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report

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

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Nick Schofield in collaboration with Agtrans Research

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Postal address: GPO Box 2182
Canberra ACT 2601

Office Location: L1, The Phoenix
86 Northbourne Ave
Braddon ACT

Telephone: 02 6263 6000

Facsimile: 02 6263 6099

Email: Land&WaterAustralia@lwa.gov.au

Internet: http://www.lwa.gov.au

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EXECUTIVE SUMMARY

Approach

For three years Land & Water Australia (LWA) has been developing a new approach to estimating the Return On Investment (ROI) from its research portfolio. The key driving question has been "What impact has Land & Water Australia's research had on achieving the sustainable use and management of Australia's natural resources?"

In developing a ROI methodology Land & Water Australia has sought to:

- Understand the impact of its total R&D investment since inception (1990)
- Identify this impact in the triple bottom line framework (economic, environmental, social)
- Estimate the ROI using benefit-cost analysis
- Understand how past innovations have performed
- Communicate the nature and impact of Land & Water Australia-funded innovations through case studies
- Develop fully transparent and explicit methods and analyses which are usable by any evaluator
- Allow for continuous improvement and regular updating of the ROI.

Some of the key features of the Portfolio Triple Bottom Line Benefit Cost Analysis (TBL-BCA) method are:

- Portfolio ROI aims to provide information on returns from the whole portfolio of investment for the life of the organisation
- TBL-BCAs 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
- The hypothesis used to improve estimates of portfolio returns is that returns from an investment portfolio are dominated by a small number of the most successful innovations
- Methods have been developed to identify and scrutinise the most successful innovations
- 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 Land & Water Australia website and include a 1-page summary. Various communication products can be derived from this material.
- Each Evaluation Case Study describes the nature of the innovation, its adoption by users, the impacts of that adoption (ie the benefits gained in triple bottom line 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 collecting data has been prepared.

- Evaluations are essentially ex-post (ie are applied to completed projects) but future benefits are calculated in each case.
- All evaluation assumptions are made transparent and summarised. Sensitivity analyses are conducted to identify the most important assumptions (parameters). Assumptions are deliberately conservative to avoid over-inflated ROI estimates.
- 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 Land & Water Australia (in a format any consultant can use in the future eg. 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 either a substantial improvement in data or methods.
- ROI performance over time can be estimated.
- Land & Water Australia can continuously track and update the impact of its most significant past investments whilst at the same time continuously improve methods and data but maintain overall longitudinal consistency.

Results so far

To date 25 innovations (covering 268 projects) have been analysed. This covers almost 25% of Land & Water Australia's R&D investment since 1990. The ROI results shown below are highly conservative, both in terms of the assumptions made and the range of benefits covered (Land & Water Australia generates mostly environmental and knowledge benefits which are difficult to evaluate).

Investment Criteria for the Twenty Five Innovations (LWA and all parties)
(all in 2004/05 dollars and discounted to June 2005)

	LWA aggregate benefits against aggregate costs for the 25 innovations	**Total benefits against costs for 25 innovations**
Present Value Benefits	$267 m	$1,520.5 m
Present Value Costs	$77 m	$392.3 m
Net Present Value	$190 m	$1,128.1 m
Benefit/Cost ratio	3.5 to 1	3.9 to 1
Internal Rate of Return	19.7 %	24.1%

The ranges are:

Net Present Value (full innovation):	$1.7m to $186 m
Net Present Value (LWA component):	$0.9 m to $26 m
Benefit:Cost ratio (LWA component):	1.1:1 to 18:1
Internal Rate of Return (LWA component):	6.5% to 63%

When the analysis for the 25 innovations was restricted to different five year periods, the results showed the B/C ratio increasing slowly to a maximum in the period from 1998 to 2002 and then declining. The IRR however, increased slowly until the period 1997 to 2001 and then rapidly accelerated.

It is thought that these results may be due to a few dominant investments entering and leaving the five year period. More investigation of these results is warranted.

Comparison to other RDCs/CRCs using similar methods shows the individual innovations analysed for Land & Water Australia display similar distributions of investment criteria to those of the other R&D institutions.

Key Messages on Investment Returns

- Both the qualitative and quantitative analyses demonstrate that Land & Water Australia has invested purposefully and successfully, at least for 25% of its investments, over the past 14 years.
- It is difficult to estimate the success of the remaining 75% of the total investment because the innovations analysed have not been drawn at random from all investments. However there is no evidence of a significant decline in Return On Investment with additional Evaluation Case Studies analysed to date.
- An important question is whether the analyses undertaken to date demonstrate any findings related to what characterises a "good" investment. While this question needs to be addressed further, it appears that investments producing a high NPV or high rate of return are associated with one or more of the following characteristics:

    (a) significantly reduced unit costs, or future potential unit costs,

    (b) contributed to increased profits,

    (c) adopted by, or expected to be adopted by, many land and water managers and/or policy developers,

    (d) adopted quickly after the initial research investment occurred.

- 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 particularly an issue for natural resource management R&D. The use of a 25 year time frame from the first year of research investment in these analyses may have exacerbated this issue to some degree. Time periods for many NRM benefits to be realised are lengthy and this should be recognised more widely not only in benefit-cost applications but also in the development of monitoring and evaluation plans for R&D programs.
- 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 are apparent there is a tendency towards increased uptake of Land & Water Australia 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 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 were significantly delayed.

- Working with industry oriented RDCs has been a successful mechanism for Land & Water Australia to promote a greater emphasis on resource sustainability issues.

Future strategy

The key constraints currently being confronted by the approach are:

- *Non-market valuations* are necessary in that many benefits from Land & Water Australia's investments are of an environmental nature. The robustness of the benefit transfers that have been made to date could be improved.
- *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 often with only scant historical information on adoption rates for NRM knowledge and technologies available.
- *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.

Improvements might be considered for:

- *Period of analysis:* Some of the case studies to date have produced relatively poor investment criteria due to the short time period for the analysis.
- *Listing and Coverage of Benefits*: It would be possible to develop a list of all the (generic) benefits identified so far from all the case studies, in a TBL table and identify which ones have been quantified. This would help to identify inconsistencies between valuations and how well each type of benefit can be and has been valued to date. The potential significance of missed benefits in the evaluations to date could then be assessed. Priorities for improving the ability to evaluate specific benefit types could also be considered.
- *Benefits from leadership and management*: There is currently no attribution of any benefits to Land & Water Australia for leadership and management. Land & Water Australia's attribution is based solely on its financial contribution.
- *Successful investments:* It would be worth further analysing characteristics of high performing and low performing investments.
- *Case Study Proforma:* There is a need to update the presentation of the earlier case studies to the latest proforma.
- *Information Management:* There is a need to improve several information management areas including historical financial data, corporate memory, and adoption.

