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Land & Water Australia's Portfolio Return on Investment & Evaluation Case Studies

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Return on investment publications by Land & Water Australia

This report is the most recent in a new series of publications by Land & Water Australia evaluating the return on investment from its natural resource management research and development portfolio. This series includes:

- Investing in our landscape—an assessment of the benefits of land and water research in Australia. Published by Land & Water Australia in 2005, 24 pp.
- Land & Water Australia's portfolio return on investment & evaluation case studies, August 2005. Authors: Nick Schofield in collaboration with Agtrans Research, available on the LWA website and including 25 case studies. www.lwa.gov.au.
- Guidelines for evaluating return on investment. Agtrans Research, in A. Campbell & N. Schofield (2006) 'The getting of knowledge—a guide to funding and managing applied research', Appendix 8, pp 78–86.
- Evaluation case study template. Agtrans Research, in A. Campbell & N. Schofield (2006) 'The getting of knowledge—a guide to funding and managing applied research', Appendix 8, pp 87–90.
- Data requirements for project and program evaluation. Agtrans Research, in A. Campbell & N. Schofield (2006) 'The getting of knowledge—a guide to funding and managing applied research', Appendix 9, pp 91–92.
- Benefit transfer methodology. Averil Cook and Steve Harrison (2005), Published by Land & Water Australia, In: Land & Water Australia's portfolio return on investment & evaluation case studies, August 2005. Authors: Nick Schofield in collaboration with Agtrans Research, Available on the LWA website and including 25 case studies. www.lwa.gov.au
- A methodology for evaluating return on investment from natural resource management R&D, January 2007. Authors: Peter Chudleigh, Sarah Simpson and Nick Schofield. Published by Land & Water Australia.
- Evaluation of R&D investment in natural resource management. Authors: Peter Chudleigh, Sarah Simpson and Nick Schofield. Published in the Evaluation Journal of Australasia, 6(2), 2006.
- Land & Water Australia's portfolio return on investment & evaluation case studies, January 2007. Authors: Nick Schofield, Peter Chudleigh and Sarah Simpson, available on the LWA website and including 28 case studies. www.lwa.gov.au.

Contents

Acknowledgments

Land & Water Australia's methodology for assessing portfolio return on investment (ROI) has been developed in collaboration with, initially, Mr Drew Collins of BDA consultants (2002) and, over the past four years, Dr Peter Chudleigh and Sarah Simpson of Agtrans Research. The evaluation case studies presented have been prepared by Agtrans Research using information provided by Land & Water Australia staff and coordinators, and from principal investigators and users. Tony Byrne of Corree Consulting and Steve Harrison of the University of Queensland assisted Agtrans with several of the case studies. Agtrans Research has developed the cost–benefit analysis guidelines and evaluation case study templates with Land & Water Australia. Mrs Averil Cook and Dr Steve Harrison of the University of Queensland have prepared a paper identifying issues relating to benefit-transfer methodology. This project has been managed by Dr Nick Schofield who has also guided the design of the ROI analysis and been responsible for the review of all material.

Executive summary

Approach

For five years Land & Water Australia (LWA) has been developing a comprehensive approach to estimating the return on investment (ROI) from its research and development (R&D) portfolio. The key driving question has been: *What impact has LWA's research had on achieving the sustainable use and management of Australia's natural resources?*

In developing a ROI methodology LWA has sought to:

- understand the impact of its total R&D investment since its inception in 1990
- identify this impact in the triple-bottom-line (TBL) framework (economic, environmental, social)
- estimate the ROI using cost–benefit analysis (CBA)
- understand how past innovations (R&D investments) have performed
- communicate the nature and impact of LWA-funded innovations through case studies
- develop fully transparent and explicit methods and analyses that are usable by any evaluator
- allow for continuous improvement and regular updating of the ROI.

Some key features of the portfolio TBL–CBA method follow.

- Portfolio ROI aims to provide information on returns from the whole portfolio of investment, for the life of the organisation or investment.
- TBL–CBAs are undertaken for R&D innovations. An innovation is a bounded, thematic suite of R&D that ranges from a single project to a full program involving many related projects.
- Methods have been developed to identify and analyse the most successful innovations first.

- Each innovation is analysed individually as an evaluation case study. All case studies are prepared to the same format and use the same methods.
- Each evaluation case study is prepared as a communication document in its own right. Case studies are prepared to a quality suitable for publication on the LWA website and include a one-page summary. Various communication products can be derived from this material.
- Each evaluation case study describes the innovation, its adoption by users, the impacts of that adoption (i.e. the benefits gained in TBL terms), the costs of R&D and implementation, and investment criteria (benefit:cost ratio, net present value, and internal rate of return).
- The analysis goes into sufficient depth in each case study to ensure an appropriate level of information is used for analysis. Information gaps are also identified for improved future analyses. A guide to data collection has been prepared.
- Evaluations are essentially ex post (i.e. are applied to completed projects) but future benefits are calculated in each case.
- All evaluation assumptions made are transparent and summarised. Assumptions are deliberately conservative to avoid over-inflated ROI estimates. Sensitivity analyses are frequently conducted to identify the most important assumptions (parameters).
- Confidence ratings are provided on ROI results based on (a) coverage of benefits and (b) strength of assumptions.
- All evaluation methods are described in detail, along with step-by-step guides. All evaluation data and spreadsheets are maintained by LWA (in a format other consultants can use in the future, e.g. for updating estimates).
- All individual case study benefits and costs are aggregated to calculate a total ROI result.
- Each year, additional case study evaluations are conducted and added to the portfolio ROI, hence improving portfolio impact estimates. Past case study evaluations are updated when there is a substantial improvement in either data or methods.
- ROI performance over time can be estimated.
- LWA can continuously track and update the impact of its most significant past investments while at the same time improving methods and data but maintaining overall longitudinal consistency.

Results so far

To date, 33 innovations and programs (incorporating 630 projects) have been analysed. These cover around 25 per cent of LWA's appropriation since 1990 and a higher proportion of completed projects. The ROI results shown below are highly conservative, both in terms of the assumptions made and the range of benefits covered (LWA generates mostly environmental and knowledge benefits, which are difficult to evaluate).

Table 1. Investment criteria for 33 innovations (Land & Water Australia (LWA) and all parties) (all in 2006–07 dollars and discounted to June 2007)

Investment criterion	Total for all 33 analyses (return to all investment)	Total for all 33 analyses (return to LWA investment)
Present value of benefits ($m)	2,964.56	481.49
Present value of costs ($m)	668.76	102.78
Net present value ($m)	2,295.79	378.71
Benefit:cost ratio	4.43 to 1	4.68 to 1
Internal rate of return (%)	23.28	26.23

Examination of the ROI attributed to LWA for different five-year periods showed the benefit: cost ratio increasing over time (Figure 1). This may imply that LWA is either making better investments or managing investments better over time, or a combination of both. However, this change requires greater understanding before such conclusions can be drawn.

Figure 2 shows the ROI attributable to LWA and its partners, over time. This initially declined slightly between 1995 and 1998. There was then a continuous but slight improvement until 2003, with the ROI falling again since that time.

Comparison with other Research and Development Corporations and with Cooperative Research Centres using similar methods shows the individual innovations analysed for LWA display similar distributions of investment criteria to those of the other R&D institutions.

Individual case studies

Table 2 summarises the results of the analyses for each of the 33 case studies. 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 far-right column reports the proportion of the total benefits attributable to LWA.

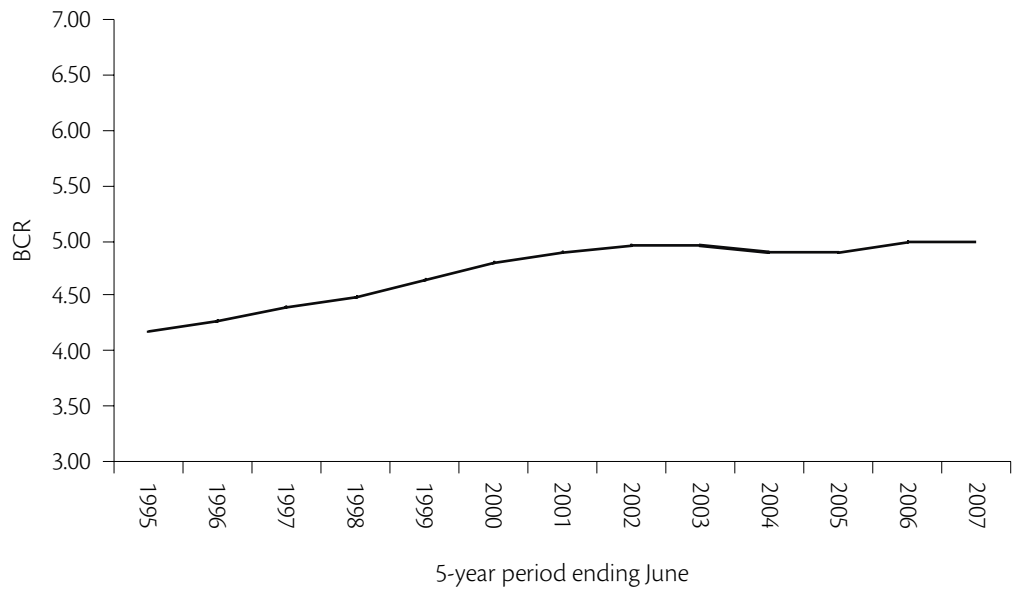

Figure 1. Plot of benefit:cost ratio (BCR) against time for Land & Water Australia investment, for five-year periods ending June 1995–2007

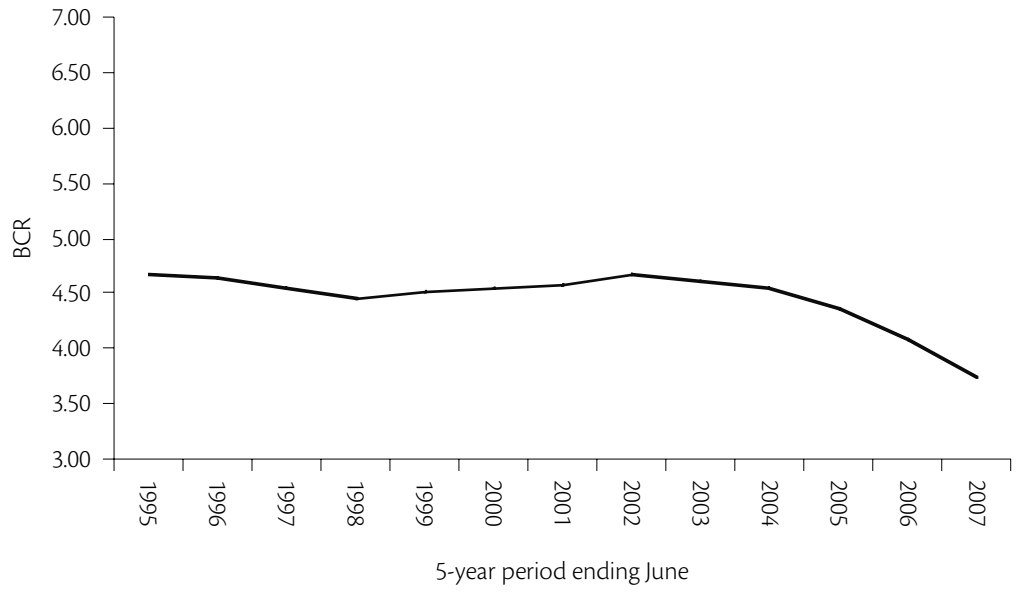

Figure 2. Plot of benefit:cost ratio (BCR) against time for investments by Land & Water Australia and partners, for five-year periods ending June 1995–2007

