

# Economic evaluation of R&D investment in natural resource management

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An approach is presented for evaluating in economic terms the investment made by a publicly funded natural resource management research and development (R&D) funding organisation (Land & Water Australia) over its 16-year life. The approach combines qualitative methods to describe research investments and their outputs, outcomes and benefits with conventional cost-benefit analyses that produce measures of the worth of the investment. While the major driver of such an approach is the need for accountability to the Australian Government, co-funders and the public, a number of other objectives are being met also. Benefits to the organisation are accruing, including a better understanding of the factors that contribute to a successful investment and how to communicate the benefits of research to stakeholders.

One of the important strengths of the process is the consistency of application of a standardised approach to cost-benefit analyses and the transparency of the analyses that have now addressed 28 separate case studies. The approach is flexible, is conducive to updating information over time, and recognises many of the difficulties involved in applying investment analysis to R&D investment. The development of the process has adopted a continuous improvement philosophy.

## Introduction

### Economic analysis of research and development investment

Agricultural research managers and administrators continue to be interested in the economic analysis of the investment in agricultural research. Cost-benefit analysis has generally been used in these economic analyses with three investment criteria often reported. Investment criteria measure the economic worth of an investment and usually include the net present value, the benefit-cost ratio and the internal rate of return.

Studies have consistently shown high internal rates of return to research investment in agriculture. For example, Alston et al. (2001) analysed 289 studies of returns to agricultural R&D that included 1821 estimates of internal rates of return that showed an average rate of return of 65%.

Lesser attention has been given to calculating investment criteria for research and development on natural resources associated with agriculture (e.g. land, water and vegetation). In the Alston et al. study the internal rates of return were found to be lower for research on natural resources than for all of agriculture. However, the natural resource areas in the studies reviewed were focused mainly on forestry and fisheries resources rather than on land, water or vegetation.

Cost-benefit analysis of agricultural research and development in Australia including natural resource research has been given increasing attention since Research and Development Corporations were developed largely due to the increasing degree of accountability imposed. For example, several sets of guidelines for R&D evaluation using investment analysis were produced during the 1990s (e.g. GRDC, 1992a, 1992b and 1992c; Chudleigh & Bond, 1993, and GRDC & RIRDC 1997).

### What is cost-benefit analysis?

Cost-benefit analysis (CBA) is a conceptual framework for the economic evaluation of projects and programs in the public sector. It differs from a financial appraisal or evaluation in that it considers all gains (benefits) and losses (costs), regardless to whom they accrue.

The cash flows of benefits and costs associated with the investment over time are defined and expressed in constant money terms by excluding price inflation. Some of the defined benefits may extend well into the future. The values of costs and benefits in each year are then aggregated to a single year using the concept of discounting, which recognises the time value of money. The summed values of costs and benefits (usually termed present values) can then be subtracted or divided in order to produce measures of the performance of the investment. These are called investment criteria.

Three investment criteria commonly used are:

- *Net present value (NPV)*. This is the discounted value of the benefits of an investment less the discounted value of the costs, that is, present value of benefits less present value of costs.
- *Benefit-cost ratio (B/C Ratio)*. This is the ratio of the present value of investment benefits to the present value of investment costs.
- *Internal rate of return (IRR)*. This is the discount rate at which an investment has a net present value of zero, that is, where the present value of benefits equals the present value of costs.

A glossary of economic terms and abbreviations used in this paper is provided on page 47.

### Land & Water Australia

Land & Water Australia (LWA) was established in 1990 as a statutory research and development corporation within the Agriculture, Fisheries and Forestry portfolio of the Australian Government. LWA is one of 15 Research and Development

Corporations (RDCs) established under the *Primary Industries and Energy Research and Development Act 1989*. LWA's mission is to invest in knowledge, partnerships, innovation and adoption to underpin sustainable natural resource management. It is one of only two RDCs where the base funding comes from the Australian Government, although LWA also manages funds from co-investors in partnership R&D programs. Many of these co-investors are from agricultural industries.

Project evaluation in LWA has traditionally been based at project level with an emphasis on the project meeting its stated objectives. Mid-term and final reviews of projects are both used, with an increasing emphasis over time since 1990 on project outputs and outcomes and how each project had contributed to LWA's goal of sustainable resource management. Many programs (groups of projects) were also subject to review, with appropriateness, effectiveness and efficiency major criteria. An extension to such reviews was the introduction of the use of CBA.