Recommendations

The portfolio analysis approach currently employed by Land & Water Australia should be continued as it is now reaching a stage of providing useful and meaningful aggregate results. Future strategies should include:

(a) 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.

(b) Expand the number of innovations analysed as resources allow using a similar scanning procedure to that used in 2005.

(c) Utilise other Land & Water Australia program/subprogram/project level evaluations for incorporation into the portfolio evaluation using the guidelines produced in this report.

(d) 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.

(e) Standardise the presentation of all 25 case studies and use the same format for any future case studies.

(f) Standardise all past 25 analyses of innovations and any future innovations analysed for a period of 50 years from the year of first R&D investment.

(g) 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.

(h) Strengthen information sources and data availability on the fate of Land & Water Australia publications regarding their users and uses so that follow up surveys on particular innovations have fruitful starting points.

(i) Further analyse characteristics of investments and the magnitude of their investment criteria.

(j) Consider developing a method of incorporating benefits from leadership and management into the case study analyses.

(k) Make the information and methods more widely available via publishing on the Land & Water Australia website and in journal articles.

1. HISTORICAL CONTEXT

Land & Water Australia (LWA) has had for over ten years an ongoing program of evaluating its Research and Development (R&D) investment. With the increasing emphasis from the Commonwealth Government and 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 Land & Water Australia evaluation program has been subject to even closer internal scrutiny over the past few years.

In order to improve their ability to meet the Commonwealth Government's accountability requirements, the combined group of RDCs has developed an approach to triple bottom line reporting on their performance. They have agreed on a broad set of economic, environmental and social performance measures on which they will individually report to DAFF on an annual basis. Also, they have agreed that, because of the methodological problems involved, any reporting on the overall R&D program will not seek to aggregate outcomes or performance measures across Corporations or industries. One method identified for improving the ability to report on the triple bottom line is to undertake some formalised investment analyses in order to estimate the economic, environmental and social returns to the Corporations' investment over time.

Land & Water Australia initiated "life of project" evaluations (LOPE) 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). Land & Water Australia has also supported a number of investment analyses as part of its reviews of specific programs, but this has not been on a consistent basis.

Land & Water Australia developed an evaluation framework as part of its 2001-06 Strategic R&D Plan. This evaluation strategy is currently being updated in the context of 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. The measurement of investment performance by Land & Water Australia is also planned to be in accord with, and contribute to, the RDC-wide triple bottom line reporting referred to above. The emphasis for the RDCs has now changed from reporting on "performance" to reporting on "outcomes". The most recent policy statement by the RDC Chairs on outcomes measurement provides for reporting on:

- economic outcomes that will be based on adoption, industry productivity and investment analysis, including benefit-cost analysis and internal rates of return;
- environmental outcomes that will be focused on water quality, environmental flows, water use efficiency, salinity, biodiversity and sustainable resource management;
- social outcomes that will be focused on occupational health and safety, human resource capacity and capability development, development of the capacity to accept and adjust to change and contributions to the development of viable rural and regional communities.

In 2002/2003 a method of assessing Return on Investment (ROI) at the portfolio level was developed by Land & Water Australia through consultancies commissioned from BDA (2002) and Agtrans Research (2003). The approach is intended to be used to ultimately track Land & Water Australia's investment performance over time. This method is based on identifying and quantifying the benefits from an increasing number of innovations in the Land & Water Australia portfolio. The benefits from the selected innovations are then compared with the cost of the Land & Water Australia investment in the years up to the time of the analysis. This approach was based on the premise that focusing on Land & Water Australia's most outstanding innovations first would provide an early estimate of the total portfolio return on investment.

2. PORTFOLIO EVALUATION APPROACH

Purpose

The Land & Water Australia portfolio evaluation approach has a number of purposes:

1. To provide evidence to government and industry of the benefits that are accruing from Land & Water Australia investment and specifically to provide an estimate of the return on the total Land & Water Australia portfolio investment since 1990;
2. To assist with overall RDC reporting along the lines agreed at the RDC Chairs' meetings;
3. To compare the rate of return with that of other RDCs (and similar bodies) to provide a benchmark with which subsequent Land & Water Australia and RDC investment returns can be compared;
4. To provide a rate of return series over time to assess Land & Water Australia progress;
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 Land & Water Australia's effectiveness;
8. To provide lessons learnt from the performance of innovations, including factors affecting adoption; and
9. To provide examples of where adoption of innovations can be monitored usefully in the future.

Most of these purposes are being addressed (see Table 1). Purpose numbers 4, 5, 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 payoffs of existing investment or additional investment between sectors. A simple but authoritative measure estimated in a robust and transparent manner is usually required (eg. a benefit-cost ratio or internal rate of return).

Compare ROI with other RDCs

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 Land & Water Australia ROI estimates are significantly different from those of other RDCs.

Provide a time series of ROI estimates

There is a need to provide a step wise (eg 3-5 year) or rolling series of ROI estimates in order to gauge change in the performance of Land & Water Australia over time and for different periods of investment. The ability to do this depends on 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 Land & Water Australia portfolio, since many of the benefits from Land & Water Australia investment are associated with natural resource sustainability and environmental improvement. 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. At least two approaches can be taken:

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

At this stage greater emphasis is given to the latter process, until there is sufficient confidence in robust methods and data for calculating 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.

Provide case studies that demonstrate effective investment

The purpose is to have the analysis of each investment presented as a case study that clearly demonstrates the effectiveness of Land & Water Australia investment. The idea is to relate 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 BCA 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

Land & Water Australia will benefit from feedback on how further information can be collected (eg. 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 past quantitative analyses.

Table 1 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 1: Achievability of Different Purposes in 2005 and in Future

Purpose	Achievable with current approach?	Achievable with different terms of reference and resources?
ROI	Yes	Yes
Comparative ROIs	Yes	Yes
Provide time series	Yes	Yes
Improve non-market valuations	Yes for 4 case studies	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 but requires further interpretation	A set of additional questions may need to be asked to address this purpose, and different evaluative techniques employed
Monitoring adoption	Limited - requires more resources	Yes – but experience elsewhere questions the benefits/costs of collecting additional adoption information.

