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Adapting to Water Scarcity: A Global Challenge for the 21st Century

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Introduction

Australians, like many others, have long been in denial about climate change, despite the warnings from scientists. As much of South Eastern Australia enters its 17th year of low flows, our major water storages have emptied and Australians are starting to realize something is wrong. We have moved from denial of this issue to anger that Governments have not done more. Hopefully we will now move quickly to acceptance and get on to address this challenge.

Today I will outline the climate change and how it is affecting the Australian water situation. I will describe the policy framework that we have agreed is the best way for us to confront water scarcity, and outline how both the urban and rural sectors may have to cope with the situation. I will finish by outlining the challenges I see for freshwater ecologists as we grapple with the issue of protecting aquatic ecosystems from the increasing pressures they are experiencing.

Climate Change and Water

We can measure the increased CO_2 in the atmosphere, and the consequential increase in temperatures. Each summer seems to bring new records for hot weather and we know that since 1950 Australian average temperatures have increased 0.9^{o} C. Further evidence of warming is provided by the snow record in southeast Australia where the snow depth at the start of October has declined 40 per cent in the past 40 years.

The best estimate of annual warming over Australia by 2030 relative to 1990 is a further increase of about 1^{o}C (CSIRO, 2007). Later in this century, the warming is projected to rise by around 1.8^{o}C for the best-case scenario and around 3.4^{o}C for a high emissions case, with a 20 to 50% chance of temperature increases exceeding 4^{o}C in inland areas. This warming will lead to more evaporation from storages, increased transpiration of water by plants and an increased frequency of mega-bushfires.

Scientists have no doubt that that increased greenhouse gases in the atmosphere are also influencing rainfall patterns. CSIRO scientists have estimated that around half the decline in rainfall in South West Western Australia is due to greenhouse gas. Predictions are of a 5-15% decrease in rainfall by 2070. It seems Australia is facing a future with declining and more erratic rainfall. Winter and spring rainfall will drop but there may be increases in summer thunderstorm activity.

A small reduction in rainfall is accompanied by a larger reduction in runoff. We can see the reduction in rainfall experienced in Perth since the 1970's, and how this reduction is magnified when considering inflows to storages. The same reduction can be seen in the records for Sydney since around 1990. The Sydney record shows that in the Eastern States there was an unusually wet period between 1950-1990, and we now appear to have returned to a drier time such as experienced in the first half of the century.

In the Murray-Darling Basin, the food bowl of Australia, the same picture emerges. This year the winter –spring rains have again failed. September inflows were 210 GL compared to a long-term average of 1610 GL. Monthly inflows have now been below average for the last 24 months. There is about half the water in the MDB storages (at 23% of capacity) now that at this time in 2006. One of the most important tributaries to the MDB is the Goulburn River, which over the last decade has delivered only 62% of the long-term flow.

As river levels in the Murray fall, saline groundwater flows into the river, potentially making the water unusable. The salinity at Morgan has almost doubled in the last 3 months, although it is still within acceptable limits and flow management is being focused at keeping it this way..

We have seen a similar pattern on our West coast. In Perth the rainfall has declined and the runoff into storages declined much more. There are fears that the East coast is now following this pattern, some 25 years after it became evident in the West.

Australia's National Water Initiative

Australia started its long and slow journey of water reform in 1994, and in 2004 the Council of Australian Governments (Premiers and Prime Minister) refreshed this with the National Water Initiative. The key principles of this reform agenda provide an effective framework for confronting water scarcity and a successful mechanism for adjusting rural communities to their new drier future.

- Understand how much water we have and how we use it
- Determine how much water we can take and still have healthy rivers and secure groundwater
- Restore over allocated systems
- Give users clear entitlement to water.
- Allow users to trade their entitlements
- Effective water planning to protect key ecological assets
- Best practice pricing to encourage efficiency in water use

While Governments have agreed to these principles in the NWI it is proving slow to implement, due to gaps in knowledge and capacity as well as political will in a Federal system where blaming other levels of Government has become the first response to difficult problems. The National Water Commission has now released its first Biennial Assessment of progress and has identified a number of areas requiring further attention.

- Dealing with over allocation
- Better integrating the management of surface and groundwater resources and in relation to land use changes that intercept significant amounts of water
- Improving water resource accounting and measurement to ensure that water is extracted, diverted, stored, traded and used in accordance with the conditions set out by water plans and defined in water access entitlements
- Enhancing the compatibility of individual southern Murray-Darling Basin registers to support timely and low cost water trading transactions across irrigation area boundaries and state borders
- Establishing arrangements for recovering costs of water planning and management.

