# The National Climate Variability Program (NCVP) and the Climate Variability in Agriculture Program (CVAP)

(final as sent by PC Oct 06 in larger ROI file)

## Introduction

Australian agricultural production systems and processes are strongly influenced by climate since Australia is located in a climatic region of high variability. Generally, rainfall is both low and variable compared to most other agricultural producing countries. Understanding this variability and improving and responding to weather and climate forecasting are critical in Australia where the outcomes of land and water management decisions are strongly influenced by the variable climate. Recent recognition of the extent to which climate is already changing as part of global warming will place further emphasis on climate risk management.

The National Climate Variability Program (NCVP) (1992/93 to 1999/2000) had its origins in the National Drought Policy of 1992. The Commonwealth Government initially allocated $2.1 m over three years to Land and Water Australia (LWA) and the Rural Industries Research and Development Corporation (RIRDC) to jointly manage an R&D program under its National Drought Strategy Initiative. A range of funding partners, mainly Research and Development Corporations (RDCs), including LWA, contributed to the program. The funds were targeted initially to help farmers and their advisers prepare for and manage drought effectively.

Additional funding of $2.5m was allocated by the Commonwealth Government in 1995. The Commonwealth Government then further extended funding with $3.5 m from 1997 to 2001 through the Department of Agriculture, Fisheries and Forestry and its Agriculture -Advancing Australia (AAA) package. The program was renamed the Climate Variability in Agriculture Program (CVAP). The CVAP ran until 2001/02. The Commonwealth funding was supported by a range of RDCs including LWA, the Grains R&D Corporation (GRDC), the Rural Industries R&D Corporation (RIRDC), the Dairy R&D Corporation (DRDC) and the Sugar R&D Corporation (SRDC). LWA managed the overall investment in seasonal climate forecasting R&D over the period. These programs (NCVP and CVAP) were the only national source of external funding available specifically for applied climate research. As a consequence virtually all the significant research projects in climate applications were at least partly funded by CVAP and its predecessor.

## Investment Description

A list of CVAP projects is presented in Table 1.

Table 1: List of CVAP Projects 1993 to 2002

| **Code** | Title | **Start date** | **Finish date** | **Principal Investigator** | **Institution** |
|---|---|---|---|---|---|
| ABA1 | Drought and the economic performance of Australian agriculture | Jul 1993 | Jun 1994 | Steve Beare | ABARE |
| ARM1 | Insurance based risk management for drought | Jul 1993 | Feb 1994 | B Mayers | Agricultural Risk Management |
| BOM1 | Development of improved seasonal forecast systems | Apr 1993 | Jun 1995 | N Nicholls | Bureau of Meteorology |
| CEX1 | Drought monitoring of the Australian continent by satellite | Jul 1993 | Jun 1995 | R Smith | CSIRO Division of Exploration and Mining |
| CWE8 | Grazier based profitable and sustainable strategies for managing climate variability | Oct 1993 | Sep 1995 | M Stafford Smith | Division of Wildlife and Ecology |
| DAN6 | Optimum replacement of farm machinery under conditions of capital rationing | Jul 1993 | Jun 1995 | K Fraser | NSW Department of Agriculture |
| DAS12 | Decision support for climatic risk management in dryland crop production | Jul 1993 | Jun 1995 | J Egan | South Australian Research and Development Institute |
| MRC1 | Strategies for maximising the persistence of perennial grasses through drought | Jul 1993 | Jun 1996 | J Scott | CSIRO Division of Animal Production |
| QP120 | Development of a national drought alert strategic information system | Jul 1993 | Jun 1995 | K Brook | Queensland Department of Primary Industries |
| UNE 16 | Economic monitoring/forecasting of rural business | Jul 1993 | Dec 1993 | R Powell | University of New England |
| UNE17 | Analysing drought strategies to enhance farm financial viability | Jul 1993 | Jun 1986 | R Powell | University of New England |
| INF2 | Drought research in progress | Jul 1993 | Sep 1993 | P Handyside | Infoscan Pty Ltd |
| WRD1 | Exploring drought opportunities: control of | Jan 1994 | Jun 1996 | R Hacker | NSW Department of Agriculture |

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| | total grazing pressure in rangelands | | | | |
| CAR3 | Atlas of near-global ENSO and climatic variability since 1871 | Mar 1995 | Dec 1995 | R Allan | CSIRO Division of Atmospheric Research |
| DRD3 | Dairy El Nino risk management study | Aug 1997 | Oct 1997 | G Hayes | Virtual Consulting Group |
| COS1 | Coordination of Managing with Climate Variability Conference "Of droughts and flooding rains" | Jul 1995 | Dec 1995 | S Kruck | Conference Solutions |
| MAC1 | Farmers training needs for managing climatic risk | Oct 1995 | Dec 1995 | P Wylie | Macro Agricultural Consultants |
| ABA6 | Integrating climate forecasting into yield predictions for the agriculture sector | Jul 1995 | Oct 1996 | R Allen | ABARE |
| COR4 (general call) | Climate variability visiting fellowship | Nov 1996 | Nov 1997 | I Rothstein | CSIRO Marine Research |
| CWE14 | Planning and preparation for Phase II of Drought Alert (QP120) | Sep 1996 | Dec 1996 | M Howden | CSIRO Wildlife and Ecology |
| HAS2 | Review of National Climatic Variability R&D Program | Mar 1997 | May 1997 | D Bennett | Hassall and Associates |
| UME24 | Research and development opportunities for using seasonal climate forecasts in the Australian water industry | Nov 1995 | Nov 1996 | T McMahon | University of Melbourne |
| UQL9 | Second Australian Conference on Agricultural Meteorology | Jul 1996 | Oct 1996 | P Noar | University of Queensland |
| RDC4 | Australian farm families experience of the drought in the 1990s: a sociological investigation | Jul 1995 | Jun 1997 | G Lawrence | Central Queensland University |
| FRD2 | Climate and fisheries on the southeast Australian continental shelf and slope | Jul 1996 | Jun 1998 | T Koslow | CSIRO Division of Fisheries |
| QPI38 | Evaluating the role of seasonal climate forecasting in tactical management of cropping systems in north-east | Jan 1996 | Jun 1999 | R Stone | Queensland Department of Primary Industries |

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| | Australia | | | | |
| WRD2 | Extension of results of fertiliser research to graziers by development of a pasture nutrition submodule for Grass Gro | Jul 1996 | Aug 1998 | A Davey | International Wool Secretariat |
| RDC7 | Further development and application of AUSTRALAN RAINMAN to improve management of climate variability | Jan 1997 | Dec 1999 | J Clewett | Queensland Department of Primary Industries |
| COR2 | Development and testing of climate models for seasonal prediction for Australia | Jan 1996 | Dec 1998 | Gary Meyers | Bureau of Meteorology |
| SRD2 | Seasonal rainfall and winter crop yield forecasting for southern Australia | Jul 1996 | Mar 1997 | J Egan | SA R&D Institute |
| QNR3 | The Australian On-Line Agrometeorological Information Service (Weather Wise) | Oct 1996 | Jun 1999 | Alan Beswick | Qld Dept Natural Resources and Mines |
| AGE1 | Program management | 1993 | 2001 | Barry White | AGEC Consulting |
| AGE2 | Communications consultant | 1997 | 2001 | Barry White | AGEC Consulting |
| BOM4 | Improved climate predictions during El Nino events | Jul 1999 | Jun 2000 | William Wright | Bureau of Meteorology |
| BRR7 | Framework for analysing climate variability for policy | Sep 1998 | Jun 2001 | Greg Laughlin | Bureau of Rural Science |
| CIC5 | Promotion of Masters of the Climate case studies | 2000 | 2001 | Tim Powell | Cox Inall Communications |
| COR5 | Extended seasonal climate predictions using a dynamic climate model | Jan 1999 | Dec 2001 | Gary Meyers | CSIRO Division of Marine Research |
| CPA1 | CVAP Communications package | 1999 | 2000 | Thomas Parkes | Capital Public Affairs Consultants |
| CPA2 | CVAP Communications package | 2000 | 2001 | Thomas Parkes | Capital Public Affairs Consultants |
| CTC16 | From oceans to farms: integrated management of climate variability | Jul 1998 | Jun 2001 | Andrew Ash | CSIRO Sustainable Ecosystems |
| CTC18 | Better management of climate variability within | Oct 1998 | Sep 2000 | Peter Carberry | CSIRO Sustainable |