LWA commenced its economic evaluation work in 1992 using small, partly random, stratified samples of projects. Most of these CBAs were initially undertaken on projects in the year in which they were first funded, repeated one or two years after and then again at a later date. Each analysis therefore was undertaken as more and more information about the outputs and outcomes of the investment were available. This approach was termed the 'life of project evaluation' (LOPE). The LOPE reports were summarised and assessed in Chudleigh (2000). The principal shortcomings of this approach were the small sample size and the use of inconsistent methods stemming from a number of different analysts and without standardised guidelines being available. As a result of the latter, no attempt was made to aggregate the results of the various analyses.

Land & Water Australia developed its first comprehensive corporate evaluation strategy in 2001 to assess the progress of its 2001–2006 Strategic R&D Plan (LWA 2001). This coincided with an increasing emphasis from the Australian Government on outcome reporting within a triple bottom-line framework. This reinforced the need for economic evaluation. These imperatives led to a reassessment of the approach to CBA with a new focus on gaining a better understanding of the benefits arising from its whole portfolio of research investment since inception. The new approach was termed the ROI (return on investment) approach.

### Objectives

In the development of the new approach, a number of objectives emerged.

#### 1 Estimate portfolio return on investment

The first and foremost objective was to estimate a portfolio level ROI using consistent, robust and transparent methods. In this way LWA management,

stakeholders and the government could be more confident about its allocation of funds to the natural resources sector. It was recognised that a simple but authoritative quantitative measure of investment performance was required (e.g. a net present value or benefit–cost ratio). Moreover, such measures needed to be based on clear assumptions and reported in a transparent manner. To achieve aggregated results across different independent investments, all analyses need to be conducted in a consistent manner, so that total benefits and costs for more than a single investment can be aggregated.

## **2 Provide lessons learnt from successful investments**

Another primary objective was to learn from each analysis about the factors that contribute to the success or otherwise of research products, so that future investment decisions could take these into account and therefore be made more effectively. By examining all case studies analysed, common success factors could be identified.

## **3 Communicate results through case study stories**

Evaluation case studies based on individual projects or larger thematic research innovations and programs were considered to be an effective vehicle for both analysing and communicating R&D impacts. Each case study was to describe the nature of the R&D investment parcel, who was using the product or knowledge, and what the net impacts of its use were in terms of the condition of natural resources, the productivity of primary industries and the social welfare of producers and their rural communities.

## **4 Provide material for triple bottom-line reporting**

This objective was to report against the three categories of impacts and benefits (economic, environmental, social) from the investment. This was particularly relevant for any assessment of the LWA portfolio, since many of the benefits from LWA investment were associated with the environmental and social components of sustainability.

## **5 Develop and improve non-market valuations**

It was recognised from the outset that there would be difficulties with valuing benefits that could not be valued through product prices and production costs, as was usual for CBA of R&D investment in agricultural production or processing. These difficulties were viewed as contributing to an underestimate of benefits when valuations are not made, or a lack of confidence in the ROI when less-than-satisfactory valuation methods are applied. Attempts at non-market valuation were to be made only where reasonable assumptions could be established. Also, it was considered that the attempt to make such valuations would develop experience that might in turn develop into future guidelines for use in non-market valuations. LWA had already agreed to take a lead on behalf of all the RDCs in advancing methods for evaluating non-market benefits.

## **6 Monitoring adoption**

An important objective of LWA is to better monitor and understand the adoption of research outputs. This information per se was seen as valuable for reporting to government and stakeholders. While the evaluation case studies were to be retrospective and require assessments of the then current adoption profiles, it was recognised that the approach could contribute to future research activities collecting appropriate adoption information as they proceeded. An ongoing system for collecting information well beyond the life of the R&D project was considered necessary.

## **7 Provide a time series of ROI estimates**

The aim was to provide a step wise (e.g. 3-5 years) or rolling series of aggregate ROI estimates in order to gauge change in the performance of LWA investment over time. This could be achieved through estimating ROIs for different periods of investment. It was recognised that this would require flexibility in assembling investment costs and some method for attributing benefits to the specific year or years in which investment was made.

## **8 Compare the ROI for LWA with other research funding bodies**

LWA was interested in benchmarking its performance against other research funding bodies and sectors. It was appreciated that this would require the use of comparable methods and a similar level of conservatism in making assumptions that affected the measure of benefits.

## **9 Continuous improvement**

An important aspect of the design for the new approach was to allow for continuous improvement in estimates of portfolio ROI. This was to be achieved by either improving methods or improving the information that was to be used in the evaluations. Past analyses could then be re-evaluated as the impact of investments changed through time. This would allow the maintenance of a consistent and updated portfolio ROI estimate.

It was realised at the outset that due to limited resources not all of these objectives could be addressed in the first year of implementation of the approach, nor that each objective could necessarily be pursued in the manner desired. The approach taken was to move gradually to the desired outcomes and adopt a ‘learning by doing’ approach whereby the process was continually improved and the objectives were more comprehensively pursued over the medium-term.

