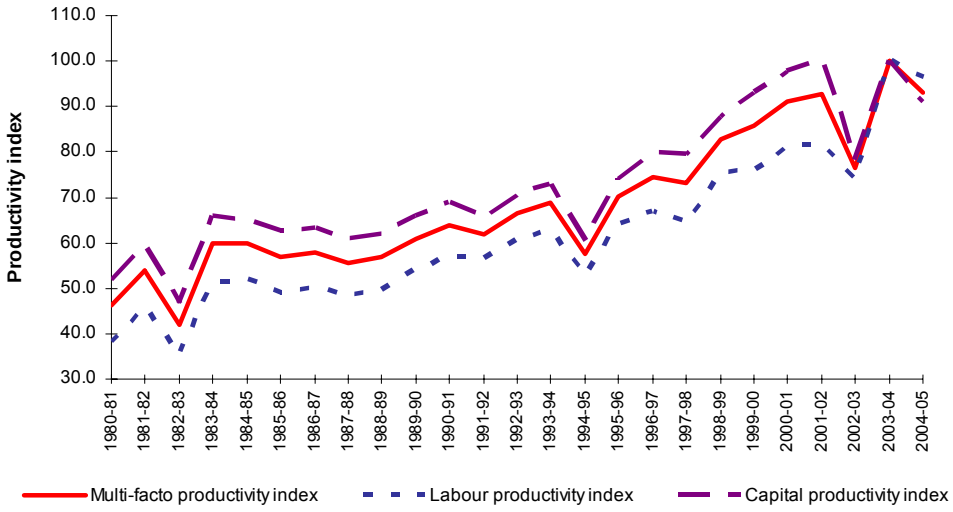
2.1.1. Improvements in AFF industry productivity

While the AFF sector's value-added contribution has been relatively volatile, its productivity has shown strong upward improvement in most years over the last 25 years (see Figure 2). There has been a significant increase in the upward trend since the early 1990s.

Figure 2 **AFF productivity indexes: 1980-81 to 2004-05**



Note: Industry sector estimates have been constructed by the Productivity Commission for 1974-75 to 2004-05. These cover broad industry groupings within the market sector. The Commission estimates are based on unpublished data provided by the ABS and the methodology that is used by the ABS to calculate market sector productivity.

Data source: Productivity Commission (2006), http://www.pc.gov.au/commission/work/productivity/performance/performance.html

2.2. Technological change and agricultural productivity

The uptake of new or improved production techniques, together with increased mechanisation of many aspects of agriculture production has made it possible to produce more with fewer workers, thus freeing up labour for use in other sectors. The data presented in Figure 2 confirms that multifactor productivity has risen substantially in the agriculture sector.

Increases in agricultural productivity has led to a reduction in the share of labour devoted to production which has been a factor in the relative decline of agriculture in Australia and other OECD countries' GDP. However, this decline reflects positive changes, namely:

- improved total factor productivity;
- falling relative prices for food and agriculture products more broadly; and
- rising demand for services as income levels rise.

These are all features of an efficient, high-income economy (Productivity Commission, 2005).

2.3. Economic rates of return to R&D and innovation

Studies of the rate of return to R&D generally estimate those returns with respect to two broad economic boundaries:

- private rates of return – the return on investments in R&D and innovation, which flow from an individual research project to the organisation or specific industry involved. More technically, the

private rate of return is the sum of the net receipts which an economic unit receives from undertaking an R&D activity; and

- social rates of return – the social rate of return on investments in R&D and innovation, that is, the dollar value of the benefits that accrue to society at large. More technically, the social rate of return is the total net benefit (positive or negative) that society gains from an R&D activity undertaken. It is the private rate of return plus the net effect of the activity upon everyone else in society.

2.3.1. Private returns to R&D and innovation: a review of the economic literature

Research efforts to assess the returns to technology have adopted a technique known as growth accounting. This involves the analysis of contributions of production factors and technological progress to economic development. Most growth models focus on substitution of labour with capital, suggesting productivity growth occurs through steady state replacement of labour with fixed capital investments (Salter and Martin, 2001).

The recent studies of economic returns to R&D coupled with the availability of standardized Organisation for Economic Co-operation and Development (OECD) data on different categories of R&D expenditure, the increasing sophistication of theoretical and econometric modeling, and the opportunity to compare private (industry specific) estimates with broader social return estimates have produced a more coherent and consistent overall picture regarding the size and nature of those returns (Dowrick, 2003).

There is now an emerging consensus within the field of economics regarding the private returns to firms' own R&D investment of between 20 and 30 percent (Table 4 below). Taking account of the risk premia required to finance commercial R&D and the depreciation of R&D capital, the net private return on R&D investment appears to be broadly comparable with the return on investment in physical capital (Dowrick, 2003).

Table 4 **Estimated private rates of return to R&D**

Author(s)	Estimated private rates of return (%)
Minnasian (1962)	25
Nadiri (1993)	20-30
Mansfield (1977)	25
Terleckyj (1974)	27
Sveikauskas (1981)	10-23
Goto and Suzuki (1989)	26
Mohen and Lepine (1988)	56
Bernstein and Nadiri (1988)	9-27
Scherer (1982, 1984)	29-43
Bernstein and Nadiri (1991)	14-23

Data source: Salter and Martin (2001).

Comprehensive reviews of the economic literature regarding the private returns to R&D and technology, undertaken by authors such as Dowrick (2003) and Salter and Martin (2000), confirm the existence of significant spillovers of knowledge from the firms that perform the R&D, to other firms within the same industry and to other industries. Taking account of measured spillovers typically raises the estimated gross rates of return on business investment into the 30 to 40 percent range. However, these are likely to underestimate the true social rate of return since the microeconomic studies do not usually cover all sectors of the economy.

2.3.2. Social rate of return to R&D and innovation: a review of the economic literature

The social rate of return is the total measurable benefit to R&D that results in increased output (GDP). The social rate of return does not include other non-measurable or intangible benefits that do not result in output improvements. A more detailed definition of the social rate of return and growth accounting is contained in Appendix B.

Studies examining the social rate of return on investments in R&D and innovation to society at large, take into account national productivity, output and R&D. These types of studies are therefore most likely to capture the full extent of inter-firm and inter-industry knowledge spillover as well as the benefits associated with training and networks.

The range of estimates produced in these studies generally lie between 50 and 80 percent, with maximum estimates over 100 percent. When compared to the estimates of microeconomic studies, this suggests that there are substantial positive spillovers which are not captured by firms in the industry in which the actual R&D investment is carried out (Dowrick, 2003).

Table 5 **Estimated social rates of return to R&D**

Author(s)	Estimated social rates of return (%)
Nadiri (1993)	50
Mansfield (1977)	56
Terleckyj (1974)	48-78
Sveikauskas (1981)	50
Goto and Suzuki (1989)	80
Mohen and Lepine (1988)	28
Bernstein and Nadiri (1988)	10-160
Scherer (1982, 1984)	64-147
Bernstein and Nadiri (1991)	20-110

Ultimately, macroeconomic studies that distinguish between public and private sector R&D and allow for longer time lags for that R&D to affect productivity, find that public sector R&D contributes significantly to productivity. A good example of such a study is Adams (1990), which developed a series of industry measures for the stock of knowledge, based on articles in academic journals and the employment of scientists. Adams found a 20–30 year lag between scientific publication (the knowledge stock) and productivity growth.

Based on his evidence, Adams (1990) suggested that the decline in scientists and subsequent fall in the stock of knowledge associated with the Second World War was responsible for approximately 15 percent of the economic slowdown in the 1970s. These findings provide a good example of the importance of time as a consideration in returns to R&D estimates.

Returns to agricultural R&D

Salter and Martin (2001) in their review of the economic benefits of publicly funded basic research present known estimates of the rate of return to publicly funded R&D in the area of agriculture. The estimates generally range from 30 to 50 percent, however the author notes that these results should be used with caution as they tended to focus on relatively successful government R&D programs and generally do not take into account the investment in complimentary assets needed to bring the technology to market. Consequently, the resulting return on investment may underestimate the true costs of technological development.

Table 6 **Estimated rates of return to publicly funded agricultural R&D**

Author(s)	Estimated social rates of return (%)
Griliches (1968)	35-40
Evenson (1968)	28-47
Davis (1979)	37
Evenson (1979)	45
Davis and Peterson (1981)	37
Huffman and Evenson (1993)	43-67

Data source: Salter and Martin (2001).