Table 2. Summary of investment criteria (Land & Water Australia (LWA) investments only) for 33 case studies (in 2006–07 dollar terms and discounted to June 2007; analyses over 40 years)

Investment	Period of research (years ending June)	Benefit: cost ratio	Internal rate of return (%)	Net present value ($m)	Proportion of total benefits attributable to LWA (%)
AusRivAS: river health assessment	1993–2000	2.71	11.03	5.48	10.49
AussieGRASS: pasture predictions	1994–2002	4.57	54.06	0.72	0.84
Benchmarking irrigation providers	1997–2003	13.90	48.79	3.51	11.12
Cotton pesticides BMP	1994–1999	5.97	33.32	36.15	15.64
Catchment management support system (CMSS)	1991–1996	4.45	13.73	2.83	20.16
CHRRUPP—regional planning	1998–2001	9.03	25.77	8.97	15.08
Climate forecasting Indian Ocean	1993–2002	3.01	13.89	0.45	1.54
CVAP	1996–2001	5.66	48.30	4.80	1.48
Controlled traffic	1993–1998	5.80	20.75	11.88	11.91
ECOGRAZE—ecosystem based grazing	1997–2001	19.06	24.53	4.27	4.29
Ecology of streams	1994–1998	2.61	12.15	3.07	52.09
Ecological risk assessment (ERA)	2001–2006	3.43	13.98	0.96	16.19
Effluent guidelines	1992–1999	8.04	24.76	27.29	12.86
Groundwater dependent ecosystems	1997–2003	4.64	15.80	8.76	39.71
Groundwater classification	1998–2000	22.86	31.82	8.87	57.83
JVAP—agroforestry (25 projects)	1994–2003	4.90	15.09	6.66	9.43
Land, Water and Wool	2002–2010	Not applicable (n.a.)	n.a.	n.a.	0.00
MCVP—managing climate variability	2003–2008	1.52	10.02	0.49	5.75
Managing riparian lands	1994–2006	6.52	89.15	87.07	60.02
Native vegetation	1995–2007	4.11	30.64	36.02	31.54
NDSP—dryland salinity	1994–2004	2.96	19.06	39.31	14.57
NEMP—eutrophication management	1996–2003	6.55	16.27	21.86	25.60
NPIRD—irrigation	1994–2002	2.68	15.28	20.12	18.65
NRC—rivers consortium	1999–2007	3.44	16.33	8.18	33.80
NRCP—river contaminants	2000-2007	2.84	16.28	3.44	16.15
OPUS—using saline land	1999–2001	11.16	25.03	0.60	14.94
PIRI—pesticide risk analysis	1997–2002	43.22	57.51	5.53	22.40
River Styles—geomorphic river assessment	1995–1999	28.65	16.74	23.37	66.75

Table 2. (continued)

Investment	Period of research (years ending June)	Benefit: cost ratio (LWA only)	Internal rate of return (LWA only) (%)	Net present value (LWA only) ($m)	Proportion of total benefits attributable to LWA (%)
SGS including Prograze	1997–2002	3.56	25.00	9.26	6.29
Tax incentives for native vegetation	1997–1999	18.23	51.93	9.45	32.47
Water use efficiency	1994–2002	5.44	32.53	21.23	19.54
Water protection guidelines	1999–2002	17.71	46.65	3.53	58.14
Wetland guidelines	1992–1999	1.97	15.35	2.26	41.22

Progress against ROI objectives

Table 3 summarises progress made in the application of the ROI approach, and its achievements against nine objectives initially set.

Table 3. Summary of the performance of the Land & Water Australia return on investment (LWA ROI) portfolio analysis

Objective	Progress/achievement
Estimate portfolio return on investment	Achieved for 25% of appropriation from 1990–91 to 2006–07. Transparency and consistency achieved.
Provide lessons learnt from successful investments	One finding was that larger investments tended to produce lower rates of return as measured by the benefit:cost ratio. In general, successful investments: • significantly reduced unit costs or future potential unit costs and contributed to increased profits • were adopted by, or expected to be adopted by, many land and water managers and/or policy developers • were adopted quickly after the initial research investment occurred.
Communicate results through case studies	Achieved through publication of case studies on the LWA website.
Provide material for triple-bottom-line reporting	Achieved through identification of 313 benefits across 33 case studies. Categorisation into economic, environmental and social benefits, as well as into those that were quantified and those that were not. Of all the 313 benefits identified, 43% were categorised as economic, 29% as environmental and 28% as social. Of the economic benefits identified, 41% were quantified. Some 28% of the environmental benefits were quantified, but only 6% of the social benefits.
Develop and improve non-market valuations	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 are not made, or a lack of confidence in the ROI when less-than-satisfactory valuation methods are applied. The approach contributed to only limited improvement of non-market valuations. However, issues and guidelines in using benefit transfer from existing willingness-to-pay studies were developed.

Table 3. (continued)

Objective	Progress/achievement
Monitoring adoption	Limited progress made but some directions developed for easing the assembly of information on adoption for future analyses.
Provide a time series of ROI estimates	Achieved through two approaches that gave consistent results. Both approaches showed that there have been changes over time in the performance of the LWA ROI as measured by the benefit:cost ratio.
Compare the ROI for LWA with other research funding bodies	The distribution of the investment criteria for the selected LWA investments has been compared from time to time with the distribution of investment criteria from analyses of projects selected from portfolios of R&D funding organisations associated with the dairy, sugar, pig, and forest and wood products industries, from earlier LWA life of project evaluations (LOPE) and from one Cooperative Research Centre. Overall, the distribution of investment criteria for the LWA projects is similar to that observed in studies for other research and development corporations.
Ensure updating of analyses is possible	Achieved. All spreadsheets for the individual 33 analyses have been maintained, as well as for the aggregation and time-series analyses.

Key messages on investment returns

- Both the qualitative and quantitative analyses demonstrate that LWA has invested purposefully and successfully, at least for 25 per cent of appropriation, over the past 17 years.
- There is no evidence of a significant decline in ROI with additional evaluation case studies analysed to date.
- Investments producing a high net present value or high rate of return are associated with one or more of the following characteristics:
  - significantly reduced unit costs, which has 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.
- The timing of benefits is a key driver of the rate of return. The usually long period from investment to delivery of outcomes from R&D is particularly an issue for natural resource management R&D. The use of a 40-year time frame from the first year of research investment in these analyses addresses this issue to some extent.
- Adoption of much of the knowledge produced from R&D investments for many of the innovations 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 in 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.

Future strategy

1. *Maintain the database* of existing evaluations and update selected analyses from time to time when further information becomes available, particularly that related to commercialisation and adoption.
2. *Expand* the number of innovations analysed as resources allow.
3. The *ROI over time* should be kept current (updated annually) as more evaluations are conducted and earlier evaluations are updated
4. Continue to develop non-market valuation methods through facilitating the assembly of metadata in particular subject areas, e.g. biodiversity, water quality valuation, and impacts of different interventions and management strategies on biodiversity and water quality.
5. *Strengthen information sources* and data availability on the fate of LWA publications in terms of their users and uses so that follow-up surveys on particular innovations have fruitful starting points.
6. *Non-market valuations* are necessary in that many benefits from LWA's investments are environmental rather than economic. The robustness of the benefit transfers that have been made to date could be improved.
7. *Knowledge of impact relationships* for interventions that affect natural resources is often lacking and the confidence in some assumptions made is not high.
8. *Future adoption assumptions* have had to be made often with only scant historical information on adoption rates for natural resource management knowledge and technologies available.
9. *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.
10. The *knowledge and adoption strategy* for ROI should be reviewed and implemented.

1 Historical context

Land & Water Australia (LWA) has had for over 15 years an ongoing program of evaluating its research and development (R&D) investment. With the increasing emphasis from the Australian Government and the Department of Agriculture, Fisheries and Forestry (DAFF) on Research and Development Corporation (RDC) reporting as a whole, on outcome reporting and on the triple-bottom-line framework, the LWA evaluation program has been subject to even closer internal scrutiny over the past few years.

LWA initiated 'life of project' evaluations (LOPEs) of its projects in 1992–93 and has published a series of investment analyses of specific projects and investments. The LOPE reports have been summarised and assessed in Chudleigh (2000). LWA has also supported a number of investment analyses as part of its reviews of specific programs, but this has not been consistent.

LWA developed an evaluation framework as part of its 2001–06 Strategic R&D Plan and an updated evaluation strategy (LWA 2005) for the new 2005–2010 Strategic R&D Plan. The framework includes measuring and monitoring its investment performance through quantitative criteria such as the benefit:cost ratio (BCR).

In 2002–2003, a method of assessing return on investment (ROI) at the portfolio level was developed by LWA through consultancies commissioned from BDA (2002) and Agtrans Research (2003). The approach is intended to be used to ultimately track LWA's investment performance over time. The method is based on identifying and quantifying the benefits from an increasing number of innovations in the LWA portfolio. The benefits from the selected innovations are then compared with the cost of the LWA investment in those innovations.

2 Portfolio evaluation approach

2.1 Purposes

The purposes of the LWA portfolio evaluation approach are:

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
3. to benchmark the rate-of-return with similar funding bodies
4. to provide a rate of return series over time to assess LWA performance trends
5. to ensure valuations of non-market benefits are developed and improved
6. to provide material for triple-bottom-line reports
7. to provide case studies to demonstrate and communicate LWA's effectiveness
8. to provide lessons learnt from the performance of innovations, including factors affecting adoption
9. to provide examples of where adoption of innovations can be monitored usefully in the future.

Most of these purposes are being met (see Table 3 in the Executive Summary). Purpose numbers 4, 5, 6, 8 and 9 are subject to ongoing development. Some of these points are discussed further below.

Return on investment

One of the principal objectives of the RDCs using investment analysis was to ascertain the rate of return to their investment, so that governments and industry can be more confident about allocating funds to the sector, and even compare the likely pay-offs of existing

investment or additional investment between sectors. A simple but authoritative measure estimated in a robust and transparent manner is usually required (e.g. a BCR or the internal rate of return (IRR)).

Compare ROI with other research funding organisations (benchmarking)

While this purpose is not explicit, it needs to be heeded, as this comparison will ultimately be made if quantitative estimates of ROI are provided. These may be misinterpreted if LWA ROI methods are significantly different from those of other RDCs.

Provide a time series of ROI estimates

There is a need to provide a rolling series of ROI estimates in order to gauge change in the performance of LWA over time and for different periods of investment. The ability to do this depends on the availability of a sufficient number of evaluations from different time periods having been effected.

Develop and improve non-market valuations

Difficulties with non-market valuations are particularly relevant when assessing the ROI for the LWA portfolio, since many of the benefits from LWA investment are associated with natural resource sustainability and environmental improvement. These difficulties can lead to under-estimates of benefits when valuations are not made; or a lack of confidence in the ROI when less-than-satisfactory valuation methods are applied. At least two approaches can be taken:

- attempt valuations of all benefits with appropriate qualifications of assumptions and accuracy of estimates
- make estimates only where reasonable assumptions can be made.

At this stage, greater emphasis is being given to the latter process until there is sufficient confidence in robust methods and data for estimating non-market values.

Provide material for triple-bottom-line reporting

The principal need here is to report the three categories of benefits (economic, environmental and social) from the evaluation. This provides useful information on the types of benefits being generated and their frequency.

