An Economic Analysis of Investment in the National Dryland Salinity Program (NDSP)

Background

Dryland salinity is caused by widespread landscape change resulting from new forms of land management since European settlement. Clearing of trees and use of annual crops and annual grasses and legumes have removed water-using deep-rooted perennials on farming land. This has led to rising watertables and, in many cases, these have brought salt from lower levels to the surface or close to it. Some of this salt can be transported to waterways so affecting water quality.

The National Dryland Salinity Program (NDSP) grew from a realisation in the early 1990s that dryland salinity was a growing and complex national problem affecting both rural and urban areas. The complexity of the problem was exacerbated by the temporal and spatial characteristics of the linkages between the potential causes and the various impacts being experienced and those expected.

As of 1992, only Victoria, New South Wales and South Australia had developed some form of strategic plan for dryland salinity management. Western Australia was in the process of finalising its strategic plan at that time. A review of these strategies instigated by Land & Water Australia (LWA) relating to research and development (R&D) coordination and priorities in particular led to the conclusion that a national program should be developed to cater for the range of tactics that were being used by the different States and to provide some flexibility so that all States could participate and benefit from a national program (PDP Australia 1992a,b). LWA then took the initiative to coordinate a national R&D program.

The Program

Project Objectives

The objectives of the first phase of the program (1993 -1998) were:

1. Develop and test an integrated catchment management approach for addressing dryland salinity, including approaches to community participation.
2. Develop and apply models for collaborative and multi-disciplinary research, development and extension that efficiently use national resources and optimise the return to investment.
3. Develop and apply techniques to manage the impacts of dryland salinity.
4. Improve the sustainable income of land use in areas affected by or contributing to dryland salinity.
5. Ensure that information, techniques and approaches generated in this program are incorporated into national and state responses to dryland salinity.

The objectives of the second phase of the program (1998-2003) were:

1. To develop options for operating environments which encourage the prevention of dryland salinity and the appropriate management of its impacts.

2. To develop understanding and demonstrate principles and practices to address the causes, costs and consequences of dryland salinity.
3. To develop an understanding, and demonstrate principles and practices, which enable the beneficial use or rehabilitation of landscape resources impacted by dryland salnity.
4. To develop an understanding of landscape processes and ecosystem functions in areas affected by, or at risk from, high watertables and salinity.

Investment costs

The program was managed and financially supported by

- LWA
- Grains Research and Development Corporation (GRDC)
- National Land and Water Resources Audit (NLWRA)
- Murray–Darling Basin Commission (MDBC)
- Meat and Livestock Australia (MLA)
- Department of Agriculture, Fisheries and Forestry Australia (AFFA)
- Rural Industries Research and Development Corporation (RIRDC)
- CSIRO
- The State governments of Western Australia, South Australia, Victoria, Tasmania, New South Wales and Queensland.

Other partners included the CRC for Plant Based Management of Dryland Salinity and the program Land, Water and Wool. Resources invested by LWA and by the NDSP partners are shown by year in Table 1. LWA resources made up 14.4% of the total investment (nominal terms).

Table 1: Resources invested (nominal dollars) by year by LWA, NDSP partners and researchers

Year	LWA[a]	NDSP partners[b]	Researcher contributions[c]	Total
Phase One				
1993–94	613,025	1,386,975	2,000,000	4,000,000
1994–95	828,475	1,171,525	2,000,000	4,000,000
1995–96	981,348	1,018,652	2,000,000	4,000,000
1996–97	1,202,912	797,088	2,000,000	4,000,000
1997–98	854,315	1,145,685	2,000,000	4,000,000
Phase Two				
1998–99	658,997	4,141,003	4,800,000	9,600,000
1999–00	646,025	4,153,975	4,800,000	9,600,000
2000–01	1,352,497	3,447,503	4,800,000	9,600,000
2001–02	1,168,702	3,631,298	4,800,000	9,600,000
2002–03	1,041,305	3,758,695	4,800,000	9,600,000
Harvest Year				
2003–04	500,000	0	0	500,000
Total	9,847,601	24,652,399	34,000,000	68,500,000

[a] LWA adjusted for income from program partners (AFFA, GRDC (administration contribution only), MDBC and RIRDC) passing though LWA accounts; subtractions made were $15,000 in 1993–94, $100,000 in 1996–97, $220,000 in 1997–98 and $155,000 in 1998–99; a total of $855,000 was subtracted evenly across the four years 1999–00 to 2002–03 ($213,750 per year).
[b] Based on cash total of $10m for Phase One and $24m for Phase Two each evenly spread over five years less the LWA contributions; GRDC funded projects to the extent of $1m per year for Phase 2 but did not contribute to Phase 1.
[c] Based on a leverage ratio of NDSP cash funds to researchers of 1 to 1.

Investment description

NDSP was the major focus of Australia's effort to better understand dryland salinity and what might be done to manage, ameliorate or prevent it. The program ran over the period 1993–94 to 2003–2004. The first phase of NDSP ended in 1997–98 and the second phase was completed in 2002–03 with a harvest year completed in 2003–04.