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| | the agribusiness service sector | | | | Ecosystems |
| CWE23 | Do government policy instruments support sustainable grazing on-farm? | Sep 1998 | Dec 2000 | Mark Stafford-Smith | CSIRO Sustainable Ecosystems |
| HAS5 | CVAP Review | 2001 | 2002 | David McClintock | Hassall and Associates |
| HRM1 | Improved management of climate variability on Australian grain farms | Aug 1998 | Jun 2001 | Peter Wylie | Horizon Rural Management |
| QNR24 | Silo II: Extension, marketing and industry focused product development | | | Alan Beswick | Qld Dept Natural Resources and Mines |
| QNR9 | AussieGRASS | Jan 1997 | Dec 1999 | Wayne Hall<br>Ken Brook | Qld Dept Natural Resources and Mines |
| QPI39 | Seasonal stream flow forecasts to improve management of water resources | Feb 1997 | Dec 1999 | N Clarkson | Qld Dept of Primary Industries |
| QPI42 | International workshop on farm management decisions with climatic risk | Jul 1998 | Dec 1999 | Rod Saal | Qld Dept of Primary Industries |
| QPI43 | CLIMARC-Computerising the Australian climate archives | Oct 1998 | Jun 2002 | Nick Clarkson | Qld Dept of Primary Industries |
| QPI44 | Can decadal variability (DCV) impact on cropping systems management | Oct 1998 | Dec 1999 | Holger Meinke | Qld Dept of Primary Industries |
| URS3 | Defining researching opportunities for improved applications for seasonal forecasting in South Eastern Australia with particular reference to the southern NSW and Victorian grain regions | 2001 | 2001 | Martin Andrew | URS |
| UWA21 | Innovative workshops to improve understanding of price and climate variability | Jan 1999 | Dec 2000 | Ross Kingwell | University of Western Australia |
| UWA23 | The influence of North-West cloud bands in Eastern Australian rainfall | 2001 | 2001 | Charitha Pattiaratchi | University of Western Australia |

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|---|---|---|---|---|---|
| VCE14 | Strategies to cope with climate variability in the perennial pasture zone of South-Eastern Australia | 1999 | 2001 | Stephen Clark | Department of Natural Resources and Environment |
| VCG5/ VIR5 | Improving the communication of climate information to dairy farmers | Oct 1998 | Jul 1999 | Greg Hayes | VCG Australia Pty Ltd |
| DAN12 | Survey of agricultural climate research, development and services in Australia | Jul 1998 | Feb 1999 | G Tupper | NSW Agriculture |
| SRC6 | Seasonal climate forecasting to improve industry competitiveness | Jul 1998 | Jun 2002 | R Muchow | CSIRO Tropical Agriculture |
| BOM3 | A century's perspective on climate variability and impacts on agriculture | 1999 | 2000 | S Power | Bureau of Meteorology |
| BOM5 | Effective implementation, adoption and utilisation of new climate model results | Jan 1999 | Jun 2001 | M Voice | Bureau of Meteorology |
| BOM6 | SILO tailored to users location and preferences for presentation | 2001 | 2001 | S Power | Bureau of Meteorology |
| CAG1 | Mid term review of CVAP | 2000 | 2000 | N Beynon | Capital Ag |
| CIC3 | Search for innovative adaptations to climatic variability | 1999 | 2000 | T Powell | Cox Inall Communications |
| QNR14 | Can seasonal climate forecasting prevent degradation of Australia's grazing lands? | Jul 1998 | Jun 2001 | G McKeon | Qld Dept Natural Resources and Mines |
| UQL20 | Seasonal climate information and farmers' risk assessment and decision making | Jan 1999 | Dec 2000 | L Dalgleish | University of Queensland |

## Investment Costs

Table 2 shows the relative contribution of the partners by year. The LWA contribution to the combined NCVP and CVAP programs over the eleven years from 1992/93 to 2000/01 was only a small percentage, with the majority of funding coming from the Commonwealth Department of Agriculture Forestry and Fisheries and other funding including that from GRDC, Dairy Australia, RIRDC, SRDC, Meat and Livestock Australia, Australian Wool Innovation, and Forest and Wood Products R&D Corporation. Some Corporations only funded projects targeted at their industries and did not contribute to generic projects.
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Table 2: Resources Invested in NCVP and CVAP by Year for LWA, Funding Partners, Third Parties and Researchers (nominal $)

| Year | LWA | CVAP (excludes contribution from LWA) | Researchers | Third parties | Total Program |
|---|---|---|---|---|---|
| 1992/93 | 0 | 44,600 | 52,350 | 4,400 | 101,350 |
| 1993/94 | 0 | 1,438,817 | 1,802,131 | 1,541,415 | 4,782,363 |
| 1994/95 | 0 | 1,157,075 | 1,786,712 | 1,691,341 | 4,635,128 |
| 1995/96 | 33,333 | 631,916 | 350,954 | 211,500 | 1,227 703 |
| 1996/97 | 33,333 | 1,399,490 | 1,252,270 | 1,137,922 | 3,823,015 |
| 1997/98 | 33,333 | 1,307,551 | 1,244,380 | 1,371,792 | 3,957,056 |
| 1998/99 | 205,590 | 1,959,914 | 2,357,046 | 1,803,065 | 6,325,615 |
| 1999/00 | 109,300 | 1,346,232 | 1,536,544 | 1,138,894 | 4,130,970 |
| 2000/01 | 100,000 | 1,049,734 | 1,136,496 | 817,044 | 3,103,274 |
| 2001/02 | 0 | 711,343 | 395,132 | 478,443 | 1,584,918 |
| 2002/03 | 0 | 39,941 | 0 | 0 | 39,941 |
| Total | 514,889 | 11,086,613 | 11,914,015 | 10,195,816 | 33,711,333 |

Source: LWA and Barry White, pers. comm.,2006

## Principal Outputs

CVAP (from here on this term includes NCVP as well as CVAP) supported the development of a range of information and products during the nine years of the investment analysed. CVAP was planned to build on (but not be limited to) the relatively recent developments in seasonal forecasting, particularly the forecasts that evolved from the improved understanding of the El Nino pattern. CVAP, as an applied climate research program was thus a relatively new focus for research. The program portfolio therefore emphasised generic approaches and tools together with capacity building to increase confidence in the understanding and use of seasonal climate forecasts.