Provide case studies that demonstrate effective investment

The aim here is to have the analysis of each investment presented as a case study that clearly demonstrates the effectiveness of LWA investment. The idea is to tell an interesting story as well as to present the quantitative investment criteria. This means that the overall description of the analysis needs to be longer and more detailed than a cost–benefit analysis (CBA) alone would require.

Provide lessons learnt from case studies

The purpose is to learn from each analysis so that future investments can be more effective. In particular, there may be a focus on investment features and measures taken that increase adoption.

Monitoring adoption

LWA will benefit from feedback on how further information can be collected (e.g. on adoption) either within the management of ongoing investment or some form of external auditing or monitoring. Such further information may be useful in reporting outcomes to DAFF, as well as in updating previous quantitative analyses.

Table 4 summarises our experiences on each of these purposes and whether the one initiative can cover all purposes. The second column suggests what has been achieved in the evaluations to date, given the existing brief, time frame and resources. The third column suggests what may be achievable in the future.

Table 4. Achievability of different purposes as of 2007 and in the future

Purpose	Achievable with current approach?	Achievable with different terms of reference and resources?
Return on investment (ROI)	Yes	Yes
Comparative ROIs	Yes	Yes
Provide time series	Yes	Yes
Improve non-market valuations	Yes, to some extent	Yes, given more resources, but could be undertaken under special initiatives
Material for triple-bottom-line reporting	Yes	Yes
Case studies	Yes	Yes
Lessons learnt	Yes, to some extent, but requires additional effort	A set of additional questions may need to be asked to achieve this purpose, and different evaluation techniques employed
Monitoring adoption	Limited to date and requires more resources	Yes—but experience elsewhere questions the benefits and costs of collecting additional adoption information.

2.2 Methodology

The ROI methodology is fully documented in Chudleigh et al. (2006). The approach includes both a quantitative and qualitative component. The quantitative component of the analysis of each innovation can be briefly summarised as follows:

(i) each innovation is defined in relation to a specific number of LWA projects or programs

(ii) the LWA R&D investment costs associated with each innovation are defined by year

(iii) the R&D investment costs of other non-LWA parties (researchers or co-funders) are defined by year

(iv) a set of benefits including expected future benefits is quantified

(v) 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 for the set of investments analysed. As more and more innovations are analysed over time, the aggregate set of criteria, including the ROI, can be updated.

This approach provides a time series of benefits and costs for each innovation that can then be organised in different ways to provide a series of investment criteria that measure different benefit types (e.g. captured already, expected in future) and that can be calculated over different time periods.

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

The process of selecting innovations for evaluation initially focused on the hypothesis that a small number of high-performing innovations would account for the majority of benefits produced. With this hypothesis in mind, a method to identify and scan for high-performing innovations was developed. However, after successively selecting and evaluating the eight highest-ranking innovations each year for three years, it was found that there was no evidence of declining performance. Hence, from the fourth year onwards, the selection of innovations for evaluation is being based on pragmatic criteria such as readiness for evaluation and relevance to national priorities.

3 Case study analyses of individual innovations

3.1 Case study process

The full guidelines for evaluation case studies are provided in Campbell & Schofield (2006). A summary of the practical steps follows:

(i) Relevant published papers and reports, reports to LWA, and other material are assembled with assistance from LWA personnel, principal investigators and others.

(ii) In all cases, innovations are closely related to one or more specific LWA projects where milestone reports and final reports are procured.

(iii) An initial description of the background to the innovation, of investment activities and projects, and of outputs, outcomes and benefits, is drafted as far as is possible. Additional information needs are identified.

(iv) Telephone and email contact is made with various personnel associated with the projects. Drafts of project analyses are sent to selected personnel knowledgeable about the innovation, for verification and extension. Some specific information requests are made.

(v) Further information is assembled from government and industry sources.

(vi) Some analyses proceed through several drafts, both within and outside the project team.

(vii) All innovations are analysed as to whether they:

- have produced benefits to date
- are likely to produce benefits at some future time
- have produced, or are likely to produce, economic, social or environmental benefits.

(viii) All benefits identified are described for each innovation. At least some benefits are valued quantitatively for each innovation, and these form the basis for the estimates of investment criteria.

(ix) A discount rate of 6 per cent is used. All annual dollar costs and benefits are expressed in 2006–07 terms and discounted to the year 2006–07. A 40-year time frame is used in all analyses, with the first year being the initial year of investment in the innovation. R&D financial investments in the innovation include those for LWA and contributions (dollars and in-kind) from other funding organisations and from any participating R&D or industry group.

(x) Assumptions for valuing benefits are made in a consistently conservative manner. Sensitivity analyses are conducted for those variables that are thought to be key drivers of the investment criteria.

(xi) The investment criteria calculated for each innovation are the net present value (NPV), the BCR and the IRR. The NPV is the difference between the present value of benefits (PVB) and the present value of costs (PVC). Present values are the sum of discounted streams of benefits and/or costs. The BCR is the ratio of the PVB to the PVC. The IRR is the discount rate that would equate the PVB and the PVC, thus making the NPV zero and giving a BCR of 1. For a fuller explanation of the terms used in the investment analyses, see Appendix 2.

(xii) Significant effort is put into valuing non-market benefits. Consideration is given to the appropriateness of using benefit-transfer techniques and different ways of ensuring that assumptions surrounding the use of such numbers are used in an appropriate context.

(xiii) In the more recent case studies, more attention is given to specifically defining deficiencies or otherwise in the existence of adoption information. The key purpose of this is to improve overall monitoring and evaluation by identifying the nature of data and information that should be pursued to allow such analyses to be improved.

Guidelines for the analysis of individual innovations have been further developed (Agtrans Research 2006). The guidelines have evolved over the five years that the analyses have been carried out.

3.2 Results for 33 evaluation case studies

The individual investment criteria for each of the 28 case studies analysed to June 2006 have been updated to 2006–07 dollar terms and discounted to June 2007. All analyses are over 40 years, except where another period is explicitly stated. Table 5 summarises these updated results, together with results for five investments analysed in 2007.

The conversion of all analyses to 2006–07 dollars has generally moved the investment criteria for all investments in a positive direction. In 2006, a decision was made to extend the time period for consideration of benefits from 25 to 40 years. All case studies have now been updated to reflect this change. This has had a variable, and sometimes dramatic, positive impact on the criteria. For example, the criteria for some investments such as AusRivAS have increased significantly due to the long lag times until benefits start to accrue and reach their maximum. At the other extreme, the extension changed the criteria only marginally for some projects where the interval for consideration of benefits was already restricted (e.g. the investment in 'Tax incentives for native vegetation', where benefits were deliberately restricted to 20 years).

Some of the program investments analysed in 2006 and 2007 (National Program for Irrigation Research and Development (NPIRD), Climate Variability in Agriculture Program (CVAP), Native Vegetation R&D Program, National Rivers Consortium, National River Contaminants Program, Managing Climate Variability Program (MCVP)), included individual projects that had been analysed in previous years. Because of overlap between the analyses, the benefits and costs of the 33 individual case studies are not mutually exclusive. This is taken account of when calculating the aggregate results.

Also presented in Table 5 is the proportion of benefits that is attributable to LWA funding. This attribution is based on the proportion of total investment costs sourced from LWA. This dilution of the total benefits according to the relative investment contribution from LWA and others does not value leverage; in fact, high leverage can work against LWA if the higher-leveraged investments return a lower rate of return than lower-leveraged investments.

Table 6 presents the 33 investments in descending order of BCR for the LWA investment. The other investment criteria for each case study are also shown, together with the proportion of benefits attributable to the LWA investment. Other columns in Table 6 show the subjective rating given to the quantitative analysis in terms of benefit coverage and the confidence in the assumption made.

Strong qualifications should be placed on the interpretation of the rankings. Because of the different coverage of benefits etc., as demonstrated by the confidence rating on benefit coverage and assumptions, the results of the case studies were never intended to be specifically compared or ranked.

Table 5. Summary of results for 33 case studies (in 2006–07 dollar terms and discounted to June 2007; analyses over 40 years)

Investment	Analysis completed	Analysis updated	Period of Land & Water Australia (LWA) research (years ending in June) and number of years in brackets	Period of research (total) (years ending in June)	Benefit: cost ratio (LWA only)	Internal rate of return (LWA only) (%)	Net present value (NPV) (LWA only) ($m)	NPV (all) ($m)	Proportion of total benefits attributable to LWA (%)	Confidence rating: coverage of benefits	Confidence rating confidence in assumptions
AusRivAS: river health assessment	2003		1993–2000 (8)	1993–2000	2.71	11.03	5.48	51.75	10.49	medium	low
AussieGRASS: pasture predictions	2004		1994–2002 (9)	1991–2002	4.57	54.06	0.72	82.93	0.84	medium	medium
Benchmarking irrigation providers	2003		1997–2003 (7)	1997–2003	13.90	48.79	3.51	31.67	11.12	high	medium
Cotton pesticides BMP	2003	2005	1994–1999 (6)	1994–2000	5.97	33.32	36.15	236.02	15.64	high	medium
Catchment management support system (CMSS)	2005		1991–1996 (6)	1989–1996	4.45	13.73	2.83	14.39	20.16	medium	low
CHRRUPP—regional planning	2003		1998–2001 (4)	1998–2002	9.03	25.77	8.97	59.63	15.08	high	medium
Climate forecasting Indian Ocean	2003		1993–2002 (10)	1993–2002	3.01	13.89	0.54	29.59	1.54	medium	low
CVAP	2006		1996–2001 (6)	1993–2003	5.66	48.30	4.80	317.05	1.48	high	medium
Controlled traffic	2003		1993–1998 (6)	1993–2001	5.80	20.75	11.88	100.97	11.91	high	high
ECOGRAZE—ecosystem based grazing	2005		1997–2001 (5)	1993–2001	19.06	24.53	4.27	98.60	4.29	medium	high
Ecology of streams	2005		1994–1998 (5)	1994–1998	2.61	12.15	3.07	5.88	52.09	high	medium
Ecological risk assessment (ERA)	2006		2001–2006 (6)	2001–2006	3.43	13.98	0.96	5.92	16.19	high	low
Effluent guidelines	2004		1992–1999 (8)	1991–2000	8.04	24.76	27.29	211.19	12.86	medium	medium
Groundwater dependent ecosystems	2004		1997–2003 (7)	1997–2003	4.64	15.80	8.76	22.02	39.71	high	low
Groundwater classification	2004		1998–2000 (3)	1998–2000	22.86	31.82	8.87	15.34	57.83	high	medium

Table 5. (continued)