Phase One focused on improving understanding of the causes of dryland salinity and on establishing a collaborative focus on the R&D effort. Five focus catchments were a central feature of the first phase.

Phase Two broadened the approach beyond the five catchments, and investigated extent, costs, institutional arrangements, management solutions and landscape processes. The goal of Phase Two was to research, develop and extend practical approaches to effectively manage dryland salinity across Australia. Several NDSP activities during Phase Two complemented the National Land and Water Resources Audit's dryland salinity investments.

A wide range of projects was funded from the program, with 43 projects being funded in Phase Two. The overall cash investment was about $10 million in Phase 1 and $24 million in Phase Two. In the eleventh year (2003–04) the emphasis was on harvesting and synthesising the findings from the program.

The legacy of the program currently rests to a large extent in the Cooperative Research Centre (CRC) for Plant Based Management of Dryland Salinity. The CRC for example, continued to maintain some of NDSP's communication products such as *SALT* magazine and the national newsletter *Focus on salt*. However, NDSP frameworks such as the Groundwater Flow Systems are used as the basis of most State salinity strategies and continue to influence modelling and further research (Richard Price, pers. omm.., June 2005).

Principal outputs

The review of Phase One of the program concluded that NDSP has improved the level of cooperation among researchers and established better links between community groups and researchers (Hayes 1997). The review also concluded that NDSP had successfully articulated the interlinking causes of dryland salinity and developed methods for valuing the impacts in the different sectors.

The goal of Phase Two was to research, develop and extend practical approaches to effectively manage dryland salinity across Australia, by focusing on causes, costs and consequences of dryland salinity, institutional arrangements for managing dryland salinity, management of saline resources, and landscape processes.

A wide range of types of outputs was produced from both phases, including reports, data and knowledge, costs of salinity, communication products including demonstration sites, decision-support tools, mapping technologies and models. While some new management systems and technologies were developed, many were not cost effective.

A communications strategy was developed that assisted with the engagement of stakeholders (including catchment management authorities and land managers), and to some extent policy makers.

For example, in 2002–03 the NDSP-supported *SALT* magazine was distributed to approximately 5000 catchment managers, researchers and agency personnel.

NDSP held a forum in 2003 to assess the overall accomplishments of the program. It was concluded that understanding of dryland salinity had been enhanced compared with 10 years earlier and a sound base for action or non-action had been developed. The purpose of the Harvest Year was to synthesise and package information for:

> … making knowledge readily available to stakeholders—policy, strategic planners, (regional and catchment level) organisations and individuals who advise farmers and other land managers and the land manager and farmers themselves.

As a result of the Harvest Year, three communication products were developed that integrated and synthesised the large amount of information that had been generated over the 10 years:

- findings (NDSP 2004a)
- resource directories for catchment managers (NDSP 2004b)
- resource directories for land managers and advisors (NDSP 2004c).

The six principal findings from the Program (NDSP 2004a) were that:

1. salinity costs are significant and rising, hence responses must be strategic
2. profitable options for reversing the trend are lacking but under development
3. there is no one salinity problem—it challenges us to look beyond traditional policy instruments
4. integrated catchment management must be seen as only one approach to deal with dryland salinity
5. vegetation management remains the key to managing water resources, although the benefit:cost ratio of revegetating catchments requires careful analysis
6. lack of capacity is an important but secondary constraint to managing salinity.

The extent of land use change required to contain dryland salinity was found to be much greater than previously thought, particularly in Western Australia, because of the hydrology and where salt is positioned in large regional groundwater basins. Also, where watertables can be controlled, response times from intervention activities (e.g. planting trees) to positive impacts (e.g. lowering of a watertable) could be very long, taking, for example, several decades. It was concluded that responses will vary with the hydrogeology of the area, as well as its soils and climate.

The two directories produced in the harvest year are linked to web-based information in order to facilitate the extraction of more detailed information as required. One directory is for use by catchment managers and is structured according to key questions that they might ask (NDSP 2004b). This directory captures information produced in both phases of the program and is structured to best inform regional decision-making. The CD-ROM provides links to all key reports including summary reports, technical reports and NDSP technical notes.

The second directory is based on information from case studies to guide salinity management for producers and advisers (NDSP 2004c). It integrates the various factors in decision-making for advisers and leading producers but is not intended for the broad producer community, which has access to a range of other management guides from local advisers and catchment management organisations.

The CD-ROM was updated once again in 2007 to capture 108 extra papers solicited from NDSP research partners that had not been published by the time the original synthesis products were developed.

In conclusion, the investment led to useful information on understanding salinity and the costs of salinity but did not make a major contribution to cost-effective solutions. The CRC for Plant-based Management of Dryland Salinity estimates that such solutions may still be another 7–14 years away (Richard Price, pers. omm.., June 2005).

Principal outcomes

Actions pursued
The NDSP found that little can be done to reverse the salinity-inducing processes that have begun in many areas. There was clearly a lack of cost-effective solutions that could be generically applied. Given the mix of public and private benefits that may be captured from interventions, the possibility existed of public policy support for interventions.

