SUBMISSION NO 36

INQUIRY INTO FUTURE WATER SUPPLIES

Land & Water Australia Submission

Land & Water Australia is a Statutory Corporation established under the Primary Industries and Energy Research and Development Act of 1989. Our mission is *to provide national leadership in generating knowledge, informing debate and inspiring innovation and action in sustainable natural resource management.*

- We wish to make a submission on two aspects of the inquiry as below:

1. Commonwealth policies and programs that could address and balance the competing demands on water resources

Land & Water Australia has for some time recognised the increasing competition for water in Australia in an environment in which many regions will be facing diminishing supplies. In particular we see the rural "water squeeze" deriving from a combination of (a) increasing industry and consumer demand, (b) the urgent need to re-allocate water to aquatic ecosystems in some locations, (c) climate change leading to higher temperatures, higher evaporation, lower rainfall and significantly lower runoff and (d) revegetation of catchments for biodiversity, salinity and erosion benefits combined with plantation and agroforestry for commercial purposes reducing runoff. These forces are already coming into play and are likely to increase in magnitude rapidly in the next decades. Fundamental to this issue is that river flow is already a small residual of the catchment water balance and the multiple factors above have the potential to exert substantial impacts on irrigation industries and dependent rural communities in a relatively short space of time. It is essential that medium to long term planning, whether for catchment rehabilitation, water allocation or industry infrastructure, takes these issues into account now.

In response to these critical issues, Land & Water Australia has invested heavily in water use efficiency R&D since the mid-1990s and was instrumental in encouraging state agencies to develop wider industry-based water use efficiency programs. Estimates suggest that around $100m has been committed to these state programs and significant improvements are already occurring in irrigation water use efficiency. Land & Water Australia's National Program for Irrigation R&D has delivered key innovations such as partial root zone drying (reducing some plant water requirements by around 50%) and the national irrigation benchmarking scheme which is becoming a world standard.

A new National Program for Sustainable Irrigation is currently in development by Land & Water Australia. This new initiative focuses strongly on designing and re-designing irrigation systems to meet pre-determined sustainability critieria, including efficiency measures. It is critical that new developments and/or redevelopments are effectively designed and do not repeat past mistakes. However it is already clear that many irrigation industries do not have the capacity to understand either their potential impacts at the catchment scale or their dependency on future water supplies. The corporation will be building on its wealth of past knowledge on irrigation, groundwater and river processes to facilitate this catchment and regional scale understanding. Linking irrigation more effectively to catchment processes and designing systems to deliver twice the product with half the water will be key challenges.

Land & Water Australia has also recently completed an extensive review of environmental water allocation, both in terms of scientific progress and experiences with implementation. The international review covered social, economic, policy and institutional dimensions as well as the core biophysical science. A range of Australian case studies were examined to draw out issues that communities and agencies are facing with implementation of water allocations to the environment. One of the clear outcomes has been the identification of the need for more holistic research and policy development in which whole river systems are considered, including the channels, floodplain and wetland connections, groundwater, catchment runoff and estuaries and near-ocean environments. Many science and policy gaps exist although good progress at both levels has been made over the last decade. The review also highlighted the need to develop robust methods to assess the benefits of environmental water allocations if industries and communities are to make the hard decisions and trade-offs. Research funders, resource managers and policy developers would also need to take account of emerging issues of climate change, complex catchment processes, water quality interactions and cultural and heritage aspects of water management.

2. The adequacy of scientific research on the approaches required for adaptation to climate variability and better weather prediction, including the reliability of forecasting systems and capacity to provide specialist forecasts

This part of the submission will concentrate on application of seasonal climate forecasts, which have been the major focus of Land & Water Australia's Climate Variability in Agriculture R&D Program (CVAP). Following a background section to provide historical context, the submission will respond to three issues raised in the terms of reference relating to the adequacy of the scientific research, issues of forecast reliability, and of the capacity to provide specialist forecasts. Increased use of seasonal forecasts which incorporate climate change influences are seen as one of the most effective ways to adapt to climate variability and climate change.

The submission includes detail that will be valuable to the inquiry. CVAP is uniquely placed to give a national overview on what is still a relatively new area of applying seasonal forecasts. For many of the issues raised, some context and background is essential.