## **Overview of approach**

The approach involved first identifying an investment parcel (project, group of projects or a whole program) that had produced an identifiable set of outputs in the form of products, technology, or knowledge. LWA had developed an Innovations Database <[www.lwa.gov.au](http://www.lwa.gov.au)> that lists many of

the new knowledge and technologies that the LWA investment had produced.

In each of the four years ending June 2003 to 2006, a small number of investment parcels were selected for detailed description and analysis. The analysis involved describing the genesis of the investment together with its associated outputs, outcomes, adoption and uses, and impact and benefits, the benefits being described in a triple bottom-line format (economic, environmental, social). A cost-benefit analysis was then conducted on each of the investment parcels.

By June 2006, 28 investment parcels incorporating 416 individual projects and covering 25% of LWA's total R&D appropriation since 1990 had been analysed. The individual cost-benefit analyses for each of the 28 investments were then integrated to produce aggregate investment criteria that were used to assess how the overall LWA investment was performing. Most of these case studies are reproduced in full on the LWA website <www.lwa.gov.au>. An overview glossy publication is also available (LWA 2005).

A record of the process over the four years can be found in the reports by Agtrans Research and BDA Group in 2003 and by Agtrans Research in 2004 and 2005 and February and August 2006. LWA is now committed to pursuing an integrated approach to investment analyses.

As the 28 investments were selected rather than chosen at random from all investments made by LWA, it was not valid to simply extrapolate the results to the remainder of the LWA portfolio. Each year additional investment parcels were evaluated so that a higher proportion of the whole portfolio has progressively been evaluated and allows the tracking of LWA's investment performance over time.

## Methods

### Data collection

After the case studies were selected, R&D proposals for the relevant projects, milestone reports, final reports, relevant published papers and any reviews were assembled. Further information needed to define outputs and outcomes was defined. Principal investigators and others in industry were contacted for information. Further information was assembled from statistical and industry sources.

Specific quantitative data assembled included the costs of the R&D investment by year for LWA, other funding partners and the research organisations (resources contributed usually in kind).

### Data analysis

An initial description of the background to the investment, description of research activities, outputs, outcomes and benefits was drafted as far as was possible. Additional information needs were identified during this process. Drafts of project analyses were sent to selected personnel knowledgeable about the investment parcel

for verification and extension. Some specific information requests were made.

As many of the identified benefits (past, current and future) as possible were valued as resources allowed, the most important benefits usually being given the most attention. Financial benefits were usually estimated through cost reductions or productivity or income increases. Benefit transfer was used in the case of environmental and social benefits in order to convert existing willingness to pay<sup>1</sup> estimates into a target context.

The central analyses included all future benefits. In some cases, appropriate attribution or probability factors were applied to the prospective benefits to produce an expected value of benefits.

This allowed cash flows of costs and benefits to be established. All annual dollar costs and benefits were expressed in constant dollar terms. Discounting was used to relate the costs and benefits of each investment to a base year, in this case the year of analysis. The discount rate used was 6%. The discounting process resulted in the estimation of the three investment criteria.

### Definition and attribution of benefits

CBA requires specific scenarios to be established regarding the 'with investment' and 'without investment' situations. The without scenario may need to assume for example, how many new producers are likely to invest in improvement in riparian lands without the R&D investment and what added number will invest given the results of the investment. Alternatively, the difference made by the investment may focus on the quality of the outcome; for example, water quality may be enhanced as a result of improved guidelines becoming available due to the investment.

For most individual investments financial resources were provided by other organisations as well as LWA. Sometimes these resources were in kind and a monetary value was attributed to them. Benefits from the total investment were attributed to LWA on the basis of the investment made by LWA as a proportion of the total investment.

### Uncertainties and judgements

As far as possible, assumptions for valuing benefits were made in a consistently conservative manner. Sensitivity analyses were conducted for those variables that were key drivers of the investment criteria to both highlight the potential range of investment criteria values and to identify which assumptions would benefit from improved future data.

Apart from sensitivity analysis to highlight key drivers and the importance of uncertain assumptions, two separate ratings of high, medium and low were used to reflect the degree of confidence in the investment criteria for each investment parcel. These ratings reflect (1) confidence in the coverage of the benefits that are evaluated quantitatively and (2) confidence in the assumptions inherent in valuing the benefits that are quantified.