Methodology

The methodology includes both a quantitative and qualitative component.

A brief summary of the quantitative component of the analysis of each innovation is as follows:

(i) each innovation is defined in relation to a specific number of Land & Water Australia projects or programs;

(ii) the Land & Water Australia research and development (R&D) investment costs associated with each selected innovation are defined by year;

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

(iv) a set of benefits including future expected benefits as well as benefits to the date of the evaluation are quantified; and

(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 (eg. captured already, future expected) and that can be calculated over different time periods.

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

3. PROCESS FOR SELECTING INNOVATIONS

The process of selecting innovations has three key steps:

1. Identifying Land & Water Australia's best innovations and placing them on the Land & Water Australia Innovations Database, located on the Land & Water Australia website.

2. Selecting the top 25 innovations for preliminary "scanning" assessment.

3. Undertaking a preliminary analysis to select the top 8-10 innovations for case study analysis in any one year.

Using the Innovations Database

The Innovations Database is "a strategic tool for disseminating information about research outcomes. Its main purpose is to summarise past, present and forthcoming investments of significance to natural resource management (NRM) and to provide a unique web-based delivery of these research outcomes and issues as summaries, full text fact sheets and knowledge articles to Land & Water Australia stakeholders, clients and the wider community" (Land & Water Australia Website on innovations, May 2003).

From an investment analysis perspective, an innovation is defined as the outputs and outcomes of a project or group of projects organised horizontally across sub-topics or vertically across the one topic over time. It is expected that the investments in these projects will have contributed to a common outcome or set of outcomes within the Land & Water Australia mandate.

The Innovations Database defines the population of innovations associated with Land & Water Australia investment. Included innovations are those identified as being the "best". The population of innovations is based on each having or being likely to have some significant outcome and that has made or is likely to make some change in natural resource management in Australia.

The development and management of the Innovations Database is a responsibility of the Land & Water Australia Science Manager. Selecting Land & Water Australia's best innovations involves: (a) program managers identifying innovations suitable for inclusion at the time of final report assessment; (b) program managers and/or program coordinators selecting high performing innovations from past Land & Water Australia-funded research and (c) the Science Manager trawling Land & Water Australia's complete set of projects. The database currently includes 70 innovations. Each innovation is described in the following format:

- Title
- Importance
- Research Summary
- Participants
- More Information
- Contacts

A resource centre is attached to the Innovations Database that allows search capability for more detailed and related information.

Selecting innovations for case study analysis

Land & Water Australia internally undertakes a ranking of all innovations against criteria of (a) significance and (b) impact, each being high, medium or low. The top 25 innovations then undergo a preliminary impact assessment by the consultant economist in order to learn more about these innovations and their appropriateness for economic evaluation.

The main sources of information utilised for the scanning were the Innovations Database on the Land & Water Australia website, project final reports, information from project files, products from the projects, and discussions with principal investigators. When collecting basic information on each of the innovations the following five criteria were considered:

1. Whether the project/s leading to the nominated innovation has/have been completed and outputs have been produced and adopted;

2. The likely availability of information regarding actual or likely adoption of any outputs and information providing links between outputs, outcomes and benefits;

3. The suitability of the benefits to valuation;

4. Whether a boundary can be easily placed around the innovation in terms of inputs over time and across funding organisations; and

5. The magnitude of Land & Water Australia investment in the innovation.

Criterion 5 is particularly hard to address at the scanning level, and therefore assessments are only preliminary. Following selection of the eight innovations for evaluation, the next step was to estimate the level of Land & Water Australia funding as a proportion of the entire investment in the innovation. If this was determined to be very low, then a decision is made on whether to replace the innovation with another of the scanned innovations. One such innovation was identified in 2005, but it was not replaced as the magnitude of the benefits was considered likely to be high.

It should be noted that these five criteria exclude the magnitude of the potential benefits as it was assumed that the innovations on the list provided by Land & Water Australia are all associated with significant benefits or potential benefits.

Thirty-seven innovations were scanned in 2005, with a number of these having been previously scanned in 2004. It is anticipated that in the future, most of these innovations will continue to be re-scanned, however some will be excluded as reasons have been identified why they are likely to never be suitable for evaluation. Additional innovations will be identified for scanning each year.

Summary of Criteria Scores for Each Innovation

For each of the above five criteria, each innovation was rated as high, medium or low. Each rating was assigned a numerical score (high = 3, medium = 2, low = 1), and a total score for each innovation was calculated, with 15 being a perfect score. Reports on each of the 37 innovations that were scanned are provided in Appendix 3. Table 2 presents the ratings for each of the 37 innovations.

All investments were considered separately, at least initially, even when a number of investments were embedded in one general heading (e.g. catchment management tools). This was necessary in order to understand the individual investments and to assess the similarity or otherwise of outcomes, an important factor in any decision to group investments. This approach meant there were 37 individual investments scanned in 2005. Where grouping of projects was suggested in the brief, the possibilities were then explored.

Table 2: Summary of Criteria Scores for the 37 Innovations

Criteria	1	2	3	4	5	Total Score
Innovation						
1. Rainman	High	Medium	Medium	Low	Low	9
2. DYRESM	High	Medium	Medium	Low	Low	9
3. PRD	Low	Medium	Low	Medium	High	9
4. Rivers of high ecological value	Low	Low	Low	High	High	9
5. EFDSS	Medium	Medium	Medium	Low	Low	8
6. Stream rehab CD	Medium	Medium	Low	Medium	High	10
7. Gwater complex aquifer	Medium	Low	Medium	Medium	High	10
8. RAAL	Medium	Low	Low	High	High	10
9. Whopper Cropper	High	High	Medium	Low	Low	10
10. In-stream Ecology	Medium	Medium	Medium	Medium	High	11
11. Landscape design	Low	Low	High	High	High	11
12. Thresholds	Medium	Low	Low	High	High	10
13. FullStop	Medium	Medium	Medium	Medium	Low	9
14. Protection guidelines	Medium	Low	Medium	High	High	11
15. Ecosystems Services	Medium	Medium	Low	Medium	Medium	9
16. Mid-infrared soil	Medium	Medium	Medium	Low	Low	8
17. NDSP	Medium	High	High	High	Medium	13
18. JVAP	Medium	High	Medium	High	High	13
Catchment Management Tools						
19. CMSS	High	Medium	Medium	High	Medium	12
20. AEAM	High	Medium	Medium	High	High	13
21. CIEP	Low	Low	Low	High	High	9
22. SHEF	Medium	Low	Medium	High	High	11
23. ICM	Medium	Medium	Low	Medium	High	10
Participatve Processes						
24. PAM	Medium	Medium	Low	Medium	High	10
25. Citizens' Juries	Medium	Low	Low	High	High	10
26. Participation in NRM	Low	Low	Low	High	High	9
Grazing in Northern Australia						
27. Thresholds	Medium	Low	Low	High	High	10
28. Beefplan	High	Medium	Medium	Medium	Low	10
29. Droughtplan	High	Medium	medium	Low	Low	9
30. Ecograze	High	High	High	Medium	Low	12
Pesticide management tools						
31. PIRI	High	High	High	High	Medium	14
32. PIEFIS	Low	Low	Medium	High	Medium	9
33. Safegauge	Medium	Low	Low	High	Medium	9
Wetland management						
34. Guidelines	High	Medium	High	Medium	High	13
35. Floodplains plants	Low	Low	Medium	High	High	10
36. Ecological processes	Medium	Low	Medium	High	High	11
37. Wetlands R&D Program	Medium	Medium	Low	High	High	11

