3/09/200213:35 Version Final

The House of Representatives Standing Committee on Agriculture, Fisheries and Forestry

Inquiry into future water supplies for Australia's rural industries and communities

CSIRO response

Contributors:
Wayne Meyer CLW
Marg Bryant CLW
Barney Foran CSE
Willem Bouma CAR
Brian Ryan CAR
Gary Meyers CMR
Mike Young CLW
Shahbaz Khan CLW
Peter Cullen CLW
Geoff Syme CLW

Context

Australia's water resources - an overview[1]

On average 24,000 GL of Australia's water is used per year. Of this, 19,000 GL of water is used from surface water sources. 20,623 GL of surface water is allocated to consumptive use. 5,000 GL of water is used from groundwater sources per year. 6,300 GL of groundwater is allocated to consumptive use. Irrigation accounts for 75% of total water use.

Australian water use increased by about 65% between 1983/84 (DPIE, 1987)[2] and 1996/97. This was mostly due to increases in irrigated agriculture while urban centres have shown either low increases or net decreases in water consumption over the same period (AATSE, 1999)[3].

The assessments show that 34 of 325 basins and 59 of 538 groundwater management units are highly or overdeveloped.

Urban water use in a number of the State capitals (while variable) declined during the 1990s. Industrial use is not large and is falling as industries become more water efficient - in some cases achieved indirectly as a result of energy efficiency gains (*AATSE/IAE, 1999*).

Diversion of water into irrigation has significantly altered and sometimes led to the reversal of the flow patterns of water in some rivers.

Australia's climatic zones[4] show a large arid interior, surrounded by areas dominated by summer (in the north) and winter (in the south) rainfall. Australian rainfall has increased slightly during the 1900s in most regions, except for south-west Western Australia and eastern Queensland, where decreases occurred. Australian rainfall shows strong interannual variability that is linked with variations in the El Niño-Southern Oscillation (ENSO) phenomenon[5]. River flow is highly variable largely driven by this 'erratic' climate.

The Australian government spent $700 million on drought relief payments or exceptional circumstance relief payments to farmers from 1992 to 1999 (SoE Report, Atmosphere, 2001). These droughts are associated with El Niño events, particularly the early 1990s and 1997 to 1998 events.

---

[1] This summary comes largely from the National Land and Water Resources web site.
[2] DPIE Department of Primary Industry and Energy (1987). 1985 Review of Australia's Water Resources and Water Use. Australian Water Resources Council, Vol 1 and 2.
[3] AATSE/IEA (1999). Water and the Australian Economy. Joint project of the Australian Academy of Technological Sciences and Engineering and the Institution of Engineers Australia.
[4] http://www.bom.gov.au/climate/environ/other/map1.shtml
[5] http://www.ea.gov.au/soe/2001/atmosphere/summary.html#climatevariability

Australia has one of the world's large aquifer systems, the Great Artesian Basin (GAB) estimated at 1.7 million km2 and a storage volume of 8,700,000 GL. Each year the GAB currently supplies 570 GL of water for a variety of uses dominated by pastoral enterprises.

Approximately 70% of Australia's irrigation occurs within the Murray Darling Basin. The Murray Darling Basin occupies about one seventh of Australia's land mass, accounting for over $8.5 billion, or over 40% of the nation's gross value of agricultural production in 1992.

The Lake Eyre Basin is one of the world's largest internal drainage basins with an area of over 1 million-km^2. Using a model similar to that of the Murray Darling Basin Commission, the Lake Eyre Basin Ministerial Forum is in the process of establishing inter-State agreements for the integrated management of this unique part of Australia.

The important role of Government

As will be emphasized in the body of the submission, Government and in particular, the Commonwealth has a pivotal and increasing role in setting the values and direction – the vision – for water use (development and conservation) in Australia. Water, along with energy and population will be consuming national issues in the 21st century.