**TABLE 1: SUMMARY OF INVESTMENT CRITERIA FOR 28 CASE STUDIES (IN 2005–06 DOLLAR TERMS AND DISCOUNTED TO JUNE 2006; ANALYSES OVER 40 YEARS)**

Investment	Period of research (total) (year ending June)	B/C Ratio (LWA only)	IRR (LWA only) (%)	NPV (LWA only) (\$m)	Proportion of total benefits attributable to LWA (%)
Controlled traffic	1993–2001	5.80	20.75	10.97	11.91
Cotton pesticides BMP	1994–2000	6.00	33.32	33.37	15.64
Regional planning	1998–2002	9.03	25.77	8.28	15.08
Seasonal forecasting	1993–2002	3.01	13.89	9.41	34.60
Benchmarking irrigation providers	1997–2003	13.88	48.51	3.46	11.88
Riparian lands	1994–2006	6.52	89.15	80.37	60.02
River health assessment	1993–2000	2.71	11.03	21.98	45.63
Sustainable grazing	1997–2002	3.56	25.00	8.55	6.29
Effluent guidelines	1991–2000	8.04	24.76	25.19	12.87
Pasture predictions	1991–2002	4.14	47.15	0.46	0.60
Geomorphic river assessment	1995–1999	28.65	16.74	21.57	66.75
Catchment classification	1998–2000	22.86	31.82	8.19	57.83
Saline land	1999–2001	11.16	25.03	1.95	52.36
Groundwater dependent ecosystems	1997–2003	4.64	15.80	8.08	39.71
Tax incentives for native vegetation	1997–1999	18.23	31.93	12.91	48.04
Water use efficiency	1994–2002	5.44	32.53	20.72	20.67
Eutrophication management	1996–2003	6.55	16.27	20.17	25.60
Pesticide risk analysis	1997–2004	43.22	57.51	5.10	22.40
Wetland guidelines	1992–2000	1.97	15.35	2.09	41.22
Dryland salinity	1994–2003	2.96	19.06	36.28	14.57
Agroforestry	1991–2003	4.90	15.09	6.15	9.43
Ecosystem-based grazing	1993–2001	19.06	24.53	3.94	4.29
Catchment management support system	1989–1996	4.45	13.73	2.61	20.16
In-stream ecology	1994–1998	2.61	12.15	2.83	52.09
Water protection guidelines	2001–2001	17.71	46.65	3.26	58.14
Climate variability	1993–2003	5.66	48.3	4.43	1.48
Ecological risk assessment	2001–2006	3.43	13.98	0.89	16.19
Irrigation	1994–2002	2.82	15.92	20.10	19.62

### Reporting

Case studies of the 28 investment parcels analysed to date have been completed, each consisting of an evaluation report of 10–30 pages. These case studies have been used by LWA in triple bottom-line reporting as well as providing a range of examples across the portfolio of successful investment. Each case study also contains the estimated individual investment criteria. The case studies are available on the LWA website.

### Aggregation

The LWA cost and benefit flows for each of the 28 investments were aggregated to produce aggregate investment criteria including the aggregate net present value (NPV), the aggregate benefit-cost ratio (B/C Ratio) and an aggregate internal rate of return (IRR). As the 28 investment parcels were selected rather than chosen at random from all investments made by LWA, it was not valid to simply extrapolate these results to the remainder of the LWA portfolio.

Another feature of the approach is that as each of the 28 investments has a time series of costs and benefits by year, aggregate investment criteria can be produced for different time periods by apportioning benefits for an individual investment to a specific period based on the proportion of total investment occurring during that specific period. The rolling time series investment criteria could then be used to explore questions such as whether LWA investment decisions are resulting in increasing or decreasing returns over time.

## Results

### Individual case studies

A summary of the results of the analyses for each of the 28 case studies is shown in Table 1 (see page 41). The first column lists the abbreviated name for the case study. The second column provides the years over which the LWA research investment was made. The next three columns provide the estimated investment criteria. The proportion of the total benefits attributable to LWA is reported in the right hand column.

### Example case studies

Two of the case studies in Table 1 are briefly described in detail to illustrate the approach. The case studies are:

- Riparian Lands
- ECOGRAZE.

#### *Riparian Lands*

The Riparian Lands R&D Program was supported by LWA over the period 1993–94 to 2004–05. The program developed guidelines and principles for sound scientific and economic management of riparian lands to contribute to the condition and value of waterways in terms of channel stability, water quality, biodiversity and in-stream ecological systems. Practical knowledge communicated through fact sheets and technical guidelines were the principal products that have emerged from the program.

The program was largely funded by LWA. Co-lead R&D agencies were the CRC for Catchment Hydrology and the Centre for Catchment and In-Stream Research (Griffith University). No other partners committed to the program on a continuing basis, but many research organisations contributed funding in-kind. As well, financial contributions were forthcoming from commodity-specific RDCs, on a specific project basis.

