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Enquiries should be addressed to:
Mr Vincent Fernandes
Corporate Strategy & Program Support
Grains Research and Development Corporation
PO Box 5367
KINGSTON ACT 2604
Phone: 02 6166 4500
Email: v.fernandes@grdc.com.au

Author:
Agtrans Research
PO Box 385
TOOWONG QLD 4066
Phone: 3870 4047
Email: info@agtrans.com.au

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An Economic Analysis of the GRDC Investment in Climate Research (2002-2007)

Contents

1. Executive Summary

The GRDC investment in projects in the Climate Cluster has been evaluated to determine likely benefits over the next 25 years in relation to the cost of the order of $6m. The Cluster included 9 projects planned to respond to the GRDC priority *'Reducing the impact of climate variability (especially variable rainfall and frost) through developing decision tools and rules in association with grower groups'* (GRDC Research Prospectus 2002-03). The Cluster projects ran over the five year period to June 2007.

The largest single investment by the Cluster was in the collaborative Managing Climate Variability R&D Program (MCVP). GRDC has been the largest investor of the Rural R&D Corporations in the current and previous collaborative programs that have had a central role in better equipping farmers to manage climate-related risks. MCVP funded over 40 projects covering generic research, capacity building, a wider range of industries and with a broader scope to include natural resource management aspects and adaptation to climate change. There were several projects in MCVP involving graingrowers to develop more effective approaches to risk management. Crop models that can simulate possible yield and economic outcomes for a range of options have been shown to be a more effective means of integrating seasonal rainfall forecasts into a broader risk management framework.

Benefits from the GRDC investment in MCVP were based on a previous evaluation. Projects in the cluster relating to frost and to using seasonal climate forecasts were evaluated in two groups. The evaluation assumed additional extension costs. There was limited data available to estimate likely benefits and adoption rates. Adoption rates for the approaches to reducing frost losses were assumed to be eventually reduced as climate change increased uncertainty on frost frequency and on the value of favoured strategies such as delaying planting faced with increasing heat stress in spring. Benefits were also eventually reduced for MCVP and for the seasonal climate forecast projects in recognition of possible climate change impacts on perceptions of the value of the forecasts.

The results of the evaluation were reasonably sensitive to the assumptions made on deterioration in the value of the information. Allowing for the assumed rates of deterioration and recognising the difficulties in estimating and quantifying benefits, the Climate Cluster is expected to show positive returns to the funds invested by GRDC. The benefit cost ratio for the GRDC investment was estimated to be 1.7 to 1.

From a broader perspective, the investment by GRDC has had a lead role in establishing Australian research as the world leader in climate risk management in agriculture and natural resource management. The Climate Cluster was also one of the first research efforts to expand the focus from managing climate variability to adapting to climate change.

2. Background

Climate research to help farmers manage climate risk is a relatively new focus for research in agriculture. Over the last two decades there have been two fundamental changes in the way farmers manage climate risk. The first followed the major El Niño of 1982/83. That event led to gradually increasing acceptance of a breakthrough that climate could sometimes and in some places be forecast with useful skill a season ahead. A seasonal climate forecast (SCF) would clearly be highly valuable if it was perceived by farmers as accurate enough to profitably modify crop management, reduce risk, or help in financial planning. More recently during the current decade farmers have had to increasingly recognise the potential impacts that climate change is likely to have on the grain industry.

Applied climate research had its origins in the 1992 National Drought Policy. The research programs since then have been administered by Land and Water Australia (LWA) on behalf of the funders. They have included Australian Government programs and, at one time or another, the majority of the RDCs (Rural Research and Development Corporations). The most recent program was MCVP (Managing Climate Variability Program) that ran over the five year period to 2007. GRDC has been the major investor of the RDCs. In addition, the GRDC funds a number of projects to meet its own priorities. The major difference between projects funded by MCVP and directly by GRDC is the generic nature of the benefits. MCVP has concentrated on projects that provide tools and techniques that can be more widely applied in other regions and industries. This evaluation includes both the GRDC contribution to MCVP and projects managed by GRDC.

Prior to 2002 GRDC had only funded a few projects in the general area of climate risk management. Most were in the GRDC Northern Region where summer rainfall dominance and soils of high moisture capacity contrast with the lighter soils in the southern and western areas of mainly winter rainfall. The Northern Region had traditionally given greater priority to understanding soil water build-up by using simulation models rather than the rules of thumb used in the south. Background factors leading to the greater focus on SCF in the Northern Region included:

- Inherently higher rainfall variability in the Northern Region, leading to -
- A better developed capacity to evaluate improved and lower risk cropping strategies using crop simulation models, contributing to -
- Earlier recognition of the greater opportunity to use SCF in cropping systems based on both summer and winter cropping.

By 2002, recent experiences of droughts and frosts had changed perceptions in the GRDC Southern and Western Regions. There was an increased demand for research using SCF.

3. The Investment

3.1. Program Objectives

Most of the projects in the Climate Cluster began in response to the research priorities listed in the GRDC Prospectus (2002-03) .The priorities were aimed at:
'Reducing the impact of climate variability (especially variable rainfall and frost) through developing decision tools and rules in association with grower groups'

3.1.1. Projects Funded by GRDC to meet Program Objectives

The cluster includes eight projects managed by GRDC, and also the substantial GRDC contribution to the collaborative program Managing Climate Variability.