Summary

Existing empirical models are limited in the extent that they can show the exact contribution of R&D and innovation to productivity gains and economic growth within a particular sector as well as the broader economy. Despite this, there appears to be an emerging consensus regarding the existence and approximate size of the returns to R&D — that is, they are both real and substantial.

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3. The Value of RRDC Funded R&D

3.1. The challenge of valuing RRDCs

A key constraint to valuing R&D includes the fact that valuations of non-market or intangible benefits are necessary for all encompassing return on investment evaluations. Future adoption assumptions have to be made with scarce historical adoption rate information while long time frames are required for all benefits to R&D to be realised.

The appropriate balance between:

the depth of analysis in a case study, especially the quantification of a range of benefits; and

the number of case studies that can be satisfactorily completed given a finite level of resources,

can be difficult to achieve.

3.1.1. Existing methodologies

Existing performance monitoring techniques include:

- adoption/commercialisation measurement (industry surveys etc.);
- cost-benefit analysis;
- triple bottom line reporting; and
- case study presentation.

Existing methodologies used to assess operational performance and, more broadly, the delivered benefits to R&D investment (for example, commercialization/adoption rates) are important performance monitoring techniques. However, the most commonly used method of traditional cost-benefit analysis, while useful in monitoring the performance of R&D programs and prioritising research expenditure at the operational level, is generally not sufficient to understand the organisation's role in a changing environment and provide an aggregate measurement of the returns from an RDC's investment activities/portfolio.

3.1.2. Real options framework

The term "real options" refers to the application of option theory (initially developed for financial markets) to "real investments" which involve uncertainty and flexibility. Options analysis (for both financial and real options) emerged form a desire to better manage downside risk, while retaining access to upside opportunities, and for providing a sound basis for the valuation of opportunities. It provides a framework for the evaluation of high risk investments such as R&D.

An option is the right to buy or sell an asset at a given price without the obligation to do so. In other words, a real option entails the right to undertake an action – such as to invest in or abandon a research idea – but without any obligation to do so. Importantly, real options analysis recognises the reality that managers can, and do, adapt to technological or market changes and that the scope for doing this is important to the value of a project.

By breaking a research theme into stages, with each being the purchase of an option to proceed to the next stage or to delay or cancel the next stage, risks are greatly reduced and the potential for useful research outcomes per dollar invested are increased.

As research proceeds through its stages of discovery, the uncertainties associated with success or failure change. Sometimes unexpected results arise that create unexpected value (Figure 3).

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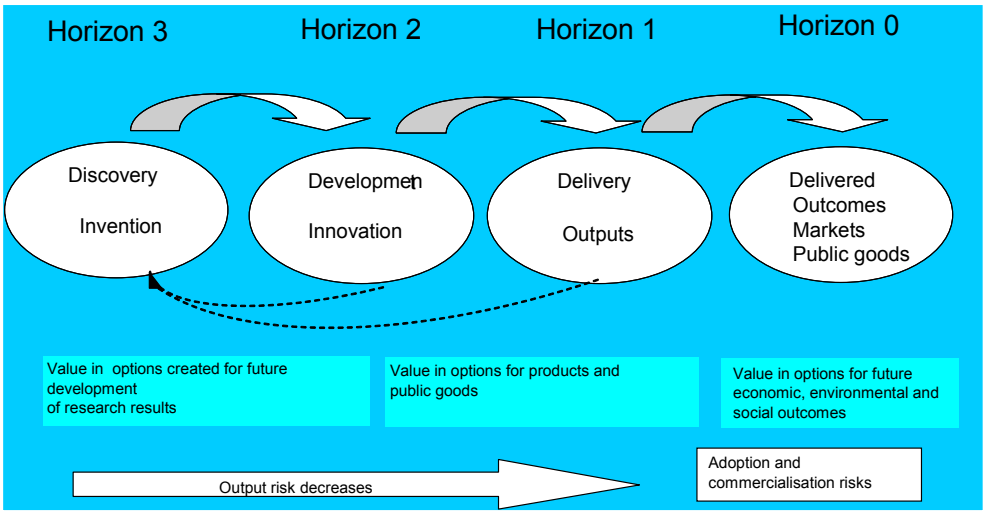
Figure 3 **Stages in research**



Data source: ACIL Tasman

In recent reviews of research and development, measurement has focussed on the measurable and demonstrated results that are associated with delivered outcomes. Such an approach was taken in the 2003 review of the CRC program.

However value is also created at the earlier stages of research (Horizons 2 to 3 in Figure 3). Assessing this value is subject to high uncertainty but assessment can be made in an options setting.

Viewing the value of research as the value of the options created for delivering future payoff gives a more comprehensive indication of its value. In this respect, option approaches to valuations are more realistic than applying discounted cash flow techniques that assume that all benefits accrue and all costs are incurred.

The options approach focuses on the value that a new or additional 'iron in the fire' brings to the prospects for achieving a potentially valuable breakthrough. In some circumstances where research is already underway, additional effort can be justified because it influences the prospects for a 'solution' emerging, brings forward the average timing of such a development, helps to tailor the investment to better cover specific Australian needs or increases the chances of controlling strategically important intellectual property (IP). All of these can usefully be viewed in an options setting.

Alternatively, if the research is not successful or does not deliver promising outcomes, further investment can be terminated.

The RDCs through the Council of RRDC Chairs will be considering the value of applying this approach to future reporting of the benefits of research and development.

3.2. An estimation of the dollar value return to RRDC investment

As outlined in Section 2.2 there is an emerging consensus within the field of R&D economics regarding the existence and size of the private and social returns to R&D investment.

Comprehensive reviews of existing economic literature regarding the private returns to R&D, undertaken by authors such as Dowrick (2003) and Salter and Martin (2000), confirm the existence of significant spillovers of knowledge from the firms that perform the R&D, to other firms within the same industry and the economy more broadly.

The results available from previous research and collated by Dowrick (2003) and Salter and Martin (2000), allow us to calculate average rates of return with which to apply to the known aggregate RRDC expenditures. The estimated average annual rates of return for private and social R&D appear in Table 7.

Table 7 **Average annual rates of return to R&D – a review of the economic literature**

Average annual estimated private returns to R&D (%)	Average annual estimated social returns to R&D (%)
34.4	64.7

Note: Averages are derived from the reviews conducted by Dowrick (2003) and Salter and Martin (2000).

Data source: Dowrick (2003) and Salter and Martin (2000).

Applying these averages to the aggregate 2004/05 RRDC expenditure of $511.3 million (both government and industry contributions) implies an expected annual:

- private return of $175.89 million (34.4% per annum); and
- social return of $330.81 million (64.7% per annum).

This means that the estimated net benefit captured by society, outside of the benefits captured by the industries represented by the rural RDCs, is in the vicinity of $154.92 million or 30.3% per annum.

A note on estimating rural R&D investment returns

In considering the estimated returns to R&D, it is important to bear in mind that rural R&D produces benefits which flow through out the community and the economy. Some of the less obvious benefits include:

- Increasing the stock of useful knowledge and the capacity for scientific and technological problem solving;
- Training skilled graduates;
- Creating new scientific instrumentation and methodologies;
- Forming networks and stimulating social interaction; and
- Creating new firms.

Since the total measurable benefit to R&D are those benefits that result in an increase in output (GDP), any growth accounting estimates of the returns from R&D, whether private or publicly funded are likely to be conservative.

3.3. Demonstrated benefits of RRDC funded R&D

In this section of the submission, examples of the benefits of R&D programs relevant to the national research priorities (NRP) are presented via individual case studies.

3.3.1. Environmentally Sustainable Australia

Australia is facing significant environmental challenges in water-use; land degradation, climate change and energy production. This NRP aims to improve our understanding of environmental systems and encourage application of new technologies and practices to better manage the nation's natural resource base for future generations (DAFF, 2005).

- The Environmentally Sustainable Australia NRP relates to the following rural research priorities:
- Sustainable Natural Resource Management; and
- Efficient Natural Resource Use.

All of the above research priorities are demonstrated in the ECOGRAZE, environmentally sustainable grazing management research project conducted by LWA.

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Box 1 **LWA ECOGRAZE – environmentally sustainable grazing management for northern Australia (1992-93 to 2000-01)**

ECOGRAZE was conceived as an investment from which to develop grazing management guidelines for open eucalypt woodlands in northern Australia. The study was conducted on five commercial grazing properties on different land types in north-east Queensland. The long-term grazing trials have demonstrated sustainable grazing management options that will optimise beneficial grasses for beef production, while minimising soil and nutrient loss.

Collaboration

The study was undertaken by researchers in the Sustainable Rangelands Group of CSIRO Sustainable Ecosystems, in conjunction with researchers in the Queensland Departments of Primary Industries and Natural Resources and Mines.