Australia can learn from the recent experiences in South Africa where the rewriting of the national water laws has caused a fundamental reassessment of the social and legal framework for water management (http://www.dwaf.gov.za/default.asp). The principles that they built the new Water Law on are:

- To achieve equitable access to water
- To achieve sustainable use of water
- To achieve effective and efficient use of water

Within the Australian community, social research about attitudes and beliefs with respect to water management and allocation shows there is increasing evidence (Syme et al 1999)[6] of support for:

[6] Syme, GJ, Nancarrow, BE, and McCreddin, JA (1999). Defining the components of fairness in the allocation of water to environmental and himan uses. Journal of Environmental Management, 57, 51-70.
Syme, GJ, Nancarrow, BE, and McCreddin, JA (1999). If water means wealth – how should we share it? In Proceedings of the Irrigation Association of Australia 1998 Conference and Exhibition, "Water is Gold". Pp. 23 – 32.

- The community's rights to have a voice in allocation decisions
- The rights of the environment and
- The concept of procedural justice

To give effect to these principles there is a need to establish a vision for water management that includes the need to protect, use and reuse, develop, conserve, manage and control water.

The vision for water management in Australia

Development and conservation of water needs to be directed through enunciation of a set of values. These values should encompass the notions of **efficiency, fairness, sustainability** and **reward for effort within the obligation to others**. In every day language these might be expressed as **"waste not, want not", "a fair go"(for people and environment), "something for our grandchildren" and "return in proportion to risk and investment"**.

The vision should also set out the fundamental principles for water use. It should assert that the primary right to water should be to satisfy the basic human need for sufficient water of adequate quality for drinking and hygiene. It should assert the right of the environment to have adequate water to maintain the integrity of the dependant ecosystems. The commercial use of water needs to be tempered by a social allocation – there should be no permanency of right to use but rather a licensing arrangement with a set of safeguards of sufficient duration to give forward planning assurance, reduce risk and enable investment.

Water as part of natural resources

Adequate management of water will not be possible unless it is done within the concept of integrated water resource management. This explicitly recognizes that water occurs in many different forms, which are all part of a unitary, interdependent cycle. This explicitly makes the linkage between water in the atmosphere, surface water and groundwater. This reality is not currently recognized within most Australian regulations that govern water allocation and use. Nor is there yet a well defined system of double entry accounting which recognizes the finite amount of water available – if water is taken for use, balanced accounting identifies where the water comes from.

Integrated water resource management is an evolving, iterative process for coordinated planning and management using a balance of technological and social approaches to achieve equitable and sustainable use of water, land and environmental resources.

TOR 1.

The role of the Commonwealth in ensuring adequate and sustainable supply of water in rural and regional Australia.

The Commonwealth has a critical and increasing role in ensuring adequate and sustainable supply of water in rural and regional Australia. It has a role in deciding what is a reasonable use of water and in deciding on the balance between conservation and use of water.

The over riding direction for the Commonwealth is set down in section 100 of the Commonwealth of Australia Constitution Act. It reads:

"100. The Commonwealth shall not, by any law or regulation of trade or commerce, abridge the right of a State or of the residents therein to the reasonable use of the waters of rivers for conservation or irrigation."

We interpret from this that the Commonwealth does have a role in deciding what is "reasonable" in terms of use and also a role in guiding the balance between "conservation or irrigation".

It is notable that the framing of section100 was controversial at the time (1900) and did not recognise the link between surface water and groundwater. Nor did it convey any sense of the lag between land use change and the effect on water resources. Both of these fundamental realities have become known with greater understanding and knowledge. These realities should now be taken into account as part of the role of the Commonwealth.

The Commonwealth should assume greater responsibility in the management of water (what is "reasonable") as a fundamental element of natural resources. It should do this because:

- Profound issues of soil, land and water management transcend state and local government borders,
- State governments still find it very difficult to come to consistent management and regulation practices around state borders despite commonality of underlying and affected resources. This leads to inefficiency in providing development and conservation guidelines, it causes delays in data provision and inconsistency in data forms and formats,
- State governments have been shown to be susceptible to "political patronage" in matters of water licensing and allocation which has resulted in a gross imbalance between conservation (especially of river systems) and irrigation,

- Local governments, while having the most significant vested interest, have neither the resources, nor the expertise, nor the encompassing political will to do a good and ongoing job of ensuring water supply.