The information produced from this investment has filled a knowledge gap in the area of riparian land management. The information has reached a wide range of target audiences. Most importantly, the information is being used in practice. Users of the information products generated include government and non-government agencies, community-based organisations including Natural

Heritage Trust recipients, Greening Australia, catchment management staff, individual land managers, industry organisations, and consultants. A range of government agencies has endorsed the guidelines. The material is influencing the priorities that are placed on riparian management in catchments and throughout natural resource management planning.

The program has been a highly successful LWA integrated investment where scientific research results produced in the early stage of the program have been extended successfully to users principally through close involvement with industries and communities and including a wide range of communication processes and products. The cost–benefit analysis for the total investment in the Riparian Lands R&D Program was based on the valuation of the following public benefits:

- Australians' willingness to pay for improved river condition
- Australians' willingness to pay for enhanced biodiversity
- the contribution made to enhanced carbon sequestration.

An assumption for willingness to pay for improved river condition was based on the choice modelling work of van Bueren and Bennett (2004) who estimated the benefit to households per 10 km per annum for river water quality improvement. This benefit was adjusted by a series of factors to equate it to a benefit attributed to the extent and effectiveness of improved riparian management caused by the investment. The length of waterways fenced off in the past of 21 000 km to 2002 and 547 km per year thereafter was obtained from reports (Hassall & Associates, 2005) and personal communication with personnel associated with government programs.

Data from a specific government program in Victoria was used as the basis for valuing the services provided by landholders to protect biodiversity on private land on a per hectare basis. The area protected was estimated from the length of waterways fenced off and the average width of the waterway.

Assumptions on the amount of carbon sequestered per annum by natural regeneration of protected areas were made and the price of carbon (carbon dioxide equivalent) was estimated from the European Union Emissions Trading Scheme and the NSW Greenhouse Gas Abatement Scheme.

As the LWA investment made up a reasonably high proportion of the total investment (60%), the benefits and costs attributed to LWA are quite high. The results of the investment analysis are shown in Table 2.

#### *ECOGRAZE*

This investment was externally funded predominantly by the northern Australia program of Meat & Livestock Australia. LWA contributed some funds to this program.

**TABLE 2: INVESTMENT CRITERIA FOR RIPARIAN LANDS PROGRAM**

INVESTMENT CRITERION	DISCOUNT RATE 6%	
	All benefits and all costs	Benefits to LWA and LWA costs
Present value of benefits (\$m)	158.19	94.94
Present value of costs (\$m)	24.39	14.57
Net present value (\$m)	133.80	80.37
Benefit–cost ratio	6.49 to 1	6.52 to 1
Internal rate of return (%)	88.00	89.15

The investment developed grazing management guidelines for open eucalypt woodlands in northern Australia. It was a long-term study (1992–93 to 2000–01) located 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.

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 Water.

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. The close cooperation between state agencies and CSIRO in the development of the grazing management guidelines and their promotion has contributed to the impact now being experienced.

The economic advantages of using the guidelines produced by ECOGRAZE are the prevention of land in good condition from converting to a deteriorated situation and can in fact assist deteriorated land to recover to good condition. There is a small annual average cash return advantage to farms that use the principles in either of these two ways. There are also benefits to producers who use the principles to prevent their land from becoming irreversibly degraded and which is then unprofitable.

Environmental benefits should accrue from the adoption of the ECOGRAZE guidelines due to reduced sediment export to waterways as well as biodiversity benefits from improved land and vegetation condition.

The cost–benefit analysis for the investment in ECOGRAZE was carried out through valuing benefits from changes in profitability for land managers who adopted the guidelines developed in ECOGRAZE. Assumptions on adoption were based on surveys of northern Australian beef producers carried out by Meat & Livestock Australia. As the LWA investment contributed only a little over 4% of the total investment, there is large difference

between the total and the LWA net present values, but the rates of return (the B/C Ratio and the internal rate of return) are much the same.

The results of the investment analysis are shown Table 3.

### Benefits identified and quantified

The various individual benefits that were identified in the 28 case studies have been categorised into economic, environmental and social benefits, as well as into those benefits that were quantified and those not quantified.

In summary, of all the 218 benefits identified, 99 (45%) were categorised as economic, 60 (28%) environmental, and 59 (27%) social. Of the economic benefits 43 (43%) were quantified with 18 (30%) of the environmental benefits quantified and only 5 (8%) of the social benefits quantified.

Far fewer identified environmental and social benefits were quantified as many of the identified environmental and social benefits were less clear-cut and linkages to the R&D were often indefinite.