Summary

Australia has a small but world-class effort in developing and applying seasonal climate forecasts. Forecasts are typically for the probability of above or below average rainfall over the next three months. The forecasts have only been widely available since 1989. Close to 40% of farmers take the forecasts into account in farm decisions. The proportion is highest in northern NSW and Queensland where there is a combination of increased variability and predictability coupled with research and extension programs to promote applications by farmers. Forecasts on a probability basis are required to responsibly convey the accuracy of the forecast.

There is substantial scope to increase the uptake of forecasts and their value to the community. Progress requires a sustained and comprehensive national approach including improvements in forecasting accuracy, in demonstrations of forecast value, and in communicating forecasts to users.

The Climate Variability in Agriculture R&D Program has had a key and unique role in progressing the application of seasonal forecasts and providing a coordinated national approach. A Prospectus for a new and broader Managing Climate Variability program to include water and natural resource management has been launched and funding partners are being sought.

Background

In 1992, also at a time of major drought, a new applied climate research program was launched by the Commonwealth. Now, a decade on, close to forty percent of Australian farmers are taking seasonal climate forecasts into account in decisions.

The research program on applications in agriculture was funded initially through the National Drought Policy aimed at increased self-reliance, and more recently through the AFFA program - *Agriculture Advancing Australia.* The research focus has broadened from drought to better managing the risks and opportunities that come with an inherently variable and now changing climate.

The leadership by AFFA gave increased recognition and credibility to what was effectively a new research area - taking advantage of seasonal forecasts in farm decisions. The first operational seasonal climate forecast became available in 1989 following development work by the Bureau of Meteorology. Agricultural researchers in the Queensland Department of Primary Industries also had a key role in demonstrating the value of seasonal climate forecasts. They also promoted the widespread recognition of the Southern Oscillation Index.

Although the forecasts can be seen as a breakthrough, they were the end result of increasing knowledge over the century. As long ago as 1910, a Bureau of Meteorology researcher had developed a relationship between northern Victorian spring rainfall and Darwin atmospheric pressure the previous winter.

The devastating 1982-83 drought was a major stimulus to improved research and monitoring of the El Niño - Southern Oscillation or (ENSO) phenomenon in the Pacific.

The Australian legacy *'of drought and flooding rains'* could now begin to be interpreted and understood. Summer droughts often can end *'not with a whimper'* but with autumn floods, a pattern now recognised as not unusual coming out of an El Niño. Understanding ENSO and fathoming the patterns of the oceans are the keys to unlocking the vagaries of our unique stop-start environment.

'Australia 's infertile soils and the trials of ENSO have forced some unusual adaptations on its plants and animals....exploiting brief windows of opportunity as they open erratically over the land '.

'The Future Eaters' Tim Flannery (1994).

How farmers use ENSO-based seasonal forecasts varies. A majority of cotton and sugar cane growers take the forecasts into account in a variety of farming decisions, from irrigation to cash flow management based on yield prospects. Farmer comments range from *'my bank manager sleeps better'* to *'we always use them only as an aid, to reinforce a decision that we are already part way to making'*!

Adoption has been less in some areas such as Western Australia, because of a reduced ENSO impact. As a result there is less inherent variability and less predictability in rainfall. In south-eastern Australia lower adoption appears to be partly based on experience in the 1990s that the forecasts were not as reliable as further north. But analyses over the last century show little change in the impact of ENSO from north to south in eastern Australia, particularly for critical spring rainfall.

Finally, it is important to place what can be achieved from better application of seasonal forecasts in a broader context. While forecasts can help farmers and natural resource managers to reduce some of the worst impacts of droughts and floods, they are not a panacea. They contribute to improved management of risks and opportunities through better informed decisions. With current levels of accuracy there will continue to be droughts in non El Niño years but not as widespread. Some regions will enjoy good seasons in El Niño years. Better information on the season ahead will over time contribute to improved profitability with less risk to the farmer's capital and natural resource base. Users of seasonal forecasts will continue to gain experience in how best to incorporate the forecasts into their risk management.

Climate Variability in Agriculture R&D Program

Seasonal climate forecasts were first publicised a little over a decade ago. The Climate Variability in Agriculture R&D Program (CVAP) has had a key national role since 1992 in improving the forecasts and developing the tools and applications needed for their more confident use in a wide range of industries. One of the first projects funded enabled the Bureau of Meteorology to add the Indian Ocean influence to that of the Pacific in seasonal forecasts of rainfall and more recently temperature.