Outcomes

The economic benefits from using ECOGRAZE principles include:

- The prevention of the deterioration of good condition land and the potential for recovery of deteriorated land
- The prevention of permanent or irreversible degradation of land which ultimately leads to the reduced profitability of grazing operations; and
- The potential for a small annual average cash return advantage to farms that apply the ECOGRAZE principles and derive either of the above two economic benefits.

The potential environmental benefits from adoption of ECOGRAZE principles are:

- Reduced sediment export to waterways as well as biodiversity benefits from improved land and vegetation condition; and
- Improved soil and insect biodiversity, and overall land and vegetation condition of grazing lands due to the retention of native perennial grasses.

Results

Cost-benefit analysis for the ECOGRAZE investment was conducted by valuing benefits from changes in profitability for land managers who adopted the guidelines developed in ECOGRAZE. The NPV that can be attributed to LWA is small relative to the total benefits likely to have been generated.

Table 8 **ECOGRAZE return on investment criteria**

Criterion	Benefits and all costs to date (2005)	All benefits and all costs	Benefits to LWA and LWA costs
Present value of benefits ($m)	0	32.08	1.38
Present value of costs ($m)	5.45	5.45	0.2
Net present value ($m)	-5.45	26.63	1.18
Benefit-cost ratio	0	5.89 to 1	6.94 to 1
Internal rate of return (%)	negative	17.62	21.94

The ECOGRAZE principles have been well developed and have gained considerable credibility in the industry, partly due to the work being undertaken on commercial properties and the messages being well documented, explained and promoted through various training programs.

Data source: LWA (2005), Land and Water Australia's Portfolio Return on Investment and Evaluation Case Studies.

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3.3.2. Promoting and Maintaining Good Health

Part of the NRP of promoting and maintaining good health is to understand and strengthen the social and economic fabric that helps Australian families and individuals live healthy, productive and fulfilling lives (DAFF, 2005). This particular NRP relates to the following rural research priorities:

- Maintaining and Improving Confidence in the Integrity of Australian Agricultural, Food, Fish and Forestry Products;
- Improving Competitiveness through a Whole-of-Industry Approach; and
- Improved Trade and Market Access.

The Australian Pork Limited (APL) pig meat hygiene program case study clearly demonstrates R&D activity that promotes and helps to maintain the good health of the Australian community (see Box 2 below). The case study outlines the nature of the APL project, the extent to which it fostered collaboration, the outcomes of the project and the measured net benefits of the project.

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Box 2 **Pig Meat Hygiene Program - maintaining good health**

Australian Pork Limited (APL) established the Pig Meat Hygiene Program (PMHP) with a view to:

- protecting domestic markets through the production and delivery of safe pork to consumers
- meeting World Trade Organisation food export standards so that access to international markets is enhanced; and to
- Assess inspection efficiency in regards to;
  - Determining lesions of food safety significance in Australia
  - Evaluating appropriate (risk assessed) inspection procedures; and
  - Recommending a national standard for pig inspection.

Collaboration

The PMHP has included projects undertaken by the South Australian Research and Development Institute (SARDI), and the Victorian Institute of Animal Sciences (VIAS).

Costs

APL's commitments to the Pig Meat Hygiene Program project is reflected in post 1995 expenditure of $927,531. Assuming similar costs for SARDI and VIAS, total project costs were approximately $1.85 million.

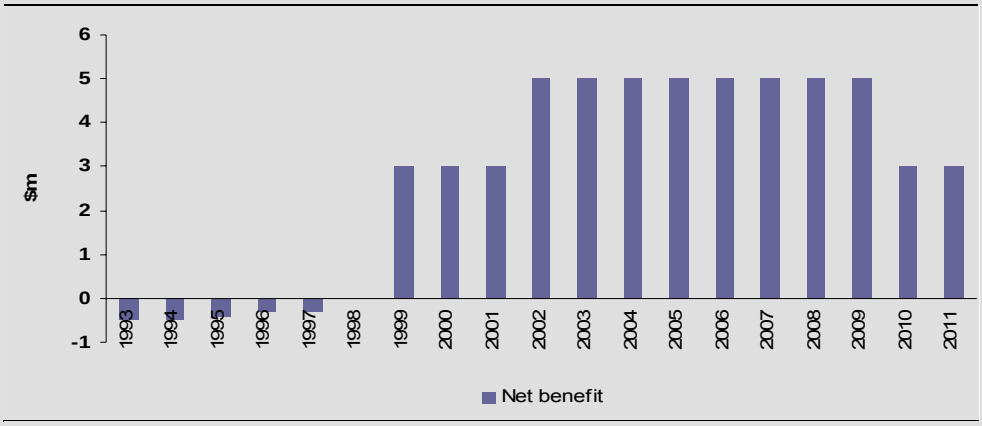
Outcomes

The meat quality assurance, risk assessments, determination of microbe prevalence and consequent adoption of these systems has reduced the potential for 'food safety' issues to affect the demand for pork. The research also led to new meat inspection practices which have reduced processing costs.

Results

The total benefit from changed inspection practices is estimated to be equivalent to $0.8 per pig slaughtered. The economic pay-off in terms of net present value (NPV) and benefit-cost ratio (BCR) are $33 million and 9:1, when a 6% discount rate is used.

Figure 4 **Pig Meat Hygiene Program - estimated net benefits through time**



Changes to meat inspection as a result of this research program has delivered considerable economic benefits to industry through labour cost savings in abattoirs and increased meat yields. Additionally, the program has reduced the probability of food poisoning outbreaks. A break-even probability of the research resulting in a lesser chance of a Salmonella outbreak of about 1% would alone be required to justify project expenditure.

Data source: APL (2004), Ex-post Benefit-Cost Analysis of Selected APL Projects.

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3.3.3. Frontier Technologies for Building and Transforming Australian Industries

The aim of this NRP is to promote the use of new technologies to develop products that provide new solutions to old problems, help build new industries and develop and transform existing industries. The priority also embraces the importance of having an 'innovation focused culture' and economy to maximise Australia's creative and technological capability. This means that industries should seek to test new tools and techniques in their business to evaluate whether or not the innovations help them build better farm businesses (DAFF, 2005).

The Frontier Technologies for Building and Transforming Australian Industries NRP involves research related to building new industries and developing and transforming existing industries that are central to an innovation focused culture. This particular NRP relates to the following rural research priorities:

- Use of Frontier Technologies; and
- Creating an Innovative Culture.

The following case study of the Rural Industries Research and Development Corporation (RIRDC) rice research portfolio clearly demonstrates R&D activity that assists with building new industries and developing and transforming existing industries that are central to an innovation focused culture (see Box 3 below). The case study outlines the nature of the RIRDC project, the project outcomes and results and the measured net benefits from the project.

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Box 3 **RIRDC rice research portfolio - an assessment of investment returns**

At 2004, RIRDC had invested approximately $55.3 million in rice industry research and development (R&D). This figure includes funding provided to researchers through the Cooperative Research Centre for Sustainable Rice Production (Rice CRC). The research has been spread across a range of areas, but particularly in the areas of industry development and sustainability.

Outcomes

The research evaluated here has led to a range of changes resulting in:

- a reduction in the unit cost of production — due to a decline in the volumes and/or price of variable inputs and due to yield increases
- an expansion in the area of rice production relative to what would otherwise have been the case;
- an increase in whole grain mill-out and associated price premium;
- an increase in water potentially released to the environment; and
- a reduction in potential environmental risks and off-site production risks (from chemical spray-drift).

Results

The results in table 1 represent the most likely pay offs to the R&D. The results indicate that in general the research has had a high payoff, most notably:

- Fertiliser management research had a very high payoff with an NPV of $63 million, a net benefit to investment ratio (NBIR) of 9 and an internal rate of return of 132 per cent. The benefits came from water savings, yield improvements and higher whole grain mill-out.
- Weed management research had a return on investment with an NBIR of 70 and an IRR of 87 per cent, and an NPV of $1.5 million on an investment of $20,000 for the SCWIIRT system.
- Under the pest management research cluster, the bloodworm and snail management research led to a NPV of $28.4 million, a NBIR of 18 and an IRR of 180 per cent. The crop rotation pest control component generated a NPV of $23.6 million, a NBIR of 23 and an IRR of 73 per cent.
- The EM-31 technology had an excellent pay-off with an NPV of $157 million, an NBIR of 99 and achieved an IRR of 81 per cent. Of this, 24 per cent accrued to growers via lower water costs and expansion in rice production area, with the rest ($120 million), a return to the environment.