We therefore submit that the prime role of the Commonwealth is to set the policy framework, supply the high level signals and assemble data and analyses at National level that transcend state and local government borders.

We would expect the policy framework to be developed by

- The Sustainable Environment Committee (SEC) of Cabinet
- The Committee Structures used for NRM and Environment (NRM Ministerial Committee, NRM Standing Committee, {made up from Land, Water and Biodiversity Advisory Committee, Marine and Coastal Advisory Committee, Programs Advisory Committee}).
- The COAG process
- The Murray Darling Basin Ministerial Council

We would encourage the maintenance of

- National programs like NHT, NAP and the Forward Climate Change Strategy
- Research directed through national agencies and academic institutions
- Commonwealth support for National Hydrological Monitoring, to preserve existing programs that collect critical long-term data to indicate trends that will never be evident from short-term intensive studies.

TOR 2.

Commonwealth policies and programs, in rural and regional Australia that COULD underpin stability of storage and supply of water for domestic consumption and other purposes.

There is no single action that could markedly improve the stability of storage and supply in all of rural and regional Australia. Rather there are a series of connected actions such as re-establishing the basic principles of water resource management to protecting the stability of the catchment areas through designation, through to better managing the demand and use of water by better climate forecasting and more tightly defining environmental flow needs.

The legislative and regulatory framework that guides rights of access, rights of use and trading rules will have a fundamental effect on the balance between supply, demand and stability of availability. Within this framework the stability of storage and supply will depend on managing both the supply of water and the demand for water.

Additional, carefully developed storages, particularly in northern Australia are likely to be needed. However all dam proposals should be required to pass cost benefit assessment. Australia needs to be more cognizant of international experience about the planning, financing, building and management of large dams, for example, by being familiar with the reports from the World Commission on Dams.

Planned use of groundwater within sustainable yield estimates is also possible in some locations. Reuse of storm waters and treated effluents will increase the spread of water sources and therefore increase stability. The opportunity to use waters of varying quality for a range of appropriate uses has not yet been fully exploited. It is not necessary to have potable quality water available for every industrial or agricultural use. Separating available waters for particular uses can help water security.

A water management framework:

The current water management framework in Australia is confused and highly variable between the States. We believe that without a significant improvement in clarity of principle and intent it will be extremely difficult to markedly improve the stability of storage and supply of water to rural and regional Australia.

The elements of a robust framework begin with a statement of the principles guiding the use and conservation of water, namely efficiency, fairness, sustainability and reward for effort within the obligation to others.

Then the primary right to water should be to satisfy the basic human need for sufficient water of adequate quality for drinking and hygiene.

There should be a right of the environment to have adequate water to maintain the integrity of the dependant ecosystems.

Within the context of a fully described water resource there should be a double entry accounting system ie. if a volume of water is taken for use (a withdrawal) there is an identified source (a deposit) to balance the "books". All users of water are shareholders, the risks and benefits are shared and security can be managed through the shareholding one is prepared to trade into. A registry system is established to track and keep account of "withdrawals" and "deposits".

A minimum balance needs to be set to maintain the quality of the supply system and the water it delivers.

Pricing signals need to fully implement the original COAG water reform intention of full cost recovery including that needed to cover the cost of "externalities".

Demand:

Through improved climate and weather forecasting it will be possible to be more proactive in managing the use of water from storages and while this will assist reduce the severity of "troughs" in supply (through demand management) it will not increase the amount of water stored.

> Seasonal and long-term climate predictions can make a major contribution in water resource planning. Useful predictions are now available for a range of lead times from one or more seasons ahead to future greenhouse scenarios. Much can be gained from climate scientists working closely with water users (e.g. water system managers, farmers) to target the predictions on specific user-needs. Targeted predictions integrated with specialist skills in water resource use and water resource technology can contribute to improved efficiency in water use and potentially decrease total demand for water.
>
> Over the next few decades global climate change will change rainfall patterns, affect temperatures and evaporation. It needs to be recognised that Australian water resources may be significantly affected and projections of future change will need to be factored into water management decisions.