Impatience with the slow progress led to the Federal Government passing legislation to provide much firmer Federal control over levels of extraction from the Murray in a context of water planning, and currently negotiations are underway to get State agreement to the principles of going forward.

Urban Water Security

Much of the water reform agenda has been focused on addressing problems of rural water, and there was a view that urban water had largely responded to the 1994 reforms. Hoverer, we have been facing a situation in the last three years where we seem to have been having a race to see which major city could run out of water first. Governments are investing in new infrastructure at a frantic rate to try and secure water supplies.

Clearly Australia is facing an uncertain water future, and urban water planning is now embracing four elements.

- Reduce our demands on water to secure supply
- Have a variety of water sources, at least some of which are independent of rainfall.
- Identify the next three or four water augmentations and do preliminary planning obtain necessary approvals and identify trigger points when construction must start
- Protect possible future water sources so that they will be available when needed

Australian cities are confronting water scarcity in a variety of ways, depending upon their specific contexts.

- Demand management programs are active, but per capita usage ranges from around 400l/person/day to 140 l/p/d in Brisbane that has severe restrictions.
- Purchase water from upstream irrigators. Adelaide has been doing this for several years, as has Perth. Melbourne and Canberra are both now planning to source future water from the over stressed MDB

- Build new storages. Brisbane has embarked upon building new dams and Adelaide is proposing to increase the size of its storages. The challenge here is to find appropriate sites that have a reasonable probability of filling under the new climate.
- Desalination. The Perth desalination plant is operating, the Gold Coast and Sydney plants are under construction, and planning is underway for plants in Melbourne, Adelaide and a second in Perth.
- Recycling. Brisbane is moving to recycle water back into potable supply; other cities are seeking to use it to replace drinking water for appropriate domestic and commercial and open space uses. Some are still using recycled water for agriculture.
- Groundwater. Several cities have turned to groundwater, but our basic knowledge and management regimes for groundwater are primitive
- Urban Stormwater. Adelaide is capturing stormwater and storing in aquifers for later recovery, but in existing cities storage of stormwater is the problem. Most jurisdictions are encouraging use of domestic tanks to trap roof water.

It is important not to exclude any options for securing a city's water supply from consideration. All need to be considered for their technical merits, economic impacts, greenhouse gas implications other environmental considerations and the social acceptability of the option. A much more sophisticated approach to engaging the community in these considerations is needed if communities are not to end in gridlock.

Reconfiguring Australian Irrigation

We have experienced some 40 years of unusually wet conditions in the MDB from 1950-1990, but in the last 15 years the Basin has been drying. Our refusal to recognize this meant we have allowed the major storages to empty, and they will not refill again without a run of wet years. The lack of water is already having a devasting impact on irrigators and their communities as we have already had the death of some permanent plantings in the Basin; more can be expected from both lack of water and from salinisation of water.

The Federal Government has committed $10 billion to improved management of the MDB. This gives us an incredible opportunity to build a foundation for an irrigation sector that can create wealth for rural communities and start to pay its own way without expecting taxpayer handouts every so often because they fail to maintain infrastructure. Much of the delivery infrastructure is old and has been poorly maintained, and there is considerable leakage. It also gives us the opportunity to address the over allocation problem which in recent years has seen marked degradation of the lower reaches of the river and estuarine system.

I believe irrigators will have to get used to around half the water they have been accustomed to last century. Water may in future be less reliable than in the past. We will have a better idea of this once the current CSIRO study of water yields under climate change is complete, which is addressing issues of interception and groundwater connection for the first time. Further work is required to estimate sustainable levels of

extraction that incorporates river health aspects and the issue of what is an economically reasonable security of supply to justify farmer investments in modern irrigation.

I expect Australian irrigation landscapes will change. I expect a reduction in the area of permanent plantings and perhaps more emphasis on annual crops that can be planted once water availability for the season is known. Irrigation properties may become larger to cope with a mix of perennial and annual plants and more opportunistic irrigation. There may be an overall contraction in the area irrigated, leading to issues of stranded assets and increasing operating costs to those remaining. The value of water will continue to increase, providing a useful pressure to drive improvements in water use efficiency. We may see dairy farms leave irrigation areas and become purchasers of fodder from irrigators and other sources. New irrigation technologies like sub surface tape may see crops move from heavier to lighter soils.

A critical issue for irrigation is whether to spend funds refurbishing old irrigation districts, where properties may be too small, and irrigation layouts inappropriate for current irrigation technologies, or to allow water to trade out and develop new irrigation enterprises on Greenfield sites. This has been happening over the last decade, and will probably continue. This will lead to the closure of some parts of existing irrigation systems.