Investment	Analysis completed	Analysis updated	Period of Land & Water Australia (LWA) research (years ending in June) and number of years in brackets	Period of research (total) (years ending in June)	Benefit: cost ratio (LWA only)	Internal rate of return (LWA only) (%)	Net present value (NPV) (LWA only) ($m)	NPV (all) ($m)	Proportion of total benefits attributable to LWA (%)	Confidence rating: coverage of benefits	Confidence rating confidence in assumptions
JVAP—agroforestry (25 projects)	2005		1994–2003 (10)	1991–2003	4.90	15.09	6.66	69.42	9.43	high	medium
Land Water and Wool	2007		2002–2010 (9)	2002–2010	NA[a]	NA	NA	115.53	0.00	high	high
MCVP—managing climate variability	2007		2003–2008 (6)	2003–2008	1.52	10.02	0.49	8.57	5.75	high	medium
Managing riparian lands	2003	2006	1994–2006 (13)	1994–2006	6.52	89.15	87.07	144.96	60.02	medium	medium
Native vegetation	2007		1995–2007 (13)	1995–2007	4.11	30.64	36.02	113.81	31.54	medium	medium
NDSP—dryland salinity	2005		1994–2004 (11)	1994–2003	2.96	19.06	39.31	273.36	14.57	high	medium
NEMP—eutrophication management	2000	2006	1996–2003 (8)	1996–2003	6.55	16.27	21.86	84.88	25.60	medium	low
NPIRD—irrigation	2006		1994–2002 (9)	1994–2002	2.68	15.28	20.12	117.24	18.65	high	medium
NRC—rivers consortium	2007		1999–2007 (9)	1999–2007	3.44	16.33	8.18	24.21	33.80	medium	low
NRCP—river contaminants	2007		2000–2007 (8)	2000–2007	2.84	16.28	3.44	21.35	16.15	medium	low
OPUS—using saline land	2004		1999–2001 (3)	1999–2001	11.16	25.03	0.60	4.03	14.94	high	high
PIRI—pesticide risk analysis	2005		1997–2002 (6)	1997–2004	43.22	57.51	5.53	24.74	22.40	high	medium
River Styles –geomorphic river assessment	2004		1995–1999 (5)	1995–1999	28.65	16.74	23.37	35.01	66.75	high	low
SGS including Prograze	2003		1997–2002 (6)	1997–2002	3.56	25.00	9.26	147.37	6.29	high	medium
Tax incentives for native vegetation	2004		1997–1999 (3)	1997–1999	18.23	51.93	9.45	29.11	32.47	medium	low
Water use efficiency	2004	2006	1994–2002 (9)	1994–2002	5.44	32.53	21.23	108.79	19.54	medium	medium
Water protection guidelines	2005		1999–2002 (4)	2001–2001	17.71	46.65	3.53	6.08	58.14	high	medium
Wetland guidelines	2005		1992–1999 (8)	1992–2000	1.97	15.35	2.26	5.25	41.22	high	medium

a NA: Not applicable. No LWA cash investment in LWW.

Table 6. Summary of results for 33 case studies in order of benefit:cost ratio (BCR) (in 2006–07 dollar terms and discounted to June 2007; analyses over 40 years)

Investment	BCR (Land & Water Australia (LWA) only)	Internal rate of return (LWA only) (%)	Net present value (LWA only) ($m)	Proportion of total benefits attributable to LWA (%)	Confidence rating: coverage of benefits	Confidence rating: confidence in assumptions
PIRI—pesticide risk analysis	43.2	57.51	5.53	22.40	high	medium
River Styles—geomorphic river assessment	28.7	16.74	23.37	66.75	high	low
Groundwater classification	22.9	31.82	8.87	57.83	high	medium
ECOGRAZE—ecosystem based grazing	19.1	24.53	4.27	4.29	medium	high
Tax incentives for native vegetation	18.2	51.93	9.45	32.47	medium	low
Water protection guidelines	17.7	46.65	3.53	58.14	high	medium
Benchmarking irrigation providers	13.9	48.79	3.51	11.12	high	medium
OPUS—using saline land	11.2	25.03	0.60	14.94	high	high
CHRRUPP—regional planning	9.0	25.77	8.97	15.08	high	medium
Effluent guidelines	8.0	24.76	27.29	12.86	medium	medium
NEMP—eutrophication management	6.6	16.27	21.86	25.60	medium	low
Managing riparian lands	6.5	89.15	87.07	60.02	medium	medium
Cotton pesticides BMP	6.0	33.32	36.15	15.64	high	medium
Controlled traffic	5.8	20.75	11.88	11.91	high	high
CVAP	5.7	48.30	4.80	1.48	high	medium
Water use efficiency	5.4	32.53	21.23	19.54	medium	medium
JVAP—agroforestry (25 projects)	4.9	15.09	6.66	9.43	high	medium
AussieGRASS: pasture predictions	4.6	54.06	0.72	0.84	medium	medium
Groundwater dependent ecosystems	4.6	15.80	8.76	39.71	high	low
Catchment management support system (CMSS)	4.5	13.73	2.83	20.16	medium	low
Native vegetation	4.1	30.64	36.02	31.54	medium	medium
SGS including Prograze	3.6	25.00	9.26	6.29	high	medium
NRC—rivers consortium	3.4	16.33	8.18	33.80	medium	low
Ecological risk assessment (ERA)	3.4	13.98	0.96	16.19	high	low
Climate forecasting Indian Ocean	3.0	13.89	0.45	1.54	medium	low

Table 6. (continued)

Investment	BCR (Land & Water Australia (LWA) only)	Internal rate of return (LWA only) (%)	Net present value (LWA only) ($m)	Proportion of total benefits attributable to LWA (%)	Confidence rating: coverage of benefits	Confidence rating: confidence in assumptions
NDSP—dryland salinity	3.0	19.06	39.31	14.57	high	medium
NRCP—river contaminants	2.8	16.28	3.44	16.15	medium	low
AusRivAS: river health assessment	2.7	11.03	5.48	10.49	medium	low
Ecology of streams	2.6	12.15	3.07	52.09	high	medium
NPIRD—irrigation	2.4	15.28	20.12	18.65	high	medium
Wetland guidelines	2.0	15.35	2.26	41.22	high	medium
MCVP—managing climate variability	1.5	10.02	0.49	5.75	high	medium
Land, Water and Wool	NA	NA	NA	0.00	high	high

Table 7 presents the case studies ranked by NPV for all partners in the investment (far-right column), while Table 8 presents the case studies ranked by BCR for all partners.

Table 7. Ranking of case studies by net present value (NPV) (all partners)

Investment	Benefit:cost ratio (BCR) Land & Water Australia (LWA) only	Internal rate of return (IRR) (LWA only) (%)	NPV (LWA only) ($m)	BCR (all)	IRR (all) (%)	NPV (all) ($m)
CVAP	5.66	48.30	4.80	5.12	27.53	317.05
NDSP—dryland salinity	2.96	19.06	39.31	3.03	20.48	273.36
Cotton pesticides BMP	5.97	33.32	36.15	6.67	45.44	236.02
Effluent guidelines	8.04	24.76	27.29	7.80	23.46	211.19
SGS including prograze	3.56	25.00	9.26	3.57	25.53	147.37
Managing riparian lands	6.52	89.15	87.07	6.49	88.00	144.96
NPIRD—irrigation	2.68	15.28	20.12	3.14	17.88	117.24
Land, Water and Wool	NA	NA	NA	3.36	21.63	115.53
Native vegetation	4.11	30.64	36.02	4.07	29.75	113.81
Water use efficiency	5.44	32.53	21.23	5.49	33.50	108.79
Controlled traffic	5.80	20.75	11.88	6.17	22.77	100.97
ECOGRAZE—ecosystem based grazing	19.06	24.53	4.27	16.16	20.28	98.60
NEMP—eutrophication management	6.55	16.27	21.86	6.34	15.76	84.88

Table 7. (continued)

Investment	Benefit:cost ratio (BCR) Land & Water Australia (LWA) only	Internal rate of return (IRR) (LWA only) (%)	NPV (LWA only) ($m)	BCR (all)	IRR (all) (%)	NPV (all) ($m)
AussieGRASS: pasture predictions	4.57	54.06	0.720	4.14	28.92	82.93
JVAP—agroforestry (25 projects)	4.90	15.09	6.66	4.60	14.09	69.42
CHRRUPP—regional planning	9.03	25.77	8.97	9.19	26.63	59.63
AusRivAS: river health assessment	2.71	11.03	5.48	2.67	10.90	51.75
NRC—rivers consortium	3.44	16.33	8.18	3.45	16.35	24.21
River Styles—geomorphic river assessment	28.65	16.74	23.37	28.76	16.76	35.01
Benchmarking irrigation providers	13.90	48.79	3.51	14.74	62.94	31.67
Climate forecasting Indian Ocean	3.01	13.89	0.45	3.04	14.07	29.59
Tax incentives for native vegetation	18.23	51.93	9.45	18.20	51.65	29.11
PIRI—pesticide risk analysis	43.22	57.51	5.53	47.87	81.77	24.74
Groundwater dependent ecosystems	4.64	15.80	8.76	4.61	15.72	22.02
NRCP—river contaminants	2.84	16.28	3.44	2.86	16.26	21.35
Groundwater classification	22.86	31.82	8.87	22.89	31.87	15.34
Catchment management support system (CMSS)	4.45	13.73	2.83	4.89	13.93	14.39
MCVP—managing climate variability	1.52	10.02	0.49	1.52	9.99	5.75
Water protection guidelines	17.71	46.65	3.53	17.88	48.38	6.08
Ecological risk assessment (ERA)	3.43	13.98	0.96	3.39	13.81	5.92
Ecology of streams	2.61	12.15	3.07	2.60	12.12	5.88
Wetland guidelines	1.97	15.35	2.26	1.88	14.82	5.25
OPUS—using saline land	11.16	25.03	0.60	11.21	25.25	4.03

Table 8. Ranking of case studies by benefit:cost ratio (BCR) (all partners)

Investment	BCR (Land & Water Australia (LWA) only)	Internal rate of return (IRR) (LWA only) (%)	Net present value (NPV) (LWA only) ($m)	BCR (all)	IRR (all) (%)	NPV (all) ($m)
PIRI—pesticide risk analysis	43.22	57.51	5.53	47.87	81.77	24.74
River Styles—geomorphic river assessment	28.65	16.74	23.37	28.76	16.76	35.01
Groundwater classification	22.86	31.82	8.87	22.89	31.87	15.34
Tax incentives for native vegetation	18.23	51.93	9.45	18.20	51.65	29.11
Water protection guidelines	17.71	46.65	3.53	17.88	48.38	6.08
ECOGRAZE—ecosystem based grazing	19.06	24.53	4.27	16.16	20.28	98.60
Benchmarking irrigation providers	13.90	48.79	3.51	14.74	62.94	31.67
OPUS—using saline land	11.16	25.03	0.60	11.21	25.25	4.03
CHRRUPP—regional planning	9.03	25.77	8.97	9.19	26.63	59.63
Effluent guidelines	8.04	24.76	27.29	7.80	23.46	211.19
Cotton pesticides BMP	5.97	33.32	36.15	6.67	45.44	236.02
Managing riparian lands	6.52	89.15	87.07	6.49	88.00	144.96
NEMP—eutrophication management	6.55	16.27	21.86	6.34	15.76	84.88
Controlled traffic	5.80	20.75	11.88	6.17	22.77	100.97
Water use efficiency	5.44	32.53	21.23	5.49	33.50	108.79
CVAP	5.66	48.30	4.80	5.12	27.53	317.05
Catchment management support system (CMSS)	4.45	13.73	2.83	4.89	13.93	14.39
Groundwater dependent ecosystems	4.64	15.80	8.76	4.61	15.72	22.02
JVAP—agroforestry (25 projects)	4.90	15.09	6.66	4.60	14.09	69.42
AussieGRASS: pasture predictions	4.57	54.06	0.72	4.14	28.92	82.93
Native vegetation	4.11	30.64	36.02	4.07	29.75	113.81
SGS including PROGRAZE	3.56	25.00	9.26	3.57	25.53	147.37
NRC—rivers consortium	3.44	16.33	8.18	3.45	16.35	24.24
Land, Water and Wool	NA	NA	NA	3.36	21.63	115.53
NDSP—dryland salinity	2.96	19.06	39.31	3.03	20.48	273.36
Ecological risk assessment (ERA)	3.43	13.98	0.96	3.39	13.81	5.92
NPIRD—irrigation	2.68	15.28	20.12	3.14	17.88	117.24
Climate forecasting Indian Ocean	3.01	13.89	0.45	3.04	14.07	29.59
NRCP—river contaminants	2.84	16.28	3.44	2.86	16.26	21.35
AusRivAS: river health assessment	2.71	11.03	5.48	2.67	10.90	51.75
Ecology of streams	2.61	12.15	3.07	2.60	12.12	5.88
Wetland guidelines	1.97	15.35	2.26	1.88	14.82	5.25
MCVP—managing climate variability	1.52	10.02	0.49	1.52	9.99	5.75

4 Portfolio return on investment

4.1 Aggregate results for the LWA portfolio

The ROI methodology is designed to allow aggregation of case study results to a single, large CBA. Through integration of the individual cash flows of benefits and costs, a CBA for 33 case studies incorporating 630 projects has been conducted.