Over the past decade, partners in CVAP (including the earlier phases with the title National Climate Variability Program) have invested about $1,000,000 annually in a broad and stretched program aiming to cover a range of regions and industries, and to provide the tools needed for research and for applications. A substantial investment was made in more strategic research on coupled ocean/atmosphere models to accelerate improvements in longer lead forecasts, and to strengthen links between users and climate and ocean scientists.

In the recently completed phase of CVAP, five of the rural R & D Corporations formed an effective partnership with AFFA in extending the range of applications. Partners are being sought for a further phase of CVAP. The Prospectus has been launched with strong support from the National Farmers Federation. Tools are now available to support a broader focus including the challenging issues in water and natural resource management. Further investment in CVAP is the most effective means available to increase the application of seasonal forecasts.

The adequacy of scientific research

Australia, with exceptional rainfall variability, needs to be a world leader in the application of climate science to sustainable management. Australian researchers through an outstanding collaborative effort do lead the world in applications to better manage climate variability. Close links between a limited number of researchers in agriculture, climate and ocean sciences has been the key ingredient in the rapid development of our capacity.

Research to improve seasonal climate forecasts is a small part of much larger climate research programs, particularly in weather and climate change issues. The research programs are dependent on observation networks and data management systems which are part of formal international arrangements. Although there are a wide range of mechanisms to coordinate responses from Australian Governmental and non Governmental science organisations on diverse international climate science issues, there is no counterpart effort in coordinating national responses to national issues. Australia has not established any formal mechanism such as a National Climate Program. There have been failed attempts.

The major agencies involved with climate research are the Bureau of Meteorology Research Centre and CSIRO (Atmospheric Research and Marine). The 1999 Review of BMRC recognised its world class research. There were no specific comments on climate variability research which is a small component of its portfolio of mainly strategic research in meteorology and climate change. The Review noted the pressure on resources in maintaining the skills base to meet the many demands. The CSIRO have a range of research specialties in climate change and climate variability. They have recently developed weather and climate forecasts targeted at the needs of specific industries. The BMRC Review noted the growing cooperative relationship between

BMRC and CSIRO (Atmospheric Research) and recommended their consideration of a single global integrated systems model.

CVAP, with its user focus, has had a significant role in achieving a more effective national focus in climate modelling. As the Chief of CSIRO Marine, Dr Nan Bray, stated: "*Australia did not have coupled, numerical models for seasonal prediction when CVAP started. After six years of co-investment by CSIRO, Bureau of Meteorology and CVAP, we now have two that are demonstrably as good as any around the world. (One is tuned for simulation of ENSO, one on how ENSO will change under greenhouse). The unique role of CVAP was to significantly enhance collaboration. Individually, no group had the critical mass to develop a dynamical prediction system.*"

The adequacy of the research effort on seasonal climate forecasts depends on the priorities set by the major research agencies and the capacity of users to influence these. With such a widespread user base, and given the increasing emphasis in research agencies on external funding, the capacity of users to collaborate becomes the major determinant of research priorities. The diversity of users clearly raises transaction costs for user-based funding. Currently Land & Water Australia is seeking funding from 13 rural R&D Corporations to launch a new Managing Climate Variability program. Core funding from AFFA had previously underwritten a national program, and enabled further contributions from partners with more specific regional or industry priorities.

The CVAP approach helps to ensure the adequacy of the research effort by recognising three factors:

- the importance of links between users, and climate and ocean scientists to develop relevant forecasts;
- the advantages of a program approach which recognise that innovative applications in regions and industries depend on national and international research efforts;
- encouraging a diversity of approaches to improved applications of forecasts within a competitive framework that focuses on the improved accuracy and value of forecasts for users; and
- recognition of the major spin-offs from applications research on specific applications to other regions and industries. Often, a small increased investment can add substantial national value to a more regionally focussed project.

In the absence of a national framework to address emerging issues of significance to the user community, many issues will be neglected and others will proceed with a narrow local focus. The limited resources nationally are more likely to be fragmented, and efforts duplicated. A national and often international perspective is essential to complement user involvement.

The three Australian regions with the most pressing drought problems over the last few years are south west Western Australia, southern Victoria, and south-east Queensland. Urban water supplies are a major issue in each region. In Western Australia, State Departments have collaboratively funded research to investigate the long term decline in rainfall. A similar initiative is being discussed in Victoria. Queensland has had a major climate variability research effort for a decade with the emphasis on applications in agriculture. Stronger links with the International Research Institute for Climate Prediction (IRI) are being developed by the Queensland Government to address their major issues.