Table 9 **Rice research evaluation outcomes**

RIRDC rice research project	NPV ($m)	Cost ($m)	NBIR	IRR (%)
Fertiliser management	63.0	7.1	8.6	132.0
Weed management - SCWIIRT	1.5	0.03	70.0	87.0
Weed management - resistance	7.8	0.65	13.0	45.0
Pest management – bloodworm and snails	28.4	1.7	18.0	180.0
Pest management - rotations	23.6	1.1	23.0	73.0
EM-31	156.9	0.4	99.0	81.0

Note: NPV results are discounted at a rate of 5 per cent.
Data source: RIRDC (2004), Evaluation of the Rice Program: An assessment of investment returns - Stage 2.

Generally the projects have satisfied the pay-off requirements for RIRDC. That is, the projects have generated either an NBIR greater than eight times research costs or an IRR greater than 25 per cent. For the total investment of $11 million, the return is estimated as $292 million, a NBIR of 27.

Of this return 59 per cent is a return to rice producers and 41 per cent reflects the value of water saved. This water could potentially be returned to the environment. On average the R&D evaluated in this report has saved rice producers around $80 a hectare per year, over an average 15 year time period. It must be noted that this $80 is not equivalent to an increase in profit, rather, it reflects how much worse off the grower (per hectare of rice) would have been in the absence of the R&D.

Data source: RIRDC (2004), Evaluation of the Rice Program: An assessment of investment returns - Stage 2.

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3.3.4. Safeguarding Australia

The increased pace of movement of people and goods around the world is placing Australia's favourable pest and disease status under threat. This NRP encompasses the importance of research into protecting Australia from invasive pests and diseases and strengthening our understanding of Australia's place in the region and world (DAFF, 2005).

The Safeguarding Australia NRP involves research related to collaboration between industry, government and research organisations which promotes understanding of potential threats to Australia and develops better management solutions. This particular NRP relates to the following rural research priority:

- Protecting Australia from Invasive Diseases and Pests.

The following MLA and AWI case study 'Safeguarding Australia through Collaboration', clearly demonstrates R&D activity that through collaboration, promotes an understanding of the potential threats to Australia and develops better management solutions (see Box 4 below). The case study outlines the nature of the project and the collaboration, the project outcomes and results and the measured net benefits of the project.

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Box 4 **MLA and AWI – safeguarding Australia through collaboration**

Biological Control of Introduced Echium Weed Species

Echium plantagineum (commonly known as Paterson's Curse, Salvation Jane or Riverina Bluebell) is an introduced winter annual pasture weed of Mediterranean origin. Due to a lack of natural occurring Australian enemies, Echium weed has become one of the dominant weeds of temperate Australia. It reduces agricultural productivity by competing with more nutritious pasture plants and because it is toxic to livestock when ingested continuously.

In 1972, CSIRO began a biological control R&D program involving 400 successful releases of insects specifically targeting the Echium species of weeds.

Collaboration

The national program on biological control of Paterson's curse is a cooperative effort involving, CSIRO Division of Entomology, state agricultural agencies in NSW, VIC, SA and WA and the CRC for Weed Management Systems. CSIRO and the state agencies have worked together to speed the release program and to develop essential extension material.

Australian meat (MLA) and wool (AWI) industries have contributed funding with other funding roles for this project provided by the Weeds CRC, CSIRO and the State agriculture agencies.

Outcomes

In the first phase of the program the natural enemies of Paterson's curse were studied in Europe and potential biological control agents were imported to Australia for thorough testing under quarantine conditions. In the second phase, cultures of insects shown to be specific to Paterson's curse were supplied to the States for rearing and release throughout the weed's distribution. Release sites are established with the cooperation of community groups and farmers to enable future collection and redistribution of the insects. Redistribution from release sites and evaluation of the effects of these insects on the weed population is the third phase of the national program.

The crown weevil has been released at over 1000 sites in Australia since 1994 and has been redistributed from 1996 onwards. Crown weevil larvae damage the crown and root, making plants less competitive and reducing their ability to produce seeds. Adults chew holes in leaf blades causing "shot hole" damage while also feeding on the leaf stalks.

Results

Annual benefits in terms of increased productivity of grazing lands are projected to increase from near zero in 2000 to some $73 million by 2015. Because lower attack and spread rates of the insects are observed in regions with late autumn breaks, a slow build up of benefits is expected to continue over many years. The discounted NPV (5%) for the total project during the 1972 to 2050 period, is estimated to be $916 million, with a B/C ratio of 47.5 to 1 and an internal rate of return above 19% (see table below).

Table 10 **Biological control of Echium weed - estimated benefits to MLA and AWI**

Return on investment measure	1972 to 2015	1972 to 2050
Net present value	90.25	319.19
Benefit-cost ratio	14.1 to 1	47.5 to 1
Internal Rate of Return	> 17%	> 19%

Note: NPV figures are a percentage of the total estimated NPV for the project. The percentage allocation represents the benefits to AWI and MLA based on the sum of MLA and AWI funding, as a proportion of the total project funding, up to and including 2001.

Keeping in mind that just over $14 million has been spent on the bio-control program for Echium, the high net present values anticipated give strong assurance of success.

Data source: Nordblom *et. al.* (2001), Benefit-cost Analysis for Biological Control of Echium Weed Species (Paterson's Curse/Salvation Jane).

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3.4. RDC collaboration

Collaboration in R&D is generally considered to provide numerous advantages, including:

- Increased efficiency and generation of a critical mass for quality research;
- Support for multidisciplinary teams required to tackle complex problems; and
- Improved quality of research (through peer exchanges) and adoption (by collaboration between researchers, end-users and any intermediaries).

Many producers manage mixed enterprise businesses and contribute levies to more than one RRDC. For them, collaboration gives more opportunity for the efficient delivery of solutions, with fewer gaps or duplication.

3.4.1. Rural RDC and industry collaboration

RRDC collaboration with industry stakeholders is important because effective adoption of R&D outputs is greatest when parties who will benefit are actively involved in the project as soon as possible. The RRDCs collaborate with both industry and research providers at the project design stage, before finalizing the contract and beginning work. Engaging the intended recipients of research outputs is as vital as the knowledge derived from R&D as simply delivering R&D does not guarantee adoption (DAFF, 2005).

However, as noted in the Rural Research and Development Corporations (2005), collaboration also comes at a cost since it:

- Requires more time in planning and negotiation before research commences;
- Generates numerous transaction costs (that increase as the number of partners increase);
- Can diminish the control and recognition of individual organisations; and
- Introduces new risks to the management and performance of a project.

It is important to appreciate that collaboration is a means to an end, not an end in itself (Rural Research and Development Corporations, 2005).

3.4.2. Current and future collaboration

The RRDCs have developed mechanisms to foster collaboration, the CRRDCC being one such mechanism.

Formally, the Chairs of the RRDCs meet biannually to discuss strategic issues and share information. More broadly, collaboration brings together researchers and stakeholders from across Australia to reach consensus on R&D priorities, desired outcomes and to facilitate adoption.

For example, LWA seeks to collaborate with other funding bodies, government agencies, rural industries and community based groups to broker partnerships for R&D programs and to build capacity within the research community to work with industry, rural communities and government.

Collaborations on specific priority issues ensure the optimal application of Government and industry resources across agencies. These partnerships influence research directions, minimize duplication, maximize research investment in key priorities and provide a great platform for increasing adoption. For example, of the $78.5 million that RRDCs invested on natural resource management outcomes in 2004/05, $9.5 million or 12 percent was spent in collaboration projects. This sum does not include sums invested in collaboration with CRCs, CSIRO and universities, various Australian Government programs, or with state agencies.

Collaboration with industry stakeholders is important because effective adoption of R&D outputs is greatest when parties who will benefit are actively involved in the project as soon as possible. The RRDCs collaborate with both industry and research providers at the project design stage, before finalizing the contract and beginning work. Engaging the intended recipients of research outputs is as vital as the knowledge derived from R&D, as simply delivering R&D does not guarantee adoption (DAFF, 2005).

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In summary, the RDCs co-invest when circumstances suggest it is the best option. Examples of recent collaboration include:

- Better Fertiliser Decisions – managed by Dairy Australia, with investment from MLA and LWA;
- The soil biology program of MLA, AWI and Grains RDC; and
- The National Cadmium Minimisation Strategy involving HAL and Grains RDC.

Table 11 records significant collaborations in which a single rural RDC (LWA) is involved. The table is not exhaustive for LWA, but nevertheless provides an indication as to the depth of collaboration amongst RRDCs.