Investment criteria were produced for:

(i) aggregate total expected benefits that could be attributed to all investors for the 33 investments against the total investment

(ii) aggregate total expected benefits that could be attributed to LWA for the 33 investments against the LWA investment in the 33 investments

(iii) aggregate investment criteria for rolling five-year periods since LWA's establishment in 1991.

Costs and benefits were expressed in 2006–07 dollar terms and present values were expressed as of the year 2006–07.

The 33 individual case studies include eight innovations analysed in 2003, eight in 2004 and eight in 2005, plus the National Eutrophication Management Program (NEMP) in 2000, three in 2006 and five in 2007. In addition, the 33 case studies include four analyses that have been updated since their original inclusion (three in 2006, and one in 2005).

Aggregate investment criteria can be calculated to demonstrate the aggregate return on investment for the 33 case studies. Table 9 presents a summary of aggregate results for the 33 analyses for LWA benefits and LWA costs only, as well as for all partners' investments in the 33 analyses. It shows that the LWA investment has produced an NPV of $481m, a BCR of 4.7 to 1 and an IRR of over 26 per cent. When all partners' investments are included, the NPV is $2,296m, with a BCR of 4.4 to 1 and an IRR of over 23 per cent.

Table 9. Investment criteria for the 33 innovations (all in 2006–07 dollars and discounted to June 2007 at a discount rate of 6%)

Investment criterion	Total for all 33 analyses (return to all investment)	Total for all 33 analyses (return to Land & Water Australia investment)
Present value of benefits ($m)	2,964.56	481.49
Present value of costs ($m)	668.76	102.78
Net present value ($m)	2,295.79	378.71
Benefit:cost ratio	4.43 to 1	4.68 to 1
Internal rate of return (%)	23.28	26.23

It should be remembered that the BCR and IRR calculated apply to only the 33 selected investments, and it is not valid to extrapolate the values for these criteria to other LWA investments.

The aggregation of the cash-flow streams for all 33 case studies was constructed to avoid any 'double-counting' of benefits and costs that might occur from investments analysed earlier. For example, WUE, ERA (partial) and Benchmarking as components of NPIRD; Seasonal forecasting and AussieGRASS as components of CVAP; Groundwater classification as a component of NDSP; Tax incentives as a component of the Native Vegetation R&D Program; and Protection guidelines as a component of the National Rivers Consortium.

Total investment made by LWA for each of the years 1990–91 to 2006–07 is shown in Table 10. This investment represents government appropriation resources only and is based on income received rather than expenditure made. Data on LWA appropriation expenditure by year are difficult to extract from LWA accounts due to mixing with other income streams.

4.2 Returns over time

A process for estimating the ROI over different periods was developed as part of the LWA ROI portfolio initiative in 2005:

Estimating investment criteria for the base period

(i) A base period of funding by LWA of the five years ending 1994–95 is assumed; this is the first five years of funding of the corporation, which began operating in the year ending June 1991.

(ii) A time series for these five years for the LWA investment over that period in each of the investments that have been evaluated to date is identified (cash flow A).

(iii) The time series of benefits for any of the 33 investments that have been funded over that base period are identified (cash flow B). If an investment was not funded over the base period then its costs and benefits are not included.

Table 10. Total government appropriation for Land & Water Australia 1990–91 to 2006–07

Year	Appropriation income ($m)	
	Nominal dollar terms	2006–07 dollar terms
1990–91	8.759	13.118
1991–92	11.026	16.205
1992–93	11.139	16.204
1993–94	11.135	15.906
1994–95	11.820	16.365
1995–96	11.320	15.039
1996–97	10.460	13.712
1997–98	10.778	14.047
1998–99	10.939	14.105
1999–00	11.049	13.807
2000–01	11.314	13.335
2001–02	11.586	13.278
2002–03	11.875	13.253
2003–04	12.241	13.332
2004–05	12.501	13.284
2005–06	12.513	12.789
2006–07	12.751	12.751

(iv) Each year of benefits in this time series is multiplied by the proportion of total costs of the R&D for the investment that fall into the base period (the investment cost adjustment factor (ICAF)) in order to produce an adjusted time series of benefits (cash flow C).

(v) Investment criteria are estimated for the adjusted benefit series against the cost series (cash flow A).

Estimating investment criteria over time

(i) One additional year of investment (e.g. 1995–96) is added to cash flow A and the first year of the original base period (e.g. 1990–91) is omitted.

(ii) The cash flow of benefits for each investment funded over the new five-year period is adjusted, a new ICAF is estimated for each investment, and a new time series of benefits (cash flow C) is estimated.

(iii) The process is repeated until the investment criteria for the latest five-year period have been calculated.

Investment criteria for the base period and five-year periods thereafter are shown in Table 11. These results apply to only 26 of the 33 investments. This is to avoid double counting of benefits and costs that are common to more than one investment, as described earlier.

Table 11. Investment criteria for 26 independent Land & Water Australia investments over different periods

Period of investment (years ending June)	Number of investments funded	Present value of benefits ($m)	Present value of costs ($m)	Net present value ($m)	Benefit: cost ratio	Internal rate of return (%)
1991–1995	13	90.86	21.77	69.09	4.17 to 1	19.46
1992–1996	15	145.33	34.07	111.27	4.27 to 1	20.12
1993–1997	19	216.07	49.08	166.99	4.40 to 1	20.88
1994–1998	20	261.67	58.40	203.27	4.48 to 1	21.50
1995–1999	22	280.65	60.49	220.15	4.64 to 1	22.92
1996–2000	23	263.92	55.05	208.87	4.79 to 1	24.68
1997–2001	22	238.10	48.79	189.32	4.88 to 1	27.46
1998–2002	22	198.04	40.03	158.01	4.95 to 1	40.14
1999–2003	22	173.33	35.02	138.31	4.95 to 1	n.s.
2000–2004	18	142.14	28.98	113.15	4.90 to 1	n.s.
2001–2005	17	119.99	24.55	95.45	4.89 to 1	n.s.
2002–2006	13	96.79	19.43	77.36	4.98 to 1	n.s.
2003–2007	10	64.37	12.92	51.45	4.98 to 1	n.s.

n.s. no solution

The average period of LWA investment was just over 7 years (7.3) across the 26 investments. The second column in Table 11 shows the number of investments funded at least in part during each period and explains the initial increase in PVC, PVB and NPV, their maxima in the eighth time period, and then later declines with the fall in the number of investments involved. However, it appears that the rate of return (BCR and IRR) has increased over time.

Table 12 presents the time-series data for all partners' investments, rather than just the LWA investment. It shows that that the BCR declines slightly until the fourth time period (1994–1998), then increases slightly until 2002, before declining again towards the end of the period. The IRR trend is much the same as for the LWA investment.

Table 12. Investment criteria for 26 independent total investments over different periods

Period of investment (year ending June)	Number of investments funded	Present value of benefits ($m)	Present value of costs ($m)	Net present value ($m)	Benefit: cost ratio	Internal rate of return (%)
1991–1995	15	651.79	139.61	512.18	4.67 to 1	18.75
1992–1996	16	883.52	190.37	693.15	4.64 to 1	19.13
1993–1997	19	1,189.52	261.41	928.10	4.55 to 1	19.67
1994–1998	20	1,404.88	314.38	1,090.49	4.47 to 1	20.32
1995–1999	22	1,519.26	337.18	1,182.08	4.51 to 1	22.07
1996–2000	23	1,500.97	330.09	1,170.88	4.55 to 1	24.51
1997–2001	22	1,483.98	323.32	1,160.66	4.59 to 1	27.96
1998–2002	23	1,348.05	289.56	1,058.55	4.66 to 1	35.17
1999–2003	24	1,225.34	266.34	959.00	4.60 to 1	n.s.
2000–2004	23	961.81	211.44	750.37	4.55 to 1	n.s.
2001–2005	20	745.49	170.49	575.00.	4.37 to 1	n.s.
2002–2006	17	567.03	139.06	427.97	4.08 to 1	n.s.
2003–2007	14	401.94	107.08	294.84	3.75 to 1	n.s.

n.s. no solution

An interesting finding from the data presented in Tables 11 and 12, and Figures 3 and 4, is that the rates of return to LWA investments have increased over time. Also, for LWA plus partners, the rates of return were increasing up until the period 1998–2002. Optimistically, this may reflect improving selection of investments for LWA, better R&D management and/or a greater emphasis on adoption. However, none of these factors can be incontrovertibly linked to improving ROI performance or otherwise in the methodology. Several caveats to interpretation should be noted:

(i) most investments analysed are represented in the middle period and drive the overall average rate of return

(ii) some higher or lower performing large investments can be influential at different times

(iii) these results apply to the selected sample but may not apply to the total portfolio.

Perhaps as or more important than trends, is that ROI for LWA funds and LWA plus partners funds has been consistently above 3.7:1 since the 1990–95 period, for a large sample of projects.

The years in which each investment was funded by LWA are shown in Table 13. It is obvious that the early and later years of the period 1991–2007 include fewer years in which the 26 investments were funded.

