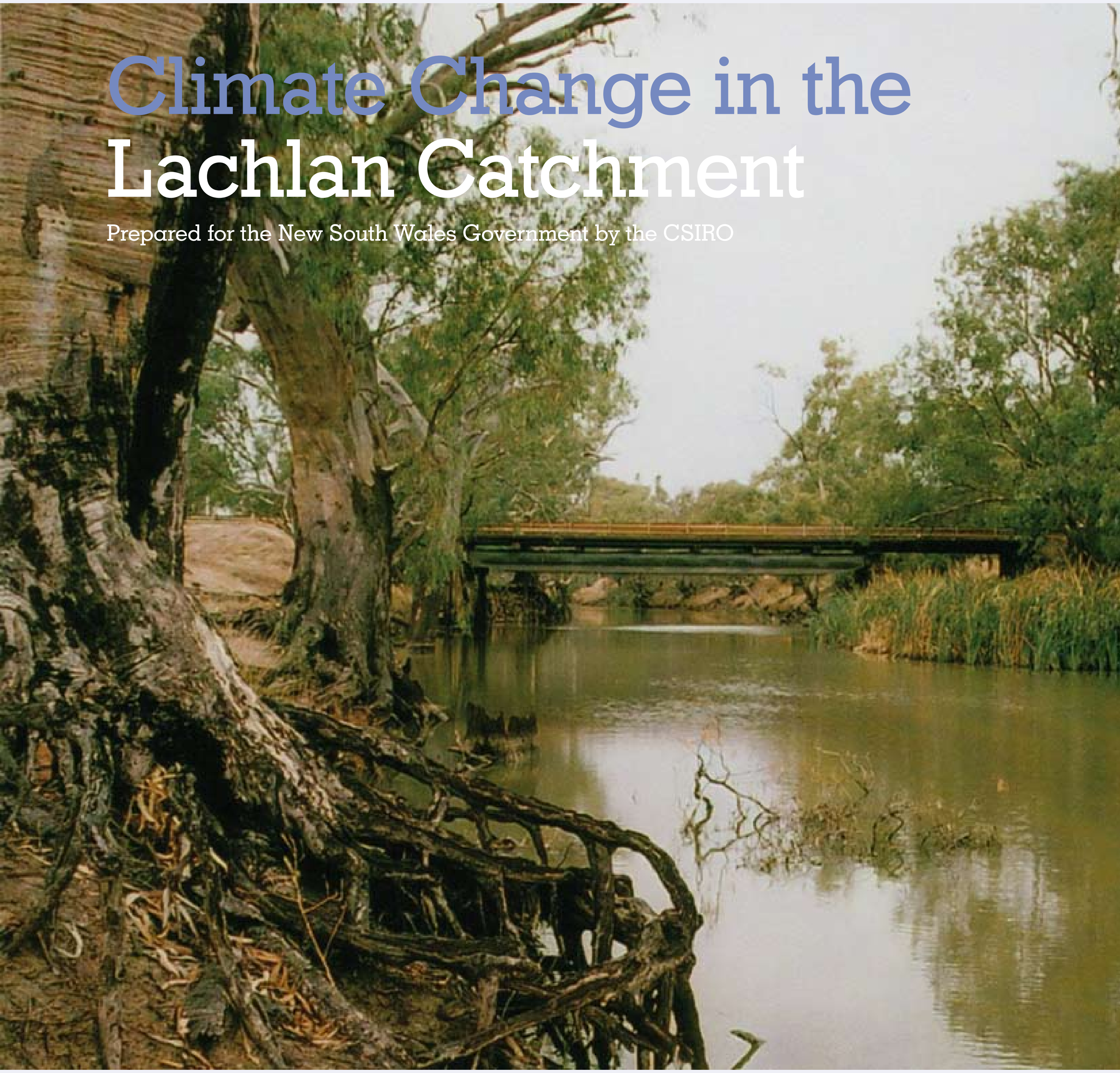
NEW SOUTH WALES GOVERNMENT | CSIRO

Climate Change in the Lachlan Catchment

Prepared for the New South Wales Government by the CSIRO



- Border Rivers-Gwydir
- Central West
- Hawkesbury-Nepean
- Hunter-Central Rivers
- **Lachlan**
- Lower Murray-Darling
- Murray
- Murrumbidgee
- Namoi
- Northern Rivers
- Southern Rivers
- Sydney Metro
- Western