Supply:

The circumstances where weather modification through cloud seeding may provide more rainfall depend critically on cloud suitability and regional climatic and geographic conditions, making it a high-risk, often controversial pathway for

attempts at resource enhancement. The absence of rain-bearing clouds during a dry period cannot be changed through cloud seeding. Guidelines for appropriate decision making and scientific conduct have been issued through ARMCANZ[7]. A statement by the World Meteorological Organisation on the Status of Weather Modification is given in Appendix 3.

A major effect on water supply can be exerted through management of the catchment. The amount of runoff from the catchment area is greatly influenced by the soil surface condition, by the vegetation type and by the amount of water retention within the catchment (for example through farm dams). Bare, compacted soil surfaces will generate the most runoff from any rain event. This condition however would totally compromise land condition (through excessive erosion) and water quality (from sediment, nutrients and some organisms).

The importance of having designated catchment areas and carefully managing their condition cannot be overemphasised. The long-term stability of these catchment areas is the key to underpinning the stability of water supplies.

It therefore follows that a major impact on water supply is associated with land clearing (tree removal) and land use change. This impact can be quite immediate on runoff amounts in higher rainfall areas or more insidiously through salinization effects on surface and ground water quality.

It would be reasonable for the Commonwealth to insist that States fully specify the duty of care of rural and regional Australia to manage resources in such a way that the quality of water for domestic consumption is not compromised. In short, there should be full specification of the duty of care obligations that will lead to an improvement in security of water quantity and an improvement in water quality.

Catchments are not only those associated with surface water storage but also with groundwater recharge where, increasingly, it is recognised that vegetation change (for example, replacing pasture with trees) will reduce recharge. CSIRO Forestry and Forest Products is investigating the impacts of plantation forestry on water resources especially in western Victoria and the south east of South Australia[8].

---

[7] Ryan, B. F., and Sadler, B. S. (1995). Guidelines for the utilisation of cloud seeding as a tool for water management in Australia: an outline of the Australian experience and principles for water managers. [Canberra]: Agricultural and Resources Management Council of Australia and New Zealand. (Occasional paper; no. 2). 28 p.

[8] An excellent summary of the science, issues and knowledge gaps associated with understanding the impacts of forestry on water resources can be found in O'Loughlin, E. and Nambiar, E.S.K. (2001), *Plantations, Farm Forestry and Water*. A discussion paper. Water and Salinity Issues in Agroforestry No. 8. RIRDC Publication No. 01/137, RIRDC, Barton ACT, 37pp.

A critical question is that of "how hard do we want to work our river systems". The harder we work them by storing and diverting water from them, the more supply and stability becomes a problem and the more we have to adjust. The answer to this critical question will not come from scientific research alone. Social and community attitudes will strongly influence the level of trade-out that is regarded as "fair" in meeting the needs to store and use water and in maintaining the river and its dependant ecosystems in a healthy state. It is during this process of water allocation that the need for affected people to "have a voice", for there to be recognition of the environmental need and for procedural justice to be invoked. It is clear that our current state of knowledge is insufficient in understanding and quantification of the amount, duration and timing of water needed to maintain "dependant ecosystems in a healthy state". This is the so-called "environmental flow". The characteristics and minimum requirements need to be appropriate for each reach of each river. **The Commonwealth should support the necessary research, testing and adaptation of knowledge that can inform the characteristics of environmental flows.** Without this knowledge it will be very difficult to develop improved management practices that underpin the stability of storage and supply of water.

While it will certainly be possible, in future, to more adequately define environmental flows we will be unable to maintain or afford to have all rivers with optimal environmental flow provisions. Within this context we suggest there will need to be designation of rivers ranging from those to be kept and maintained as "national rivers" with near natural flow conditions down to those which have various levels of sub-optimal and base environmental flow regimes. The decision process to bring about designation will require considerable research and transparent public involvement processes.

The stability of storage and supply of water can be enhanced by removing many of the current mechanisms which erode the quantity and quality of water that is currently available. For example:

- The increased availability of water through improved water use efficiency are currently retained by the users
- There is a failure to monitor, measure and cap limited water sources which means we are unable to adequately manage the resource
- There is a failure to control land use change and to fully account for its effect on water quantity and quality, and
- Within catchments there is a failure to control farm dam storage or at the very least to adequately assess its effect on local and regional hydrology.