Table 13. Timing of Land & Water Australia investment (year ending June) in 26 case studies

Investment	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
AusRivAS																	
Cotton pesticides BMP																	
Catchment management support system (CMSS)																	
CHRRUPP—regional planning																	
CVAP																	
Controlled traffic																	
ECOGRAZE—ecosystem based grazing																	
Ecology of streams																	
Ecological risk assessment (ERA)																	
Effluent guidelines																	
Groundwater dependent ecosystems																	
JVAP—agroforestry (25 projects)																	
Land Water and Wool																	
MCVP—managing climate variability																	
Managing riparian lands																	
Native vegetation																	
NDSP—dryland salinity																	
NEMP—eutrophication management																	
NPIRD—irrigation																	
NRC—rivers consortium																	
NRCP—river contaminants																	
OPUS—using saline land																	
PIRI—pesticide risk analysis																	
River Styles—geomorphic river assessment																	
SGS including PROGRAZE																	
Wetland guidelines																	

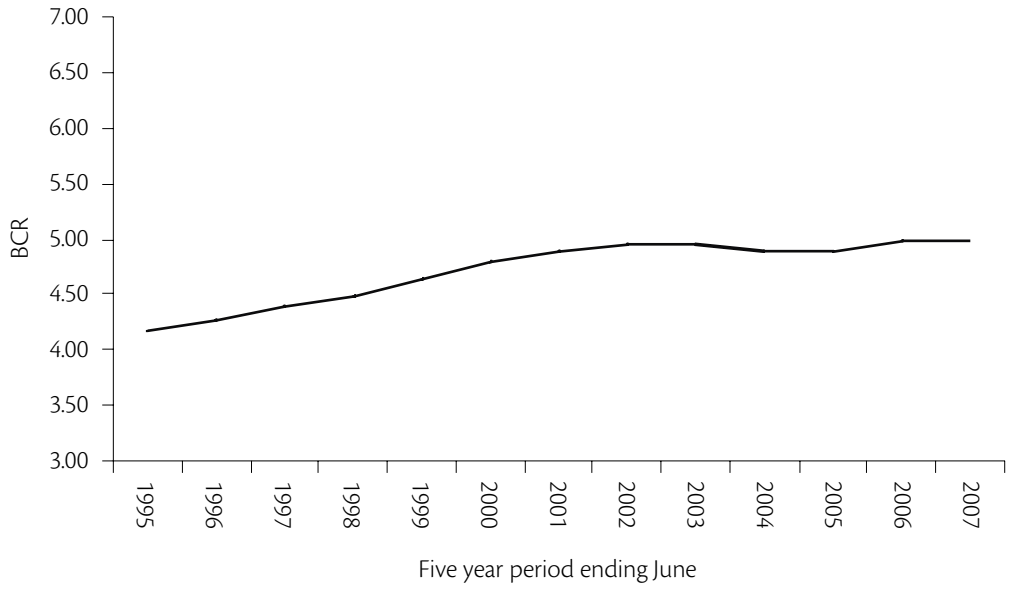

Figure 3. Plot of benefit:cost ratio (BCR) against time for Land & Water Australia investment, five-year periods ending June 1995–2007

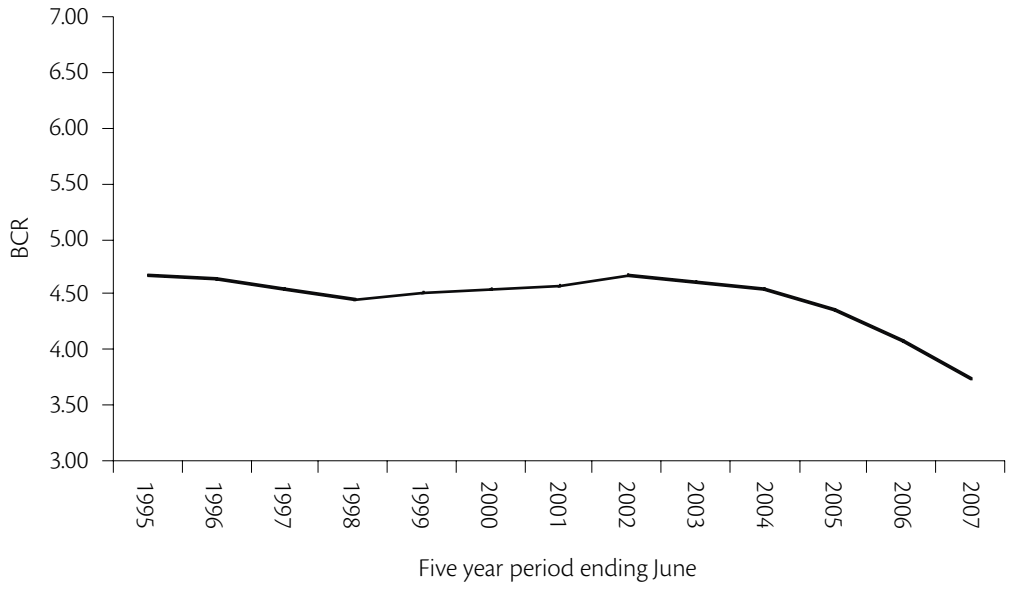

Figure 4. Plot of benefit:cost ratio (BCR) against time for investments by Land & Water Australia and partners, five-year periods ending June 1995–2007

5 Analysis of benefits evaluated

5.1 Categorisation of benefits

The various individual benefits that were identified in the 33 case studies have been categorised into economic, environmental and social benefits, and into those quantified and those not.

In summary, of all the 313 benefits identified, 133 (43 per cent) were categorised as economic, 92 (29 per cent) as environmental and 88 (28 per cent) as social. Of the economic benefits, 55 (41 per cent) were quantified. Twenty-six (28 per cent) of the environmental benefits were quantified, as were 5 (6 per cent) of the social benefits.

That far fewer environmental and social benefits were quantified is worthy of comment. One reason for this is that for many of them the linkages to the R&D were often somewhat indefinite.

5.2 Economic benefits

The principal categories of economic benefits identified were:

A. Productivity improvements such as increased crop yields

B. Variable or capital cost reductions at the farm level

C. Cost reductions for government agencies, rural communities, agribusiness, or non-rural sectors of the economy

D. More-effective infrastructure management

E. Improved policy decision-making in natural resource management by government, including in the areas of monitoring, priority setting and expenditure decisions

F. Expansion, or avoidance of contraction, in some rural industries

G. Other.

Table 14 gives the distribution of quantified and non-quantified benefits across these categories.

Table 14. Distribution of quantified and non-quantified benefits by category of economic benefit

Category	Number of benefits valued	Number of benefits not valued	Total number of benefits identified
A. Farm productivity improvements	17	16	33
B. Cost reductions—farm level	7	10	17
C. Cost reductions—off farm	19	22	41
D. More effective infrastructure management	2	5	7
E. Improved policy decision-making	5	16	21
F. Avoidance of contraction of agricultural industries or stimulating new revenue	3	4	7
G. Other	2	5	7
Total	55	78	133

Cost reductions off-farm were the most frequently identified and quantified benefits. The next most frequently identified and quantified economic benefits were on-farm productivity improvements and improved policy decision-making; however, only 5 of the 21 policy benefits identified were quantified. Further attempts at quantification of policy benefits are suggested for future analyses.

The following were among the major reasons for economic benefits not being quantified:

- The scientific relationship between the research investment and the actual R&D outcomes and associated benefits was suspect, weak or uncertain.
- It was difficult to develop a generalised assumption or there were no readily available, specific examples of actual benefits.
- The benefit was thought to be of only minor value.
- There was some uncertainty in the assumptions concerning the counterfactual ('without the R&D') scenario.

5.3 Environmental benefits

Ninety-two environmental benefits were identified, and 26 of them quantified. The principal categories of environmental benefits identified were:

A. Reduced soil erosion

B. Reduced greenhouse gases

C. Reduced pesticide impacts

D. Reduced salinity and waterlogging impacts

E. Improved water allocation for the environment

F. Improved biodiversity on farms

G. Reduced sediment and nutrient export

H. Improved water quality in general

I. More sustainable land and water systems.

Tables 15 gives the distribution of quantified and non-quantified environmental benefits across these categories.

Table 15. Distribution of quantified and non-quantified environmental benefits, by category

Category of environmental benefit	Number of benefits valued	Number of benefits not valued	Total number of benefits identified
A. Reduced soil erosion	2	8	10
B. Reduced greenhouse gases	2	5	7
C. Reduced pesticide impacts	0	3	3
D. Reduced salinity and waterlogging impacts	2	11	13
E. Improved water allocation for the environment	3	4	7
F. Improved biodiversity on farm	9	5	14
G. Reduced sediment and nutrient export	1	4	5
H. Improved water quality in general	6	9	15
I. More sustainable land and water systems	1	17	18
Total	26	66	92

The most frequently identified environmental benefits were sustainable land and water systems (I), improved water quality (H), improved biodiversity on farm (F), and reduced salinity and waterlogging impacts (D). The proportions of I, H, F and D benefits quantified were, respectively, 6, 40, 64 and 15 per cent.

The major reasons for other environmental benefits not being quantified were similar to those for unquantified economic benefits. They included the following:

- Scientific relationships with the actual R&D outcomes were suspect, weak or uncertain.
- There were difficulties in generalising, or lack of readily available, specific examples of benefits.
- The benefits were thought to be minor.
- The benefits were strongly associated with some uncertainty in the counterfactual.

There is a problem in distinguishing some benefits as economic or environmental, thus exposing a difficulty with the triple-bottom-line approach. Where the impacts can be separated (e.g. salinity impacts), this can be managed satisfactorily, but categorisation issues remain with carbon sequestration and where there are interactions between environmental and productivity and other cost-saving improvements.

5.4 Social benefits

Of the 88 social benefits identified, only 5 were quantified. The principal categories of social benefits identified were:

A. Reduced anxiety

B. Increase in individual and community skills and capacity

C. Improved communication and understanding

D. Enhanced wellbeing, pride and confidence

E. Enhanced aesthetic, amenity and recreation values

F. Reduction in health costs

G. Preservation of future values

H. Improved cultural heritage conservation.

I. Improved equity.

Table 16 gives the distribution of quantified and non-quantified benefits across these categories.

Table 16. Distribution of quantified and non-quantified social benefits, by category

Category of social benefit	Number of benefits valued	Number of benefits not valued	Total number of benefits identified
A. Reduced anxiety	2	8	10
B. Increase in individual and community skills and capacity	1	24	25
C. Improved communication and understanding	0	14	14
D. Enhanced well being, pride and confidence	0	10	10
E. Enhanced aesthetic, amenity and recreation values	2	14	16
F. Reduction in health costs	0	9	9
G. Preservation of future values	0	2	2
H. Improved cultural heritage conservation	0	1	1
I. Improved equity	0	1	1
Total	5	83	88

The social benefit identified most frequently was an increase in individual and community capacity. This was followed by enhanced aesthetic, amenity and recreation values, improved communication and understanding, reduced anxiety and enhanced wellbeing, pride and confidence. Where reduced anxiety was identified, it was valued through benefit transfer in two of seven cases.

None of the nine health benefits (F) was quantified, nor were any of the communication and understanding benefits (C). It is recommended that valuation for these two types of benefits be further investigated, although it is suggested that health improvements could be more readily quantified if relationships between the outcomes and health costs were more evident than they were in the nine case studies here. In many cases, the health benefits were mainly indirect (reduced health impacts from investments in improved use of cotton pesticides, from effluent guidelines, and from reduced algal blooms). Further, the benefits from improved capacity were quantified in only 1 of the 25 cases in which this benefit was identified, and further consideration should be given to developing evaluation methods for this type of benefit.

The major reasons for many of the social benefits not being quantified included the following:

- There was only a weak or uncertain social implication from the actual R&D outcomes.
- There were difficulties in generalising, or lack of readily available, specific examples of benefits.
- The benefits were thought to be minor.
- The benefits were strongly associated with some uncertainty in the counterfactual.
- Valuation methods for, and examples of, social-benefit valuation generally are sparse in the literature.

6 Understanding portfolio returns

6.1 Objective

Having analysed 33 separate innovations and an aggregated portfolio of 630 projects, there is the potential to analyse the characteristics of the portfolio returns and identify some of the factors that contribute to high-performing investments. This latter information is ostensibly captured in each case study—here we attempt to identify relationships between the investment criteria and plot some broader portfolio return characteristics.

Although the investment criteria are estimates made with only a moderate degree of confidence, they were all estimated using a consistent method and conservative assumptions.

6.2 Data

Data on the three principal investment criteria were compiled (NPV, BCR and IRR), along with the components of NPV, namely PVB and PVC. Present values were produced using a 6 per cent discount rate, were all expressed in the same dollar terms (2006–07) and referred to the 2006–07 financial year. Investment criteria were included for both 'total benefits and costs' and for 'LWA benefits and costs'. Other information compiled was:

- LWA program or project/project group
- start year for the investment
- number of years the investment was made by LWA
- the number of years from the first year of investment until benefits began to accrue.