Table 1: Projects Funded by GRDC in the Climate Cluster

Project Code, Title and Duration	Objective
CAG00002 - On Farm Evaluation of Frost Minimisation Techniques and Risk Management Strategies 1/7/2002 to 30/6/2005	Verify effectiveness of options to minimise impacts of frost.
CSP00040 - Can we forecast seasonal wheat grain yields and protein in Western Australia? 1/4/2003 to 31/10/2005	Determine the skill and value of seasonal climate forecasts for predicting wheat yields and protein in Western Australia
DAQ00006 - Whopper Cropper - A risk management learning tool for advisers 1/7/2002 to 30/6/2005	Develop a computer simulation program to contribute to improved management of production risks in the GRDC Northern Region
DAS00017 - Reducing the impact of climate variability (frost) 1/7/2002 to 30/6/2005	Develop decision support tools to manage major climate risks including frost in the GRDC Southern Region
DAV00006 - Tools to reduce the impact of climate variability in South Eastern Australia 1/1/2003 to 30/6/2006	Increased and more stable economic performance of South-Eastern Australian farming systems through the development of tools that integrate seasonal climate forecasts, climate variability and management options.
DAW00040 - Promoting tools for assessing and managing seasonal conditions in dryland crop production. 1/1/2003 to 31/12/2004	Improve capacity of farmers in the GRDC Western Region to manage climate risk
DAW00087 - Better long-lead seasonal and crop forecasts for southern Australia 1/7/2003 to 30/6/2006	Research climate anomalies to validate improved rainfall and yield forecasts for southern Australia
DAW00088 - Climate change, wheat yield and cropping risks in Western Australia 1/7/2003 to 30/6/2008	Develop a clearer understanding of climate change projections and impacts on wheat production and quality at a regional level in Western Australia
LWR25 - Managing Climate Variability Program 1/7/04 to 30/6/2007	Contribute to a coordinated national research program on managing climate variability to more effectively develop generic forecasts and tools

Source: Project Proposals

3.2. Investments

The financial investments made in the Climate Cluster are listed by project in Table 2.

Table 2: Expenditure on the Projects in the Climate Cluster

Project	Project Expenditure		
	GRDC	Host Organisations	Total
CAG00002 – On Farm Evaluation of Frost Minimisation Techniques and Risk Management Strategies	222,000	47,700	269,700
CSP00040 – Can we forecast seasonal wheat grain yields and protein in Western Australia?	350,000	258,558	608,558
DAQ00006 – Whopper Cropper – A risk management learning tool for advisers	324,172	555,000	879,172
DAS00017 – Reducing the impact of climate variability (frost)	655,113	1,022,934	1,678,047
DAV00006 – Tools to reduce the impact of climate variability in South Eastern Australia	658,420	829,700	1,488,120
DAW00040 – Promoting tools for assessing and managing seasonal conditions in dryland crop production	161,149	386,600	547,749
DAW00087 – Better long-lead seasonal and crop forecasts for southern Australia	415,786	745,405	1,161,191
DAW00088 – Climate change, wheat yield and cropping risks in Western Australia	411,238	596,500	1,007,738
LWR25 – Managing Climate Variability Program	2,723,947	3,107,036	5,830,983
Total	5,921,825	7,549,433	13,471,258

Source: Project Proposals.

Estimates of the funding by year and by source for the projects as listed in Table 2 is shown in Table 3

Table 3: Expenditure for the Climate Cluster for the Period from 2003 to 2007

Year To 30 June	GRDC	Host Organisations	Total
2003	605,973	616,287	1,222,260
2004	1,428,901	1,793,204	3,222,105
2005	1,582,955	2,044,905	3,627,860
2006	1,306,399	1,896,909	3,203,308
2007	997,597	1,198,128	2,195,725
Total	5,921,825	7,549,433	13,471,258

Source: Project Proposals, Years are financial years to 30 June.

For the projects reported above, GRDC has contributed 44 percent of resources in nominal terms with the remaining support provided by the host organisations.

3.3. Program Description

The projects in the Climate Cluster were funded to give grain farmers better information to reduce climate impacts, particularly those resulting from variable rainfall and from frost. Projects aimed to develop decision tools and rules in association with grower groups to increase understanding and contribute to improved climate risk management.

The nine projects in the Climate Cluster can be placed in four groups to describe the major research directions and to simplify the assessment of the benefits from the Climate Cluster.

1. Managing Frost Risk (CAG00002, DAS00017, DAW00040))

Wheat is particularly vulnerable to frost at flowering. Yield loss can range from total to imperceptible. Quality is also impacted. One estimate is of Australia-wide losses on average of more than $100 million annually (Olsen, 2005). Three projects were undertaken in South Australia and Western Australia to consolidate what information was known that could help reduce frost risk, and to research practical approaches and the best economic options. GRDC also conducts research on more frost-resistant varieties, but that investment was not included. (Some allowance was made for benefits to be eventually reduced because the new varieties could make some strategies that address climate at least partially redundant)

2. Using Seasonal Forecasts (CSP00040, DAQ00006, DAV00006))

Three projects were funded to provide information of direct value in crop management decisions. Experience particularly in the GRDC Northern Region had shown that using crop simulation models was a more effective way to assess and communicate options for crop management given a specific forecast and information on other key factors such as soil moisture. Rainfall forecasts using probabilities of above and below median have presented some difficulties for farmers. Their approaches to risk management have usually evolved over long periods and are often based on simple rules of thumb. Crop models that show the yield consequences of different options have been shown to be more readily understood. The projects in this group were the first in the Southern and Western Regions to use crop simulation models for more extensive evaluation of their value in guiding cropping decisions.

3. Supporting Projects (DAW00087, DAW00088)

The two projects in this group were conducted in Western Australia and were designed to provide information to the grains industry to contribute to planning and policy. One project was on impacts from climate change and one on further testing of an experimental seasonal forecast developed in recognition of the reduced value of the then current seasonal climate forecasts in Western Australia compared with eastern Australia.