The outputs from the CVAP can be summarised as:

- Improved seasonal outlook forecasts from both improved statistical input and improved coupling of atmospheric and ocean models.

- Integration of seasonal outlook forecasts with management decision making in farm management, agribusiness management and in natural resource management (e.g. the agricultural production systems simulator - APSIM, and the AussieGrass and Streamflow packages).
- Enhanced availability of continuous historical climate data itself with an improved presentational format with advantages for decision makers requiring data for use directly in different applications (SILO).
- Increased availability of communication products associated with climate including the CLIMAG newsletter and Fact Sheets
- A range of knowledge, products and tools emanating from joint projects with the commodity specific RDCs including grains, sugar, and dairy.

**Improved Seasonal Forecasts**

Seasonal climate forecasts had only been available for a few years when CVAP commenced. The Bureau of Meteorology (BoM) launched a seasonal outlook in 1989 based on the Southern Oscillation Index (SOI) and the then QDPI promoted a similar product based on five phases of the SOI (Stone and Auliciems, 1992).

CVAP has produced or contributed to improved seasonal outlook forecasts from applied research on improved statistical approaches and strategic research on improved coupling of atmospheric and ocean models. Through improved coordination of research CVAP has contributed to approaches that demonstrate the value of forecasts, particularly by the evaluation of strategies and decision rules using simulation models driven by the historical rainfall record. The forecasts are now seen as more relevant and have a wider coverage in terms of regions and industries. Specific outputs include:

- The BoM seasonal outlook forecast based on sea surface temperature in the Indian and Pacific Oceans
- Improved capacity of APSIM to demonstrate the value of seasonal forecasts in a wide range of regions and industries
- Software package such as RAINMAN and RAINMAN (Streamflow version) that maintain a data base for 3,800 Australian locations so that users can undertake analyses of local rainfall patterns using the SOI and sea surface temperatures
- Readily accessible climate data bases such as SILO which contain continuous meteorological records developed by interpolation to fill data gaps

*Example*

The Seasonal Outlook produced by the National Climate Centre of BoM commenced in 1989. These forecasts used simple linear lagged regression methods to predict rainfall ahead from the SOI, a long established and simple measure of the EL Nino-Southern Oscillation (Nicholls, 1998). The new seasonal outlook forecast commenced in October 1998. The statistical results linked predictions for climatic parameters (rainfall and temperatures) 3 months ahead to changes in Pacific and Indian Ocean sea surface temperatures. The Pacific Ocean sea surface temperatures are correlated with the SOI while the new information from the Indian Ocean has been used to improve seasonal and spatial coverage of seasonal forecasts.

The new information gave more confidence for many users in the three month seasonal forecasts because the Indian Ocean was seen to be an important influence particularly across southern Australia.  There was a perception that the SOI was more effective in northern Australia where it had been more widely promoted.  The Bureau forecasts can now be provided at least two weeks prior to the start of the target season, rather than during the target season. The system is also claimed to be more robust than the SOI method on the basis that sea surface temperatures are less volatile than the SOI which is based on atmospheric pressure gradients.  The forecast coverage was expanded to include seasonal temperature forecasts that had not previously been available.  Temperature forecasts are more accurate than rainfall forecasts because they are less subject to local and short term variations compared with rainfall.

The CVAP investment advanced coupled modelling in Australia in two projects that were undertaken by two CSIRO Divisions and in collaboration with BoM. This investment included improving an atmospheric model as a rainfall prediction tool and improving an ocean model with regard to currents near Australia. These two models were then coupled to produce a climate prediction system.  The coupled model displayed moderate prediction capability of observed climatic characteristics when run over several ENSO cycles (eg sea level pressure, sea surface temperatures and rainfall anomalies over the ocean).  In the medium term, the coupled model approach is the preferred approach to seasonal forecasting because of the longer lead times likely to be available and because coupled models are likely to be more robust in accommodating climate change aspects.

Although detailed information on the number of producers who use seasonal climate forecasting (SCF) beneficially is limited, longitudinal surveys conducted for the AAA program (unpublished, Solutions Marketing and Research 2000 and 2002) have demonstrated a high and increasing level of awareness among producers of the forecasts (Climag, 2005).  In industries such as sugar and cotton, over 60 per cent of farmers report that they take seasonal climate forecasts into account in farm management. The national surveys of 2,500 farmers showed that from 2000 to 2002 (a major drought year) the proportion of farmers in Queensland and New South Wales taking forecasts into account increased from 44 percent to 50 percent.  The corresponding figures for the other States were from 30 per cent in 2000 to 40 per cent in 2002. The two most common decisions involved were for crop inputs and livestock management.  A survey in the Hassall's Review of CVAP (2002) indicated farmers had reported 93 different applications of the use of seasonal forecasts.

Other more detailed industry surveys have shown increased use of seasonal climate forecasts by producers and water managers, as well as improved risk management.  The surveys have shown that a high proportion of farmers have difficulty in interpreting probability-based forecasts but they have developed a basic and very general understanding of the importance of El Niño in shifting rainfall probabilities (Keogh et al 2004 a, b).

The proportion of farmers taking account of seasonal forecasts can be seen as indicating rapid adoption over the period from when forecasts first became available in the late 1980s. Limited accuracy is the most common reason farmers give for not taking forecasts into account. For example, during an El Niño event, a forecast may show a greater than usual chance of below average rainfall for the coming season. The outcome will vary spatially, for example from below average to above average in some locations. Experience with CVAP, for example the Masters of Climate (2005), shows that as farmers become more experienced in using seasonal climate forecasts, they use forecasts less for picking the likely outcome and more for ensuring they have managed the risks associated with above and below average rainfall seasons.

Given the probabilistic nature of seasonal forecasts and the large variations in their accuracy and perceptions of their accuracy, it is not surprising that many farmers have been slow and even reluctant to use them routinely. In many regions and industries, the forecasts do not provide much additional information at critical decision times. In other regions, the value of the forecasts needs to be considered in relation to other key factors such as soil moisture reserves.

The seasonal forecasts that are widely promoted have been developed from long periods of record. Independent assessments of how they perform are necessarily limited by the short period of operational use. For the Bureau forecasts it has been shown (Fawcett, pers. comm. to Barry White, 2005) that despite the relatively short period of forecasts available for verification, the Bureau forecasts have proved to be generally reliable and to have shown modest forecast skill which is consistent with expectations from hindcast validation and theory. This conclusion contrasts with that of Vizard *et al* (2005) which showed that for four of the twelve monthly forecasts, the forecasts had limited value compared with perfect knowledge.

While the AAA survey showed that only 10 per cent of farmers were aware of CVAP, the CVAP did not have a major role in the promotion and distribution of seasonal climate forecasts. The CVAP role was more indirect in terms of funding R&D projects used by agencies, capacity building and increasing confidence in the use of forecasts through better understanding of their value in decisions relevant to farmers.

## Modelling for Management Decision Making

*General*

Seasonal climate forecasts are particularly useful when forecast information can be used in a climate risk management context to guide industry decisions (e.g. forward selling, fertilizer amount and timing, time of sowing, varieties etc stock sales, whole range of industry operations such as harvesting, and planning decisions that affect taxation). Most focus has been on farm economics although many decisions that may be influenced can impact on environmental and social issues.

Products to improve climate risk management have aimed to demonstrate the local relevance and value of seasonal forecasts and how new information can be integrated with what are usually long established approaches to managing climate-related risks.