6.3 Method

Only 25 of the 33 case studies were analysed. Eight case studies were omitted as they were nested, or partially nested (e.g. ERA), within larger investments. The average and distribution of the selected investment criteria were estimated. Simple linear regression was then used to identify any significant statistical relationships (at both 90 per cent and 95 per cent confidence levels) between the investment criteria, their components and the other variables on which data were available.

6.4 Results

6.4.1 Averages and distributions

The simple averages for selected variables across 24 investments (excludes Land, Water and Wool) are shown in Table 17

Table 17. Average investment criteria and characteristics for the 24 investments

Criterion or characteristic	Simple average for the 24 investments
Present value of benefits for Land & Water Australia (LWA)	$20.01m
Present value of costs for LWA	$4.27m
Net present value for LWA	$15.74m
LWA contribution to total resources invested	23%
Benefit:cost ratio for LWA	8.0 to 1
Internal rate of return for LWA	25%
Length of investment	7.3 years (range 3–13)
Period from first year of investment to first year of benefits	6.7 years (range 0–17)

It should be noted that the simple average of the BCRs (8 to 1) is higher than that estimated from aggregating the cash flows across the 33 investments (4.7 to 1). This is due to the weighting inherent in aggregating cash flows and some large investments with low BCRs.

The distributions of the three investment criteria for the 24 investments (LWA investment only) in relation to PVC are shown in Figures 5–7.

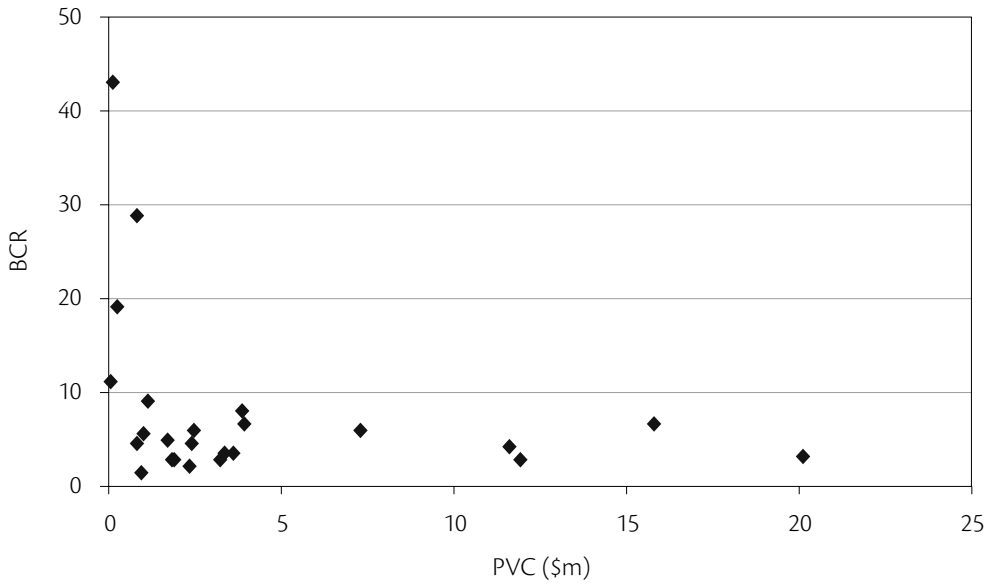

Figure 5. Plot of benefit:cost ratio (BCR) against present value of costs (PVC)

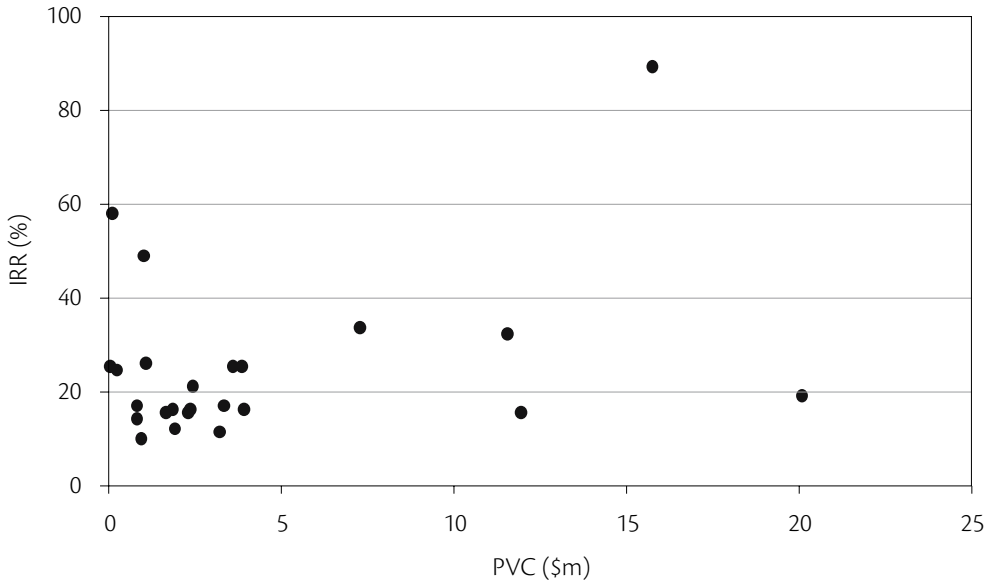

Figure 6. Plot of internal rate of return (IRR) against present value of costs (PVC)

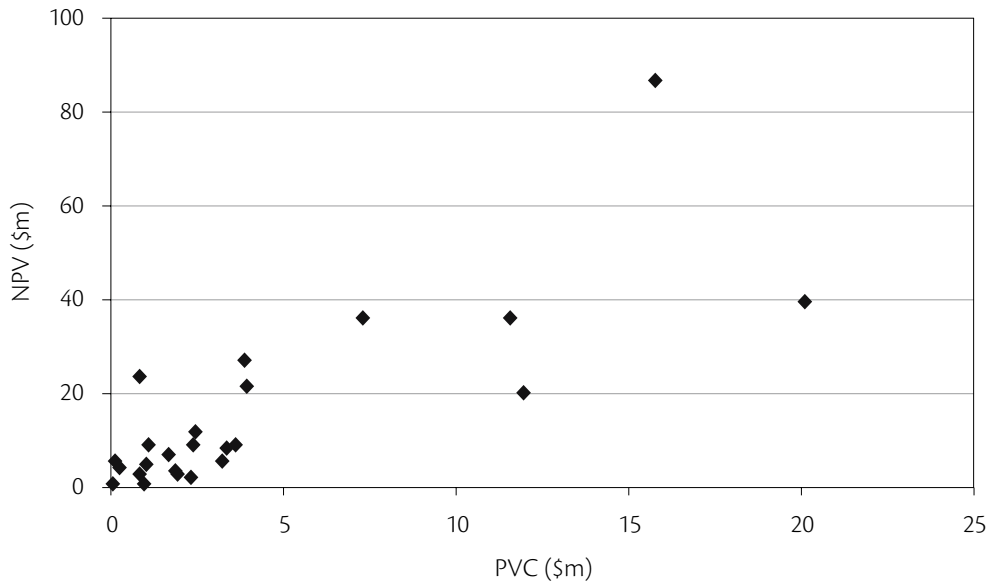

Figure 7. Plot of net present value (NPV) against present value of costs (PVC)

Figures 5 and 6 show that the rate of return appears to decrease as the PVC increases, whereas Figure 7 indicates that the NPV increases with increases in the size of the LWA investment.

Figures 8 and 9 plot the cumulative PVB against the cumulative PVC when the 24 investments are ordered by BCR. Starting with the highest BCR investment, the cumulative PVB and PVC are calculated by adding the investment with the next highest BCR until the 24th investment, which has the lowest BCR, is included. Figures 8 and 9 show that cumulative benefits rise at a decreasing rate.

In fact, 15 investments that have the highest BCRs make up only 52 per cent of the total PVC but provide 71 per cent of the benefits, whereas the nine investments that have the lowest BCRs make up 48 per cent of the investment cost and provide only 29 per cent of the total benefits.

The shape of the curve cannot be used to infer anything about investments that have yet to be analysed.

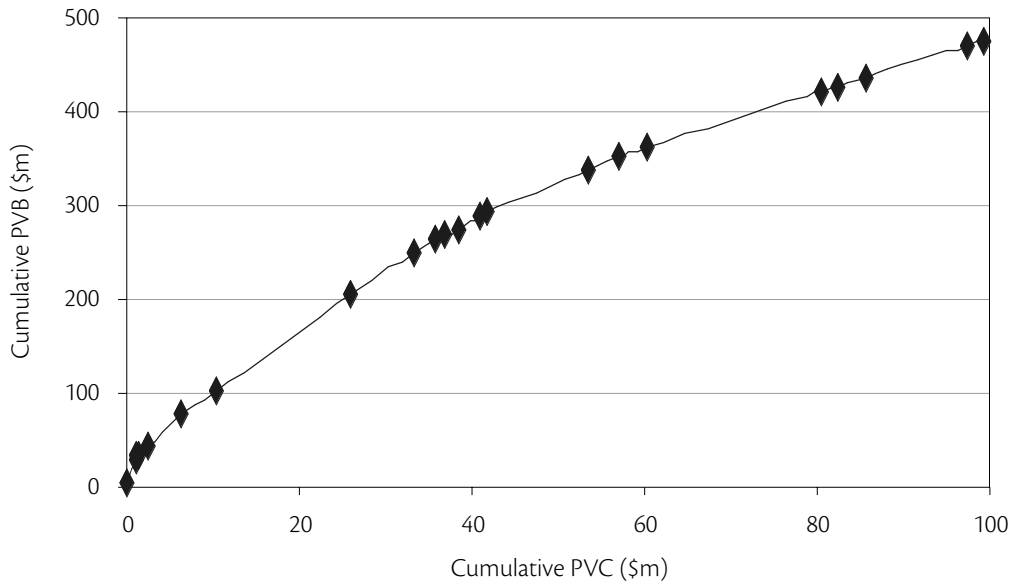

Figure 8. Plot of cumulative present value of benefits (PVB) against cumulative present value of costs (PVC) (projects ordered from highest to lowest benefit:cost ratio that includes only Land & Water Australia investments

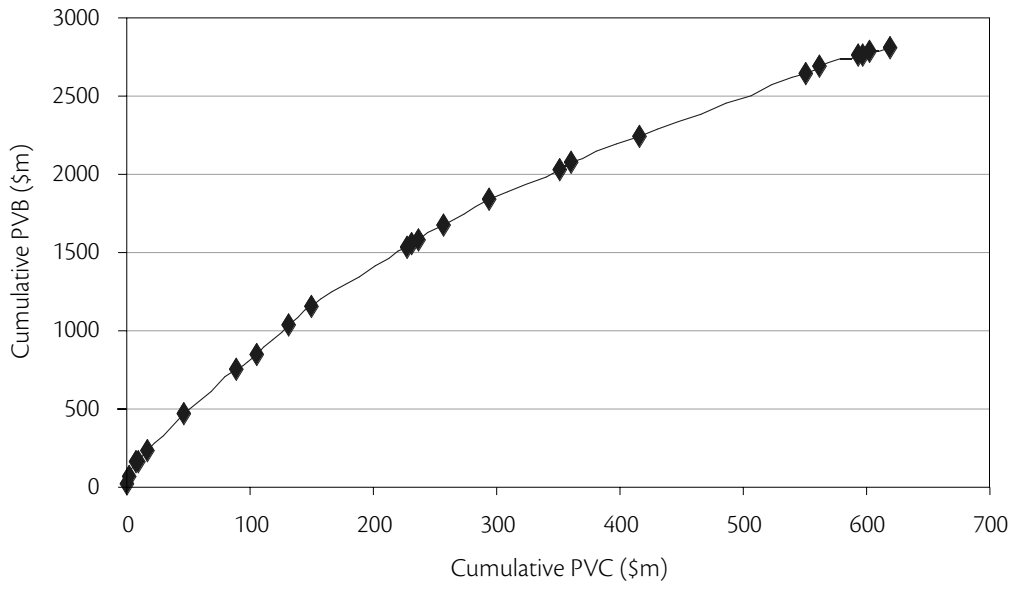

Figure 9. Plot of cumulative present value of benefits (PVB) against cumulative present value of costs (PVC) (projects ordered from highest to lowest benefit:cost ratio that includes Land & Water Australia and partners investments

6.4.2 Regression relationships

The results reported here are based on simple regression analysis and refer to the LWA components of both benefits and costs. There was no statistically significant relationship between either the BCR and the PVC or the IRR and the PVC.