4. Collaborative MCVP Investment
Of the Rural R&D Corporations, GRDC has been the major contributor to the various phases of the applied climate variability research programs administered by Land and Water Australia. For MCVP, two notable changes from previous phases were:

a) the increasing emphasis on adapting to climate change in the short term, and
b) the need to strengthen the program in developing products more relevant to water and natural resource management issues.

There were over 40 research projects in MCVP. Coverage includes a number of rural industries, regions and research directions. There were seven organisations contributing to funding. MCVP has been an outstanding example of collaboration between the RDCs.

4. Outputs

The principal outputs from the investment made over the period from 2003 to 2007 are listed in Table 4. As discussed in the previous section describing the Climate Cluster, the projects have been grouped based on their outputs as a basis for evaluating benefits in a later section.

Table 4: Outputs Achieved by the Four Groups of Projects in the Climate Cluster

Projects (grouped by output type)	Outputs
Managing frost risk	
CAG00002 - On Farm Evaluation of Frost Minimisation Techniques and Risk Management Strategies	• Tested options for frost management based on field data
DAS00017 - Reducing the impact of climate variability (frost)	• Parameters developed for decision support systems • Analyses of frost minimisation techniques
DAW00040 - Promoting tools for assessing and managing seasonal conditions in dryland crop production	• Information kit for undertaking yield and climate risk analyses
Using seasonal forecasts	
CSP00040 - Can we forecast seasonal wheat grain yields and protein in Western Australia?	• Forecast skill and value for alternative forecast systems used to adjust crop management
DAQ00006 - Whopper Cropper - A risk management learning tool for advisers	• Additional priority risk management features added • Training courses delivered and evaluated
DAV00006 - Tools to reduce the impact of climate variability in South Eastern Australia	• Value of forecasting tools to managed climate risk • Case studies demonstrating use of tools
Supporting projects	
DAW00087 - Better long-lead seasonal and crop forecasts for southern Australia	• Climate forecasting system based on atmospheric pressure index values at different latitudes • System tested with cross validation and independent period analysis
DAW00088 - Climate change, wheat yield and cropping risks in Western Australia	• Improved understanding of climate change projections and impacts on wheat production and quality at a regional level in WA
Collaborative MCVP Investment	

LWR25 - Managing Climate Variability Program	• Increased adoption of products to improve climate risk management in regions and industries • Increased adoption of products to improve climate risk management in Natural Resources Management, • Improved seasonal climate forecasts

5. Outcomes

The principal outcome of the investment has been the increased profitability of grain production and the reduced impact of climate risk. The most significant outcomes from the program are in the form of increased profitability and the more difficult to quantify benefits from more sustainable natural resource management. The increase is typically a consequence of changes in management practice following increased awareness and use of new tools and techniques and how these add to existing traditional approaches to climate risk management.

6. Benefits

6.1. Productivity and profitability

The Climate Cluster aimed to reduce the impact of climate variability, especially variable rainfall and frost, major factors contributing to large fluctuations in farmer profitability. The Australian grains industry has benefited from the investment in the Climate Cluster initially through improved productivity, for example by changing crop inputs to better match forecast yield. The past analyses of SCF applications support the premise that increased profits can result from use of SCF and there is potential also for capturing natural resource management benefits. An evaluation of MCVP (Agtrans Research and AGEC Consulting, 2007) lists 11 studies showing potential increases in productivity and profitability from improved approaches to climate risk management.

6.2. Economic benefits

The major economic benefits arise from the increases in profitability and reductions in risk resulting from improved climate information. The principal assumption associated with analysing the benefits from the investment is an increased adoption level of the use of the information developed, particularly improved relevance of SCF.

6.3. Environmental benefits

Tools developed in the Climate Cluster aim to develop farming systems better attuned to the rainfall pattern. SCF can contribute for example by changing a management option that would reduce erosion risk when a wetter than average season is forecast. Similar approaches can minimise fertiliser losses through leaching and reducing harmful nutrient buildup in streams.

The analysis has not included any quantified environmental benefits from the investment. Crimp et al (2007) have shown for example that using SCF to alter stubble levels has favourable impacts on key natural resource management indicators such as run-off and deep drainage. However, it is difficult to measure relationships between the changes in the indicators and the possible outcomes regarding water quality, biodiversity and soil erosion. To some extent the benefit is correlated with profit orientated decision making from SCF that can be valued with more confidence.

6.4. Social Benefits

The research has contributed to improved understanding and capacity for farmers and regional communities to manage climate risk. Understanding of the major drivers of rainfall, for example from El Niño events ensures that farmers and their local communities are less vulnerable to droughts and other climate impacts.

A summary of the categories of benefits is presented in Table 5.

Table 5: Categories of Benefits from the Investment in the Climate Cluster

Benefits
Economic -Productivity and Profitability • Overall increase in average level of profits for farm businesses • Decreased risk and farm income variability
Environmental • Improved understanding of the patterns of climate variability including drought and flood extremes to inform natural resource management decisions
Social • Improved personal capacity of land managers and communities to understand and manage climatic variability and climate change and to reduce risk.

6.5. Public versus Private Benefits

The readily quantified benefits identified from the investment are predominantly private benefits. Some of the benefits of the avoided yield losses and the associated higher production will be passed along supply chain to grain processors and other users of grain including consumers. The supply chain will also benefit from improved climate information, for example from more accurate and timely yield forecasts with implications for stock management and marketing. As the grains industry is predominantly export orientated, grain producers will capture benefits in the main.