There have been Australian efforts in recent years to develop a national focus on climate applications which could have also included a more active role in IRI. The Queensland Government undertook a feasibility study to consider the development of an Australian Institute of Climate Applications. Although some support in principle was apparent from the key national agencies, the effort languished.

The absence of a Cooperative Research Centre with a focus on climate forecasting applications is also indicative of a less than adequate national effort. Part of the problem is the limited focus in Universities on climate science and applications. There is more University research in meteorological science. Nevertheless, the launch of a climate degree at the University of Southern Queensland is seen as a world first.

Increasing the uptake of our existing knowledge on climate variability requires a major commitment to applications research coupled with extension and training programs to involve potential users. Apart from a major Queensland initiative through the Queensland Centre for Climate Applications, other states have typically only a few staff dedicated to improved applications. The Prospectus for a new CVAP aims to increase adoption from current levels of about 40% to more than 60%. New applications in water and natural resource management are also planned if the program achieves an appropriate level of funding.

Continuity of the research effort is also a major constraint on the adequacy of the research effort. User interest has typically been greatest during major droughts.

Reliability of forecasting systems

Poor forecast accuracy is the most common reason advanced by those farmers not taking forecasts into account. (Reliability has a specific meaning in meteorological studies of forecast performance relating for example whether droughts or rain days occur as frequently as forecast. Reliability in this context is understood to relate to accuracy in general terms).

Current seasonal forecasts for the next three months are expressed in terms of probabilities – for example, only a 30% chance of above average (median) rainfall. Some users would interpret the forecast as inaccurate if the more unlikely outcome of above average rain resulted. This will be more likely if the media concentrate on the most likely outcome and ignore the probability. Many users and to some extent the media, prefer categorical forecasts, for example either rain or fine as for weather forecasts. Wider adoption of probability-based forecasts for weather would increase understanding of seasonal forecasts. Routine weather forecasts from the Bureau of Meteorology do not incorporate probabilities, except in a long running trial in Canberra. This is understood to be based on the assumption that some confusion could result. However other countries routinely express forecasts in probability terms, and Canberrans appear to be coping.

CVAP research has contributed to improved communication and understanding of forecasts. One project demonstrated that expressing forecasts in frequency terms, for example 3 years out of 10, was more effective than the probabilistic statement using 30% chance. Another project has funded the Bureau of Meteorology to develop a system for a user at any location to evaluate past forecast performance of the Bureau Seasonal Outlook.

Current forecasts are based on historical relationships and have variable accuracy, both seasonally and regionally. The patterns reflect the historic impacts of El Niño and La Niña events. The patterns are the basis for the forecasts which reflect the extent to which rainfall outlooks differs from the historic pattern. El Niño and La Niña events have each occurred about every four years or so on average, and have significant impacts peaking in spring. Thus the forecasts will only reflect a substantial change in the outlook in some years and at some times of the year. Further there is substantial regional variation and in the extent of particular events. The variable nature of what users perceive as the accuracy and value of forecasts requires on-going programs to increase understanding of the probability basis of the forecasts. The major research issue with the seasonal pattern of accuracy is the limited guidance the forecasts give in autumn – the autumn predictability gap – generally before an ENSO pattern has developed, but when winter crop planting decisions are being made.

Policy decisions to limit current forecasts to three months ahead denies users the opportunity to take advantage of skill at longer lead times. During El Niño and La Niña events there are opportunities to provide useful forecasts at longer lead times. To some extent simulation models of crop growth pick up skill at longer lead times.

CVAP research has included two key directions to increase the potential value of forecasts. These are:

- the development of coupled models of the ocean and atmosphere to give forecast skill at longer lead times than current models; and
- increased understanding of the importance of variability at decadal time scales and associated opportunities to improve current forecasts.

Both areas require substantial further investment to determine their operational value.

For the future, climate change brings new challenges. A warmer world will increase moisture stress and drought. A more variable future will require more rapid adaptation through better managing climate variability as it happens. Greater adoption of seasonal climate forecasts will itself stimulate improved adaptation to new levels of variability. Australia's world-leading research effort in managing climate variability needs to keep meeting the challenges.