The Commonwealth, through its own policies and programs and through its relations with the States can exert considerable influence to redress the range of limitations that influence the stability of storage and supply of water.

TOR 3.

The effect of Commonwealth policies and programs on current and future water use in rural Australia.

Current policies and programs, while bringing the importance of efficient water use to the attention of water users, do not yet sufficiently emphasise the need to reduce extraction from over allocated rivers and groundwaters nor do they provide a clear direction on the availability of water for irrigation and the conditions needed to achieve sustainable irrigated areas.

The imposition of the "cap" on additional extraction from water sources in the Murray Darling Basin in 1995 was a very clear sign that there was recognition of over allocation and excessive extraction. There are examples in nearly every State of over allocation of particular groundwater resources. Clearly, in some systems, we need to reduce use – they are over-allocated. As indicated previously, Australian science and policy with respect to environmental flow still needs a lot of research, testing and refinement before it is robust.

Any consideration of stability of supply and storage cannot sensibly take place without consideration of the effects of water diverted for irrigation purposes. Australia is likely to follow world trends – total water use will increase but irrigation will take a smaller proportion of use. It is likely that there will be consolidation of existing irrigated areas in southern Australia. Water trading will encourage water to move to slightly higher rainfall areas where supplemental irrigation of high value crops is profitable. There will continue to be increased irrigation water use in northern Australia. **Any further development of "diverting rivers inland" should not proceed until there is a thorough planning and assessment process in place that sets acceptable sustainability criteria**. The knowledge base to make adequate assessment of likely effects of increased flows in some of our major ephemeral and episodic inland river systems is very limited. We believe that a decade of concerted research will be needed to provide an adequate base.

We can certainly use our current water more efficiently. Analyses of losses from the point of storage to the use by irrigated plants show that up to 70% of the initial stored water is lost in transit. In urban reticulated systems losses of up to 30% are not uncommon. It is only in the last decade that there has been an increased awareness that these losses of water are not only contributing to a loss of potential productivity but they also, in many cases substantially contribute to water table rises and the onset of salinization. The effects of implementing the COAG Policy of full cost recovery for water delivery have certainly been beneficial in focusing on more efficient water use. However the water pricing reform process that emanated from the COAG agreement has not fully followed through the intention of full cost recovery including the cost of "externalities".

Externalities include the effects that drainage has on quality of water in surface and ground waters.

We see a need to:

- Support studies on the costs of piping large volumes of water relative to the environmental and water savings benefits,
- Encourage the development of an Australian ethos that values water conservation through education and taxation systems.

A combination of full cost recovery, a directed water trading market, an explicit water allocation policy and the development of an ethos that values water conservation will be needed to underpin the stability of water supply and use. This combination represents the balance between the external motivations of pricing and self interest and the moral values associated with notions of "a fair go" and having the opportunity to be involved in the decision making.

Effective demand management can reduce the need to secure new supplies of water. In several urban areas of Australia effective management of use and expectation have been successful and more can be done. Options available include infrastructure change such as fixing leaking supply systems, dual flush toilets, increased capture of rainwater, capture and re-use of storm water, and use of reclaimed water for non-potable purposes combined with concerted education and economic incentives.

While demand management – through more conscious efforts to reduce waste and conserve water – has been effective in several major urban areas of Australia, the continued push for greater water use efficiency in irrigated areas has, as yet, only had a limited effect. However in irrigated areas improved water use efficiency does not usually lead to reduced demand – quite the contrary, there is an increased demand as irrigators either intensify or expand their operations in response to being able to "spread" the water further. Improved water use efficiency which will enable reduced demand will need to be encouraged through incentive or trade out systems (for example, water delivery infrastructure improvements are subsidized on the basis of forfeiture of the saved water).

A conscious policy should be developed to enhance the potential for water re-use and aquifer recharge (using urban stormwater for example) to provide for storage either in terms of reducing demands for cities and country towns or for using this water as a potential source of supply for irrigators. This policy should address long term funding issues (eg the potential use of superannuation funds) to

overcome current cost issues. A National Water Conservation and Re-Use Research Program should be developed (there has already been progress in this regard) and supported.