If GRDC did not receive funding (or received less funding) from the Commonwealth, most of the projects with the possible exception of MCVP probably still would have been funded at some significant level. Overall, it is postulated that the investment in projects specifically of benefit to grain farmers would have remained a high priority for GRDC and that the level of funding would probably not have been reduced significantly in the event of a Commonwealth Government reduction in funding to GRDC. If the government contribution was removed altogether, there probably would have been varying degrees of reduction in funding despite the increasing recognition of climate research. One factor would be the extent to which climate research is seen as public good research.

6.6. Collaborative and Spillover Aspects

Some consideration of spillovers is warranted for MCVP. GRDC has contributed 38 percent of the partner funds invested by MCVP. The GRDC contribution was 60 percent of the total contributed by the RDCs. Because GRDC is a major funder in MCVP, several projects target applications in the grains industry. Some of these projects had generic aspects, for example developing ways to more effectively involve farmers in accessing and interacting with simulation models using data relevant to their farm. There are a wide range of projects covering a range of research and communication activities across regions and industries. Each would need to be analysed to better define spillovers from the GRDC investment. Such an analysis would most likely show that net spillovers from the GRDC contribution alone to other rural industries would only be minor; however, the other industry RDCs would benefit from the overall MCVP investment to which they contributed. It should be noted that 44 percent of Australian farmers taking SCF into account are grain farmers (Climag, 2005), almost double the relative contribution of the grains industry to the gross value of farm production (ABARE, 2006).

The fate of funding for the collaborative MCVP in the event of reduced Commonwealth funding to GRDC and other partners could be expected to be different, given that MCVP funding has produced spillover benefits to sectors other than those represented by the rural RDCs. To some extent MCVP undertook generic projects of economy-wide benefit by default. There were no other sources of competitive funding and climate research funding was increasingly focusing on climate change issues. The opportunities for a demand driven approach to influence national research were limited by the absence of effective consultation mechanisms and by user understanding of the research agenda. It is unlikely that the MCVP research activities would have been competitive with more traditional areas in the event of reduced Commonwealth funding.

Another factor to be considered is the additional Commonwealth funding from programs such as the Natural Heritage Trust and Agriculture Advancing Australia which together contributed 35 percent of the MCVP partner funding, slightly less than the GRDC component. When the research programs started as part of the National Drought Policy there was a clear expectation that such Commonwealth funding would be dependent on matching by the RDCs. The funding was seen as seed money to promote a greater involvement by RDCs in research on drought and climate risk management. Without the major input from GRDC the program may have been in jeopardy unless the Commonwealth became a dominant partner. Whilst this may have been a possibility, it seems more likely that MCVP would have continued but at an inefficient level in terms of scale. A smaller program would have been less likely to have achieved critical mass anywhere near sufficient to achieve change on a national scale.

The MCVP approach had to accept free rider problems and the high transaction costs inevitable when there are diverse beneficiaries of such a program. There was also recognition that some of the research would more appropriately, and in some ways efficiently, have been publicly funded as core responsibilities of national organisations. This has happened recently with research on climate adaptation in agriculture. Collaborative activities such as MCVP are built directly from stakeholder priorities and that can be a major advantage. Climate research undertaken by GRDC and MCVP has been a relatively new focus for research and is sometimes seen as risky. It is unlikely that the more generic climate research (where spillovers are greatest) would have been competitive with more traditional areas in the event of reduced Commonwealth funding.

The advantages offered by the MCVP approach within the RDC system were identified as key factors contributing to the success of the approach in an international comparison conducted for the USA Academy of Sciences (Cash and Buizer, 2005). They were:

- effective knowledge-action systems that define and frame the problem to be addressed via collaboration between knowledge users and knowledge producers,
- they tend to be end-to-end systems that link user needs to basic scientific findings and observations,
- they are often anchored in "boundary organisations" that act as intermediaries between nodes in the system - most notably between scientists and decision makers;
- they feature flexible processes and institutions to be responsive to what is learned;
- they use funding strategies tailored to the dual public/private character of such systems; and
- they require people who can work across disciplines, issue areas, and the knowledge action interface.

In summary, the collaborative approach does offer major advantages to the GRDC and to other RDCs particularly in a new field of research and where there is substantial generic investment required. As an example, each RDC would not expect to have the skills in house to manage a new research field particularly in terms of developing effective linkages. But there are some trade-offs including loss of control and more complex accountability and evaluation in the collaborative approach.

6.7. Match with National Priorities

The Australian Government's national and rural R&D priorities are reproduced in Table 6.

Table 6: National and Rural R&D Research Priorities 2007-08

Australian Government	
National Research Priorities	**Rural Research Priorities**
1. An environmentally sustainable Australia [1] 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

[1] Includes "Responding to climate change and variability" as one of seven enabling priorities.

The Climate Cluster makes its primary contribution to Rural Research Priority 1 on productivity and adding value. There are also benefits to Priority 2 through improved information for managing the supply chain. Farming systems better attuned to natural variability are an important contributor to Priority 3 (Natural resource management).

In relation to Priority 4 (Climate variability and climate change), the MCVP has been the outstanding example of a program developing a coordinated national approach to improving tools to enable better analyses of climate variability and climate change and of their impacts. The GRDC projects in the Climate Cluster were developed following recognition of the value of applied climate research done in predecessor programs to MCVP.