4. CASE STUDY ANALYSES OF INDIVIDUAL INNOVATIONS

The full guidelines for Evaluation Case Studies are provided in Appendix 3.1. A summary of the practical steps follows:

a) Relevant published papers and reports, reports to Land & Water Australia, and other material were assembled with assistance from Land & Water Australia personnel, principal investigators and others.

b) In all cases innovations were closely related to one or more specific Land & Water Australia projects where milestone reports and final reports were procured.

c) An initial description of the background to the innovation, description of investment activities and projects, outputs, outcomes and benefits were drafted as far as was possible. Additional information needs were identified.

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

e) Further information was assembled from government and industry sources.

f) Some analyses proceeded through several drafts, both internally within the project team, as well as externally.

g) All innovations were analysed as to whether they:

- had produced benefits to date;
- were likely to produce benefits at some future time; and
- had produced, or were likely to produce, economic, social or environmental benefits.

h) All benefits identified were described for each innovation. At least some benefits were valued quantitatively for each innovation, and these formed the basis for the estimates of investment criteria.

i) A discount rate of 6% was used. All annual dollar costs and benefits were expressed in 2004/05 terms and discounted to the year 2004/05. A twenty five year time frame was used in all analyses, with the first year being the initial year of investment in the innovation. R&D financial investment in the innovation included those for Land & Water Australia as well as contributions (dollars and in-kind) from other funding organisations as well as from any participating R&D or industry group.

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

k) Where there were some benefits that had accrued before 30 June 2005, analyses were also effected for those benefits alone with benefits expected after that year disregarded. In some cases, appropriate attribution factors were applied to the prospective benefits to produce an expected value of benefits.

l) The investment criteria calculated for each innovation were the Net Present Value (NPV), the Benefit-Cost Ratio (B/C Ratio) and the Internal Rate of Return (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 B/C Ratio 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 the B/C ratio 1:1. For a fuller explanation of the terms used in the investment analyses, please see the Glossary of Terms at Appendix 4.

m) For four of the case studies (Wetland Guidelines, In-stream Ecology, Protection Guidelines and PIRI) an increased effort was put into valuing non-market benefits. Consideration was given to the appropriateness of using benefit transfer techniques (see Appendix 3.3) and different ways of ensuring that assumptions surrounding the use of such numbers are used in an appropriate context.

n) In 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 and are provided in Appendix 3.1. The guidelines have evolved over the three years that the analyses have been carried out. The guidelines presented in 2004 have largely been used when carrying out the 2005 analyses. The new 2005 guidelines in Appendix 3.1 include additions and improvements based on lessons learnt when carrying out the 2005 analyses.

5. RESULTS OF PORTFOLIO EVALUATION

All Analyses

The individual investment criteria for each of the 17 innovations analysed to July 2004 have all been updated to 2004/05 dollar terms and discounted to June 2005. A summary of these updated results, together with the summary results for the 8 innovations analysed in 2005 are presented in Table 3.

Due to the inclusion of two case studies that include multiple projects in 2005 (NDSP and 25 selected JVAP projects), and the inclusion of individual projects in previous years that overlap with these innovations, the benefits and costs of the 25 individual case studies are not mutually exclusive. This is taken account of when calculating the aggregate results.

Also presented in Table 3 is the proportion of benefits that is attributable to Land & Water Australia funding. This attribution is based on the proportion of total investment costs sourced from Land & Water Australia. This dilution of the total benefits according to the relative investment contribution from Land & Water Australia and others does not value leverage, in fact high leverage can work against Land & Water Australia if the highly leveraged investments return a lower rate of return than lesser leveraged investments. Information to explore this relationship was available for the 25 innovations.

Table 4 presents the 25 innovations in order of B/C ratio for the Land & Water Australia investment. The other investment criteria for each innovation are also shown as well as the proportion of benefits attributable to the Land & Water Australia investment. Other columns in the table show the subjective rating given to the quantitative analysis in terms of benefit coverage and the confidence in the assumptions made.

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

The B/C ratio, IRR and the NPV were all regressed on the percentage of resources contributed by Land & Water Australia. The regression coefficient for the B/C ratio was positive but negative for the IRR, but both coefficients were not significant. The coefficient for the NPV was negative and significant. These results can be interpreted as demonstrating, that for these 25 innovations, the rate of return (B/C ratio and IRR) was not related to the leverage characteristics of an Land & Water Australia investment. However, the higher the proportion of Land & Water Australia funding in an investment, the smaller the NPV. Or conversely the higher leveraged investments tend to produce higher NPVs for Land & Water Australia. This is not surprising given that large amounts of Land & Water Australia resources are usually allocated to partnership projects. It would be useful to test these hypotheses further by including further variables such as the PVC.

The leverage performance of Land & Water Australia is covered elsewhere in the Corporation's Evaluation Strategy.