Many farmers use forecasts to take account of increased drought risk in their industry which may influence livestock prices or feed availability. For example the eight most severe droughts in production terms in the grain industry have all been in El Niño years. In recent years, and particularly since the record temperatures during the 2002 drought, there has been increased recognition of the extent to which climate change is already occurring. The two most relevant issues for CVAP are its role in preparing farmers to better adapt to climate change and the extent to which forecast accuracy is compromised by climate change.

The tools developed by CVAP will have a central role in the studies being undertaken on regional impacts and adaptation to climate change. The forecast issue is more complex. Although difficult to assess in the short term, monitoring has not shown any marked change in forecast performance. On the other hand if climate change is amplifying the El Niño influence, then that might even tend to increase forecast accuracy.

*AussieGrass*

A range of products have emerged from AussieGrass, particularly for applications in drought monitoring and grazing management. As of 2001, some 28 products (mainly maps) were identified/developed for each State and the NT including some Australia wide maps (Hall et al, 2001). Since October 2002 outputs from AussieGRASS have been available on a web site and are updated monthly (www.longpaddock.qld.gov.au). These include rainfall, pasture growth and pasture biomass, actual and relative to other seasons. Products include:

- Various maps for each State showing information for recent past periods and expected in the next three months, relative to the long-term averages; maps include those for rainfall, pasture biomass, and pasture growth;
- Queensland monthly report of seasonal conditions in Queensland where model outputs are presented in conjunction with recorded and forecast rainfall, satellite imagery, SOI and current and drought declarations to build a comparative picture of the current and future seasonal conditions;
- A four page colour leaflet mailed out each month to subscribers.

One of the major applications for AussieGrass has been its use in assisting with submissions by the States on Exceptional Circumstances for drought funding from the Commonwealth. To attract this funding, submissions from the States have to make a case that the region or industry is suffering hardship and that the event has been rare and severe. This means that information is needed for such submissions. AussieGrass was used by a range of states (WA, QLD, NSW and SA) for submissions regarding exceptional circumstance provisions in the 2001/2004 drought. The use of AussieGrass gave greater objectivity and assurance to submissions and to subsequent decisions made.

With regard to grazing management, AussieGrass can assist landholders to better understand management systems, optional responses and implications so that they can better cope with various climatic conditions. The projected desirable outcomes include the advantages of earlier disposing of surplus animals, experiencing less mortalities, maintaining a core breeding herd and being in a sounder financial condition at the end of a drought. For example, in the 2002 El Nino period there was strong reinforcement for those using AussieGrass to destock. Also, the concept of “safe carrying capacity” can be promoted by reference to AussieGrass with drought alerts issued that may have a significant lessening of environmental impacts during major droughts.

Uses of these products in the sustainability and environmental area include:

- A land degradation alert that identifies areas where the resource base is at risk e.g. low rainfall, low pasture availability and high stocking rates; and
- An environmental calculator, such as predicting methane emissions from predictions of pasture growth and quality, and numbers of animals.

*Developing APSRU capacity to incorporate seasonal climate forecasts*
Two major CVAP projects made substantial contributions to the capacity and credibility of the Toowoomba-based APSRU group to expand applications of seasonal climate forecasts in numerous regions and industries around Australia. For example, there are several grain industry projects in the current Managing Climate Variability (MCV) Program which have origins in projects undertaken during the 1990s.

QPI38 was a major project undertaken with GRDC to improve the capacity of APSIM in assessing seasonal climate forecasts. The project developed approaches which have since been widely used by working with farmers in case studies to examine a range of cropping options. Recognition of the vast number of combinations of crops, varieties and agronomic factors gave rise to the Whopper Cropper concept and to its recent uptake in other regions.

CTC18 was a project with CSIRO which aimed to develop potential new markets for CVAP products in the agribusiness sector. Previously the CSIRO APSIM group had concentrated on farmer level applications and these could only reach a limited audience. As part of the current MCV Program, CSIRO have now developed licensing arrangements for use of climate risk management tools based on APSIM with intermediaries such as the Birchip Cropping Group. The tools had previously been further developed by APSRU as part of a FarmBiz project funded by AAA. In 2005 there were 236 subscribers through the Birchip Group.

*Rainman and Rainman Streamflow*
RAINMAN is a tool for producers, extension officers and other businesses to use to assist decision making regarding climate risk and the application of seasonal forecasts. Rainman was first produced in 1991 and 2,100 copies have been distributed. Total usage of the software is estimated at 10,000 people. Users of the software include primary producers, government and private extension services, research and education professionals and business people from the agricultural, construction, tourism, health, mining and financial sectors.

The original investment in RAINMAN applied to Queensland only and was developed by QDPI supported by the Bureau of Meteorology in 1991. QDPI further developed RAINMAN for a national coverage supported by RIRDC.

The CVAP funded component of RAINMAN largely relates to the development of Streamflow. This project ran from 1 Feb 1997 to 31 March 2000.The objective was to develop methods of forecasting streamflow, assemble a national streamflow and run off data set, work with water managers to asses the value of streamflow forecasts, and to build a communications program that would improve water management practices. The data, new forecasting tools and modified software were launched nationally in a Streamflow supplement to Australian Rainman in November 2001.

Streamflow includes data for more than 400 gauging stations throughout Australia and allows users to examine historical records of streamflow and forecast seasonal streamflow based on the SOI and other predictors. It can be used to assess water availability for pumping under licence conditions such as when, how often and how much (Hassall and Associates, 2002, p 57).

Pilot studies found that the value of forecasting depended on the opportunity to change water use or business decisions. The full benefit of forecasting may not be available where a catchment is dominated by a large storage or where some external policy constraint affects water availability.

*DroughtPlan*

DroughtPlan was a major initiative to manage rainfall variability. Nine products were developed regarding financial management and long and short term stock management decisions. There is a CD ROM available with products (launched March 1999) including safe stocking rates, seasonal forecasting, nutrition etc. The CD contains much of the information and decision support produced. There is a network of about 250 producers, agency personnel and researchers across Australia. The project involved CSIRO and QDPI (QICA) and ran for two years.

Some of the products are region specific creating difficulties regarding assessing adoption levels overall. For example, the Safe Carrying Capacity output has been adopted widely, especially in south western Queensland. It has also been adapted later to the Mitchell Grass country in central and north western Qld and some principles may have reached the Northern Territory. Cobon (pers. comm., 2005) believes that the 30 or so case studies on how industry leaders manage climate variability were also a very useful output. Some of the other outputs from DroughtPlan have been used in conjunction with other products (eg Rainman, pasture growth models).

Cobon (pers comm, 2005) believes that some 3,000-5,000 pastoralists may have been influenced in some way; some perhaps from principles that emerged later than the actual products.

A number of outputs were produced from the investment in the two years, but many have been subsequently developed further so the latter are not necessarily directly attributable to DroughtPlan. It would be difficult to assemble data to support assumptions on productivity, profitability or sustainability changes.

**Enhanced Data Availability**
SILO is an internet web site initiated in 1997 to make national meteorological data more accessible to decision makers, researchers and to those in the educational area, with special emphasis on those involved in agricultural activities. It was established to produce an information service that would encourage greater focus on climatic risk management techniques by landholders and agribusiness. The interface provides weather reports, rainfall, temperature and solar radiation information, rainfall deficiency maps and drought statements, seasonal climate outlook information, patched point datasets to produce continuous meteorological information, and data drills that provide synthetic meteorological data for any location in Australia.