In addition to its inclusion in the Rural Research Priorities, a new category 'Responding to climate change and variability' was added to the National Research Priority 'An Environmentally Sustainable Australia' after the projects in the Climate Cluster had been funded. The Cluster does however include several projects either specifically on climate change or on the interaction of climate change and climate variability. Those projects make a major contribution to the enabling strategies specified for the National Priorities, particularly:

- Responding to climate change and variability
- Increasing our understanding of the impact of climate change and variability at the regional level across Australia, and
- Addressing the consequences of these factors on the environment and on communities.

The investment has made a significant contribution to National Research Priority 3 on Frontier Technologies and has demonstrated innovation skills and new technologies (Supporting Rural Research priorities). Australia is the acknowledged world leader in developing approaches to managing climate variability. The approaches developed in the Climate Cluster continue to underpin achievements in adapting to climate change. The lead role that GRDC has taken in investing in the Climate Cluster has been a significant catalyst for a wide range of agencies to develop their own capacity in climate risk management. The investments by partner agencies including CSIRO, Universities, and Sate Government Departments with roles in agriculture have contributed to the agencies developing core expertise and a mainstream role in integrating climate risk management.

7. Quantification of Benefits

There are a wide range of outputs from the projects in the Climate Cluster. In the following, the four groups in Table 4 are used to simplify valuing benefits. MCVP has already been subject to a comprehensive analysis for Land and Water Australia and that gives a starting point. Assumptions for valuing benefits were made in a consistently conservative manner in all analyses. The investment criteria produced are highly dependent on the assumptions made in each analysis.

There are two areas of potential concern with regards to confidence in the analyses. The first is the coverage of benefits and how rapidly they will be achieved following the research phase. The second involves the assumptions relating to the difference that the investment has made. Some of these assumptions can be contentious and many made in the analyses are a matter of judgment. To help address the uncertain assumptions, a sensitivity analysis was carried out where the investment criteria are recalculated with variations of some of the uncertain assumptions.

The Climate Supplement (GRDC, 2007) in the GRDC publication *Ground Cover* distributed to all graingrowers demonstrates new concerns with climate risk management. Stephens (2002) has shown how climate variability impacts on regional cropping performance. The main impact is through yield variability and the increasing level of risk associated with a high-input, high-yield, farming system. The high rates of productivity gain being achieved in the grain industry demand more skilled climate risk management.

Before identifying likely benefits for the three groups of projects, some common issues can be identified. Extension costs need to be included so that benefits are net of the resources needed to increase adoption. For the main projects in the Northern GRDC Region, the benefits from the Cluster are mainly from a project where delivery will be by the private sector so the cost is not included. For the other two regions, there are additional climate risk extension activities but a new management practice will require additional resources. Overall an annual allowance of $100,000 has been costed for the first decade of the adoption phase, equivalent to a person year across two regions.

A consistent approach is also required for a decline in benefits due to for example decline in forecast skill, or from obsolescence. As outlined in the following section on MCVP, a factor for forecast deterioration was included in the previous MCVP analysis. The rate is assumed to be less for the seasonal climate forecast group in the cluster because they incorporate seasonal climate forecasts into cropping models where benefits are also determined by other factors. Even though seasonal climate forecasts may have been the catalyst initially driving adoption, experience has been that the value of the model will endure because value is much more than that due to the forecast. For the frost projects, seasonal climate forecasts are not a factor. Benefits are assumed to peak later and then undergo more rapid deterioration as uncertainty becomes more prominent in relation to frost frequency and climate change.

<u>1. Managing Frost Risk</u>

The three projects account for 18 percent of GRDC investment in the cluster. A guide to managing frost risk for southern Australia (Rebbeck and Knell, 2007) was published as an output of the frost research projects. The frequency of damaging frosts has decreased in the GRDC Northern Region. There is no clear trend, perhaps even an increase in the Southern and Western Regions (Crimp et al, 2007). Depending on their perception of the risk, farmers will have some strategies in place to reduce frost impacts. Improved information can be valuable; particularly as uncertainty on likely future impacts with climate change has increased. Although there is clearly an upward trend in average temperatures, there is increasing evidence that variability is also increasing. Therefore frost frequency need not immediately decrease with global warming. But for the present, many farmers in southern Australia accept the reality of some continuing minor and unavoidable degree of frost damage in many years, and severe perhaps partly avoidable damage on the more frost prone parts of their farm less frequently. Therefore the project is unlikely to have a major impact on the overall level of losses from frost. Instead, the benefits will result from some more frost prone farmers increasingly adopting some of the measures developed as experience on the benefits and the risks accumulates. Adoption is still likely to be limited because many farmers rarely experience the mainly unpredictable major events, and it is likely that changing uncertainty on how the risk is changing will be a factor.

One strategy that is sometimes used is to delay planting to avoid the crop flowering at a risky time. But with climate change an increasing yield penalty can be incurred by delayed planting as temperatures and moisture stress increase in spring. The frost risk guide gives an example of yield decreasing by $14 to $24/ha for delays in planting of 10 to 26 days. This decline has to be offset against the expected loss from frost, for example $100 once in ten years. Crimp et al (2007) showed in a simulation study using recent historic climate that the delay strategy was only optimal at some locations.

A factsheet based on the frost research lists eight factors that determine frost risk and eight strategies to reduce the risk. All the strategies involve costs and risks. Many of them would already be used by some farmers. For example sowing a more frost resistant crop such as oats might result in lower profits in years of low frost incidence on the expectation of increased profit in a season when frosts are severe. Other strategies such as delving (similar to deep ripping to bring up clay subsoil retaining moisture and heat) involve a significant capital cost of the order of $100/ha.