TOR 4.

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

The essential elements in addressing and balancing competing demands will revolve around managing the size of the demand, setting environmental standards for some water sources, and putting in place processes for trading between uses and processes to identify trade-offs between different uses.

Conserving water and managing total demand –

- Identify goods, services and practices that are water conserving and provide a consumer information rating from zero to five frogs. Make it in everybody's financial interest to conserve water and keep it clean through taxation advantages for improving practice.

Environmental standard for protected rivers and estuaries -

- Define those rivers that are to be protected (Heritage rivers) and those designed to be healthy working rivers and those that will have greater demands placed on them from multiple uses
- Set up a Rivers Corporation as recommended at the 8th meeting of the Prime Ministers Science, Engineering and Innovation Council[9]. This Corporation would gather and hold environmental allocations financed through Government programs.

Defining responsibility through duty of care -

- Agriculture remains a safe harbour from environmental regulation. The standards for agriculture should be the same as those for the rest of Australia. Why, for example, are practices that cause salinity being allowed to continue?

Processes for trading and specification of interests -

- Establish principles to be applied to the priority for multiple and competing uses and link them to the financial transfer system. COAG Mark II should push the agenda and require

[9] PMSEIC Report. Recommendation 3, 8th Meeting, 31 May 2002.

- full specification of interests in water by separation of the component parts, namely an entitlement, an allocation and a licence to use. See Appendix 5, Young and McColl.
- Force pricing and or other mechanisms that force full signalling of all costs, including externalities. For example by developing markets for river salinity at the individual level. (At present, all trade is among States, not among individuals so there is little incentive to improve).

Processes for deciding trade-offs –

- Pilot programs that facilitate stakeholder understanding of and successful participation in, the water resource planning process, are needed e.g. development of regionally focussed, web-based 'data clearinghouses' that promote communication & encourage involvement by providing stakeholder access to available data, research findings, and other integrated regional information.

- There is a need within the COAG process for the Commonwealth to provide for adequate social assessment including participatory processes to address the issues of justice and fairness in sharing and a demonstration of procedural justice. As Dale et al (2001)[10] conclude "Social assessment is often treated as an administrative hurdle, not as a planning tool that can aid and enhance project planning and facilitate the integration of projects or plans into the surrounding community". This social assessment should provide for adequate regionally based ongoing social evaluation as to the operation of markets and environmental flows to avoid unintended rural poverty traps.

The need to measure and monitor -

- The Commonwealth has a strong leadership role in bringing about standardisation of metrics and monitoring in relation to defining available water through a regular audit process and further in reinforcing the linkage between surface and ground waters by insisting on commonality of volumetric measurement and allocation. **It will not be possible to adequately manage without consistent measurement.** Support is needed for surface and groundwater monitoring programmes to underpin resource assessment studies. Commonwealth support for National Hydrological Monitoring, through an activity run on similar lines to the Australian Collaborative Land Evaluation Program (ACLEP), is critical because it provides the leadership signals for other jurisdictions to get involved.

[10] Social Assessment in Natural Resource Management Institutions. Dale,A., Taylor, N. and Lane, M. (2001). CSIRO Publishing . page 284.

- Systematic and persistent assessment of river health, together with standard hydrologic measures are needed if we are to establish the current state of our water resources and to monitor change over time.

- The Commonwealth should increase the resources available to systematically assemble integrated national data sets (such as the National Land and Water Resources Audit, NLWRA). On-going support for NLWRA 2 will be critical in indicating trends in water availability and use to enable analysis and research that is pro-active for management and adaptation.

- The Commonwealth should increase sponsorship and encouragement of data sharing arrangements between all levels of government. Current arrangements represent a considerable constraint to the conduct of analysis and provision of timely advice on the status of water resources.

- The critical role that water resources will play in the ongoing development of Australia means that our measurement base, our research expertise, our management expertise and our education and training capabilities all need to be improved. The Commonwealth must increase support for education and training initiatives in water resource management.
- In cases where there is market failure in providing adequate financial support for strategic research, it is imperative for Commonwealth and State and Territory Governments to fund the underpinning public good research and development.