The most frequent economic benefit identified and quantified was cost reductions off-farm. The next most frequently identified and quantified economic benefits were on-farm productivity improvements and on-farm cost reductions. The most frequently identified environmental benefits were reduced salinity and waterlogging impacts, followed by improved biodiversity on farm, improved water quality and more sustainable land and water systems. The most frequent social benefit identified was an increase in individual and community capacity, followed by improved communication and understanding, enhanced aesthetic and amenity values, reduced health costs, and reduced anxiety.

### Relationships between investment criteria and investment characteristics

An important question is whether the analyses undertaken to date demonstrate any findings related to what characterises a ‘good’ investment. It appears that investments producing a high NPV or high rate of return are associated with one or more of the following characteristics:

- significantly reduced unit costs, or future potential unit costs

**TABLE 3: INVESTMENT CRITERIA FOR ECOGRAZE**

INVESTMENT CRITERION	DISCOUNT RATE 6%	
	All benefits and all costs	Benefits to LWA and LWA costs
Present value of benefits (\$m)	32.08	1.38
Present value of costs (\$m)	5.45	0.20
Net present value (\$m)	26.63	1.18
Benefit–cost ratio	5.89 to 1	6.94 to 1
Internal rate of return (%)	17.62	21.94

- contributed to increased profits
- adopted by, or expected to be adopted by, many land and water managers and/or policy developers
- adopted quickly after the initial research investment occurred.

Several generalised observations of the results are as follows.

- 1 Larger investments tended to produce lower rates of return as measured by the B/C Ratio. There are a number of interpretations of this finding, for example that larger investments are often associated with programs where support costs are higher, or that the quantification of benefits in the larger investments tend to focus on fewer and broader benefit sets than the scope of the program may cover.
- 2 The timing of benefits is a key driver of the rate of return. The usual long time period from investment to delivery of outcomes from R&D is an important issue for natural resource management R&D. Time periods for many natural resource management benefits to be realised are lengthy and this should be recognised more widely not only in cost–benefit applications but also in the development of monitoring and evaluation plans for R&D programs.
- 3 Adoption of much of the knowledge produced from R&D investments for many of the investments analysed has been slow and only partial. Where the target audience is public management or policy development groups, adoption is not always widespread due to a wide variation of needs (or at least perceived needs and preferences), and the availability of a number of competing guidelines, models, methods, etc. Where private benefits to land and water managers are apparent there is a tendency towards increased uptake of LWA-generated information. Higher levels of adoption are achieved when higher profitability outcomes are targeted.
- 4 The impact of an investment can be greatly influenced by changing institutional structures and priorities over time. For example, the impact of the Catchment Management Support System

(CMSS) was reduced partly due to a general shift in the topical issues regarding water quality from algal blooms in the 1990s to environmental flows and salinity and then to water sharing and native vegetation and land management that affect water quality. This changing situation, together with catchment management structural changes, meant that the implementation of plans developed from the use of CMSS was significantly delayed.

- 5 Working with industry-oriented RDCs has been a successful mechanism for LWA to promote a greater emphasis on resource sustainability issues.

**Aggregate results**

Aggregate investment criteria were calculated to demonstrate the aggregate return on investment for the 28 case studies as a whole. Aggregate investment criteria were produced for:

- aggregate total expected benefits that could be attributed to all investors for the 28 investments against the total cost of the 28 investments
- aggregate total expected benefits that could be attributed to LWA for the 28 investments against the LWA investment in the 28 investments
- aggregate total expected benefits for the 28 investments that could be attributed to LWA against the total LWA portfolio costs from 1991–92 to 2005–06 to estimate a minimal return on the entire portfolio investment
- aggregate investment criteria for rolling five-year periods since LWA’s establishment in 1991.

Table 4 presents the present value of benefits (PVB), the present value of costs (PVC), and the three investment criteria (NPV, B/C Ratio and IRR) for the 28 analyses for LWA benefits and LWA costs only, as well as for all partners’ investment. It shows that the LWA investment has produced an NPV of \$341m, a B/C Ratio of 4.8 to 1, and an IRR of over 24%. When all partners’ investment is included, the NPV is \$1886m, with a B/C Ratio of 4.7 to 1 and an IRR of over 23%. This means that for these investments every dollar invested has produced nearly \$5 worth of benefits and the rate of return of 24% is well above the return that can be earned on many other options for the use of government funds.

**TABLE 4: INVESTMENT CRITERIA FOR THE 28 INVESTMENT PARCELS (ALL IN 2005–06 DOLLARS AND DISCOUNTED TO JUNE 2006) AT A DISCOUNT RATE OF 6%**

Investment criterion	Total for all 28 analyses (all investment)	Total for all 28 analyses (LWA investment only)
Present value of benefits (\$m)	2390.70	430.46
Present value of costs (\$m)	504.84	89.35
Net present value (\$m)	1885.86	341.11
Benefit–cost ratio	4.74 to 1	4.82 to 1
Internal rate of return (%)	23.45	24.62

It should be remembered that the investment criteria estimated apply only to the 28 selected investments, and it is not valid to extrapolate from these criteria to other LWA investments. This is because the 28 case studies analysed have not been randomly selected and are therefore not necessarily representative of the entire portfolio. To estimate the ROI for the whole portfolio, more investments would need to be evaluated. However, it is interesting to observe that the benefits attributed to the LWA investment for the 28 analyses are greater than the total value of government appropriation funding provided to LWA over the period.