In the absence of data on the likely uptake of strategies that can be attributed to the frost research, estimates as in Table 7 have been made based on the area where frost damage can be economically reduced, the likely benefit and the rate of adoption. In addition, benefits have been assumed to eventually decline because increasing uncertainty can be expected on frost risk and on the benefits. Frost tolerant varieties for example could make some of this research redundant.

<u>2. Using Seasonal Forecasts</u>

The three projects account for 22 percent of the GRDC investment in the cluster. The projects were funded to provide information of more direct value in crop management decisions. Forecast value is determined by forecast accuracy, or more correctly, skill (is it better than chance?), and an opportunity to change management. The project in the Northern Region resulted in training of 155 public and private sector advisers in the use of a decision aid to evaluate risk and returns from a range of cropping options. The project was a consolidation of extensive research based on seasonal climate forecasts developed over the previous decade. The Western Australian project was the first regional project to comprehensively assess the potential value of forecasts particularly in fine tuning fertiliser decisions. However, the forecast skill of the tested forecasting approaches was usually lower in Western Australia compared to Eastern Australia. The Victorian research was also the first regional project to comprehensively assess forecast skill and value. The analysis showed that farmers in southern Australia could have confidence in the skill and value of a July forecast to help determine a fertiliser top dressing strategy (Anwar et al, 2007).

The benefits of each of the projects will be mainly confined to their region. There are a range of studies that show that nationally about one half of grain farmers take seasonal climate forecasts into account in their management decisions. Experience has also been that demonstrations of relevance and value for typical decisions made in a region are an important determinant of whether farmers go an extra step and extract value from forecasts. The three projects in the group will do this and provide a base for more effective communication by advisory programs.

The assessment of the likely rate of adoption and the benefits are conservative, particularly because they are marginal gains on the achievements of programs such as MCVP and its predecessors. The improved profitability of $5/ha is also assumed to be less than shown in a wide range of similar studies. Previous simulation analyses of benefits have concentrated on the northern grain areas where both skill and opportunities can be more favourable to larger benefits.

3. Supporting projects.

The two projects account for 14 percent of GRDC investment in the cluster. The projects in this group were conducted in Western Australia and were designed to provide information to the grains industry to contribute to planning and policy. The climate change study used data generated by a GCM (Global Climate Model) to develop a more realistic scenario of the likely future impacts of climate change on the wheat industry.

The project on seasonal climate forecasting aimed to consolidate the research effort on an existing experimental forecast system that had been routinely made available since 2001. The forecasts were released in February each year to meet a grain industry need for improved long-lead information to plan the winter cropping program. The forecasts are based on the ENSO Sequence System (ESS), an experimental system to predict with a more useful lead-time. It compares indices of global atmospheric pressure and sea surface temperatures in the eastern Pacific to select the five most similar analogue years. The assessment of the skill of the forecasting system has not been finalised in a way that would lead to an assessment of value. As there is no feasible basis to assess the benefits of these projects in a quantitative sense, benefits will be considered qualitatively in the concluding section.

4. Collaborative MCVP Investment

The investment accounts for 46 percent of the GRDC investment in the cluster. GRDC was a major funder in MCVP contributing 38 percent of the funds invested by MCVP. Several MCVP projects target applications in the grains industry using APSIM (Keating et al, 2003). Some of these projects had generic aspects, for example developing ways to more effectively involve farmers in accessing and interacting with simulation models using data relevant to their farm.

Of the Rural R&D Corporations, GRDC has been the major contributor to the various phases of the applied climate variability research programs administered by Land and Water Australia. MCVP also had an increased emphasis on natural resource management over earlier phases of the program. Some of the projects pioneered more effective approaches in the grains industry using the capacity of the APSIM model to simulate deep drainage and nutrient losses, two important contributors to off-farm impacts from cropping enterprises.

The following summarises the approach to evaluating MCVP as detailed in the previous analysis (Agtrans and Agec Consulting, 2007). The analysis was done as part of LWA's Return on Investment initiative. Two farmer surveys in 2000 and 2002 (Climag, 2005) showed the rate of adoption as indicated by the proportion of farmers taking seasonal climate forecasts into account in decision making increased from 37.3 percent in 2000 to 44.7 percent in 2002, an increase of 3.7 percent annually. MCVP was assumed to result in a 5 percent increase in the proportion of farmers taking seasonal forecasts into account and this increase would be phased in over ten years. Benefits were assumed additional to those specified for analyses of the predecessor programs to MCVP. It was assumed that MCVP has made a difference by increasing the numbers who take seasonal forecasts into account from 50 percent to 55 percent. The proportion of farmers adopting the use of SCF that obtain dollar benefits from its use is assumed 10 percent. The level of profit for those obtaining financial benefits for those driven to adopt by MCVP would be 10 percent. The 10 percent profit increase is based on a range of analyses which show optimal returns for some specific decisions when there are significant shifts in probabilities.

Previous analyses have used an allowance to take account of forecast deterioration because of climate change. The allowance covers an actual erosion of skill as well as some loss in marketability from a perception of deterioration. There is little published information on decline in skill to date as would be expected given the relatively short period since forecasts were first developed. The Bureau of Meteorology (2006) has published a verification for the 2005-06 forecasts for their seasonal climate outlooks. Only a combined figure is presented for rainfall and maximum and minimum temperatures. The skill level of 59 percent compares with a no skill value of 50 percent for climatology. Given that temperature forecasts are known to be higher skill than rainfall, the actual rainfall forecast performance for that year appears to be little better than chance. Whilst it is difficult to generalise from one year for forecasts known to have low to moderate skill with high spatial and temporal variability in skill, it seems prudent to introduce a risk factor regarding future benefits. A 50 percent risk factor from the year 2012/13 has been assumed. The other widely used forecast is based on the SOI (Southern Oscillation Index). There in no published data on changing skill levels for the SOI. However the SOI has been clearly a good indicator of the 2007-08 La Niña event.