Table 3: Summary of Results for 25 Case Studies (in 2004/05 $ terms and discounted to June 2005)

Innovation	Analysis completed[1]	Analysis updated	Period of research (LWA) (YE June) and number of years in brackets	Period of research (total) YE June)	B/C (LWA only)	IRR (LWA only)(%)	NPV (LWA only)	NPV (All)	Proportion of total benefits attributable to LWA (%)	Confidence rating: coverage of benefits	Confidence rating: confidence in assumptions
Controlled traffic	2003		1993-1998 (6)	1993-2001	4.40	20.35	7.04	57.49	12.34	high	high
Cotton pesticides BMP	2003	2005	1994-1999 (6)	1994-2000	5.29	33.30	26.16	171.33	15.64	high	medium
CHRRUPP	2003		1998-2001 (4)	1998-2002	6.69	25.53	5.33	35.46	15.08	high	medium
Seasonal forecasting	2003		1993-2002 (10)	1993-2002	1.98	12.18	4.15	12.12	34.60	medium	low
Benchmarking irrigation providers	2003		1997-2003 (7)	1997-2003	10.87	48.51	2.40	20.35	11.88	high	medium
Riparian Lands	2003		1994-2003 (10)	1994-2003	1.68	11.53	7.30	13.44	55.37	medium	medium
AUSRIVAS	2003		1993-2000 (8)	1993-2000	1.08	6.53	0.93	1.69	45.63	medium	low
SGS including prograze	2003		1997-2002 (6)	1997-2002	2.93	24.84	5.86	93.21	6.29	high	medium
Effluent guidelines	2004		1992-1999 (8)	1991-2000	5.57	24.29	14.87	114.78	12.87	medium	medium
AussieGRASS	2004		1994-2002 (9)	1991-2002	3.70	47.18	0.36	59.69	0.6	medium	medium
RIVERSTYLES	2004		1995-1999 (5)	1995-1999	6.91	12.18	4.18	6.71	62.97	high	low
Catchment classification	2004		1998-2000 (3)	1998-2000	18.53	31.64	5.96	10.31	57.83	high	medium
Saline land	2004		1999-2001 (3)	1999-2001	7.40	24.64	1.11	2.13	52.36	high	high
GDEs	2004		1997-2003 (7)	1997-2003	3.28	14.91	4.60	**11.54**	39.71	high	low
Tax incentives for natveg	2004		1997-1999 (3)	1997-1999	18.24	51.94	11.73	24.40	48.04	medium	low
WUE	2004		1993-2003 (11)	1993-2003	4.86	38.14	16.11	74.38	21.73	medium	low
NEMP	2000		1996-2002 (7)	1996-2002	12.75	27.85	26.06	113.30	23.00	medium	low
PIRI	2005		1997-2002 (6)	1997-2004	28.89	57.47	3.06	13.71	22.40	high	medium
Wetland Guidelines	2005		1992-1999 (8)	1992-2000	1.97	15.34	1.90	4.39	41.22	high	medium
NDSP	2005		1994-2004 (11)	1994-2003	2.60	18.97	26.57	185.76	14.57	high	medium
JVAP (25 projects)	2005		1994-2003 (10)	1991-2003	1.35	8.34	0.50	4.28	9.43	high	medium
ECOGRAZE	2005		1997-2001 (5)	1993-2001	6.94	21.94	1.18	26.63	4.29	medium	high
CMSS	2005		1991-1996 (6)	1989-1996	2.36	13.51	0.74	3.47	20.16	medium	low
In-stream Ecology	2005		1994-1998 (5)	1994-1998	1.68	10.29	1.09	2.09	52.09	high	medium
Protection Guidelines	2005		1999-2002 (4)	2001-2001	14.03	46.62	2.31	3.97	58.14	high	medium

Table 4: Summary of Results for 25 Case Studies in Order of B/C Ratio (in 2004/05 $ terms and discounted to June 2005)

Innovation	B/C (LWA only)	IRR (LWA only)(%)	NPV (LWA only)	Proportion of total benefits attributable to LWA (%)	Confidence rating: coverage of benefits	Confidence rating: confidence in assumptions
PIRI	28.89	57.47	3.06	22.40	high	medium
Catchment classification	18.53	31.64	5.96	57.83	high	medium
Tax incentives for natveg	18.24	51.94	11.73	48.04	medium	low
Protection Guidelines	14.03	46.62	2.31	58.14	high	medium
NEMP	12.75	27.85	26.06	23.00	medium	low
Benchmarking irrigation providers	10.87	48.51	2.40	11.88	high	medium
Saline land	7.40	24.64	1.11	52.36	high	high
ECOGRAZE	6.94	21.94	1.18	4.29	medium	high
RIVERSTYLES	6.91	12.18	4.18	62.97	high	low
CHRRUPP	6.69	25.53	5.33	15.08	high	medium
Effluent guidelines	5.57	24.29	14.87	12.87	medium	medium
Cotton pesticides BMP	5.29	33.30	26.16	15.64	high	medium
WUE	4.86	38.14	16.11	21.73	medium	low
Controlled traffic	4.40	20.35	7.04	12.34	high	high
AussieGRASS	3.70	47.18	0.36	0.6	medium	medium
GDEs	3.28	14.91	4.60	39.71	high	low
SGS including prograze	2.93	24.84	5.86	6.29	high	medium
NDSP	2.60	18.97	26.57	14.57	high	medium
CMSS	2.36	13.51	0.74	20.16	medium	low
Seasonal forecasting	1.98	12.18	4.15	34.60	medium	low
Wetland Guidelines	1.97	15.34	1.90	41.22	high	medium
Riparian Lands	1.68	11.53	7.30	55.37	medium	medium
In-stream Ecology	1.68	10.29	1.09	52.09	high	medium
JVAP (25 projects)	1.35	8.34	0.50	9.43	high	medium
AUSRIVAS	1.08	6.53	0.93	45.63	medium	low

Aggregate Results for the LWA Portfolio

Agtrans Research has now conducted benefit-cost analyses for 25 individual innovations for Land & Water Australia. This includes eight innovations analysed in 2003, eight innovations analysed in 2004, eight innovations analysed in 2005, and the National Eutrophication Management Program (NEMP) in 2000.

Aggregate investment criteria can be calculated to demonstrate the aggregate return on investment for the 25 innovations. Table 5 presents a summary of results for the 25 analyses (LWA benefits and LWA costs only). It shows that the 25 analyses as a whole have an NPV of $190 million, a benefit-cost ratio of 3.5 to 1, and an IRR of 19.7%.