The NDSP played a major role in raising awareness of land managers and policy makers of the salinity problem. For example, its role in precipitating the report to the Prime Minister’s Science, Engineering and Innovation Council (PMSEIC) (PMSEIC 1999) assisted the case for the National Action Plan for Salinity and Water Quality (NAP). The House of Representatives report on salinity (HOR 2004) considered evidence that there was sufficient knowledge to support some positive landscape changes, but that a sufficient number of economically viable management solutions to deal with salinity were not yet available. There was some concern that the design of NAP may not reflect the scientific insights and research outputs of salinity research. Solutions are complex and sometimes not applicable or cost effective in many circumstances.

Solutions and management practice change
At the beginning of the program, PDP Australia (1992a,b) reported that hard data on the level of adoption of control technologies for dryland salinity was difficult to obtain. While reporting some data, PDP concluded that generally only a very small proportion of affected land had been treated with tree planting. In this start-of-program survey, the control technologies on which information was sought included:

- tree/shrub planting in recharge areas and between recharge and discharge areas
- perennial pasture improvements
- cropping management
- structures to divert water from recharge areas or to reduce waterlogging
- establishment/or utilisation of salt tolerant plant species
- exclusion and/or controlled stocking to promote regeneration
- use of sacrificial areas
- aquifer pumping to lower watertables
- sub-surface drainage to lower watertables.

Three States were unable to supply data on the level of adoption of technologies in recharge and discharge areas. Most adoption levels in Western Australia were negligible, with the exception of some areas having had improved cropping management adopted, some use of salt-tolerant plant species, and some instances of exclusion/controlled stocking to promote regeneration and structures to reduce waterlogging. While these data do not provide a baseline with which to compare adoption levels in future, they do suggest that potential management systems were similar to what is currently recommended.

The outcomes from the NDSP are therefore likely to be associated with the role and choice of different management options in particular circumstances rather than the management systems themselves. The underlying theme is that there is no quick or generic fix to salinity and that in many cases landholders and communities will have to live with salinity for many years.

A review of the outputs, outcomes and impacts of the NDSP was carried out in a triple-bottom-line report by the Centre for International Economics (CIE) in 2003 (CIE 2003).

In 2006, an evaluation of the NDSP harvest products was carried out via a client survey in order to assist with providing insights to inform the use of similar ‘ harvest’ or legacy products from other R&D programs. Some of the key findings from this evaluation with respect to use and impact were (Stone and Coutts, 2006):

- The main levels of interest in the NDSP Harvest Products came from the research and extension/advisory communities, followed by policy and planning and educational sectors. The producers/landholders was the lowest interest group.

- There was very positive feedback about the products from all groups in all surveys – in particular as an excellent reference or as a salinity resource.
- The main use of these products was as a reference manual for salinity, as a teaching or learning resource, for policy or planning and as a way of improving information associated with extension or advisory work.
- The main current users are policy, advisory and extension personnel for planning, learning and teaching reasons. The products can be regarded as tools for an adoption influencer to use, rather than an influencing factor in technology adoption in their own right.

The survey identified that users of the products identified the chief benefits as having a ready reference, awareness raising, and providing some practical guidance. Other conclusions with respect to benefits and impacts included (Stone and Coutts, 2006):

- Two-thirds of the general product users indicated that they had been able to directly use information from the products in work settings.
- There was a strong feeling by product developers that the products would significantly contribute to reaching the goal of reducing salinity losses by 10% in the future.
- Uses of the products include informing the research, advisory, policy, education and landholder sectors. It provides authoritative information on salinity.

Benefits associated with the investment

There is no doubt that salinity is impacting on agricultural industry, urban and rural infrastructure, and the environment. Associated with these economic and environmental costs are the social costs that individuals and communities are incurring. There is also the strong likelihood that future costs of salinity will be significantly greater than they were in 2005. The NDSP has identified many of these costs, but that in itself is not a significant benefit to Australian society.

Economic

Seeking to minimise these costs in the future is a natural response from society that firstly requires understanding of how the advance of salinity can be prevented or at least slowed. Adequacy of the science base was addressed in the House of Representatives report (HOR 2004), albeit through divergent views. It was concluded that large-scale land use changes were needed in Western Australia due to the hydrology and large areas of the landscape would need to be revegetated (perhaps greater than 50% of the landscape) for any effect. In the east, there was greater scope for localised solutions based on existing knowledge, options and technologies. However, most of the dryland salinity areas are in Western Australia.

This understanding is still not complete, but the information from the program has been synthesised into advice to landholders about prevention, recovery, and containment. In particular, a range of remedial options has been identified, including retaining and re-invigorating remnant vegetation, establishing and enhancing perennial pastures, phase farming and intercropping with lucerne, opportunity cropping and farm forestry, different types of drains, banks and wells, as well as managing land that has already become salinised. However, these options are not significantly different to those available in the early 1990s.

However, the enhanced understanding derived from the NDSP has already led to more appropriate use of these potential solutions to salinity such as tree clearing, revegetation, greater use of deep-rooted perennial species, and some engineering work.