7.1. Counterfactual

The situation in the absence of the Climate Cluster ideally needs to be considered for each of the three benefit streams included in the analysis. There is a key common issue and that is the likelihood of the research being carried out by other organisations if GRDC had not funded the projects in the cluster. Experience shows that the agencies with the capacity to undertake the applied climate research involved have not undertaken significant research of this type without external funding. Although there is a clear industry benefit as in the Cluster Projects, no agency would fund the research on a commercial basis where the public good nature of the benefits is significant. Spillover benefits further reduce the likelihood of other funding sources being involved.

Two of the projects in the Cluster have a commercial involvement in the form of a public-private partnership. It is not yet clear how these will evolve when they are beyond the research phase. However it is clear that commercial agencies have not funded projects similar to those in the Cluster. It can reasonably be assumed that the Cluster projects have not simply brought forward a benefit that would have happened anyway.

The analysis was therefore undertaken by defining only the additional benefits that could be attributed to the investment. In the case of the frost projects, recognition was given of the extent to which farmers already make decisions in relation to frost so the emphasis was on the value of the additional information brought together by the projects.

7.2. Summary of Assumptions

A summary of the key assumptions made is shown in Table 7.

Table 7: Summary of Assumptions for the Three Streams of Benefits from the Investment in the Climate Cluster

Variable	Value	Source
Frost Projects (Increase compared to 'Without Frost Projects'))		
Area where frost damage can be economically reduced	100,000 ha	Based on average losses of $100m (Olsen, 2005), loss of $100/ha and 10% of average area damaged (Barry White)
Increased income from frost reduction measures	$10/ha	Based on examples in Rebbeck and Knell (2007)
First year of increased net income	2006/07	Barry White
Phase in of gains	Over 10 years from 2006/07	Barry White
Risk factor for benefits due to decline in value of information from climate change and new research	Decline gradually from 2016/17 so benefits halved by end of analysis	Barry White
Climate Cluster projects on seasonal climate forecasts (Increase compared to 'Without Projects')		
Additional area of grain where there are extra benefits from farmers taking seasonal forecasting into account	150,000 ha	1% of area of wheat and barley (Barry White)
Potential benefit/ha	$5/ha	Anwar et al (2007)
First year of increased net income	2006/07	Barry White

Phase in of gains	Over six years from 2006/07	Barry White
Risk factor for benefits due to forecasting deterioration	Decline gradually from 2012/13 so benefits halved by end of analysis	Agtrans Research
With MCVP - includes contribution from GRDC (changes only		
Additional proportion of Australian farmers that take seasonal climate forecasting into account	Added 5% due to MCVP	Reduced increase compared to annual trend from 2000 to 2002 (Climag, 2005)
Five year average net value of Australian farm production	$8.48 billion	ABARE Commodity Statistics (Table 17) for five years ending June 2006, expressed in 2006/07 dollar terms
Potential increase in profits	10%	Agtrans and Agec Consulting (2007)
Proportion of farmers taking seasonal forecasting into account that actually benefit	10%	Agtrans and Agec Consulting (2007)
First year of increased net income	2006/07	As above
Phase in of gains	Over ten years from 2006/07	As above
Risk factor for benefits due to forecasting deterioration	0.5 from 2012/13 to end of analysis	As above

8. Results

All past costs 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, notwithstanding a high level of uncertainty for many of the estimates. All analyses ran for the length of the investment period plus 25 years from the last year of investment (2007/08 to the final year of benefits assumed (2032/33).

Investment criteria were estimated for both total investment and for the GRDC investment alone. Each set of investment criteria were estimated for different periods of benefits. The investment criteria were all highly positive as reported in Tables 8 and 9.

Table 8: Investment Criteria for Total Investment
(discount rate 5%)

Criterion	0 years	5 years	10 years	15 years	20 years	25 years
Present value of benefits (m$)	1.58	13.05	24.45	33.45	40.04	44.83
Present value of costs (m$)	25.56	25.56	25.56	25.56	25.56	25.56
Net present value (m$)	-23.99	-12.52	-1.11	7.89	14.47	19.27
Benefit cost ratio	0.06	0.51	0.96	1.31	1.57	1.75
Internal rate of return (%)	negative	negative	4.4	8.0	9.4	10.0

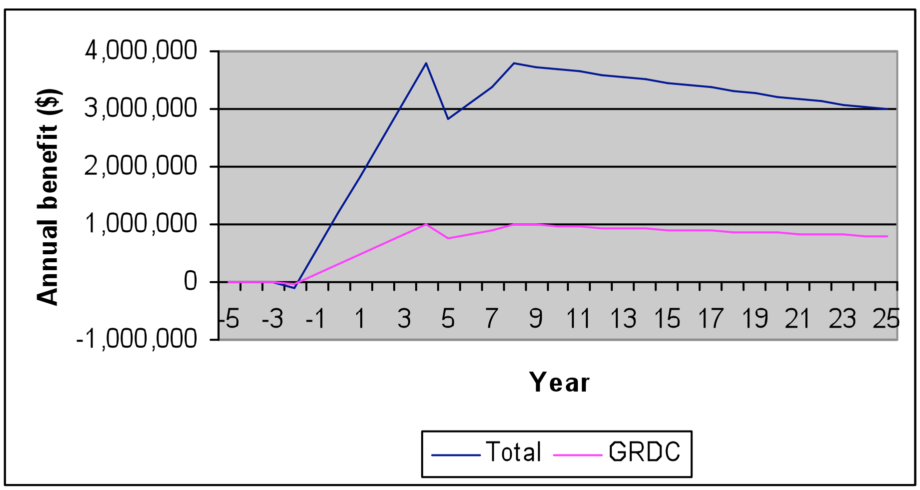
Table 9: Investment Criteria for GRDC Investment
(discount rate 5%)