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Table 11 **Significant LWA RDC collaborations**

RDC	Recent Collaboration	Current Collaboration
Australian Pork Ltd	MEDLI	
Australian Wool Innovation	SGS*	Land, Water & Wool National Annual Pasture Legume Improvement Program (NAPLIP)* Managing Climate Variability Cooperative Venture for Building Capacity* Grain & Graze
Cotton RDC	**Pesticide BMPs** Water use efficiency NPIRD	National Program for Sustainable Irrigation Riparian Guidelines Evaluation Case studies
Dairy Australia	National Land & Water Resources Audit Climate Variability in Agriculture Oral history Effluent management through the general call Gippsland Riparian project NPIRD (nutrients)	Riparian Guidelines Managing Climate Variability Cooperative Venture for Building Capacity* **Better Fertiliser Decisions*** CMA Knowledge Management project Dairy catchment Dairy Australia workshop
Fisheries RDC	Drainage techniques for sugar lands on coastal floodplains Project re: Impact of catchments on estuaries Ord-Bonaparte Program Scoping Study	
Forests & Wood Products RDC	Joint Venture Agroforestry Program	Joint Venture Agroforestry Program
Grains RDC	Climate Variability in Agriculture Program Native vegetation project Adoption Program	National Dryland Salinity Program Managing Climate Variability National Annual Pasture Legume Improvement Program (NAPLIP)* Cooperative Venture for Building Capacity* Grain & Graze
Grape & Wine RDC	National Program for Irrigation R&D (partial root zone drying (PRD))	Acidity Audit Cooperative Venture for Building Capacity*
Horticulture Australia	National Land & Water Resources Audit Pesticide risk assessment NPIRD (PRD, soil /organic matter)	National Program for Sustainable Irrigation Building Capacity for Innovation*
Meat & Livestock Australia	**North Australia Program*** **Sustainable Grazing Systems*** Adoption Program	Grain & Graze Land, Water & Wool (SGSL) Cooperative Venture for Building Capacity* Better Fertiliser Decisions* Managing Climate Variability (Northern Program) National Dryland Salinity Program
Rural Industries RDC	Climate Variability in Agriculture Program Adoption Program Pesticides project (rice)	**Joint Venture Agroforestry Program*** Managing Climate Variability National Dryland Salinity Program NLWRA outputs Managing Riparian Lands guidelines **Cooperative Venture for Building Capacity***
Sugar RDC	Climate Variability in Agriculture Program Drainage techniques for sugar lands on coastal floodplains Riparian Guidelines Acid sulphates project work Trash blanketing project NPIRD (water use efficiency) Nitrogen work at project level	Managing Climate Variability Cooperative Venture for Building Capacity*

Data source: LWA (2005).

3.4.3. Collaboration case study – LWA water use efficiency

The following case study relates to the LWA 'Water Use Efficiency in Irrigation' program which began in 1993/94.

Box 5 **LWA – collaboration in water use efficiency**

R&D investment in water use efficiency studies by LWA commenced with the National Program for Irrigation Research and Development (NPIRD) in 1993. Over the period to 2002-03, NPIRD funded about 30 projects associated with water use efficiency.

Collaboration – who was involved

NPIRD was a partnership for R&D investment managed by LWA (formerly LWRRDC) and funded by LWA, Murray Darling Basin Commission (MDBC), State government agencies, Irrigation water providers, irrigators and a number of other agencies and corporations. A range of research organisations were also involved in the 230 projects funded.

Outcomes

The benefits to this collaboration project, in a triple bottom line format have included:

Economic

Less water use by irrigators in producing a given level of crop or pasture yield through;

- New irrigation technology or management systems
- More effective land and water management plans in irrigated areas; and
- Less wastage of water through improved infrastructure and more effective delivery systems by water providers.

Environmental

Reduced water wastage of water (over watering, leaky channels), resulting in;

- Lowered accessions to groundwater leading to less salt export to rivers
- Potentially more water for environmental flows; and
- Less nutrient export to waterways.

Social

- Improved capacity of individuals and groups to understand and relate to other groups interested in water use efficiency concepts.

A benefit-cost analysis for the total investment in this innovation was carried out with the key benefits valued being:

- Cost savings to cane farmers in north Queensland as a result of the investment; and
- The contribution NPIRD R&D has made to water savings, particularly in southern states.

Investment analysis – quantitative results

	Discount rate (6%)		
Criterion	Benefits to date only/all costs	All benefits and all costs	LWA benefits and LWA costs
Present value of benefits ($m)	35.4	85.8	18.7
Present value of costs ($m)	14.8	14.8	3.2
Net present value ($m)	20.6	71.0	15.4
Benefit-cost ratio	2.4	6.0	6.0
Internal rate of return (%)	42.0	47.0	47.0

The results show that the investment has been an excellent one for NPIRD and for LWA.

Data source: LWA (2005).

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3.5. Decision making principles and program design

Examination of each of the rural RDCs' R&D program evaluation procedures shows that the process of determining which R&D projects to undertake, through to the completion and evaluation of the returns to those projects, generally involves the following processes:

- Determining broad R&D priorities;
- Program planning;
- Ex-ante R&D project evaluation and planning;
- R&D investment;
- R&D management monitoring; and
- Ex-post R&D project evaluation.

The Fisheries RDC and LWA program evaluation procedures provide good working examples from which to gain a more detailed insight into the R&D investment decision process. They are typical of the approaches taken by the RDCs.

Fisheries RDC

Determining R&D priorities

Development of fisheries and aquaculture priorities is a bottom-up process in which beneficiaries and end-users determine the priorities for relevant jurisdictions, industries and enterprises. The Fisheries Research Advisory Bodies (FRABs) then assess the priorities for R&D funding applications in their jurisdictions, rank the applications and refer them to the FRDC board. Those who co-invest in the FRDC-funded R&D help determine the priorities for investment in partnership with the corporation (FRDC, 2005).

R&D planning

The FRDC continually reviews its planning processes. The FRDC also encourages the FRABs to undertake planning for R&D in consultation with governments, industry, other stakeholders and research providers. These plans help to develop and maintain a strong focus for strategic directions and to avoid duplication of R&D.

The FRDCs formal planning processes are augmented by conferences, workshops and meetings relating to fisheries resources and the fishing industry and by steering committees' advice about managed subprograms and specific projects (FRDC, 2005).

R&D evaluation

The FRDC's criteria for evaluating its investments comprise various attractiveness and feasibility criteria. The attractiveness criteria are as follows:

- Is the application relevant to the FRDC's R&D programs?
- Is the need and planned outcomes well-defined and relevant to R&D priorities that are documented in strategic plans for R&D produced by FRABs and/or other entities?
- Is the application a priority of the appropriate FRAB(s), industry sectors(s), fisheries management agency/agencies and other potential beneficiaries? Does the application demonstrate the support of users and beneficiaries and a commitment to utilise the outputs?
- Does the application describe the scope and pathway by which the nation will capture the benefits of the research?
- Is the applicant, potential beneficiary or other entity making an appropriate financial contribution to the project?

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- Will the planned outcomes, if achieved, provide a high-benefit cost ratio of a sound return on investment for money?
- Is there an appropriate level of collaboration between researchers and between researchers, fisheries mangers and fishing industry interests?
- Is the application innovative? Does it add-value to previous R&D?

The feasibility criteria include:

- Are the planned outputs well described and is the strategy for extending the outputs sufficient to achieve the planned outcomes?
- Are the objectives clearly specified and are they consistent with planned project outputs?
- Are the methods well described, and are they consistent with the projects stated objectives?
- Does the applicant have the capacity and commitment to produce planned outputs?
- Are the principal investigator and other researchers to be engaged on the project competent? Have they performed well in the past?
- Is there a strategy for managing data arising from the project so that it will be easily accessible to others in the future?

R&D investment

There are four avenues through which the FRDC invests in R&D:

- Via an annual competitive cycle
- By commissioning a research provider, requesting tenders or forming a joint venture entity
- Through seafood services Australia limited; and
- Via the seafood industry development fund.

R&D management

The FRDC manages projects through a range of mechanisms:

- The FRDC quality management system is the framework that allows the FRDC to manage R&D effectively and efficiently.
- The FRDCs project management information system which integrates technical, financial and administrative data monitors the status of projects and informs FRDC staff when key project milestones are not met.
- FRDC staff assisted when necessary by external advisers, technically evaluates milestone reports to ensure that agreed requirements are met.
- FRDC staff also conducts on-site audits of financial management, risk management and compliance with conditions in project agreements.
- The FRDC uses a range of external information sources to monitor projects between reporting periods including conferences, workshops, and meetings of management advisory committees, FRABs, managed subprograms and other parties involved in research. This information may prompt intervention when projects are not meeting their reporting schedule or other agreed performance indicators (FRDC, 2005).