The NPV is positively related to the IRR (98 per cent confidence level) but not related to the BCR.

The NPV is strongly positively related to both PVB (R^2 = 0.98) and PVC (R^2 = 0.62).

The PVB and PVC are strongly related to one another (R^2 = 0.75). The two measures of rate of return are positively associated with one another, but the test for a significant coefficient just failed at the 90 per cent confidence level.

Each case study was assigned to the year in which the investment commenced. Each year was then assigned a number, with 1990 being year 1, 1990 being year 2 and so on. There were no statistically significant relationships with time.

Neither the BCR nor IRR was statistically significantly related to the length of the investment period.

On the other hand, the IRR (but not the BCR) was negatively related at the 95 per cent confidence level to the number of years between the year of first investment and the year in which benefits commence.

6.5 Summary

The above findings relate to only the 24 independent investments analysed, which represent only about 25 per cent of the total LWA investment over the 17-year period. Whether these findings are applicable to the remainder of the portfolio is unknown. Also, since only simple linear regression was used to test statistical relationships, any confounding relationships between variables may not have been identified. Given these provisos, the findings can be summarised as follows:

(i) As the size of the LWA investment increases, NPV generally increases. This is because PVB, PVC and NPV are all positively and strongly correlated.

(ii) As the time to the realisation of benefits increases, the IRR falls.

7 Key messages from ROI analyses

7.1 Strengths of the approach

Strengths of the approach developed and applied to date include:

- *standardisation of the approach* for each case study in terms of the description of the investment and associated outcomes and benefits, as well as in the approach used in the quantitative investment analyses
- *capacity to update* quantitative results since all spreadsheets follow the same format, and assumptions used are clearly laid out in the written case study and in the spreadsheet
- *analyses are flexible over time* since all benefits and costs for any innovation refer to specific years
- *continuous improvement* is evident because, after each round of analyses, areas for improvement can be identified and changes made to guidelines for future analyses
- *multiple objectives* are served in that accountability in terms of benefits, triple-bottom-line reporting, and a historical record of innovations are provided
- although care has to be exercised due to differences between the quantitative analyses in terms of benefit coverage and uncertainty in assumptions made, the investment criteria of individual innovations can provide useful data to identify the characteristics of investment success of innovations

7.2 Constraints currently faced

The key constraints currently being confronted by the approach can be summarised as follows:

- *Non-market valuations* are necessary in that many benefits from LWA's investments are environmental. The validity of the benefit transfers that have been made to date could be questioned.
- *Knowledge of impact relationships* for interventions that impact on natural resources is often lacking and the confidence in some assumptions made is not high.
- *Future adoption assumptions* have had to be made with only scant historical information available on adoption rates for natural resource management knowledge and technologies.
- *The long time frame for benefits* to occur from interventions affecting natural resources and the environment works against discounting methods traditionally used in investment analysis.
- *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.
- *The continuous improvement* approach involves some time-consuming changes to past analyses to ensure that all case studies are using the same processes and are presented in a similar manner.
- *Portfolio return on investment* is difficult to calculate because the innovations analysed have not been drawn at random from all investments and it is difficult to estimate the success of the remainder of the investment.

7.3 Outcome messages

Following the 2007 evaluation, the analyses now cover about 25 per cent of the total LWA appropriation monies from 1990–91 to 2006–07 ($406.26m in present value terms). Each case study has its own messages on how it has performed as an investment. Increasingly, as the number of case studies increases, some key messages at the investment portfolio level are emerging. A first attempt at synthesising these messages follows:

- Both the qualitative and quantitative analyses demonstrate that LWA has invested purposefully and successfully, at least for 25 per cent of its appropriation, over the past 17 years.
- An important question is whether the analyses undertaken to date demonstrate any findings related to what constitutes a 'good' investment. While this question needs further investigation, 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
  - contribution to increased profits
  - adoption, or expected adoption, by many land and water managers and/or policy developers
  - rapid adoption after the initial research investment occurred.
- Many of the reasons for investment performance are linked to the nature and context of individual investments. For example, the factors influencing the strong performance of the riparian program are that:
  - improving riparian land management is a high-priority area in natural resource management in terms of impacting on improvements in biodiversity and water quality
  - LWA has demonstrated national leadership in this R&D area
  - the adoption of R&D outputs that may not have proved economic to the private sector was supported strongly by other government programs (e.g. the Natural Heritage Trust).
- Adoption of much of the knowledge produced from R&D investments for many of the innovations 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.
- The impact of an innovation can be greatly influenced by changing institutional structures and priorities over time. For example, the impact of CMSS was reduced partly due to a general shift in the topical issues, from water quality from algal blooms in the 1990s, to environmental flows and salinity, 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 were significantly delayed.
- Commercialisation through intellectual property protection is not always the most desirable way of supporting adoption of new knowledge. For example, the PIRI and CMSS models were developed in different ways. PIRI was continually supported by CSIRO and has been a relatively successful approach. CMSS was originally supported by CSIRO and a period of attempted commercialisation appears to have retarded its use. Eventually, CMSS regained CSIRO support and is publicly available.
- Working with industry-oriented RDCs has been a successful mechanism for LWA to promote a greater emphasis on resource sustainability issues.

- The various individual benefits that were identified in the 33 case studies were categorised into economic, environmental and social benefits. They were also categorised as either quantified or not quantified. Of all the 313 benefits identified, 43 per cent were categorised as economic, 29 per cent as environmental and 28 per cent as social. Of the economic benefits identified, 41 per cent were quantified as were 28 per cent of the environmental benefits but only 6 per cent of the social benefits.
- An analysis of the LWA investment criteria and various characteristics of the 24 independent investments showed that:
  - as the size of the LWA investment increases, NPV generally increases—this is because PVB, PVC, and NPV are all strongly positively correlated
  - as the time to the realisation of benefits increases, the IRR falls

8 Recommendations for the future

The portfolio analysis approach currently employed by LWA should be continued as it is has now reached a stage of providing useful and meaningful aggregate results.

Future actions should include the following:

1. Maintain the data base of existing evaluations and update selected analyses from time to time when further information becomes available, particularly that related to commercialisation and adoption.
2. Expand the number of case studies analysed as resources allow, with selected projects, groups of projects or programs analysed as they are completed, as it is the contemporary investments that need to be added in future.
3. Utilise other LWA program/subprogram/project level evaluations for incorporation into the portfolio evaluation using the guidelines produced in this report.
4. Now that a method for evaluating ROI performance over time has been developed, the ROI over time should be kept current (updated annually) as more evaluations are conducted and earlier evaluations are updated.
5. Continue to develop non-market valuation methods through facilitating the assembly of metadata in particular subject areas, e.g. biodiversity, water quality valuation and impacts of different interventions and management strategies on biodiversity and water quality.
6. Strengthen information sources and data availability on the users and uses of LWA publications, so that follow-up surveys on particular innovations have fruitful starting points.
7. LWA, through its knowledge and adoption strategy, should continue to strengthen information on adoption rates.
8. LWA should consider funding studies on non-market valuations and benefit-transfer databases.

9. LWA could consider communicating the practical difficulties identified in the portfolio analyses in using benefit transfer to those involved in willingness-to-pay studies that are conducted in the future.

10. There are sometimes difficulties in accessing information on the financial inputs to research investment. For example, when a project or program is not managed directly by LWA, LWA's only record of expenditure appears to be in the individual project files. Complete financial information is not always clear, as budgets are often changed by the external project managers and this may need additional communication to discover. Continuing problems of this type in 2007 slowed the consultancy and was time-consuming for LWA.

11. There are also difficulties with accessing financial information about large programs with multiple funding partners, even when LWA is the manager. Efforts should be made to ensure that the specific LWA financial input to those projects and programs is isolated, not just the value that LWA 'manages', which often includes contributions from other funding partners.

12. If an outcome is the result of more than one project, tracing the evolution of the outcome and its attribution to various projects and funders can become dependent on the existence of one or two key researchers or research managers who maintain corporate memory. The information required for such purposes is not often documented in project files, and hence loss of corporate memory is a serious risk for undertaking such case studies, particularly on those research investments that were completed some time ago. The importance of this issue may lessen as more-contemporary investments are analysed.

13. There is a balance required between ensuring sufficient time has elapsed after the investment to ensure some adoption and information on outcomes and impact, and ensuring relevant personnel with 'memory' can still be located and can contribute meaningfully.

14. In order to assist with defining the 'without research' scenario for evaluation purposes, it would be helpful for R&D proposers in their backgrounding statements to ensure they report information relating to existing state-of-the-art knowledge and technologies that they are hoping to supersede or develop further.

15. There are three general types of outputs from LWA-funded research, and each has different issues associated with tracking 'adoption'.

    (a) Where a publication or a 'guideline' for a general audience (that is, not one particular industry or well-defined target group) is a key output of a research project or program, there has generally been little or no attempt made to track the fate of those publications. This has been exacerbated by the availability of such documents for free download on the LWA website. As a result, it has been difficult to conduct surveys of users of such publications to determine the level of influence

the publications have had on decision-making or policy. It is recognised that the costs of tracking the distribution of such publications in some cases may be prohibitive when compared to the utility of the information likely to be collected.

(b) It can be difficult to build a time series for the adoption of innovations that are in the form of models, guidelines or policy recommendations designed for use by government or community organisations. This is because they have been used in some cases in a one-off situation, whereas in others their use is ongoing. Options for obtaining information on the adoption and use of these types of LWA innovations include (1) a survey of a wide range of organisations within the targeted user groups of the innovation, or (2) asking the researcher or ongoing contact for an innovation to record use of the innovation by agency and year to allow follow up with those users. Difficulties with the first option come from loss of corporate memory about whether the organisation being surveyed has actually used an innovation at some point in the past.

(c) Where an innovation has been targeted at a particular industry or target audience within an industry, it can be easier to obtain information on adoption or practice change from industry surveys. For example, a Meat & Livestock Australia producer survey as part of its North Australia Program provided valuable data for the ECOGRAZE case study.

In order to improve the availability of adoption information it is recommended that:

(i) target audiences be clearly defined at the project funding stage and that, in some cases, steps be put in place to monitor those target audiences for adoption

(ii) benchmarking of existing practices or 'situation statements' should be prepared at the beginning of each project

(iii) surveys, which are a valuable source of information, should be considered for target audiences of innovations both during and at the end of R&D investments.

9 References and background papers

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Appendix
1 Evaluation case studies