Criterion	0 years	5 years	10 years	15 years	20 years	25 years
Present value of benefits (m$)	0.41	3.43	6.43	8.81	10.54	11.80
Present value of costs (m$)	6.87	6.87	6.87	6.87	6.87	6.87
Net present value (m$)	-6.46	-3.44	-0.44	1.93	3.67	4.93
Benefit cost ratio	0.06	0.50	0.94	1.28	1.53	1.72
Internal rate of return (%)	negative	negative	4.2	7.6	9.0	9.6

In terms of the quantified benefits, 100% could be attributed to the productivity and adding value component of the rural research priorities.

The cash flow of benefits is shown in Figure 1 for both the total investment and for the GRDC investment.

Figure 1: Annual Benefit Cash Flow



Sensitivity Analyses
The analysis will be most sensitive to assumptions relating to the potential size of the benefits and whether risk factors are included to account for various uncertainties relating to climate change generally and to the impact of climate change on perceptions of the value of seasonal climate forecasts. Sensitivity analyses were carried out on these two variables and results are reported in Tables 10 and 11. All sensitivity analyses were performed using a 5% discount rate with benefits taken over the life of the investment plus 25 years from the year of last investment. Sensitivity analyses were performed on

the GRDC investment rather than on the total investment. All other parameters were held at their base values when one factor was changed.

Table 10 provides the investment criteria when the expected benefits are either decreased by one third or increased by one third.

Table 10: Sensitivity to Assumption Regarding Magnitude of Benefits
(GRDC investment in cluster, 5% discount rate; 25 years)

Criterion	Annual Benefits Decreased by One Third	Base	Annual Benefits Increased by One Third
Present value of benefits (m$)	7.87	11.80	15.73
Present value of costs (m$)	6.87	6.87	6.87
Net present value (m$)	1.00	4.93	8.86
Benefit cost ratio	1.14	1.72	2.29
Internal rate of return (%)	6.1	9.6	12.5

The sensitivity of the investment criteria to completely omitting the risk factors due to climate change affecting current forecasting skill is shown in Table 12. While the prospective decline in forecasting skill is uncertain, the results show a moderately high sensitivity and demonstrate the importance of maintaining seasonal forecasting skill in the presence of climate change.

Table 12: Sensitivity to Whether Risk Factor for Climate Change Included
(GRDC investment in cluster, 5% discount rate; 25 years)

Criterion	Risk Factors Included (Base)	Risk Factors Excluded
Present value of benefits (m$)	11.80	18.01
Present value of costs (m$)	6.87	6.87
Net present value (m$)	4.93	11.14
Benefit cost ratio	1.72	2.62
Internal rate of return (%)	9.6	12.9

9. Conclusions

Cost-benefit analysis undertaken in this report indicates that funds invested in the Climate Cluster will generate a return from benefits that are well in excess of costs. The investment by GRDC is estimated to have provided a net present value of $4.93 million in 2006/07 dollar terms, a benefit cost ratio of 1.7 to 1 and an internal rate of return of 9.6%. The benefits were reasonably sensitive to a key set of assumptions on the uncertain extent to which the information generated would deteriorate as climate change impacts increase. Current information is based on historical analyses so that climate change is not incorporated.

The evaluation is conservative for a number of reasons. The benefits attributable to the value of the additional information generated by the Cluster are difficult to evaluate. They are only one part of a complex and largely intuitive decision processes used by farmers. The evaluation only included estimates of the economic benefits and did not attempt to quantify environmental benefits.

The three benefit streams considered included most of the projects. The fourth stream on climate change and forecast skill has value in terms of policy. Of the three streams, the investment in the collaborative program, MCVP dominated the results. The benefits were proportioned from a previous evaluation of MCVP. The relatively low return reflected that large gains had been made in the previous phase of MCVP. MCVP had a broad agenda as a catalyst to develop activities in new regions and industries, and to include natural resource management issues. Many of the activities were effectively capacity building and difficult to evaluate. A conservative top-down approach was used to evaluate MCVP whereas the other two streams in the Cluster used a more targeted bottom-up approach. The benefits from MCVP were also substantially reduced because of the possible impact of climate change on the accuracy and value of seasonal climate forecasts.

The investment stream on frost was evaluated by possible benefits from reducing crop losses. Climate change was also recognised as an increasing cause of concern in terms of likely frost frequencies and impacts. For example the benefits of planting later in autumn to avoid frost will eventually reduce as heat stress increases in spring. Benefits were reduced accordingly. The projects on using seasonal climate forecasts were all based on the use of cropping models so that other factors are integrated and the likely impacts of a seasonal climate forecast are amplified. The forecasts are thus more likely to be rapidly adopted, and they will retain more value if climate change does reduce forecast accuracy.

Conservative assumptions were also used in apportioning benefits from MCVP to the GRDC investment. This downplays the key role GRDC has had in the success of MCVP and its predecessors. GRDC has been the major investor of the RDCs. Both generic benefits and benefits to the grain industry have featured in MCVP, a program which is recognised as a leading example of the value of a collaborative approach. MCVP has had a key role in establishing Australian research as the world leader in climate risk management in agriculture and natural resource management.

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