Land and Water Australia

For Land and Water Australia (LWA) the R&D management processes are focussed on:

- the identification of national priorities

- selection of topics where they can add most value
- development of the most effective interventions
- design and implementation of the research and adoption process; and
- evaluation of results.

The R&D management process comprises the following processes:

- investment and portfolio planning; and
- monitoring and evaluation framework.

Investment and portfolio planning

A biennial investment planning process underpins the LWA strategic R&D plan. The assessment of R&D priorities enables the corporation to respond in a timely manner to emerging R&D needs and issues (LWA, 2005). The key steps are:

  - Scanning – an ongoing process of scanning the business environment by nominated staff and board members and external agencies, with particular emphasis on emerging issues and opportunities. Potential R&D investments are collated assessed and short-listed by the board.
  - Scoring – a process in which the board evaluates the short-listed issues/opportunities against attractiveness and feasibility criteria and selects several for more detailed scoping.
  - Scoping – this is the detailed investigation of the issue/opportunity. The scoping process entails a detailed analysis of the investment opportunity and design of the investment strategy. In considering the R&D programs the LWA board requires an assessment against a template of questions:
  - What is the national or generic significance of the natural resource management issue or opportunity and alignment with the National and Rural Research priorities?
  - What are the key factors or innovations that are believed to contribute to the natural resource management?
  - What mechanisms are available for improving action to address the issue or opportunity? What are the relative strengths and weaknesses of alternative mechanisms?
  - What are the specific outcomes being sought? What R&D will help achieve these outcomes? Who are the clients for this R&D and what is their adoption capacity?
  - What role, if any, should LWA play? What partnerships if any would be necessary to achieve the anticipated benefits of intervention?
  - What is the potential for the R&D investment to provide benefits to the Australian community?

- Program planning – this phase focuses on the assessment and negotiation of potential partnerships and the construction of a detailed program plan in a specified format. The plan is submitted to the LWA board for funding approval.

The programs developed in this way by LWA are allocated for management through one of four broad R&D arenas:

- Industries
- Landscapes
- People; and
- Innovation.

Box 6 **Land and Water Australia: a portfolio evaluation approach**

The LWA portfolio evaluation approach has a number of purposes:

1. To provide evidence to government and industry of the benefits that are accruing from LWA investment and specifically to provide an estimate of the return on the total LWA portfolio investment since 1990.
2. To assist with overall RDC reporting along the lines agreed at the RDC Chairs' meetings
3. To compare the rate of return with that of other RDCs (and similar bodies) to provide a benchmark with which subsequent LWA and RDC investment returns can be compared
4. To provide a rate of return series over time to assess LWA progress
5. To ensure evaluations of non-market benefits are developed and improved
6. To provide material for reports
7. To provide case studies to demonstrate and communicate LWA effectiveness
8. To provide lessons learnt from the performance of innovations, including factors affecting adoption; and
9. To provide examples of where adoption of innovations can be monitored

Return on investment

One of the principal objectives of the RDCs using investment analysis was to ascertain the rate of return of their investment so that governments and industry can be more confident about allocating funds to the sector and compare the likely payoffs of existing investment or additional investment between sectors.

Methodology

The methodology for the portfolio investment evaluation includes both a quantitative and qualitative component. The quantitative component comprises the following:

- Each innovation is defined in relation to a specific number of LWA projects or programs
- The LWA R&D investment costs associated with each selected innovation are defined by year
- The R&D investment costs of other non-LWA parties (researchers or co-funders) are defined by year
- A set of benefits including future expected benefits as well as benefits to the date of the evaluation are quantified; and
- A set of investment criteria for each innovation is produced.

The results of the individual quantitative evaluations are combined to form a set of aggregate investment criteria that measure different benefit types (for example, captured benefits, future benefits etc.) and that can be calculated over different time periods.

The qualitative component mainly provides background to the quantitative evaluation as well as provides information for triple bottom line reporting. The qualitative component also provides detailed case studies that illustrate the effectiveness of LWA investments.

Selecting Innovations

The process of selecting innovations has three key steps:

1. Identifying LWA's best innovations and placing them on LWA innovations database, located on the LWA website
2. Selecting the top 25 innovations for preliminary "scanning" assessment
3. Undertaking a preliminary analysis to select the top 8-10 innovations for case study analysis in any one year.

Data source: LWA, 2005.

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4. RRDCs Role in Managing Public R&D Funds

The previous sections of this submission have discussed the advantages of the RDC model and the benefits that their investments generate for the industries that fund them and the wider public. However, an outstanding question remains – would these benefits be generated to the same extent without matching Government contributions?

There are two main arguments for Government contributing to the RDCs, they are:

- to provide an incentive to for industry to increase expenditure on rural R&D; and
- to generate investments in areas that generate a public good that would be underinvested in by primary producers.

The points above are not concurrent but rather are cumulative. In addition to these points the contribution to the RDCs from Government must also been seen in the context of broader industry R&D support. At present there are tax concessions of between 125 percent and 175 percent for certain types of R&D expenditure for other sectors of the economy. Rural industries forego this tax concession in return for receiving matching funding through the RDCs.

In the 1995 Industry Commission review of Research and Development several unique characteristics of rural industries were cited as justification for collective action (levy funded R&D) and matching funds from Government, they were:

- the non-rival nature of agricultural production;
- large intra and inter industry spillovers
- spillovers to the community beyond those that occurred from investments that can be justified by industry on the private benefits they generate; and
- the large number of small businesses that comprised the sector and the apparent robustness of the family farm as an economic unit.

While rural industries have undergone some structural change since the Industry Commission's report, these unique characteristics remain in place.

The Industry Commission did not attempt to quantify the difference these characteristics may equate to in respective of different rates of Government contributions to rural industries and other sectors of the economy. However, the Industry Commission acknowledged that they should be taken into account when considering the level of Government support for rural R&D.

If the Government were to only fund the R&D that produced a benefit to the public it would have to make a judgement about the amount and type of research the RDCs would be willing to undertake, and then subsidise the additional research up to the point where the marginal social return equals the costs. Clearly this would be difficult to do and the returns may not exceed the transaction costs. As the Industry Commission concluded the Governments take a more pragmatic approach.

> 'In practice, therefore, when Governments subsidise industry research, they also subsidise research which would have been undertaken anyway. However, the expectation is that it will induce additional research, and as a result, generate more worthwhile spillovers than otherwise would have occurred' (Industry Commission 1995).

The rest of this section discusses the funding models within the RDCs and expands on the primary arguments for Government contributions to the RDCs.

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4.1. Funding of the RRDC model

There are two general funding approaches within the RRDC model:

For industry RRDCs, industry-initiated levies are matched dollar-for-dollar by the Australian Government up to a ceiling of 0.5 percent of gross value of production (GVP) for a particular industry; and

For the LWA and non-industry specific elements of RIRDC and Fisheries RDC, there is an unmatched government funding component.

4.1.1. Industry RRDCs

The industry-initiated levies inherent in the RRDC model are a collective action of rural industry designed to overcome market failures that inhibit the conduct of an optimal level of R&D. The market failures are associated with large numbers of producers having significantly reduced individual incentive to undertake R&D because of the limited capacity to capture the benefits of that R&D.

The Australian Government's legislation overcomes the market failure, but does not of itself guarantee optimal levels of investment in R&D. The Government's matching contribution provides leverage to induce industry to initiate a level of funding for R&D at least up to the 0.5 percent GVP ceiling.

The outcome is that each industry that accepts the matching funding invests at least 1 percent of GVP in R&D through the relevant RRDC. An inspection of the data in **Table 1** (see Chapter 1) shows that the Grains RDC and the Wool Innovation RDCs adopted funding levels significantly beyond the incentive level offered by the Government.

It is important to recognise that in accepting the Government's offer of matching funding, industry forgoes the range of taxation concessions that are associated with R&D expenditure. Further, the RRDCs accept the R&D priorities established by the Government and, recognising the Government funding contribution, invest in those priorities. An example is the level of funding directed to natural resource management by the RRDCs, which is described in Section 4.1.4 below.

4.1.2. Sole government funding

With regard to the full government funding of the LWA and the non-industry specific elements of other RRDCs, a part of the rationale is that these RRDCs provide an efficient and effective model for leveraging and managing R&D on issues that would not be expected to be addressed if left to industry-based RRDCs. Not only is this research supported, the management through the RRDCs achieves a degree of coordination among research institutions, research providers and industry adopters, which would otherwise occur in an ad hoc and resource wasteful fashion.