Capacity to provide specialist forecasts

In addition to research to improve forecast accuracy, CVAP has been effective in developing the capacity and the tools to provide specialist forecasts in agricultural production and water resources applications. Climate data is now readily available to drive simulation models of crop and pasture growth. The ENSO impact on seasonal rainfall is often magnified when an indicator such as crop yield is used to integrate the seasonal impact of an ENSO event. The models can be used to compare alternative decisions depending on the current seasonal forecast. The value of the forecast can then be assessed. For example in northern cropping regions, a simulation model can evaluate the likely yield of an additional opportunity crop if there is a favourable seasonal forecast indicating an increased chance of above average rain. The additional crop can reduce runoff and deep drainage providing environmental benefits as well as increased profitability.

Applications showing increased value from using forecasts have only been made operational in some industries and regions. The major constraints have been limited funding and recognition by users and researchers of opportunities. For example, the first major research project on using seasonal climate forecasts to reduce the impact of climate variability on southern grain farms will begin shortly.

AUSTRALIAN RAINMAN is one of the flagship products supported in its development and upgrades by CVAP. RAINMAN aids management by giving farmers the capacity to analyse local rainfall and to incorporate their own records. The combination of relevant information and analyses readily done by the user is a powerful learning tool. The end result is an understanding of how ENSO shifts the odds for their own situation.

A new RAINMAN supplement with data for 400 streams now gives the capacity to forecast streamflow. This will be a valuable new tool in a range of applications from irrigation planning to environmental flows.

The impact of ENSO on streamflow is often amplified compared to the rainfall impact. For the Lachlan River in central NSW, an ENSO forecast can change the odds markedly. For example in La Niña-like years about one year in two is likely to have above average streamflow. In El Niñolike years the chances of above average are only about one in ten. The example is based on spring (Aug-Oct) inflows to Wyangala Dam based on the SOI from May to July.

Forecasts of streamflows can be invaluable in managing variability. ENSO indicators such as the SOI and SST (Sea Surface Temperatures in the Pacific and Indian Oceans) have been used in statistical forecast schemes for rainfall a season ahead. The streamflow relationship is often amplified through spatial and temporal integration compared with an equivalent rainfall forecast.

There are indications that variations in climate and ocean systems over decadal time scales modulate ENSO impacts. For example the SOI correlation with Murray River flows is much higher when a measure of decadal variability in the Pacific is negative compared to when the index is positive.

The accumulating knowledge on major drivers of climate variability has had little application in water resources management, partly because of very conservative risk management approaches which have been based on high security of initial allocations. In addition, the concentration on planning for sustainable levels of extraction to meet increasing demand for water has resulted in a lower priority on operational issues. In the case of environmental flow regimes, the initial challenge is to reverse the cycle of seasonal flows back to the natural seasonal cycle. The ENSO component of the natural cycle will then be relevant.

Two case studies have shown that use of seasonal climate forecasts could increase the managed water yield from a water resources system by 10 to 20%. The increases shown are for irrigation systems where irrigation requirements and crop requirements from rainfall are negatively correlated. Environmental requirements are more likely to be positively correlated with rainfall. There are therefore opportunities to reduce trade-offs required to meet environmental requirements by using seasonal climate forecasts.

For the Lachlan River catchment for example, a 14% expansion in area planted appears possible with little extra risk if seasonal climate forecasts were used. A 23% expansion seems possible with some extra risk. A further case study showed that for a northern Murray Darling system, an increase in cropped area of up to 30% was possible comparing positive and negative SOI phases. This analysis was based on an irrigator decision in June on October cotton plantings. A later decision would be even more valuable. The potential exists to better allocate additional water to irrigation and environmental uses at less risk.

Environmental flow regimes which attempt to retain and mimic elements of the natural regime will clearly be inadequate if they fail to account for ENSO. Statistical approaches which simply capture the monthly characteristics and month-to-month persistence will completely miss the ENSO pattern at a longer seasonal and annual time scales. The key characteristics are :

- Interannual variability at continental scale (important for migratory species);
- El Niño and La Niña events, each averaging once every four to five years, but with protracted episodes;
- Possible increased frequency of El Niño events and increased streamflow variability with climate change;
- Droughts and wet periods associated with major ENSO events often extending for up to a year from autumn; and
- A tendency for droughts and floods to alternate (*a land of droughts and flooding rains*).

I would be happy to expand on any of these points in person.

Andrew Campbell
Executive Director
Land & Water Australia
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