The CLIMARC (Computerising the Australian Climate Archives) project has made a major contribution to availability of longer term data of particular value where a long term perspective requires simulation studies and in climate change analysis. The project has computerised the daily climate records for 51 key climate locations across Australia. Previously only rainfall records were available on a daily basis prior to 1957. The CLIMARC data, together with other pre-1957 daily climate data, have been spatially interpolated and the new pre-1957 daily climate surfaces have now been incorporated into the SILO Patched Point Dataset and Data Drill.

**Communication Products**
The major communication outputs were launched in 1998-1999. These included the newsletter CLIMAG, factsheets and the CVAP website with visits averaging 2,500 pages/month. CLIMAG has a distribution of over 4,000 and a high degree of reader satisfaction has been maintained. A survey with 273 respondents showed 80 per cent of readers either agreed or strongly agreed with a range of positive statements on CLIMAG content. Success was further indicated by the 72 per cent of readers intending to follow up on articles covered in CLIMAG. Factsheets were developed at the start of all projects and updated at the end of the project (available on www.cvap.gov.au)

**Regional and Industry Examples**
*Sugar Industry*
A seasonal forecasting system for the sugar industry was developed that gave prospects for rainfall in coming seasons in different locations. The 5 phase SOI system as developed by BOM was the benchmark system adopted due to its use of analogue years, although the 9 phase system incorporating sea surface systems was considered. An updated historical climate data base was also developed.

The project provided probabilities and forward indications of significantly wetter or drier harvest periods that may potentially disrupt mechanical harvesting and sugar supply.

Statistical relationships between yield estimates and forecasts and key climatic indicators were developed.

There is now greater appreciation of some of the critical decision areas that may be addressed by those managing different parts of the value chain, for example, those involved in marketing raw sugar (e.g. forward selling, organisation of sugar shipments), planning mill start dates and planning for wet weather disruption, the scheduling of the harvest in terms of which crops in which areas may be best harvested first, and improved irrigation planning leading to better use of scarce water resources.

The potential for improved decision making resulting in enhanced profitability in the industry has been demonstrated by an economic analysis of the value of seasonal forecasting in the Herbert region covering cane farming, harvesting and milling decisions. This study was carried out in conjunction with the Herbert Seasonal Forecasting Consultation Committee. The analysis was based on the 1998 season, a La Nina event and a particularly wet year for most of the industry. It compared what actually happened in that year with what could have occurred if perfect knowledge of the seasonal climate characteristics had been known beforehand. This suggested a saving of $19 million for that particular year across the industry. But seasonal forecasts are by no means perfect so that this benefit would represent a potential, but at this stage, an unrealistic benefit. When decisions based solely on the actual forecasts were used, there were no savings but these decisions were unrealistic as they assumed uniform rainfall over the whole of the Herbert as only one set of weather station records for the whole region was used. This limited flexibility in simulated decisions, compared to what would have been the case, is reflected in the decisions that were actually made in that season. For example, simulated harvesting was forced to stop after rainfall was received at the one station. When corrections were made to allow for variations within the region, the savings fell from $19 million to $1.7 million for the 1998 season, reflecting the low predictive skill of the forecasts.

A survey suggested that about 10% of those in the Herbert were using seasonal climate forecasting in their decision making.

While most of the outcomes are economic in nature, some environmental outcomes have been achieved in relation to planning more effective water management strategies. Social outcomes in terms of capacity building for decision making are apparent, in particular building the understanding that working together along the value chain is necessary to take maximum advantage of additional information on seasonal climate expectations.

*Dairy*

Concern at the potential impacts of the El Niño that developed rapidly in mid 1997 resulted in a study of the potential impacts and response strategies (VCG, 1997). Pasture simulations demonstrated likely impacts on pasture production. The major impact on the industry was likely to be reduced profitability due to substantial increases in purchased feeds to maintain milk production. For the worst scenario, increased feed purchases of over $400m were possible. Preferred tactical approaches were demonstrated using a pay-off matrix to compare alternatives using expected values. The project identified that dairy farmers in general had a limited understanding of seasonal climate forecast and how they might be used in a risk management context. However by 2002 there was a substantial increase in the number of dairy farmers taking seasonal forecasts into account.

**General**

A review of the program in 1997 (Hassall and Associates, 1997) concluded that many of the projects had yet to contribute to improved resource management. A Planning Workshop in 1997 developed a new strategy with more user involvement and the application of information to management decisions and with a major focus on applications in seasonal climate forecasting (1-6 months ) (LWA 1998).

A second review by Hassall and Associates (2002) concluded that the program had made considerable progress in relation to developing improved understanding of climate variability and developing specific products that are relevant to the agricultural sector. The review reported that the need to focus more on adoption was a persistent theme delivered by stakeholders.

## Principal Outcomes

CVAP has resulted in improved seasonal forecasts and increased confidence by many decision makers in rural industries and servicing organisations from an enhanced understanding of the use of seasonal climate forecasts. Seasonal forecasts are now seen as more relevant and have a wider coverage in terms of regions and industries.

Many of the models supported by CVAP (AussieGrass, Rainman Streamflow, APSRU model, DroughtPlan) are being used in the industry for a range of purposes. Many farmers use forecasts or models encompassing seasonal forecasts to take account of increased drought risk in their industry which may influence livestock prices or feed availability.

CVAP has provided an improved understanding of climate variability by a large number of people operating in the agriculture sector. Further, the program has produced a range of outputs and products that can be used to advantage in decisions that involve climate. The program has given a national focus for climate risk management.

## Benefits Associated with the Investment

The Hassall and Associates final review of CVAP (Hassall and Associates, 2002) identified the following counterfactual scenarios (without CVAP):

- Fewer products would have been available for use
- Farmers would not have had the necessary tools and understanding in order to become more self reliant and better managers of climate risk
- There would have been a lack of coordination of climate variability R&D and less networking between agencies and R&D groups

The review also recognised that despite the last few years of CVAP giving more attention to understanding what influences farmer decision making, the level of uptake of information and tools was still a major issue and a greater focus in future in extension and communication activities was needed, as was further investigation of the prospects for addressing enhanced natural resource management outcomes.

**Economic Benefits**

The most readily evaluated benefits that have been derived from the investment in CVAP have been largely through improved management by those who take seasonal forecasts into account in their decision making. This implies benefits such as higher average profitability via crop yields, lowered drought management costs, water savings, or less financial risk. However there is anecdotal support for the role that increased awareness of the major cause of climate variability has in itself promoted a better informed approach to climate risk management simply from a greater awareness of the inherent variability. Specific benefits from seasonal climate forecasts may arise from:

- drought planning that may not only reduce financial losses, but also may reduce land and water degradation (e.g. land use decisions, earlier destocking etc)
- higher profits by cropping farmers over the long term if notice is taken of the seasonal predictions via time of sowing, variety choice, fertiliser policies etc
- the pastoral sector where improved destocking and restocking decisions may be developed for improving profits, reducing variability and improving sustainability of soil and pasture resources
- higher level of income for producers due to avoidance of forced destocking at adverse times and quicker pasture recovery and restocking after a drought event
- the extent and timing of pasture sowing where seasonal conditions after establishment may determine the rate of establishment and the ultimate strength of the sward
- crop forecasting where decisions of producers, input supply groups, handling authorities, marketing groups and in some cases, governments, are all dependent on crop forecasts
- improved efficiency of use of drought support via the submissions made regarding Exceptional Circumstances; for example the impact would be greater for the same resources expended or the same impact could be generated with less resources; and
- the emergency services sector through improved planning and timeliness of preparedness messages
- hydro-electricity generation decisions regarding spike supply and interaction with irrigation and environmental flow requirements
- more effective resource planning and management for water applications with benefits to irrigators and the environment

The most common approach to evaluating seasonal climate forecast has been by using simulation models to compare various strategies. Hammer (2000) suggests that typical increases in profit (as indicated by a gross margin) from using a forecast in a specific way are of the order of 10-15 %. This difference takes into account the risk as measured by chance of making a loss. Estimates of benefits are complicated by the need to take risk into account. For example Lythgoe et al (2004) reported that farmers in south eastern

Australia can increase profit without increasing the risk of making a loss by adopting a seasonal climate forecast to tune crop nitrogen nutrition.