The following brochure has been prepared by the CSIRO to provide information regarding climate change and its consequences for landowners, landusers and the general public within the Lachlan Catchment. The information presented here is based upon recent technical reports produced for the New South Wales Government by the CSIRO as well as data from the Australian Bureau of Meteorology and other peer-reviewed scientific studies. This brief summary provides an entry-point for raising awareness about climate change and for locating additional information.

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1.0 The Problem of Climate Change

The Earth's plants and animals depend on the climate to which they are exposed – they benefit when conditions are favourable, and they suffer when conditions become extreme. Humans are no exception.

The crops and water resources that we use to sustain our communities are linked to the climate, and the economic as well as human losses that we experience from hail, cyclones, floods, droughts and bushfires are a reminder of our ever-present vulnerability to the climate system.

It is increasingly clear that our climate is changing. Whereas in the past humans have learned to cope with climatic variability and change that was natural in origin, we are now living in a climate of our own making. The rate at which our climate is being transformed is unprecedented throughout much of human history.

Evidence of a Changing Global Climate

- Temperatures in the northern hemisphere at the end of the 20th century are believed to have been warmer than they have been at any time in the previous 1,000 to 2,000 years.
- The average global temperature in 2005 was the warmest on record, and eight of the ten warmest years have occurred since 1997.
- The Earth's average surface temperature has risen 0.7°C since 1900.
- Heatwaves and extreme rainfall have become more common in many regions.
- The sea level has risen 1.8 mm per year since 1950 and that rate is accelerating.
- There have been fewer frosts and the ice sheets of Antarctica and Greenland are shrinking.
- The timing of physiological processes in plants and animals is changing throughout the world, and populations are shifting their distributions.

Evidence of Australian Climate Change

- Average temperatures in Australia rose 0.9°C from 1910 to 2004. There have been more heatwaves and fewer frosts.
- Since 1950, annual rainfall has declined on the eastern seaboard and in the south of the continent, but increased in the northwest.
- Since 1973, droughts have become more intense, and extreme rainfall events have increased in the northeast and southwest.

According to the United Nations' Intergovernmental Panel on Climate Change "most of the warming observed over the last 50 years is attributable to human activities." These activities – mainly the burning of fossil fuels such as coal, oil, and natural gas – have released vast quantities of greenhouse gases into the atmosphere.