The implication for identifying benefits is the potential reduction in wastage from applying solutions and resources in situations that are not appropriate and will not be cost effective. This may well apply to savings in both individual landholder and community resources. Adjustment processes to living with salinity may come quicker in the light of the NDSP investment.

Some management practices have already changed but progress in realising benefits is likely to be slow for a number of reasons: investment costs and opportunity costs of change, availability of resources, the extended time lags, spatial uncertainties, and uncertainty of success, even allowing for a long time lag. Many of the interventions may result in slowing impacts or preventing greater salinity impacts such as lowered yields.

Environmental

Significant environmental benefits can accrue if the advance of salinity is halted or slowed or, more realistically, if some key environmental assets are protected through various interventions. This is most likely to be achieved via reduced damage to native vegetation and associated biodiversity benefits. A second environmental benefit could be ascribed to actions derived from NDSP that result in lowered salinity levels in streams and the implications for biodiversity. However, there would be some uncertainty as to the extent of this benefit due to one or other of the following factors:

- the limited responsiveness of salinised waterways to interventions
- thresholds critical to biodiversity improvements not being reached in existing salinised waterways
- thresholds critical to biodiversity change still being reached in catchments where salt levels in waterways are worsening despite some positive impacts of actions.

The interventions suggested by the NDSP will have wider benefits than those from salinity management alone. For example, perennials in the farming system will improve nutrient management, soil health and acidification management, with associated productivity, environmental and natural resource sustainability benefits (Richard Price, pers. omm.., June 2005).

Social

Land and catchment manager capacity to deal with salinity issues has been enhanced by NDSP, even if this means in some cases a more positive acceptance of salinity, learning to live with it and the costs it imposes. This is supported by the survey of farmers, advisers and the public carried out by CIE in 2003 (CIE 2003, p. 37).

In that some rural aesthetics may be improved by reduced salinisation impacts, other areas may be made worse by interventions that involve sacrificial areas. Some cultural heritage values may be better protected as a result of salinity mapping and a better understanding of likely time scales.

Type of benefits
A summary of the principal types of benefits associated with the NDSP investment is shown in Table 2.

Table 2: Categories of Benefits from the Investment

Benefits
Productivity and Profitability • More-effective use of private and public resources (less wastage) by being able to better identify and assess priorities, and the potential costs and effectiveness of such investments. • Improved productivity of land managers due to reduced extent or rate of salinisation and use of alternative production systems
Environmental • Reduced loss of biodiversity (fauna and flora) through vegetation changes and hence habitat • Reduced impact on biodiversity in waterways affected by salinity
Social • Enhanced land and catchment management capacity to deal with salinity

Public versus Private Benefits
As indicated above, there are both public and private benefits generated by NDSP. Private benefits are in the form of productivity benefits to agricultural producers, and some environmental and social benefits that accrue on-farm (e.g. aesthetics, individual capacity building). There are also some private benefits associated with improved effectiveness of spending on remedial or preventative measures. Public benefits accrue in the form of improved effectiveness of government and private spending and some environmental benefits.

Benefits to Primary Industries
Benefits from addressing the dryland salinity problem in Australia will accrue to all agricultural industries, but particularly broadacre industries (red meat, wool, broadacre cropping). There will also be some impact on other agricultural industries dependent on irrigation, due to likely water quality impacts. Benefits to industry will be mostly in the form of avoided productivity losses. There may also be some increased operating costs associated with adopting some technical solutions developed.

Distribution of Benefits Along the Supply Chain
As the research investment will result in benefits to a wide range of primary industries, it is difficult to draw conclusions regarding the distribution of benefits along the supply chain. However, it can be assumed that most as benefits will be in the form of avoided productivity loss, the distribution will take the form of most productivity related benefits,

being a mix of consumer and producer benefits, with the relative proportions dependent on the demand and supply elasticities in the particular industry.

Match with National Priorities
The Australian Government's national and rural R&D priorities are reproduced in Table 3.

Table 3: National and Rural R&D Research Priorities 2007-08

Australian Government	
National Research Priorities	**Rural Research Priorities**
1. An environmentally sustainable Australia 2. Promoting and maintaining good health 3. Frontier technologies for building and transforming Australian industries 4. Safeguarding Australia	1. Productivity and adding value 2. Supply chain and markets 3. Natural resource management 4. Climate variability and climate change 5. Biosecurity *Supporting the priorities:* 1. Innovation skills 2. Technology

The NDSP research is aimed at improving sustainability and natural resource management (National Research Priority 1 and Rural Research Priority 3). It also attempted to use and develop frontier technologies (National Research Priority 3 and Supporting Priorities 1 and 2). The program also sought to influence agricultural productivity (Rural Research Priority 1) through its strengthening the understanding of dryland salinity processes and promoting consideration of responses suited to particular situations.

Quantification of benefits

Introduction and qualifications
This evaluation does not attempt to compare what has happened with NDSP with what might have happened without NDSP and the coordinating role played by LWA.

However, the evaluation recognises that at least some of the NDSP investment would probably have been made independently by its partners without a central coordinating mechanism.