Robinson and Butler (2002) showed that it was difficult to generalise on the benefits from using SOI phase forecasts. Their analysis tested results using independent data but was limited to decisions at two locations for a specific time of planting. Most benefits were associated with one of the five SOI phases (SOI negative). There is substantial spatial and temporal variability in the SOI phase forecasts and this is reflected in their evaluations. Most of the major shifts in probabilities are limited to the El Nino and La Nina years.

Leath (pers. comm. to Barry White) has shown in a LWW survey of graziers that a shift from a 50% chance of above median rainfall to about 65% is sufficient for graziers to rank forecasts as useful to very useful. Shifts of this magnitude are not uncommon during El Nino and La Nina years at a wide range of locations particularly in eastern Australia. White (2004) showed using a simple expected value Cost/Loss approach that forecasts of a 65% chance (in terms of odds about 2 to 1) could be quite profitable. In general the per cent return on extra costs to protect against a low rainfall period can be up to twice the percentage shift in the probability.

What can be concluded from the above analyses is that benefits depend heavily on the shift in probabilities, and the relative magnitude of the cost and losses involved in the decision compared to an alternative approach.

The studies that have been done are typically prescriptive in that they show what the decision should be in a specific decision situation, for example a crop choice for a particular location in a particular month. Descriptive studies describing what farmers actually recall doing intuitively are usually not able to directly link a specific decision to a forecast in an objective way.

**Environmental Benefits**

Drought planning has the potential to benefit from improved seasonal climate outlooks through ground cover management via stocking rate adjustments accompanied by lower land degradation impacts with a reduction in soil loss and erosion. The management of allocation of water resources to the environment/irrigators and the use of flushing flows in rivers to manage algal blooms are also examples of potential environmental benefits. The timing of natural resource management initiatives such as tree planting can be assisted by improved seasonal forecasts.

Simulation analyses of grazing systems have included performance criteria relevant to soil loss and pasture utilisation. Ash et al (2000) concluded that increased animal production derived from applying a forecast is not at the expense of the resource base. Also, if the aim was more to reduce production risk rather than increase production, significant reductions in soil loss could be achieved.

**Social Benefits**

Some direct uses of seasonal outlook improvements may benefit individuals (for example, holiday planning) but individual social benefits are more likely to be generated through improved planning in other sectors such as emergency services preparedness and increased safety and reduced personal losses through extreme climatic events such as floods and fires.

The greater understanding of climate variability and the selective use of the tools generated by CVAP can produce social benefits such as:

- Improved capacity of land managers to plan ahead and manage uncertainty
- Reduced social stress of landholders and managers due to more objective information used in drought assessments
- Greater cohesion in society through less potential for the drought assistance system to be abused

There are reports that the initial investments in climate applications R&D by several organisations were encouraged because there was a national program that gave the new field of research credibility and status. Other climate research infrastructure developments linked to the CVAP investment include the NSW Agricultural Climate Applications Unit and the Queensland Institute for Climate Applications.

A summary of the types of benefits emanating from the investment in CVAP is provided in Table 3

Table 3: Summary of the Economic, Environmental and Social Benefits from the Investment in CVAP

| Economic | Environmental | Social |
|---|---|---|
| Increase in average level of profits for farm businesses | Improved sustainability of land and pasture resources | Reduced stress for land and water managers due to more objective processes in decision making and being able to plan ahead. |
| Decreased farm income variability | Reduced wind and water erosion and soil export to waterways | Greater equity between landholders in drought support decisions |
| Improved success rate of improved pasture establishment | Improved understanding of the patterns of climate variability to inform natural resource management decisions | Improved personal capacity of land managers to manage climatic variability |
| Improved planning for agribusiness (e.g. physical inputs) | Improved success rate for tree planting for natural resource management purposes | |
| Improved management of water storages for irrigators | Improved allocation of water to the environment | |

| | | |
|---|---|---|
| More efficient and effective government policies for delivery of drought support | Improved forecasting for bushfires | |
| Improved management processes for non rural sectors such as electricity generation and emergency services | | |

## Quantification of Benefits

### Past Analyses

Some analyses of constituent CVAP projects have been undertaken in the past by Agtrans as part of the LWA Portfolio Analysis Program. These include those concerning Indian Ocean Forecasting (2003) and AussieGrass (2005). Other analyses reported here include "Seasonal Climate Forecasting for the Sugar Industry" (Agtrans Research, 2004). Two other unpublished studies by Agtrans were "SOI based forecasting and extension for northern wheat production" (Agtrans Research, 1997a), and "SOI based forecasting systems and extension for sunflower, sorghum and cotton production" in the same report. Other studies reported here include those of Black (undated), Petersen and Fraser (undated), and Edward and Kingwell (2003). A brief summary of the results from these studies are presented here.

The two analyses already conducted as part of the LWA Portfolio Evaluation initiative are:

*1. The contribution of Indian Ocean Information to Climatic Forecasting in Australia Projects BOM1, COR2 and COR5.*

The return to a nominal research investment of $6.6 m over the period 1993 to 2002 produced a conservative return of 12% with a benefit-cost ratio of 2 to 1. This estimate excluded significant strategic knowledge produced that could enhance future applications.

Other benefits not quantified included increased adoption of more efficient water storage strategies. The investment criteria (at a 6% discount rate) for this investment are presented in Table 4.

Table 4: Investment Criteria for Indian Ocean Forecasting
(discount rate 6%; $ terms 2002/03$; discounting to 2002/03 year)

| Criteria | All Benefits |
|---|---|
| Net Present Value | $10.2 m |
| Internal Rate of Return | 12.4% |
| Benefit to Cost Ratio | 2.0 to 1 |

*2. Australian Grassland and Rangeland Assessment by Spatial Simulation (AussieGrass) Projects QPI20, CWE14, QNR9, QNR3, QNR24.* The investment criteria (at a discount rate of 6%) are presented in Table 5.

Table 5: Investment Criteria for AussieGrass
(discount rate 6%; $ terms 2004/5$; discounting to 2004/05 year)

| Criteria | All Benefits |
|---|---|
| Net Present Value | $54.8 m |
| Internal Rate of Return | 29% |
| Benefit to cost ratio | 3.7 to 1 |

A third CVAP investment already analysed is one co-funded by the Sugar Research and Development Corporation (SRDC) with CVAP:

*3. Seasonal Climate Forecasting to Improve Industry Competitiveness. Projects CVA 001 and CTA 036 (SRDC projects).*
The investment criteria (at a 5% discount rate) are presented in Table 6. The investment ran from 1999 to 2003 and totaled $1.4 m (nominal). Conservative assumptions were used regarding the level of benefits along the value chain and included growing, harvesting and milling decisions. Results showed a benefit-cost ratio of 3.4 to 1 and an internal rate of return of 17%. Some environmental benefits were also achieved in the form of planning more effective water management strategies, but these were not valued in the analysis.