Table 5: Investment Criteria for the Twenty Five Innovations (all in 2004/05 dollars and discounted to June 2005)

	NEMP	2003 Analysis (8 innovations)	2004 Analysis(8 innovations)	2005 Analysis(8 innovations)	Total for all 25 Analyses
PVB ($)	44.54	107.46	70.40	60.00	266.90
PVC ($)	3.49	39.10	11.48	23.00	76.56
NPV ($)	41.04	68.36	59.92	37.00	190.34
B/C ratio	12.75	2.75 to 1	6.13 to 1	2.61 to 1	3.49 to 1
IRR (%)	27.85	18.36	26.90	17.57	19.66

It should be remembered that the benefit:cost ratio and internal rate of return calculated only apply to the 25 selected innovations, and it is not valid to extrapolate from these criteria to other LWA investments. This is because the 25 innovations analysed have not been randomly selected and are therefore not necessarily representative of the entire portfolio. Rather they are investments that have been selected for analysis on the basis that they were considered of high impact and high significance.

As two innovations analysed in 2005 included multiple projects (NDSP and 25 selected JVAP projects), the aggregation of the cash flow streams for all 25 case studies had to carefully consider whether any 'double-counting' of benefits and costs might occur with regards to innovations analysed earlier in 2003 and 2004. This consideration resulted in selected benefits and costs being excluded for 2 innovations. The first of these was "catchment classification" which was analysed in 2004. The costs of this innovation were also included in both the NDSP and JVAP analyses, and the benefits of the innovation were also calculated as part of the JVAP analysis. Therefore both the costs and benefits were excluded when calculating the investment criteria for all 25 analyses. The second was "saline land" which was also analysed in 2004. The costs of this innovation were included in the NDSP analysis. However, the benefits quantified did not overlap with the benefits quantified for NDSP, and therefore only the costs of the "saline land" innovation were excluded when calculating the investment criteria for all 25 analyses.

In 2005, the cotton BMP innovation that had been previously analysed in 2003 was updated due to the availability of new information on some assumptions. The investment criteria calculated in 2003 are still used in the second column of Table 5, however the updated 2005 investment criteria are used in their place when calculating the investment criteria for all 25 analyses.

Total investment made by LWA for each of the years 1990/91 to 2004/05 is shown in Table 6. This investment represents government appropriation resources only and is based on income received rather than expenditure made. Data on LWA appropriations expenditure by year is difficult to extract from LWA accounts due to mixing with other income streams.

Table 6: Total Government Appropriation for LWA 1990/91 to 2004/05 (2004/05 $)

Year	Expenditure ($m)
1990/91	12.11
1991/92	14.47
1992/93	14.35
1993/94	14.21
1994/95	14.81
1995/96	13.74
1996/97	12.19
1997/98	12.40
1998/99	13.28
1999/00	13.00
2000/01	12.56
2001/02	12.50
2002/03	12.48
2003/04	12.56
2004/05	12.50

The sources of information for this table are as follows:

- The years 1990/91 to 1997/98 are sourced as "government appropriations" from the CIE Leverage Report 2001 and are converted from their 2001 dollar terms to 2005 dollar terms.
- The years 1998/99 to 2003/04 are sourced as "revenue from government" from the LWA Annual Reports and are converted from nominal terms to 2005 dollar terms.
- The 2004/05 government appropriation has been estimated by Nick Schofield.

The benefits attributed to Land & Water Australia from the 25 innovations have been aggregated and placed against the total LWA portfolio costs to calculate a return on investment to the entire Land & Water Australia portfolio. This assumes appropriation expenditure in each year equals appropriation revenue. The results show a return on investment of 4.78% (Table 7).

Table 7: Investment Criteria for the Benefits Attributed to LWA from the 25 Innovations and Total LWA Appropriation Revenues from Government from 1990/91 to 2004/05

Criterion	Discount Rate 6%
Present value of benefits ($m)	266.90
Present value of costs ($m)	308.73
Net present value ($m)	-41.82
Benefit cost ratio	0.86 to 1
Internal rate of return (%)	4.78%

Interpretation of Aggregate Results

The benefits from the 25 innovations have covered only a proportion of the total investment costs. This is not surprising since the 25 innovations analysed were associated with LWA investment of $77m in present value terms, whereas the total investment over the period was $309 m in present value terms; that is they represented only 24.8% of the total LWA investment. The benefits from the 25 innovations covered 86% of the total LWA appropriation revenue over the period.

The estimated 4.78% return assumes that the other 75% of appropriation monies invested has provided a zero rate of return. This is a most unlikely assumption, even given that some of the most

successful innovations have most likely been included in the 25. If all investments were analysed it is most likely that a rate of return far greater than 4.78% would result.

There is no sign of declining returns to the additional investments analysed in 2005. In fact the combined benefit-cost ratio of the eight innovations analysed in 2005 (2.6 to 1) is roughly equal to the eight analysed in 2003 (2.7 to 1), although the eight analysed in 2004 gave a combined benefit-cost ratio of 6 to 1.

Given there is no strong indication of declining returns to the last eight innovations analysed, it can be argued that a larger part of the LWA investment needs to be analysed in order to conclude that the total benefits from all LWA investment provide an overall return of 6% or more (6% being the chosen discount rate).

Returns over Time

Previous analyses in 2003 and 2004 did not provide a time series of changing returns over time. However, now that a significant amount of data is available on LWA benefits and costs by year and by innovation, a process for estimating the ROI over different time periods has been developed.

The process used for this is as follows:

Estimating investment criteria for the base period

a. A base period of funding by LWA of the five years ending 1994/95 is assumed; this is the first five years of funding since the Corporation commenced operations in the year ending June 1991.

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

c. The time series of benefits for any of the 25 innovations that have been funded over that base period are identified (cash flow B). If an innovation was not funded over the base period then its costs and benefits are not included.

d. Each year of benefits in this time series is multiplied by the proportion of total costs of the R&D for the innovations 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).

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

Estimating investment criteria over time

f. 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.

g. The cash flow of benefits for each innovation funded over the new 5 year time period is adjusted, a new ICAF is estimated for each innovation, and a new time series of benefits (cash flow C) is estimated.

h. The process is repeated until the investment criteria for the last five year period have been calculated.

Investment criteria for the base period and five year periods thereafter are shown in Table 8.