The approach is to document the resources that were invested by LWA and its partners and then assess the benefits to Australia compared with the situation if that investment had not been made at all. The benefits attributable to LWA are therefore only a fraction of the total benefits, in line with the proportion of the total investment that was made by LWA.

Area affected by salinity
Statistics on areas of land affected by salinity vary between 'at risk', 'showing signs of salinity' and 'unsuitable for agricultural production'. For example, NLWRA (2001) reports the area at risk or affected by salinity as being 5.7 million ha. PMSEIC (1999) estimated the area of salinity affected land at 2.5 million ha. A land management survey by the Australian Bureau of Statistics (ABS) in 2002 (ABS 2002) reported that 1.97 million ha of agricultural land in Australia were identified as showing signs of salinity. An area of 0.82 million ha was affected to the extent that it was unsuitable for agricultural production, with Western Australia having the largest area of salinity.

Costs of dryland salinity
Dryland salinity costs are pervasive across the landscape. Impacts are not restricted to agricultural land but also to infrastructure such as roads, sewerage and water pipes, bridges, railways, buildings, and parks and gardens, and environmental assets such as floodplain wetlands and other habitats. For example, as of 2004, there were at least 220 rural towns and cities located throughout the Murray–Darling Basin currently experiencing an urban salinity problem (Wilson 2004).

Water quality in rivers and streams is affected through its subsequent use in irrigation and for industrial and domestic purposes, water often requiring increased treatment and hence increased costs. Aquatic biodiversity, cultural heritage, aesthetic and recreational values can also be affected.

The estimates of the costs of dryland salinity to Australia vary. The total cost of dryland salinity was reported to be $243 million per annum in lost agricultural production alone (Hill 1997). The total cost across the Murray–Darling Basin was estimated as approximately $305 million per annum of which only 33 per cent is incurred by dryland agricultural producers (Wilson 2004). Households, commerce and industry incurred some 46% of this total cost, largely due to the costs imposed from saline water supplies. The estimate does not include any values for environmental costs. The most authoritative annual cost to agriculture (loss of profits) due to salinity in the year 2000 is $187 million increasing to $287 million in 2002 (NLWRA, 2002).

There are significant costs of dryland salinity to the environment through damage to natural and planted vegetation, riparian zones, wetlands, fragmentation of wildlife corridors and general biodiversity loss. For example, it is suggested that in Western Australia, at least 1500 plant species will suffer from dryland salinity, with 450 of them possibly subject to extinction. Fauna species are likely be reduced by 30 per cent (NLWRA 2001). However, as identified by CIE (2003), it is likely that engineering works may be the most offered response to this threat and any linkage to NDSP may not be strong.

In summary, while the costs to the environment, infrastructure damage and lowered water quality are high, they may not be significantly reduced by interventions due to knowledge produced by NDSP. Also, where reductions in future impact do occur, the costs of the interventions may at least equal the costs averted. Averting productivity loss on land that otherwise may be damaged by salinity in the future and regaining some production from land already affected by salinity are the main avenues from which benefits from NDSP will be realised.

The extent of practice change

Some evidence that Australian farmers are taking action to manage salinity is provided in the ABS salinity survey carried out in 2002 across both dryland and irrigated farmers (ABS, 2002). ABS state that 'a key finding was that nearly 30,000 farms have changed land management practice to manage or prevent salinity'. The type and extent of land management practices undertaken wholly or partly for the management or prevention of salinity are shown in Table 4.

Table 4: Land management practices by state for the management or prevention of salinity

State	Crops, pastures and fodder plants sown for salinity management ('000 ha)	Trees planted for salinity management ('000 ha)	Land fenced from grazing for salinity management ('000 ha)	Earthworks undertaken for salinity management ('000 km)
New South Wales/Australian Capital Territory	1,096	91	17	43
Victoria	680	40	40	37
Queensland	331	126	27	15
South Australia	452	14	29	13
Western Australia	633	500	352	98
Tasmania	7	5	1	3
Northern Territory	6	–	–	
Total Australia	3,205	776	466	208

Source: ABS (2002).

The reasons for changing practices include farm sustainability (66 per cent), improved environmental protection (56 per cent) and increased productivity (54 per cent). Barriers to change reported included the lack of financial resources (68 per cent reported as limiting or very limiting) and lack of time (57 per cent reported as limiting). Doubt about likely success and lack of information did not appear to be major barriers to the majority of respondents. Some 23 per cent of farmers described lack of information as limiting or very limiting and 25 per cent reported doubts about likely success as limiting or very limiting. Non-irrigated farms accounted for 93 per cent of the agricultural land showing signs of salinity.

The National Action Plan for Salinity and Water Quality (NAP) was established to enable landholders and regional communities from 21 priority catchments across Australia to combat dryland salinity and ameliorate its impacts within the context of water quality management. The 21 priority regions for the NAP accounted for approximately 87 per cent of the farms and 66 per cent of agricultural land showing signs of salinity (ABS, 2002). In reality, not all NAP regions suffer from a salinity problem, and here NAP investments focus on other aspects of water quality.