Table 6: Investment Criteria for Seasonal Climate Forecasting for the Sugar Industry
(Discount rate 5%; $ terms 2002/03; discounting to 2002/03 year)

| Criteria | All Benefits |
|---|---|
| Net Present Value | $3.78 m |
| Internal Rate of Return | 17.59% |
| Benefit to cost ratio | 3.4 to 1 |

A summary of other economic analyses is given in Table 7.

Table 7: Summary of Other Benefit-Cost Analyses of Investment in Climate Science and Applications

| Author(s) | Description of analysis | Findings |
|---|---|---|
| Black (undated) | Ex-ante analysis of SARDI climate risk management program (1998-2010) for low rainfall cropping systems | B/C Ratio was 20 to 1. As well as industry efficiency benefits, benefits to environment (less top soil loss due to lesser areas of planting in dry years) and to the regional community |
| Petersen and Fraser (undated) | Ex-ante analysis of seasonal forecasting technology for WA farmers | Assumption of a decrease in uncertainty by 30% provided an increase of 5% in expected profits and a decrease in variability of profits; aggregate profits would amount to $2 m per year in one small wheat growing area of WA. |
| Edward and Kingwell (2003) | Ex ante analysis of benefits to wheat growers in WA from investment in seasonal forecasting | Using conservative assumptions, the B/C Ratio was 3 to 1. Benefits to industry (agribusiness) were greater than on-farm benefits due to forward planning in harvesting. |
| Agtrans Research (1997) | Analysis of investment in SOI based forecasting system and extension for wheat production in northern wheat areas. Benefits based on those in Marshall et al (1996). | Maximum potential benefit of $1.4 m per annum after maximum adoption of 10% after 10 years. The investment was estimated to produce a B/C Ratio of 7 to 1 and an internal rate of return of 34%. |
| Agtrans Research (1997) | Analysis of investment in SOI based forecasting system and extension for sunflower, sorghum and cotton production. Benefits based on those in Hammer and McCown (1995) | The investment was estimated to produce a B/C Ratio of approximately 2 to 1 and an internal rate of return of 13%. |

All of these studies suggest a positive return on investment. This is not surprising given the outputs and outcomes reported earlier as emanating from the CVAP investment.

One of the reasons for the positive rates of return to such investment is the role of climate and its variability as key drivers within the Australian industrial and business environment. The frequency of extreme climatic events in Australia and the associated large costs to industry and community is well recognised. The population of potential users of a specific climate application is often large so that even a small change in the average cost of production due to a specific climate application can translate into a large aggregate benefit across an industry. Also, new climate science findings (e.g. improved seasonal forecasting performance) can find their way into a very wide range of applications and hence deliver a diverse set of benefits.

Table 8 provides supporting evidence regarding potential benefits and profits from using climate applications.

Table 8: Supporting Evidence for the Existence of Potential Benefits from Use of Climate Applications

| Author(s) | Description of analysis | Findings |
|---|---|---|
| 1. Hammer and McCown (1995) | Reduced risk of exposure and improved profits from variety selection and management of nitrogen fertilizer for sorghum, sunflower and cotton | Depending on the risk level assumed, the mean value of increased profits from using SOI based seasonal forecasts varied from 0-20% for sorghum and sunflower and from 1 to 9% for cotton. |
| 2. Stafford Smith et al (1996a, 1996b) | Utility of seasonal forecasting based on SOI values to pasture sheep and beef management in three Queensland locations | Long-term economic benefits and some long-term resource protection benefits identified in first study. Second study identified little benefit, due to the then current level of forecasting skill. Improved skill in forecasting appeared to have significant potential to increase economic returns and protect natural resources. |
| 3. Marshall et al (1996) | Benefits to a Goondiwindi wheat grower from using seasonal forecasts | Mean value of the forecasting system was estimated at $3.52 per hectare. |
| 4. Hammer et al (1996) | The value of skill in seasonal climate forecasting to wheat crop management in the northern grain belt | Nitrogen fertiliser rates and variety choice in relation to time of last frost were evaluated using tactics based on seasonal forecasting. Average long-term profits increased by about $10 per ha for nitrogen management and $5-10 per ha for choice of cultivar maturity. |
| 5. Abawi et al (2000) | Forecasting of streamflow in the Border Rivers catchment in the northern Murray Darling Basin. | The value of the forecast to irrigated cotton producers could be up to $192 per ha but was linked to risk preferences. Irrigators with neutral or moderate risk averse attitudes would gain more. |
| 6. Cobon and McKeon (2000) | Potential value of seasonal forecasts in managing grazing systems in western Queensland | Use of seasonal forecasting was valued at $1.07 per ha more than a constant grazing strategy measured at the district average stocking rate. Potential mean increase of almost $10,000 per annum for the property examined was produced with 19% less sheep with implications for reduced deterioration of the native pasture |

| | | |
|---|---|---|
| | | resource. |
| 7. Chiew and MacMahon (2001) | Seasonal streamflow forecasting | Together with the Abawi et al (2001) study, these studies have shown the use of seasonal forecasts could increase the managed water yield from a water resource system by 10 to 20%. |
| 8.Ash et al (2002) | Evaluation of seasonal climate forecasts for the extensive grazing industry in North-East Queensland | The study showed that significant economic benefits can be obtained by using seasonal climate forecasts in the extensive grazing industries. Modelling showed that average pre-tax profits could be increased by 14-19% by the use of seasonal forecasting (SOI based or surface sea temperature forecasts) |
| Jakeman, A.J. and Cuddy, S.M. (2003) | Improved Water Management Incorporating Risk and Climate Awareness | Further analysis using a range of alternative strategies showing increased gross margins of the order of 10-15% and with reduced risk. |
| Lythgoe *et al* (2004) | Seasonal climate forecasting has economic value for farmers in south eastern Australia | Farmers in south eastern Australia can increase profit without increasing the risk of making a loss by adopting a seasonal climate forecast to tune crop nitrogen nutrition |
| White (2004) | How valuable are seasonal climate forecasts | In general, returns on cost of up to twice the per cent shift in the forecast profitability can be achieved. |

**Current Economic Analysis of CVAP**

The past analyses of seasonal climate forecasting applications suggest the potential exists for increasing profits as well as capturing natural resource management benefits. Most of the benefits quantified in the past are from modelling exercises where the implications of decisions with and without the use of seasonal climate forecasts are compared.

A major assumption associated with analysing the benefits from the CVAP investment is the adoption levels of use of CVAP information. First it is known that many rural producers use seasonal climate forecasts in their operational management. CVAP has extended its findings generically as well as to specific industries. The use of seasonal climate information differs between states, with Victorian farmers using it less than those in north east Australia (Hassall and Associates, 2002).

CVAP has surveyed some of the factors involved in the adoption of such technologies (URS, 2001). The more recent survey information showed the gap is closing (Climag, 2005). In recent years there has been much greater support from organisations in southern Australia for projects which seek to better understand and promote the value of seasonal forecasts in southern Australia.