ToR 5

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.

Our capacity to provide specialist forecasts has improved considerably over the last two decades. Three to five day forecasts are now as reliable as one to three day forecasts of a few years ago. However our ability to forecast seasonal conditions and therefore to reliably manage water demand is still limited, although improving. The level of scientific research for adaptation to climate variability and better weather prediction, while world class in content, is certainly not comparable in terms of quantum especially in relation to the massive area and variability of the Australian continent.

The effect of climate variability and use of weather prediction on rural water storage and supply should be considered on both the supply and demand ends.

Effect on supply –

- Strategic Research/Climate Science

  There have been major national and international advances in our understanding of the causes of natural climatic variability in Australia, in particular with respect to the role of the Pacific Ocean and El Nino[11]. Based on these advances organizations like the Bureau of Meteorology, the CSIRO and the Queensland Centre for Climate Applications are able to provide seasonal climate outlooks, and advice to specific industries and regions (see below).

  However, major uncertainties persist, such as the role of the Indian and Southern Oceans, and the impact of the Indonesian throughflow, all of which are known to be significant factors in Australian climate variability.

  Global climate change due to the greenhouse effect will have a significant impact on Australia. The Intergovernmental Panel on Climate Change Third Assessment Report (IPCC TAR)[12] has extensively reviewed the evidence for climate change and determined where it is highly likely to be occurring as a consequence of human activity. Drying of Australia and other regions of

[11] Australian Academy of Sciences (2002): Australian Climate System Modelling Workshop Report, Convenor: M. Manton, Canberra, 19pp.

[12] Working Group I of the IPCC (2001): Climate Change 2001: The Scientific Basis--Summary for Policy Makers, World Meteorological Organization/United Nations Environment Program, 20 pp.

moderate to low rainfall is a consistent theme in the report. This is going to have a significant effect on Australia in years to come. Already a 40% decrease in the flow of water into the reservoirs for Perth due to decreased rainfall has been partially attributed to the greenhouse effect[13]. The WA Government in response is spending about $100M p.a. to capture new water for the system. The Bureau of Meteorology records show that the climate has changed over recent decades in other regions of Australia. Thus in addition to natural climate variability, Australian water resources are most likely going to also be affected by longer term climatic change. Improved understanding of our climate and improved predictions are required to guide adaptation to these changes.

- Climate Prediction

Recent advances in scientific understanding and in climate model development have improved Australia's capacity to provide seasonal climate outlooks (issued by the Bureau of Meteorology), supported by the jointly developed BoM/CSIRO climate prediction model 'POAMA' (see earlier).

There have also been major advances in the provision of long-term predictions of climate change due to global warming (using both the CSIRO global and regional climate models), leading to regional climate impact assessments. There is an urgent need (and good scientific prospects) for extending this research on climate change impacts, and to link it to the development of adaptation strategies.

It should be noted, however, that significant further research is required to reach sufficient regionally specific detail and to reduce major uncertainties in climate change science. Already, a number of preliminary studies are available that assess regional climate change impacts on selected areas, such as Western Australia and the Murray-Darling Basin[14]. An excellent multidisciplinary study that includes social and economic assessments can be found in Hassall and Associates (1998)[15].

---

[13] Indian Ocean Climate Initiative (in press): "Climate variability and change in south west Western Australia", c/- Executive Officer IOCIP, Department of Environment, Water and Catchment Protection, Hyatt Centre 3 Plain St, East Perth, Western Australia 6004

[14] Charles, S. P., Bates, B. C., Whetton, P. H., and Hughes, J. P. (1999). Validation of downscaling models for changed climate conditions: case study of southwestern Australia. Climate Research, 12 (1): 1-14. Schreider, S. Y., Whetton, P. H., Jakeman, A. J., and Pittock, A. B. (1997). Runoff modelling for snow-affected catchments in the Australian alpine region, eastern Victoria. Journal of Hydrology, 200 (1-4): 1-23.
Suppiah, R., Jones, R. N., and Hennessy, K. J. (2002). Impacts of climate change on water resources in Australia. In: Proceedings First International Workshop on Climate Change and Water-related Disasters, Tsukuba International Congress Center. Tsukuba, Japan: National Institute for Earth Science and Disaster Prevention. p. 8-9. Jones, R. N. (2000). Analysing the risk of climate change using an irrigation demand model. Climate Research, 14 (2): 89-100.