The emphasis on writing evaluation case studies as a communication product has been an indispensable aid to tracking and disseminating innovations and their natural resource management outcomes since the organisation commenced. Each study contains many lessons in research investment and management that contribute to improving future investment performance.

A process for estimating the ROI over different time periods was developed in 2005 as part of the LWA ROI portfolio initiative. A key finding from the application of this process was that the rate of return to LWA investment has increased over time.

Figure 1 presents the total B/C Ratio over time (all benefits and all investment by LWA and others).

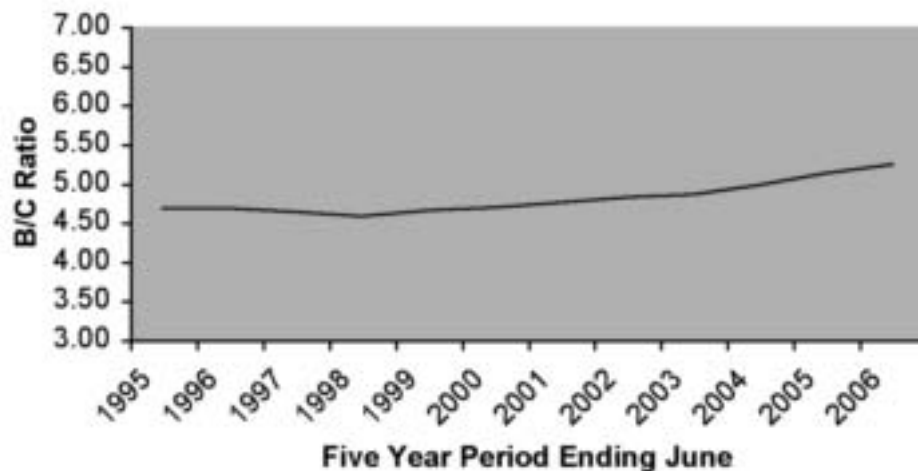
There are a number of qualifications and interpretations (not mutually exclusive) of this finding including:

- this finding applies to the selected sample but may not apply to the total portfolio
- improving management and decision-making on resource allocation by LWA
- most investments analysed are represented in the middle period and drive the overall average rate of return
- some of the larger investments with low rates of return dominate the first five years of the selected investments.

**Dissemination and learning**

The ROI analysis and evaluation case studies have been a powerful source of information in meeting LWA’s accountability needs and in communicating its research and development outcomes. Evaluating the impact of R&D is a high priority of the Australian Government and the robust, transparent

**FIGURE 1: TOTAL B/C RATIO OVER TIME**



**TABLE 5: SUMMARY OF PERFORMANCE OF THE LWA ROI PORTFOLIO ANALYSIS**

<b>Objective</b>	<b>Progress/achievement</b>
<i>Estimate portfolio return on investment</i>	Achieved for 25% of investment to 2005–06. Transparency and consistency achieved.
<i>Provide lessons learnt from successful investments</i>	One finding was that larger investments tended to produce lower rates of return as measured by the B/C Ratio. In general, successful investments: <ul style="list-style-type: none"> <li>■ significantly reduced unit costs or future potential unit costs and contributed to increased profits</li> <li>■ were adopted by, or expected to be adopted by, many land and water managers and/or policy developers</li> <li>■ were adopted quickly after the initial research investment occurred.</li> </ul>
<i>Communicate results through case studies</i>	Achieved through publication of case studies on LWA website and other media.
<i>Provide material for triple bottom-line reporting</i>	Achieved through identification of 218 benefits across 28 case studies.
<i>Develop and improve non-market valuations</i>	It was recognised from the outset that there would be difficulties with non-market valuations. These difficulties can lead to underestimates of benefits when valuations have not been made, or a lack of confidence in the ROI when less-than-satisfactory valuation methods are applied. Limited improvement of non-market valuations was contributed by the approach but issues and guidelines in exercising benefit transfer from existing willingness to pay studies were developed.
<i>Monitoring adoption</i>	Limited progress made but some directions developed for easing the assembly of information on adoption for future analyses.
<i>Provide a time series of ROI estimates</i>	Achieved through two approaches that gave consistent results for the 25% of the portfolio analysed. Both approaches showed that there have been increases over time in the performance of the LWA ROI as measured by the aggregate B/C Ratio.
<i>Compare the ROI for LWA with other research funding bodies</i>	The distribution of the investment criteria for the selected LWA investments have been compared from time to time with the distribution of other investment criteria from analysis of investments selected from portfolios of R&D funding organisations associated with the dairy, sugar, pigs, forest and wood products industries, earlier LWA analyses (LOPE) and one Cooperative Research Centre (CRC). Overall, the distribution of investment criteria for the LWA projects is not dissimilar to those observed in studies for other RDCs.
<i>Ensure updating of analyses is possible</i>	Achieved. All spreadsheets for the individual 28 analyses have been maintained, as well as for the aggregation and time series analyses.