This is an important issue for the Federal Government who have allocated some $3 billion to purchase water entitlements and nearly $6 billion to refurbish irrigation systems. It is important to enter the market and purchase the water before developing infrastructure, or there is every chance expensive pipes and channels will go to areas where irrigation may be contracting. Refurbishing last century's infrastructure may be silly when whole regions must be reconfigured with bigger farms and different irrigation layouts. What is the relative role for publicly provided infrastructure and that of the landholder?

Australia has a tremendous opportunity to build a 21st century irrigation sector that can double the wealth obtained from around half the water. It will be interesting to see if our political system has the capacity to deliver this outcome.

The Challenge of Environmental Water

The challenge for aquatic scientists and river managers is to determine what are the environmentally sustainable levels of extraction. This will be contested by interest groups fearful of losing access to water and will probably be tested in the courts. And this has to be done in a period when rainfall appears is decreasing, and competition for available water is becoming intense.

Australia has been at the forefront of developing environmental flow rules, and in various ways these are reflected, if only partially, in many of the existing water plans. We have gone through four stages in the development of our thinking about river flow and river health.

- Firstly, we decided that each managed river should have at least some minimum flow all the time to maintain its ecology. Some dams had minimum release rules for most of the 20th century..
- Secondly, we moved to trying to mimic natural flow patterns by releasing a certain proportion of the inflow water to a dam. This led to a "hard wiring" approach that required releases that may have been insufficient to achieve required outcomes.
- Thirdly we developed an understanding of the various ecological processes driven by different parts of the hydrograph, and we tried to build on natural flow events to ensure that these processes were enabled.
- The final approach is based on identifying the important ecological assets that must be maintained, and then deciding what are the appropriate flow regimes needed to protect them.

In some ways this latter is a form of prioritizing, in other ways a simplification of a complex decision process. It has probably led to a wider understanding, but also a view amongst some that environmental assets are little more than an irrigation field that must be watered efficiently. This view has strengthened as water has become more scarce and we are in danger of having a few "icon sites" that are intermittently watered and managed as museum piece landscapes.

Australian ecosystems have a variety of mechanisms by which they cope with the droughts and floods that characterize our country. Our climate is changing and we can expect to see more prolonged drought conditions. It is important for science to understand how our systems cope with drought and ensure we do not inadvertently damage these coping mechanisms. For example as rivers cease to flow many organisms survive in the deeper pools that remain as refuges. These pools are therefore important ecological assets that act as refuges to provide resilience to allow the system to recover.

Rivers, and their associated wetlands and floodplains are dynamic elements in the landscape, often with connections to the groundwater system. The challenge is to identify the relationship between the damaging function (flow alteration, riparian damage, pollution and so on), and the health of the river. These are not simple linear relationships, but are often stepped functions where little change is observed initially, but once some threshold is reached change can be sudden and may be hard to reverse. We have many examples of water bodies being able to tolerate nutrient pollution for some time, but then suddenly switching from being systems dominated by aquatic plants to being dominated by algal growth, and being hard to switch back. This idea that there are thresholds of potential concern, which has been developed by Rogers and his colleagues in Kruger National Park gives us a useful framework for assessing the risk of undesirable changes.

The idea that our aquatic ecosystems can accommodate various pressures up to some point such as they can recover once the pressure is removed is referred to as the

ecological resilience of the system (see Brand and Jax, 2007. However once some threshold is crossed, then recovery is unlikely and we may move to a different system.

This resilience framework makes it clear that we must manage for the extreme rather average conditions. As we approach these thresholds of potential concern, it seems resilience is reduced and we risk flipping to some alternate system. The challenge is then to identify these thresholds and to have management systems in place that can respond before the threshold is crossed.

In recent years we have lost thousands of redgums on the Lower Murray floodplain because these trees were not able to cope with a harsh drought coming on top of the man made drought our over extraction of water has caused. It is unlikely that many of these trees will return. We were unaware we were approaching such a threshold, and now subsequently having crossed it may find it to be irreversible. We may have also done this to the estuarine system of the Coorong at ther mouth of the Murray that has now become hypersaline and is fast becoming Australia's Dead Sea; a situation that may also be irreversible.

Planning for water dependent ecosystems is therefore about maintaining or reestablishing the resilience of these systems to cope with a fluctuating climate and other stresses, including water extraction. Water extraction beyond sustainable levels will be most obvious when the river is stressed by a natural drought at the same time. Water planning needs to identify the likely thresholds that will lead to dramatic changes in the aquatic systems once crossed. Environmental water must be managed to avoid crossing these thresholds if possible. This requires a skilled environmental manager with access to sufficient environmental water to sustain these systems.