Table 8: Investment Criteria for LWA Investments over Different Periods

Period of investment (YE June)	Number of innovations funded	PVB (m $)	PVC (m $)	NPV (m $)	B/C	IRR (%)
1991 to 1995	14	51.51	17.32	34.19	2.97 to 1	16.80
1992 to 1996	14	79.78	28.33	51.45	2.82 to 1	16.34
1993 to 1997	20	128.40	41.97	86.43	3.06 to 1	17.28
1994 to 1998	24	164.17	50.53	113.65	3.25 to 1	18.04
1995 to 1999	25	181.60	53.31	128.29	3.41 to 1	18.63
1996 to 2000	25	177.30	48.63	128.68	3.65 to 1	19.70
1997 to 2001	24	166.10	41.80	124.30	3.97 to 1	21.84
1998 to 2002	23	128.76	31.48	97.28	4.09 to 1	24.34
1999 to 2003	22	94.02	23.45	70.57	4.01 to 1	27.51
2000 to 2004	17	60.56	15.70	44.86	3.86 to 1	34.71
2001 to 2005	14	38.09	10.62	27.48	3.59 to 1	48.83

The average period of LWA investment in an innovation was nearly 7 years (6.8) across the 25 innovations. The second column in Table 8 shows the number of innovations funded at least in part during each period and explains the initial increase in PVC, PVB, and NPV, their maxima when all 25 innovations were being funded in the middle periods, and the later decline as the number of innovations included declines.

To illustrate this further, the years in which each innovation was funded are shown in Table 9. It is obvious that the early and later years of the period 1991 to 2004 include lesser numbers of years in which the 25 innovations were funded. For example, the year ending June 1998 was associated with investment in all but three of the 25 innovations.

The investment criteria expressing rate of return (B/C ratio and IRR) however, should represent the actual performance of the portfolio investment for the different periods, and it is here that a more interesting interpretation may be developed. It is surmised that the changes in the B/C ratio and the IRR are due to several significant innovations entering and leaving the five year period as it moves forward. These include cotton pesticides, effluent guidelines, tax incentives, water use efficiency, NEMP and NDSP.

The B/C ratio increased as the high performing rate of return projects (in terms of B/C ratio and high levels of benefits and costs) entered the five year period (e.g. cotton pesticides, water use efficiency, effluent guidelines, tax incentives, and NEMP). When the dominance of some of these innovations began to wane (cotton pesticides, effluent guidelines and tax incentives), the most dominant of the remainder was NDSP which had high levels of benefits and costs but only a modest B/C ratio.

The IRR shows a gradual increase over time. Up until the third last period considered this is explainable in terms of the dominant investments (high levels of benefits and costs) also showing higher IRRs than the average innovation. For the last three periods, NDSP was the dominant innovation and was associated with an IRR of about the average, rather than below average as was its B/C ratio. Further, other innovations present in the last three periods, although not highly dominant in terms of benefit and cost levels, had very high IRRs (e.g. PIRI, water use efficiency and benchmarking). This explanation needs further testing and this could be effected by omitting one or more of these possible dominant innovations from the analysis and reflecting on changes in the results.

Table 9: Timing of LWA Investment (year ending June) in 25 Case Studies

Innovation	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Controlled traffic															
Cotton pesticides BMP															
CHRRUPP															
Seasonal forecasting															
Benchmarking irrigation providers															
Riparian Lands															
AUSRIVAS															
SGS including prograze															
Effluent guidelines															
AussieGRASS															
RIVERSTYLES															
Catchment classification															
Saline land															
GDEs															
Tax incentives for natveg															
WUE															
NEMP															
PIRI															
Wetland Guidelines															
NDSP															
JVAP (25 projects)															
ECOGRAZE															
CMSS															
In-stream Ecology															
Protection Guidelines															

6. COMPARISON WITH OTHER RDCs

Distribution of Investment Criteria and Comparison with Other RDCs

Tables 10 and 11 present a comparison of the distribution of the investment criteria calculated for the present analyses with the investment criteria calculated in similar analyses undertaken recently by Agtrans Research.

Table 10: Comparison of NPVs with Other Analyses

Range of NPV ($m)	LWA (2005) selected	FWPRDC (2001) random	SRDC; BSES, SRI (1998) random	SRDC (2003) random	CRC TPP (2004) selected
Discount rate (%)	6	5	5	5	5
Negative	0	0	0	0	0
0-5	16	7	6	11	4
5-10	3	2	5	0	2
10-15	2	2	0	2	0
15-50	4	2	3	1	4
50-100	0	0	0	0	0
100-300	0	1	0	0	0
>300	0	0	0	0	0
Total	25	14	14	14	10

Source: Agtrans Research

Table 11: Comparison of B/C Ratios with Other Analyses

Range of B/C ratios (to 1)	LWA (2005) selected	FWPRDC (2001) random	SRDC, BSES,SRI (1998) random	SRDC (2003) random	CRC TPP (2004) selected
Negative	0	0	0	0	0
0-5	12	8	3	9	4
5-10	7	2	4	1	1
10-20	5	1	3	3	3
20-50	1	1	1	1	1
50-100	0	2	3	0	1
>100	0	0	0	0	0
Total	25	14	14	14	10

Source: Agtrans Research

Overall, the distribution of investment criteria for the LWA projects is not dissimilar to those observed in other recent studies carried out by Agtrans Research. However, the LWA investments produce fewer very high B:Cs than the compared organisations, with only one investment exceeding 20:1.

7. KEY MESSAGES FROM EVALUATION ANALYSES

Portfolio level messages

The 2005 portfolio evaluation study has further developed the previous methods used in the LWA portfolio evaluation. The analyses now cover nearly 25% of the total LWA investment funded by appropriation monies since 1991. Each individual case study has its own messages on how it has performed as an investment. Increasingly, as the number of case studies increase, some key messages at the investment portfolio level are emerging. A first attempt at synthesising these messages is presented below:

- Both the qualitative and quantitative analyses demonstrate that LWA has invested purposefully and successfully, at least for 25% of its investments, over the past 14 years.
- Because the innovations analysed have not been drawn at random from all investments, it is difficult to estimate the success of the remaining 75% of the total investment.
- An important question is whether the analyses undertaken to date demonstrate any findings related to what constitutes a "good" investment. While this question needs to be addressed further, it appears that investments producing a high NPV or high rate of return are associated with one or more of the following characteristics:
    a. significantly reduced unit costs, or future potential unit costs,
    b. contributed to increased profits,
    c. adopted by, or expected to be adopted by, many land and water managers and/or policy developers,
    d. adopted quickly after the initial research investment occurred.
- 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 particularly an issue for natural resource management R&D. The use of a 25 year time frame from the first year of research investment in these analyses may have exacerbated this issue to some degree. Time periods for many NRM benefits to be realised are lengthy and this should be recognised more widely not only in benefit-cost applications but also in the development of monitoring and evaluation plans for R&D programs.
- 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 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 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 has come back to be supported by CSIRO 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.