There are also specific rationales that relate to each of the three RRDCs concerned and are associated with the high component of public good in the operating environment of these RDCs:

- Fisheries RDC - with regard to fisheries, wild-catch fishing has significance for the FRDC's revenue base. The Australian Government's contribution of 0.5 per cent of average gross value of Australian fisheries production (AGVP) is made on the grounds that the Australian Government exercises a stewardship role in relation to fisheries resources on behalf of the Australian community.
- LWA – requires income to conduct R&D which generates returns such as off-farm environmental benefits. This is an area subject to 'market failure'. Many of the environmental gains are unpriced public goods or externalities.
- RIRDC - much agricultural information still has public good characteristics and market failure can occur even with services that might otherwise be deemed to be private goods.

4.1.3. R&D as a public good

Rural R&D is a good that will be under-supplied by the market due to an industries' inability to internalise or appropriate all of the benefits and/or because the capacity to produce or utilise existing knowledge and information is costly (expensive to acquire and maintain).

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Examples of public goods in the rural R&D setting include:

- fundamental knowledge flowing from basic research
- research to improve the management of natural resources and enhance environmental quality
- improved knowledge about food and product safety risks and protection from such risks
- improved nutrition and health
- protection against national food security risks such as those associated with the breaching of Australian quarantine barriers; and
- knowledge essential to the accomplishment of public goals such as social equity, economic efficiency and informed public policy making such as that associated with international trade.

The public good argument is also relevant to the spillovers from rural R&D between farms in the same industry and across farms in different industries. Spillovers which flow from farmer to farmer occur, for example, where a farmer has developed a better way to harvest a crop and the new technique is observed and copied by other farmers growing the same crop, who did not contribute to the cost of the research.

Such intra-industry spillovers are thought to be large partly because of the nature of farming (PC, 1995). However, the benefits are even larger when inter-industry spillovers are taken into account. For example, the work done by the Dairy RDC on pastures has proved very valuable for pasture development in the cattle and sheep industries which did not contribute to the original R&D.

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Box 7 **Provision of public goods case study – MLA Predictive Microbiology**

The predictive microbiology project has aimed to understand the link between temperature/environment and microbiological growth through time. This allows industry and regulators to see how different temperature paths change the final outcome of microbiological growth. From this understanding, models provide information on whether particular temperature paths through time provide an appropriate level of food safety.

Predictive microbiology has enabled new markets and become a mechanism for regulation. For regulators, predictive microbiology offers increased certainty about food quality. For industry, the flexibility has allowed for reduced compliance costs, the development of new and less costly processing techniques and enabled the continued use of processing techniques that were previously being called into question.

Predictive microbiology has been used to model how changes to the processing of luncheon meats, pates and cooked sausages could impact on illness and death due to listeriosis. Current estimates are that 44 people per year in Australia contract listeriosis from these smallgoods. Mortality rates for those affected can be in the order of 20 per cent to 30 per cent. The predictive microbiology project identified that the addition of antimicrobial additives to the meats at the processing stage could reduce the number of cases to around 6 per year.

The health benefits of such an action would be to lower the number of cases of listeriosis from smallgoods by 38. This impact is estimated at saving 290 disability adjusted life years (DALYs) or the equivalent to saving around four lifetimes every year. Therefore, predictive microbiology has reduced the risk of illness and death from listeriosis, contributing to saving the equivalent of four lives every year.

The estimates of the value of a DALY can vary widely. However, one estimate is $60,000 per DALY which is widely used by government departments (see for example Commonwealth Department of Health and Ageing 2003). Using the assumption above, additives to listeriosis can generate health benefits of $17.4 million per year. Furthermore, if these benefits last for the next thirty years the total benefits from the predictive microbiology project would be $281 million.

The predictive microbiology project has also contributed to improving the safety of meat and meat products. MLA's surveys of microbiological quality of Australian beef and sheep meat show that a primary measure of overall microbiological count, mean log total variable count, fell by 47.1 per cent in beef and 35.9 per cent in sheep meat between 1998 and 2004. This measure also fell between 1993/94 and 1998, although not by as much as in the later period. About 20 to 30 per cent of this is thought to be due to the activities of the predictive microbiology program.

There is currently no direct quantified link between microbiological count and human illness and death. This is partly because any outbreak and illness/death requires a number of failures along the supply chain. Common sense suggests that such a link exists, but the nature of the relationship is not known.

Data source: Meat and Livestock Australia (2006).

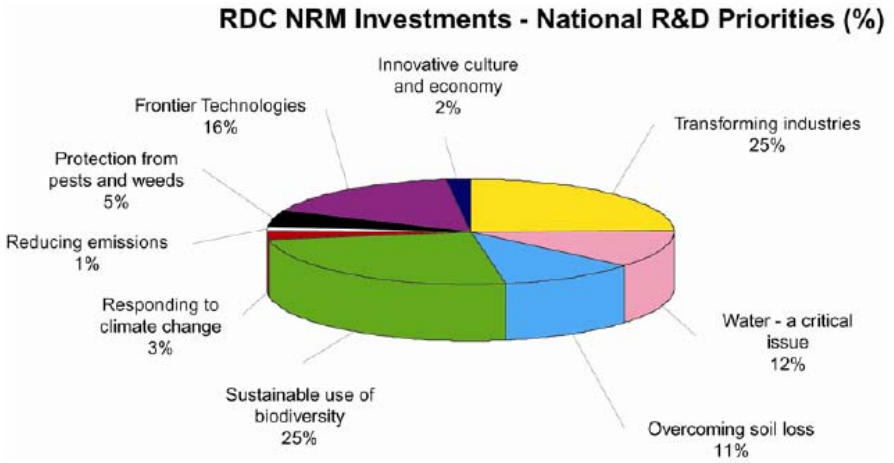
4.1.4. Natural resource management investment and collaboration

The rural RRDCs collectively invested $78.5 million during 2004/05 towards natural resource management (NRM) issues. The $78.5 million represents more than 20 percent of the RRDCs research investment.

Analysis of the investment shows the priorities were (see also Figure 5):

- Investigating environmental priorities such as water, soils, biodiversity and climate (57 percent);
- Transforming Australian industries (25 percent); and
- Frontier technology and innovation (18 percent).

Figure 5 **NRM investment by national R&D sub-priority**



Data source: Rural Research and Development Corporations (2005).

The rural RRDC model encourages NRM issues to be incorporated with production issues and with other elements of value chain management. Coupled with considerable attention to building the capacity of producers (15 percent is directed to improving understanding, knowledge and skills), this results in the rapid adoption of management practices that are both profitable and environmentally sustainable (Rural Research and Development Corporations, 2005).

4.2. Impediments to the innovation system

The key impediment to better outcomes in rural R&D is the loss of R&D and adoption capacity in the innovation system. The number of quality scientists available to carry out the programs that industry and government commission through the RRDCs is of particular concern.

Future R&D capacity and the supply of a SET skilled workforce

The recent 2006 Department of Education Science and Training report, '*Audit of Science Engineering and Technology Skills*' found that there are sectoral science engineering and technology (SET) labour supply issues. There has been strong recent growth in demand for some SET skills, reflecting growth in the resources sector. This has lead to recruitment difficulties with respect to several SET skills, including earth sciences, chemistry and entomology.

Future participation in SET will be impacted by demographics, including;

- the ageing of the SET workforce
- a decline in the number of school leavers from 2010 onwards as a result of demographic change
- the low community profile of SET; and
- the lack of community awareness of the benefits of investment in the sector.

In summary, there is declining participation in SET study which relates to an inadequate supply of suitably qualified teachers. The ability to attract high quality candidates into SET will also impact on Australia's ability to build its future SET capacity (DEST, 2006).

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Future supply of a SET skilled workforce

On the supply side, the pool of SET workers will shrink dramatically due to substantial losses at the experienced end of the spectrum and an insufficient pool of potential recruitments being available at the other end of the spectrum. This will be a result of the ageing of the current SET workforce leading to increased age based retirement and a decline in the number of school leavers from 2010 onwards. Furthermore, recent trends toward static or declining participation in SET if continued, will also impact adversely on supply.

Australia's SET skills supply will face challenges from international demand for SET skills as OECD countries place increasing emphasis on R&D. These countries also face age-based retirement issues (DEST, 2006).