and conservative methods applied here have dramatically increased the credibility of evaluation with LWA's stakeholders. The lessons captured and documented in the case studies help improve research management and build the organisation's corporate knowledge. The positive results continue to drive organisational pride and morale.

#### **Progress in meeting objectives**

The evaluation approach currently employed by LWA has been successful in addressing most of the objectives considered appropriate for the portfolio ROI analysis in 2003. The progress on the application of the ROI approach and its achievements against the nine objectives initially set is summarised in Table 5.

#### **Conclusions**

An effective methodology has been developed to evaluate the return on investment of a natural resource management R&D funding organisation. The approach utilises standard cost–benefit analysis methods in an innovative way that is generically applicable.

The strengths of the approach are:

- transparency and consistency in methods
- explicit assumptions
- confidence ratings on results
- ability to aggregate from projects/innovations to larger group analyses, and ultimately a full portfolio
- ability to track progress of investments and their adoption and impact over time

- identification of all benefits and evaluation of social, economic and environmental benefits
- ability to communicate results and stories effectively
- ability to report on organisational performance over time
- ability to update the analysis at least annually
- allows for continuous improvement in methods and information.

The standardised approach described here provides a valuable knowledge asset for LWA in assessing the return to investment that is being achieved and documenting a wide variety of case studies. The approach recognises many of the difficulties involved in applying cost–benefit analysis to R&D investment. The acknowledgement of the various uncertainties in the assumptions made and the emphasis on continuous improvement and communication are strengths of the approach.

Aggregate investment criteria have been calculated to demonstrate the aggregate return on investment for the 28 case studies. The 28 analyses as a whole have an NPV of \$341m, a B/C Ratio of 4.8 to 1, and an IRR of over 24%.

Both the qualitative and quantitative analyses demonstrate that LWA has invested purposefully and successfully. The 28 investments analysed were associated with about 25% of the LWA total investment of appropriation monies (\$363m in present value terms). The benefits from the 28 investments have covered more than the total investment of government appropriation monies by LWA.

While there are still challenges to overcome, the method being applied has served multiple purposes and has been found useful in not only an accountability sense, but also in reporting and communication about the LWA investments at a range of levels.

## GLOSSARY

### Economic terms

- **Benefit transfer** The transfer of estimated benefits from an original source site to a new or target site.
- **Benefit–cost ratio (B/C Ratio)** The ratio of the present value of investment benefits to the present value of investment costs.
- **Cost–benefit analysis (CBA)** A conceptual framework for the economic evaluation of projects and programs in the public sector. It differs from a financial appraisal or evaluation in that it considers all gains (benefits) and losses (costs), regardless of to whom they accrue.
- **Discounting** The process of relating the costs and benefits of an investment to a base year using a stated discount rate.
- **Internal rate of return (IRR)** The discount rate at which an investment has a net present value of zero, that is, where present value of benefits = present value of costs.
- **Investment criteria** Measures of the economic worth of an investment such as net present value, benefit–cost ratio, and internal rate of return.
- **Net present value (NPV)** The discounted value of the benefits of an investment less the discounted value of the costs, that is, present value of benefits – present value of costs.
- **Present value of benefits (PVB)** The discounted value of benefits.
- **Present value of costs (PVC)** The discounted value of costs.
- **Willingness to pay (WTP)** The amount an individual is willing to pay to acquire a good or service, often elicited from stated or revealed preference approaches.

### Abbreviations

- **CMSS** Catchment Management Support System
- **CRC** Cooperative Research Centre
- **GRDC** Grains Research and Development Corporation
- **LOPE** life of project evaluation
- **LWA** Land & Water Australia
- **R&D** research and development
- **RDC** Research and Development Corporation
- **RIRDC** Rural Industries Research and Development Corporation
- **ROI** return on investment

**Note**

- 1 Willingness to pay is the amount an individual is willing to pay to acquire a good or service, often elicited from stated or revealed preference approaches.

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