Lessons for LWA Information Management

Several issues apparent in the 2005 case studies are:

(a) There are sometimes difficulties in accessing information on the financial inputs to research investment. For example, when the 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 can necessitate additional communication in discovery.

(b) There are also difficulties with accessing financial information with respect to 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.

(c) Often if an innovation is the result of more than one project, tracing the evolution of an innovation 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 in the future.

(d) 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.

(e) 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.

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

(f) 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 no or little 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. This has made it difficult to conduct surveys of users of such publications to determine the level of influence the publications have had in 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.

(g) 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 in some cases they have been used in a one-off situation and in others used on an ongoing basis. Options for obtaining information on the adoption and use

of these type of LWA innovations include (1) a survey of a wide range of organisations within the targeted user groups of the innovation; or (2) ask 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 over whether the organisation being surveyed has actually used an innovation at some point in the past.

(h) 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:

a. Target audiences are clearly defined at the project funding stage, and in some cases steps are put in place to monitor those target audiences for adoption

b. Benchmarking of existing practices or 'situation statements' should be prepared at the beginning of each project

c. Surveys are a valuable source of information which should be considered for target audiences of innovations both during and at the end of R&D investments.

8. FUTURE DEVELOPMENTS

Strengths of the Approach

Some of the strengths of the approach developed and applied to date include:

- Selection of investments of high impact and high importance, followed by a further scanning process to identify the investments for evaluation.
- 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 as after each round of analyses and 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 for analysis to investigate the characteristics of investment success of innovations.

Constraints Currently Faced

A summary of the key constraints currently being confronted by the approach follows:

- Non-market valuations are necessary in that many benefits from LWA's investments are of an environmental nature. The validity of many 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 on adoption rates for NRM knowledge and technologies available.
- 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.

Future Developments of Methodology

The following provides commentary on some of the specific issues of concern and where improvements might be considered.

Period of analysis

Some of the case studies to date have produced relatively poor investment criteria due to the short time period for the analysis, particularly when benefits from say agroforestry and natural resource improvements accrue only in the distant future. A number of factors are involved:

(a) some NRM benefits only appear after a long period e.g. salinity remediation, some vegetation and biodiversity improvements, reduction of phosphorus in waterways, and also some economic/ industry benefits derived from agroforestry enterprises.

(b) the discount factors become very small after about 30-40 years.

(c) a number of analysts prefer to limit the period for benefit accrual due to other technologies and knowledge becoming available in the future which makes the technology being evaluated redundant and no longer used at some point in the future. We generally argue against this position except in some circumstances.

(d) An improvement may be to standardise the time period for 50 years from the year of first investment, based on:

- the discount factor at 6% at 30 years is 0.18, at 40 years is 0.10 and at 50 years is 0.06; but bear in mind that we are discounting back to say 2005 while most investment starts say 5-12 years earlier
- the 25 years used currently is biased against those investments where benefits don't start accruing until many years after the initial investment

(e) If this change were applied it would necessitate adjusting the spreadsheets for all 25 innovations. A result would be that most of the NPVs would rise.

Listing and Coverage of Benefits

It would be possible to develop a list of all the (generic) benefits identified so far from all the case studies, in a TBL table and identify which ones have been quantified. This would help to identify inconsistencies between valuations and how well each type of benefit can be and has been valued to date. The potential significance of missed benefits in the evaluations to date could then be assessed. Priorities for improving the ability to evaluate specific benefit types could also be considered.

The decision to quantify a benefit is complex and is not just based on the time to quantify, the ease of quantifying, whether standard values are available etc. More important is the assessment of whether and how strongly the R&D has contributed to the possible benefit. That is, is it meaningful and credible to actually place some value on it and attribute some of this benefit to the R&D? The extent of impact is quite often not known e.g. ECOGRAZE and the link between better grazing management and biodiversity impact (e.g. which biodiversity- soil biota, birds etc).

The potential significance of unquantified benefits could be assessed in a more thoughtful and descriptive kind of way and if then appropriate, priorities could be addressed for improving the ability to evaluate specific benefit types. A start on this has been made through the confidence ratings for coverage of benefits.

Benefits from leadership and management

There is currently no attribution of any benefits to LWA for leadership and management. One approach would be to rate each case study in terms of a set of criteria that would sit alongside the evaluation results. Criteria could include leadership, coordination, influence and management. Careful definition of each would need to be made.

Another alternative would be to adjust the attribution base on costs. e.g. increase the attribution by 20%, 10%, 5%, and zero based on a subjective rating of the contribution to leadership and management. The rating could be based on three criteria:

1. LWA pursued an idea and assembled critical funding and interest to make the investment successful.
2. LWA assembled a scientific effort that would not otherwise have formed e.g. cotton pesticides.
3. The management of the investment was considered above average thus contributing to the outcome.

If this approach were undertaken it may be necessary to "deduct" an appropriate (average) factor from LWA's cost contribution share of benefits in situations where LWA was not the manager e.g. JVAP.

Successful investments

It would be worth further analysing characteristics of investment and their associated investment criteria to assess any relationships. For example, analysis could address:

- LWA managed versus externally managed
- Size of LWA investment
- Period of LWA investment (getting in and out quickly with a strategic investment, versus being in for the long haul)
- Simple projects with single partners versus complex investments with multiple partners

Case Study Proforma

The 2005 case studies have been written in a standard proforma and a template has been prepared based on this for inclusion in the guidelines (Appendix 3.2). There is a need to standardise the presentation of the earlier case studies at some stage. For example, there are some differences in the section structures and benefits are not always reported in a triple bottom line tabular form.

10. RECOMMENDATIONS

The portfolio analysis approach currently employed by LWA should be continued as it is now reaching a stage of providing useful and meaningful aggregate results. Future strategies should include:

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 innovations analysed as resources allow using a similar scanning procedure to that used in 2005.
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. Standardise the presentation of all 25 case studies and use the same format for any future case studies.
6. Standardise all past 25 analyses of innovations and any future innovations analysed for a period of 50 years from the year of first R&D investment.
7. 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.
8. Strengthen information sources and data availability on the fate of LWA publications regarding their users and uses so that follow up surveys on particular innovations have fruitful starting points.
9. Further analyse characteristics of investments and the magnitude of their investment criteria.
10. Consider developing a method of incorporating benefits from leadership and management into the case study analyses.
11. Make the information and methods more widely available via publishing on the LWA website and in journal articles.

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APPENDIX I

Evaluation case studies