Impact of practice change
The expected benefits from NDSP in the agricultural sector will fall into two classes, with perhaps some benefits from each class representing the real world situation. Both of these benefits have been recognised in the CIE evaluation of NDSP (CIE 2003) and the following assumptions recognise and draw on those made by CIE.

The first class of benefit is that the degree of negative impacts that would have occurred in the future may not occur or may be delayed due to the management actions that may be taken in catchments and regions. However, the extent and magnitude of these benefits are uncertain and will still probably apply to only a proportion of the interventions that are made. The costs of these interventions need to be recognised in estimating these benefits as does the considerable uncertainty about the timing of the benefits.

For purposes of this analysis it is assumed that 10 per cent of future agricultural production losses from salinity (including the increases in losses in the future) will be avoided due to the application of NDSP knowledge. The 10 per cent is net of the cost of the interventions and is in addition to any saved costs due to actions that would have occurred without the additional knowledge produced by NDSP. The 10 per cent is supported by the stakeholder survey reported in CIE (2003). It is further assumed that interventions based on NDSP knowledge commence in 2001/02 and continue thereafter and, assuming a 10 year lag, benefits (avoided costs of 10 per cent of expected productivity losses) begin to accrue in 2011–12.

The second class of benefit is that the increased knowledge due to NDSP has saved significant futile investment from occurring. For example, uninformed tree planting in some situations may not slow or stop salinity and may even exacerbate the situation through reducing run-off and interfering with the subsequent salinity dilution effects in some waterways.

It is assumed that, as a result of the NDSP, there will be a reduction in ineffective expenditure of private and public monies on reducing the impact of salinity. It is assumed that $1.4 billion in public monies from the Australian Government and the States is expended over the seven-year period 2001–02 to 2007–08 and will be matched equally by private investment. It is further assumed that 2.5 per cent of this money will therefore be saved from ineffective investment (zero or negative returns) and will be invested in more fruitful endeavours. Another way of viewing this class of benefit is that the overall result from the NAP and associated private investment could be achieved with 2.5 per cent less resources. Hence, it is assumed that these benefits accrue evenly over the period in which NAP expenditure is made.

Attribution to NDSP

It is important to recognise that although the NDSP was the largest single investment made in terms of R&D on dryland salinity over the period, there were other R&D investments made that would have contributed to the benefits to Australia from salinity R&D over the entire period. Other R&D outside the NDSP has been undertaken by MDBC, the CRC programs, CSIRO, universities, and some Research and Development Corporations other than those involved directly in the program. In many of these cases the R&D investments were consistent with NDSP priorities and were influenced by them. NDSP communication channels also promoted research results emerging from non-NDSP projects. In summary, a high proportion of all R&D outputs appear to have emanated from NDSP.

The assumptions made in this analysis recognise these other contributions but the assumptions on benefits refer to the impact from NDSP alone.

Summary of assumptions

A summary of all assumptions made is given in Table 5.

Table 5: Assumptions for the valuation of benefits from NDSP

Variable	**Value**	**Source**
Cost of dryland salinity to Australia		
Current cost to Australian agriculture of dryland salinity	$187m per annum in 2000	NLWRA (2002)
Future cost to Australian agriculture of dryland salinity	$287m per annum in 2020-21	NLWRA (2002)
Value of benefits		
A. Avoided wastage in public and private investment		
Expected public and private expenditure in interventions in medium term	$1.4 billion over 7 years from 2001–02 to 2007–08 matched equally by private investment.	National Action Plan for Salinity and Water Quality and assumption by Agtrans regarding matching by private investment
Years in which wastage avoided	2002–03 to 2008–09	Assumed a one year lag from NAP investment period
Level of wastage avoided	10%	Agtrans assumption
B. Future costs avoided due to actions taken using information from the program		

Increase in agricultural costs of salinity	$5m per annum cumulative commencing from 2001–02	Difference between $187m per annum and $287m per annum over 20 years
Level of costs avoided	10% of annual future costs	Agtrans assumption based on survey in CIE (2003)
Year in which avoided costs commence	A 10-year lag so benefits commence in 2011–12	Assumed most investment would be relatively short term with benefits commencing about ten years after investment

Results

All past cost and benefits were expressed in 2006-07 dollar terms using the CPI. All benefits after 2006-07 were expressed in 2006-07 dollar terms. All costs and benefits were discounted to 2006-07 using a discount rate of 5%. The base run used the best estimates of each variable, not withstanding a high level of uncertainty for many of the estimates. The base analyses ran for the length of the investment period plus 25 years from the last year of investment (2003-04) to the final year of benefits assumed (2028-29).

Investment criteria were estimated for both total investment and for the LWA investment alone. As well as for the 25 year benefit period, each set of investment criteria were estimated for different periods of benefits. Benefits for LWA investment criteria were estimated as 14.6% of the total benefits, 14.6% representing the proportion of total costs contributed by LWA. The investment criteria are reported in Tables 6 and 7.