Additional issues – R&D policy

The 1999 '*Inquiry into the Effects on Research and Development of Public Policy Reforms in the Past Decade*' conducted by the Standing Committee on Industry Science and Resources found some additional impediments to the future of R&D in Australia that were highly significant. These included;

- The need for Australian managers and financiers to gain a greater familiarity with science and technology
- The need for greater stability in government policy towards R&D; and
- More coherence and streamlining in the implementation of that policy.

With regard to the last two points this inquiry noted that Australian Federal Government incentive schemes in support of private sector R&D have not in general been implemented within any long-term strategic plan for building Australia's competitive strengths. They have been subject to change and have not recognised the necessary long-term commitment of most R&D ventures. It is counter productive to approach R&D as an item to be reset to zero every few years as the result of an election. Other countries have both major parties agree to the way forward in order to protect and encourage consistency with regards to the national R&D policy (Standing Committee on Industry Science and Resources, 1999).

4.2.1. Agriculture R&D extension issues

Agricultural extension is defined as the application of scientific research and new knowledge to agricultural practices through farmer education. The process of Agricultural extension in Australia has undergone considerable change over the past decade.

Gradual policy changes through the 1990s saw State Government departments of agriculture and primary industries subject to a process of review and re-structuring that has affected the nature of the services they provide and the ways that those services are provided.

New policies have resulted in a large proportion of extension now being undertaken by the private sector rather than traditional public sector providers. The trend towards privatisation appears related to factors such as the declining relative importance of agriculture in the economy and budget pressures on governments. These changes continue and present the agricultural community including the R&D sector, with particular challenges. These challenges relate to:

- Research capability and informational flows;
    - For RDCs whose role can be seen as information wholesale, information needs to be collated and efficiently delivered to a variety of extension providers. Private sector researchers may be less likely to share information and findings.
    - The weakening of research/extension links in particular relating to the decreased ability of farmers to provide feedback to researchers could become a problem as state public sector agencies cut back on production-orientated extension.
- Market failure and the public-good nature of agricultural information;

- Increasing privatisation of extension services raises concerns that some state governments may ultimately neglect goods which are under provided by the market.

A 1999 report by the Rural Industries Research and Development Corporation, '*Agricultural Extension – A Decade of Change*' states that respective Australian state and national governments need to develop a strategy to address key problems and challenges discussed in this report, including:

- Issues related to the privatisation of extension
- Issues of cooperation and coordination between research organisations, government agencies and consulting organisations
- The escalation of transaction costs
- Over reliance on group-based extension methods; and
- Potential problems associated with restricting government extension activities to areas of public good (RIRDC, 1999).

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A. The Rural R&D Corporations

The Council of Rural Research and Development Corporation Chairs

Section 142 of the Primary Industries and Energy Research and Development Act 1989 (the PIERD Act) requires that the Chairperson of each Research and Development Corporation and each Research and Development Council (hereafter referred to as the RRDCs) must meet at co-ordination meetings at least once each financial year for the purposes of:

> ….considering, and, as far as practicable, co-ordinating, R&D activities pursued, or proposed to be pursued, by the RDCs (PIERD Act Section 142 (2)).

The Council of Rural Research and Development Corporations Chairs (CRRDCC, The Chairs or The Council) undertakes this co-ordination role. While the PIERD Act specifies a minimum level of coordination, the RRDCs have taken it upon themselves to take a more active strategic coordination role in the interests of all of their stakeholders.

The CRRDCC's 2006-07 annual operating plan identifies The Council's overarching objective to:

> Further develop the effectiveness and achievements of the Rural Research and Development Corporation (RRDC) model to ensure its continued support.

This overarching objective is underpinned by the following three broad strategic objectives:

1. Promoting the benefits of R&D through improved communication activity based on examples of positive and measured research outcomes;
2. Effectively participating in policy development; and
3. Demonstrating the effectiveness and quality of R&D ensuring the maximum return from stakeholder investment in R&D.

The following sections provide background on the RRDC model and the RRDCs which are represented on The Council, as well as some context for the strategic objectives.

The RRDC Model

The RRDC model stems from the *Primary Industries and Energy Research and Development Act 1989* (PIERD Act) which legislated for the existence of the RRDCs. Under this legislation, the broad objectives of the RRDCs are to:

- Expand Australia's rural R&D effort;
- Improve industry efficiency and effectiveness by investing in high priority areas; and
- Enhance industry's international competitiveness through more effective uptake of research results.

Prior to 1997, all RRDCs were established by regulation under the PIERD Act. However, the RRDC model today is a mix of statutory and industry owned companies. The industry-owned companies are responsible to their members under the *Corporations Act* (2001) and have contractual arrangements (Statutory Funding Agreements (SFAs)) with the Australian Government to plan, fund and disseminate R&D in a manner consistent with the objectives of the original RRDC model.

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The industry-owned R&D companies were formed in response to an industry desire to have more control over their affairs and increased flexibility, including regulation, industry representation and fostering market driven R&D that will be widely adopted by industry.

The RDC's have three key roles in supporting the competitiveness and sustainability of Australia's primary industries:

- They set priorities for primary industry R&D reflecting industry identified needs and Government priorities
- In line with industry and government objectives to increase competitiveness and sustainability, the RDCs invest in R&D services and purchase research from providers such as CSIRO, universities, state and territory agricultural departments and the private sector. They also undertake strategic investment in the undertaking of R&D, including through joint venture companies and they hold intellectual property; and
- The RDCs communicate research findings and technologies to industry. The RDCs fully appreciate that engaging intended recipients of research output is as vital as the knowledge derived from R&D.

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B. Growth Accounting and Social Rates of Return

In typical economic models of growth, sustained growth occurs only in the presence of technological progress. Without technological progress, capital accumulation runs into diminishing returns. With technological progress however, improvements in technology continually offset the diminishing returns to capital accumulation. Labour productivity grows as a result, both directly because of the improvements in technology and indirectly because of the additional capital accumulation these improvements make possible (Jones, 1998).

Growth accounting attempts to break down growth in output into growth in capital, growth in labour and growth in technological change. Technological change is driven by research and development. With no research, no new ideas would be created, technology would be constant and there would be no per capita growth in the economy. Growth accounting therefore attempts to measure the contribution to economic output (GDP) as a result of technological change and thus R&D (Jones, 1998).

Growth accounting is the main method among aggregate studies that attempt to measure the total economic benefits in relation to the total costs of R&D. The total costs of R&D include the costs of more and less successful (that is, all) projects together to assess the overall social value or return. The costs of R&D are typically obtained through surveys of business accounts or through national accounts statistics. Measurement of the economic benefits is more difficult (Dorwick, 2003).

A common approach in measuring the economic benefits of R&D is to estimate the contribution of either R&D expenditures or the stock of accumulated R&D capital, on the level of output or productivity, controlling for the contribution of other inputs such as physical capital and labour. The results are usually presented in one of two ways:

- Estimates of the marginal product of R&D, sometimes referred to as the rate return; or
- Estimates of the elasticity of output with respect to stock of R&D capital.

The measurable economic benefit or the rates of return (marginal product) to R&D are restricted to those benefits which show up in increased out put or productivity. There are of course other objectives/benefits of R&D such as national security, environmental protection, health and social cohesion which need to be taken into account in assessing the overall benefits to R&D.

We can thus define the average social rate of return as the total measurable benefit to R&D that results in increased output (GDP). The social rate of return does not include other non-measurable or intangible benefits that do not result in output improvements.

A large body of research suggests that social returns to R&D and innovation remain well above private returns. Although the prizes that the market offers to potential innovators are substantial, these prizes still fall short of the total gain to society from innovations This gap between social and private returns suggests that large gains are still available from the creation of new mechanisms designed to encourage research (Jones, 1998).

Recent growth accounting in Australia

The Productivity Commission recently conducted econometric modelling of the relationship between R&D and productivity growth in Australia, in its “Econometric Modelling of R&D and Australia’s Productivity” staff working paper. The research was unable to find a consistent robust measure of the impact of R&D on productivity. In addition to core data measurement issues, the most likely explanation is that the extra data period includes disruptions or ‘shocks’ to the relationship between R&D and productivity performance in Australia. This has frustrated attempts to clearly determine the magnitude of any long-term relationship between R&D and Australian productivity.

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The productivity commission concluded that “a major message from all the analysis is that, at least for the time being, empirical estimates of the effects of R&D on Australian productivity are unreliable”. The logic of this conclusion is such that all previous research (although somewhat dated) is no longer applicable as this study could not successfully measure the impact of R&D on Australia’s recent productivity. It could be argued that the previous research provides the only successful existing estimates of the effect of R&D on productivity.

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