[15] Hassall and Associates (1998). Climate change scenarios and managing the scarce water resources of the Macquarie River, Australian Greenhouse Office, Canberra, 113pp.

Finally, it should be noted that CSIRO in recent years has combined its scientific advances in climate and hydrological research to develop a regional hydrological forecasting capacity linked to global and regional climate modeling. A prime example of practical applications to water resource issues can be found in the Indian Ocean Climate Initiative, IOCI (a project involving CSIRO Atmospheric Research, CSIRO Marine, CSIRO Land and Water, Bureau of Meteorology and Department of Agriculture, commissioned by the Western Australian Government). IOCI is improving the scientific basis for water management decisions as WA adapts to decreased rainfall.

- Rainfall is likely to exhibit considerable regional variations due to the enhanced greenhouse effect, because of the complicated relationships between orography, large-scale atmospheric circulation, and rainfall. So more detailed model experiments and research to improve confidence in projections of rainfall change at the regional scale are needed.

- More detailed study of the synoptic meteorological events leading to rainfall, and the way these events have changed over the 20th century, is needed. Such work may allow a more definitive determination of how rainfall variability is related to changes in these synoptic systems.

- Research is also needed to determine whether other, more local or regional, factors could be affecting climate variability. For instance, model experiments could be undertaken to provide a better estimate of the possible impacts of local land-use changes on the region. The results of studies of the climate impact of global land-use changes could also be examined, to determine if these have contributed to observed rainfall declines.

- Currently two main frameworks are available for rainfall and stream flow forecasting i.e. Australian Rainman and its Streamflow addition. These tools have been developed on the basis of DPI, Qld, University of Melbourne and Bureau of Meteorology research efforts. The stream flow addition to Australian Rainman is not perfect; still a lot of work needs to be done to include climate variability in seasonal allocation, to quantify risk in planting decisions and to understand long term availability of water under climate change scenarios.

Effect on demand –

- Demand for water is highly dependant on seasonal and longer term climate conditions. In an irrigation context the reliability of supply is a critical influence on investment decisions both in the short (seasonal) and long term. To date, there are very few examples of serious integration where water supply, water delivery (through rivers and channels) and

water use have been combined with irrigation and other uses to look at the risks and economic consequences of particular supply/demand prospects. Until now we have managed by over design and being conservative. With increased pressures on water resources we will need much more informed decision making processes. These will need to be researched and tested. We will need complete hydrologic economic approaches such as Ocean-to-Farms: an integrated approach to developing targeted applications of seasonal climate predictions combining the skills of ocean, climate and farming researchers supported by CSIRO and the Climate Variability in Agriculture Program (CVAP) of Land and Water Australia.

- There is need for greater standardization of fundamental information such as evapotranspiration estimates across jurisdictions. This will enable greater confidence in the methodology, in regional comparisons and in ongoing improvements of predictions.

Appendices

1. The water eaters. Australians are adopting an enlightened approach to water management, but atoning for past mistakes will require major changes in food production and a new reverence for water catchments. Wayne S Meyer

2. Water in Australia. Wayne S Meyer

3. Extract from the World Metrological Organisation (Report of the Executive Council Panel of Experts/CAS Working Group on Physics and Chemistry of Clouds and Weather Modification Research (WMP Report Series No 36), 2001.

4. Robust Separation: A search for a generic framework to simplify registration and trading of interests in natural resources. M.D. Young and J.C. McColl, Policy and Economic Research Unit. August 2002 Folio No: S/02/1578

5. Imagine if we valued ecosystems as if they mattered – Towards Opportunity and Prosperity. By Mike Young. Reprinted from The Australian, Edition 1, Mon. 25 Mar. 2002. Page 010.