Table 6: Investment criteria for total costs and benefits (discount rate 5%)

Criterion	0 years	5 years	10 years	15 years	20 years	25 years
Present value of benefits ($m)	94.9	295.4	308.8	333.3	357.1	376.0
Present value of costs ($m)	124.3	124.3	124.3	124.3	124.3	124.3
Net present value ($m)	-29.4	171.1	184.5	209.0	232.8	251.7
Benefit:cost ratio	0.8	2.4	2.5	2.7	2.9	3.0
Internal rate of return (%)	Negative	18.7	19.0	19.3	19.4	19.5

Table 7: Investment criteria for LWA costs and benefits (discount rate 5%)

Criterion	0 years	5 years	10 years	15 years	20 years	25 years
Present value of benefits ($m)	13.8	42.8	44.8	48.3	51.8	54.5
Present value of costs ($m)	18.5	18.5	18.5	18.5	18.5	18.5
Net present value ($m)	-4.7	24.3	26.3	29.8	33.3	36.0

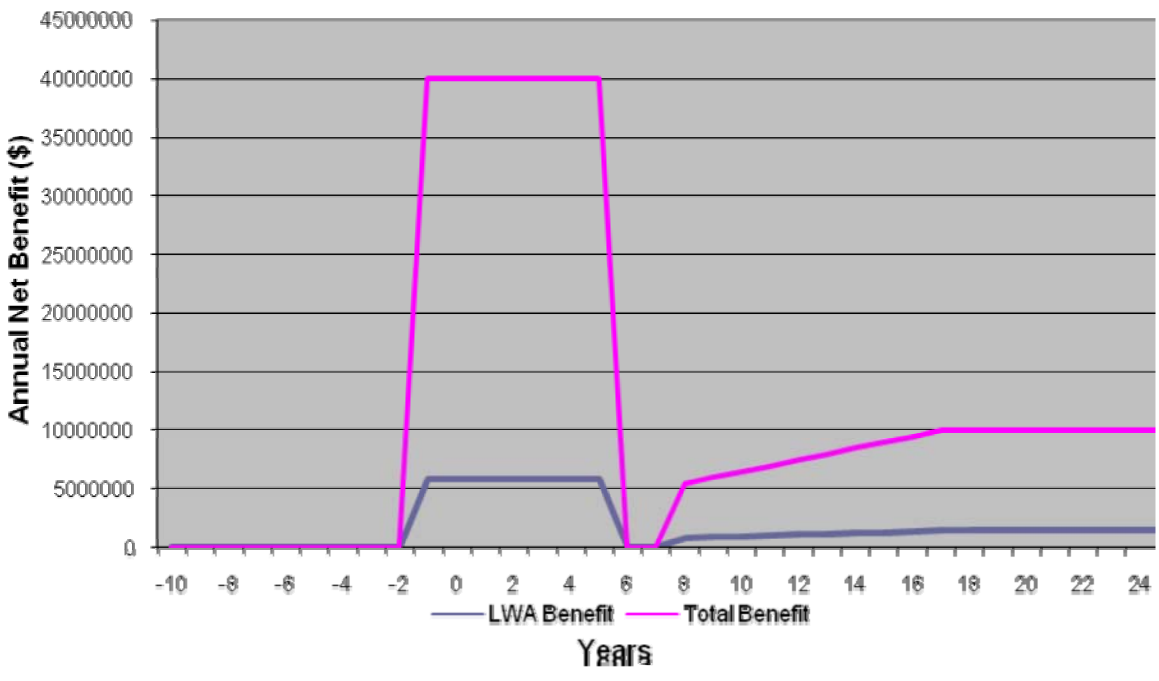
Benefit:cost ratio	0.7	2.3	2.4	2.6	2.8	2.9
Internal rate of return (%)	Negative	17.2	17.5	17.8	18.0	18.0

Given the assumptions made, the proportions of benefits estimated for each source (for the 25 year analysis) is 79 per cent for the avoided wastage in resources (public and private investment) and 21 per cent from the reduction in future salinity costs for agriculture. The reduction in future salinity costs for agriculture is considered an industry benefit, as the value of future salinity costs is based on agricultural productivity losses. The avoided wastage in resources benefit is both a public and private economic benefit. No environmental or social benefits were quantified.

One of the reasons for the relatively low proportion of benefits from the reduction in future salinity costs is the assumed long time period between future investment using NDSP knowledge and the time when benefits will accrue.

Figure 1 demonstrates the rate at which net benefits accrue. The disjointed line represents the contribution from the two separate benefits.