In a survey of farmers in 2000 (AAA survey) it was reported that 72% of the sample were aware of seasonal climate forecasting and 37% took the seasonal forecast into account when making on-farm decisions. A high proportion of these decisions were associated with inputs, some for outputs and less for financial decisions. The Hassall and Associates review in 2002 made the case that if 37% took seasonal forecasts into account then it can be assumed that it is useful. Another argument raised in the review was that some tools developed with the assistance of CVAP are self funding (SILO, AussieGRASS, RAINMAN), the implication being that if people were prepared to pay for them then they are likely to be economically beneficial to the user.

The main reason why producers did not use seasonal climate forecasting was that they considered the forecasts were not reliable enough.

*Improved Decision Making*

The key assumption is that the use of seasonal forecast information allows average profits for those who use it appropriately to be increased by approximately 10% per annum. This is based on a range of analyses which show optimal returns for some specific decisions when there are significant shifts in probabilities. The potential users are all producers of Australian agricultural products.

The average net value of farm production over the past 5 years to 30$^{th}$ June 2005 was $7.783 billion per annum. This value of potential additional profits from better decisions behind the farm gate is most likely an underestimate as others along the value chain can also make use of such information to their advantage (e.g. marketers, processors, importers, and even researchers).

The potential gain is therefore 10% of $7.78 billion, a sum of $778 million per annum
It is assumed that CVAP has made a difference by increasing the numbers who take seasonal forecasts into account from 40% to 50% and by increasing those who effectively gain from use of the forecast from 5% to 10%. Hence, even with CVAP it is assumed that only about 10% of farmers who take seasonal forecasts into account use the information sufficiently to generate the 10% gain. .

An allowance is made for a risk factor regarding the benefits after year 20 of the analysis and up to year 40. This 50% risk factor for the benefits assumed in those years is due to the uncertainty of the continuing validity of the forecasting system due to the forthcoming climate change causing a deterioration in future forecasts based on the past investment in CVAP.

A summary of the assumptions made is provided in Table 9.

Table 9: Summary of Assumptions for Investment Analysis of CVAP

| Variable | Value | Source |
|---|---|---|
| Five year average net value of Australian farm production | $7.783 billion | ABARE Commodity Statistics (2005) for five years ending June 2005 |
| *Without CVAP* | | |
| Proportion of Australian farmers that would take seasonal climate forecasting into account | 40% | Agtrans Research and Barry White |
| Potential increase in profits without CVAP | 10% | Agtrans Research and Barry White |
| Proportion of farmers taking seasonal forecasting into account that actually benefit | 5% | Agtrans Research and Barry White |
| First year of increased net income | 1996/97 | Agtrans Research |
| Phase in of gains | Over 10 years to 2005/06 | Agtrans Research |
| *With CVAP* | | |
| Proportion of Australian farmers that take seasonal climate forecasting into account | 50% | Various surveys including those of AAA |
| Potential increase in profits with CVAP | 10% | Agtrans Research and Barry White |
| Proportion of farmers taking seasonal forecasting into account that actually benefit from CVAP | 10% | Agtrans Research and Barry White |
| First year of increased net income | 1996/97 | Agtrans Research |
| Phase in of gains | Over 10 years to 2005/06 | Agtrans Research |
| Risk factor for benefits due to forecasting deterioration | 0.5 over years 20-40 of the benefit period | Agtrans Research |

## Results

The resulting investment criteria are presented in Table 10. The period of analysis was for 40 years after the first year of investment. The results are expressed in 2005/06 $ terms and all benefits and costs are discounted to the 2005/06 year.

Table 10: Investment Criteria by Type of Benefit and Costs Included
(Discount rate is 6%)

| **Criterion** | **All Benefits and All Costs** | **CVAP Benefits and CVAP costs (includes LWA)** | **LWA Benefits and LWA Costs** |
|---|---|---|---|
| Present value of benefits ($m) | 363.8 | 124.2 | 5.4 |
| Present value of costs ($m) | 71.1 | 24.0 | 0.95 |
| Net present value ($m) | 292.7 | 100.2 | 4.4 |
| Benefit-cost ratio | 5.1 to 1 | 5.2 to 1 | 5.7 to 1 |
| Internal rate of return (%) | 27.53 | 28.5 | 48.3 |

**Sensitivity Analysis**
The sensitivity of the investment criteria to the percentage increase in profit is shown in Table 11.

Table 11: Sensitivity of Investment Criteria to Assumption of Increase in Average Profits from Use of Seasonal Forecasting
(LWA Benefits and Costs)

| | **Discount rate 6%** | | |
|---|---|---|---|
| | **Low Value 5%** | **Base value 10%** | **High value 15%** |
| Present value of benefits ($ m) | 2.7 | 5.4 | 8.1 |
| Present value of costs ($ m) | 0.95 | 0.95 | 0.95 |
| Net present value ($ m) | 1.74 | 4.44 | 7.1 |
| Benefit-cost ratio | 2.8 to 1 | 5.7 to 1 | 8.5 to 1 |
| Internal rate of return (%) | 22.4 | 48.3 | 81.4 |

## Summary of Adoption Information

There is strong evidence that a significant number of Australian primary producers take seasonal climate forecasts into account in their decision making. Others in agribusiness also refer to seasonal climate forecasts. Further, it is accepted that CVAP and its predecessor NCVP played an important role in fostering this increased recognition and use. This increased recognition has been brought about by some enhancement of the forecasts themselves but also by the development and demonstration of forecasting applications to management decision making.

The use of seasonal climate forecasts can provide improved net farm income if used consistently over time, as the benefits are only captured in a probabilistic sense and mostly in the long term. Short term contingencies often arise in farm management that can hinder or prevent effective long-term benefit capture. Further there are some applications and locations where benefit capture are more easily “capturable” than others.

While there is a high level of awareness of seasonal climate forecasting and its applications, the issue of lack of accuracy in the forecasts is the major factor inhibiting more widespread use. If accuracy of the forecasts could be improved, the use of seasonal climate forecasts would be considerably increased as would the widespread successful application to farm decision making.

## Conclusions

Over the nine years from 1992/93 to 2000/01, the total investment in NCVP and CVAP has been just over $33 m in total nominal dollars, or on average between $3-4 m per year. This investment includes the leveraging of further investment from the recipient organisations and third parties.

While there has been ongoing investment in seasonal climate forecasting outside of CVAP, the CVAP investment has undoubtedly contributed to an enhanced seasonal forecasting capacity in Australia, particularly in the application of such forecasts to management decision making on farm. Seasonal climate forecasts are now taken account of by about half of Australian primary producers. Without the CVAP investment, this recognition and use of the forecasts would be much lower. There is insufficient information on how seasonal climate forecasts are actually used and their degree of continuing influence.

Most of the improved decision making that has resulted has captured an increase in medium to long-term average farm cash incomes. However, there are likely to be accompanying benefits in reduced variability of income and in improved natural resource management, particularly in relation to water use and reduced sediment export off-farm. Other benefits are likely to be captured by those in the policy area (e.g. drought assistance via Exceptional Circumstances) and along the value added chain in agriculture.

An attempt has been in this economic evaluation to estimate the economic benefits and hence investment criteria for the CVAP investment. Benefits have been restricted to those accruing through an increase in average profits from improved management decision making on farm. Results show that the returns to the investment are positive The Net Present Value of the LWA investment in CVAP is estimated at $4.4 m, providing a benefit-cost ratio of 5.7 to 1 and an internal rate of return of 48%.

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