Knowledge Investments by the National Water Commission

The National Water Commission is an independent body established to report on how Governments met their commitments under the National Water Initiative, and to advise the Australian Government on how to spend funds from the Australian Government Water Fund. There is a $200 million "Raising National Water Standards" fund to invest in data and science to support implementation of the NWI and to improve water management. In the area of aquatic ecosystems the Commission has the following investment priorities.

- River and Wetland Health Assessment
- Identification of Environmental Outcomes
- Determination of Sustainable Levels of Extraction of Water
- Managing Environmental Water

River and Wetland Health Assessment.

Since the need to improve the health of rivers and wetland systems is one of the key drivers of national water reform it is important to have a nationally acceptable approach

to periodically measuring river health to allow progress to be tracked and adaptive management undertaken as necessary. The NWC has undertaken a baseline study of Australia's Water Resources 2005. This study was based on existing data but only two States, Victoria and Tasmania, have ongoing programs to measure river health. The Murray-Darling Basin Commission is developing a comprehensive river health assessment, the Sustainable Rivers Audit, which is starting to report, but which needs to be accelerated. The NWC has worked with all the jurisdictions to agree on a framework for measuring river and wetland health. This framework is now being tested in various environments and hopefully will provide for an agreed national approach to measuring river health with ongoing data collection, analysis and reporting

Identification of Environmental Outcomes.

The allocation of any water to sustain environmental processes is contested by those who believe water can be used for better purposes. The NWI requires accountability in the use of environmental water and clear specification of the environmental outcomes that will be achieved.

River, floodplain, wetlands and their associated estuaries provide ecosystem services in terms of flood control, water purification, biodiversity, fishing, recreation and aesthetics and water supply. Environmental water may be used to wet a floodplain, refresh wetlands, scour sediment or biota from a river channel, provide cues for fish breeding, reoxygenate and flush pools, provide connectivity and maintain habitat through breeding cycles (fish, waterbirds). Identification and quantification of these outcomes is an investment priority

Determination of Sustainable Levels of Extraction of Water

Work here is focused on identifying relationships between wetting patterns and ecologic responses, with a particular concern to develop understanding of likely thresholds that can guide management actions. Particular projects are underway looking at waterbirds, aquatic plants and fish, as well as wetlands, floodplains and groundwater dependent ecosystems. Existing data sets are being collated to to identify thresholds of potential concern and further data is being collected in priority areas.

Identification and provision for high conservation value systems.

These high value assets need to be identified in water plans and appropriate watering regimes provided to maintain them. These include wetlands, floodplains, river channels and groundwater dependent systems.

Managing Environmental Water.

The governance arrangements around environmental water are an interest to the NWC and it is planned to facilitate a "community of practice" amongst practicing environmental water managers in Australia, regardless of the organizational structures

within which they work. The idea is to facilitate sharing of knowledge and experience, and to help identify future knowledge investments to support the management of environmental water.

Groundwater

The NWC is aware of the growing dependence on groundwater systems by rural and urban communities and are concerned about the intellectual capacity to understand and manage our groundwater resources. Considerable investments are being made in groundwater, including a new national centre of excellence in this area.

A Challenge for Freshwater Science

Much of the water reform I have outlined here is built upon the work of freshwater ecologists, some of whom have worked in Government or with Government agencies over a long period. However, the limnological capacity in Australia is spread across a number of universities and research groups, and few of them have sufficient capacity to have the depth and breadth needed to address many of these problems. A number of Universities are attempting to develop "networked" centres within and even between Universities with centralized strategic brokering capacity.

While a number of our freshwater ecologists have been effective at raising the public profile of freshwater ecology, and enjoy good relations with Government, more is needed. From Governments perspective there is always the concern of special pleading of groups seeking to beat up issues to gain funding, and to sell Governments on an idea to fund research that is already largely done. Government has limited capacity to understand much of the science agenda, and is confronted by a group of many players all pushing particular agendas, which commonly reek of self-interest.

There is an opportunity for the ecological sciences to inform these debates if it were able to come together and make a clear and simple statement of priorities to Government. Developing such a consensus is challenging, since if it is to be useful it needs to focus attention and investment on particular areas, which inevitably means some areas miss out. There has been a recent opportunity in Australia, with the exploration of funding for a Terrestrial Ecosystem Research Network within the National Collaborative Research Infrastructure Strategy.

I urge freshwater ecologists to work within Australian Society of Limnology and develop some strategic ways forward to guide science investment in Australia. We also need to ensure that the insights we already have about our freshwater ecology is made accessible to Governments and our community as we confront serious water scarcity.

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