Figure 1: Annual Net Benefit Flow



Sensitivity analysis
The sensitivity of the investment criteria to four key assumptions was tested (for the 20 year analysis; LWA benefits only). All other assumptions remained the same when the one factor was varied. The key assumptions tested are:

- the level of expected public and private expenditure in interventions in the medium term (Table 8)

- the percentage of wastage of resources avoided due to knowledge generated by NDSP (Table 9)
- the future cost to Australian agriculture of dryland salinity (Table 10)
- the percentage of costs avoided due to knowledge generated by NDSP (Table 11)

Table 8: Sensitivity of investment criteria to level of expected public and private expenditure in interventions (LWA benefits and costs only)

Criterion	**Discount rate 5%**		
	75% of base value	**Base value ($2.8b)**	**200% of base value**
Present value of benefits ($m)	41.0	51.8	94.6
Present value of costs ($m)	18.5	18.5	18.5
Net present value ($m)	22.6	33.3	76.1
Benefit:cost ratio	2.2	2.8	5.1
Internal rate of return (%)	14.4	18.0	27.9

Table 9: Sensitivity of investment criteria to percentage reduction in wastage of future salinity investment (LWA benefits and costs only)

Criterion	**Discount rate 5%**		
	5%	**Base value (10%)**	**15%**
Present value of benefits ($m)	30.3	51.8	73.2
Present value of costs ($m)	18.5	18.5	18.5
Net present value ($m)	11.9	33.3	54.7
Benefit:cost ratio	1.6	2.8	4.0
Internal rate of return (%)	10.1	18.0	23.6

Table 10: Sensitivity of investment criteria to future salinity costs to agriculture (LWA benefits and costs only)

Criterion	**Discount rate 5%**		
	75% of base value	**Base value ($287m)**	**200% of base value**
Present value of benefits ($m)	49.5	51.8	60.7
Present value of costs ($m)	18.5	18.5	18.5
Net present value ($m)	31.0	33.3	42.2
Benefit:cost ratio	2.7	2.8	3.3
Internal rate of	17.8	18.0	18.6

return (%)			

Table 11: Sensitivity of investment criteria to percentage of future salinity costs avoided (LWA benefits and costs only)

Criterion	**Discount rate 5%**		
	5%	**Base value (10%)**	**15%**
Present value of benefits ($m)	47.3	51.8	56.2
Present value of costs ($m)	18.5	18.5	18.5
Net present value ($m)	28.8	33.3	37.7
Benefit:cost ratio	2.6	2.8	3.0
Internal rate of return (%)	17.6	18.0	18.3

The percentage of wastage of resources avoided and percentage of salinity costs avoided are assumed to represent adoption, and therefore Table 12 presents the NPV for low, expected and high values for these two assumptions, for each of the 0, 5, 10, 15, 20 and 25 year timeframes (for all investment).

Table 12: Sensitivity of net present value to adoption (all investment)

NPV	Project Horizon					
	0 years	5 years	10 years	15 years	20 years	25 years
Low (5% and 5%)	-76.8	23.4	30.1	42.3	54.3	63.7
Expected (10% and 10%)	-29.4	171.1	184.5	209.0	232.8	251.7
High (15% and 15%)	18.1	318.8	338.9	375.6	411.4	439.7

These results can be considered to be a conservative estimate of investment performance since:

- environmental benefits, such as those to riparian zones and wetlands, biodiversity in waterways, and reduced impacts on remnant vegetation, are not valued
- no impact has been assumed on the current costs to agriculture of dryland salinity (that is, impact commences 2011/12)
- no impacts on water quality or the current or future costs imposed on rural and urban infrastructure have been included.

In terms of the NDSP program as a whole, the ABS (2002) survey is a major source of information about land management practices to address salinity, the types of practices, and the reasons for and barriers to change. However, there is no direct link from these actions to the NDSP investment. In fact, many of the same type of management practices were being adopted before NDSP commenced. It is reasonable to assume that the management practices being adopted at the time of the ABS survey were much better informed than if the NDSP investment had not occurred.

Adoption of information concerning specific public environmental assets or amelioration of private or public infrastructure assets does not appear to be readily available. The magnitude and duration of the NDSP meant that it was instrumental in raising awareness of dryland salinity among Australians. One of the outcomes of the NDSP was therefore the realisation of the huge investment needed to ameliorate the impacts of dryland salinity in the future. This realisation was a driver of the NAP. The NAP is to some extent the action plan for use of knowledge derived from NDSP.

Conclusions

The national investment under NDSP was perhaps the largest nationally coordinated R&D investment in a single land resource issue over the past 10 years. The investment produced a high level of research outputs and significant knowledge concerning dryland salinity, particularly about its current and future potential impacts and costs. However, solutions that are economically viable for government and producers were proven to be varied, scarce and localised.

The NDSP concluded that there was no universal solution to dryland salinity. Localised solutions included vegetation management (maintenance of native vegetation and regeneration in some instances), the use of perennial pasture species to control watertables, and selected drainage initiatives. However, widespread farming system changes are unlikely to be economic given current knowledge (e.g. revegetating 50 per cent of the landscape with deep-rooted perennials).

Some actions have taken place by landholders and more are likely to be undertaken through NAP resources being delivered under the regional delivery model. It is assumed that the deployment of these resources will be more effective with the availability of knowledge generated from the NDSP.

The investment analysis of the NDSP suffers from the long periods expected between the time of expenditure on R&D and the timing of some of the impacts. These long periods mean that time discounting will not provide an overly high rate of return compared with many other R&D investments. The impact of this timing has been ameliorated to some extent in this analysis by the assumption concerning the shorter-term reduced wastage in resources that occur during NAP expenditure.

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