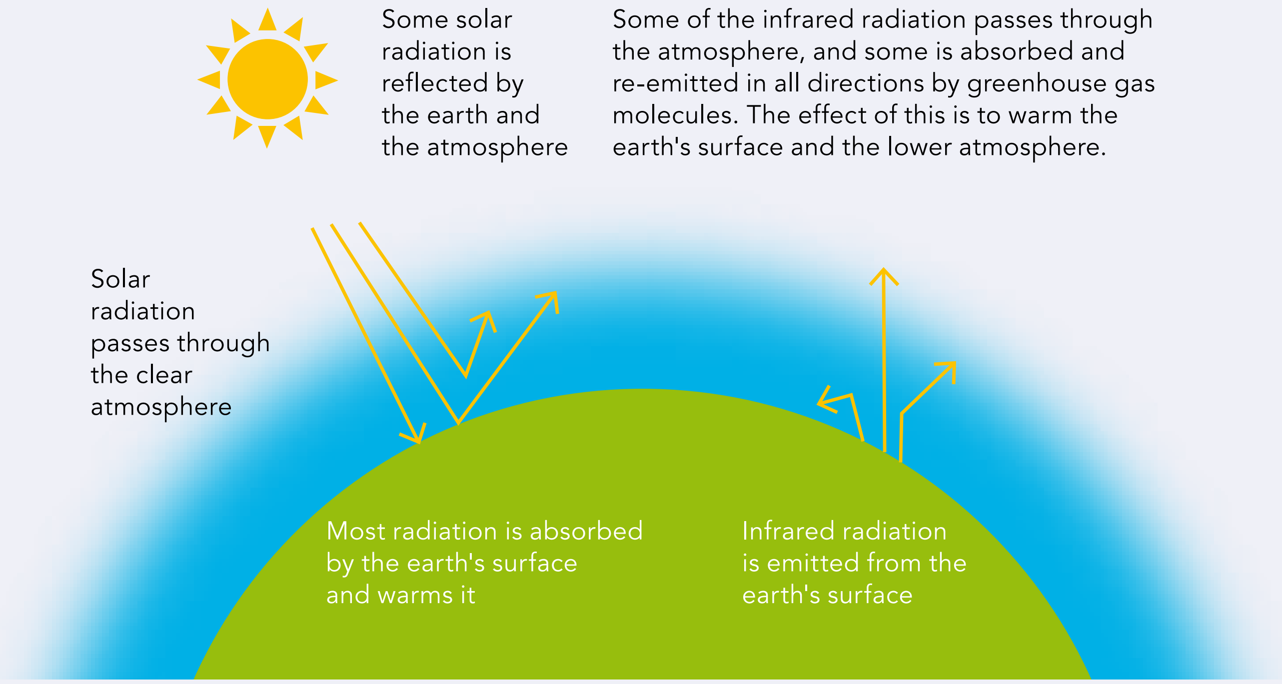
Most greenhouse gases have a long lifetime in the atmosphere. This means that even with reductions in greenhouse gas emissions, there would be a delay of several decades before those reductions have a significant effect on greenhouse gas levels in the atmosphere. Recent studies indicate that no matter how quickly we act, we are already committed to additional global warming during the 21st century of around 0.5°C and the subsequent impacts that are likely to follow.

1.1 What is Causing Climate Change?

Much of the energy that drives the Earth's natural processes comes directly from the Sun. Around half of the Sun's energy that reaches the Earth breaks through the atmosphere, warming the surface of the planet. The land and oceans then radiate that heat, some of which is trapped by greenhouse gases in the atmosphere. The principal greenhouse gases are water vapour, carbon dioxide, methane and nitrous oxide.

This trapping of heat energy is known as the 'greenhouse effect' – keeping temperatures higher than they otherwise would be, just like a glass greenhouse keeps plants warm (Figure 1). Without this process, the global average surface temperature would be closer to minus 18°C, instead of the current 15°C.

Figure 1. The Greenhouse Effect



The problem we now face is that human actions - particularly burning fossil fuels, agriculture and land clearing - are increasing concentrations of greenhouse gases in the atmosphere. Since 1750, the amount of carbon dioxide in the atmosphere has risen 35%, and the current concentration is higher than at any time in at least the past 650,000 years. The level of nitrous oxide has also risen 17% and methane 151%. **This has enhanced the greenhouse effect by trapping more heat, leading to global warming.**

Scientists assert that there will be continued warming and increases in sea levels with significant impacts on natural and human systems. Globally, these impacts include coastal flooding; more heatwaves, storms and droughts; less frost, snow and polar ice; more people at risk of food and water shortage; reduced habitat for many plant and animal species and more people exposed to infectious diseases such as malaria.

In response to this challenge, we need to do two things: start planning adaptation strategies to minimise the negative consequences, and reduce greenhouse gas emissions to slow the rate of global climate change.

2.0 Climate Change in New South Wales

In 2004, the CSIRO and the Bureau of Meteorology released a report on behalf of the NSW Government which looked at past and likely future changes to NSW's climate.

The report found that between 1950–2003, NSW became 0.9°C warmer, with more hot days/nights and fewer cold days/nights. Annual total rainfall declined by an average of 14 mm per decade, with the largest declines in rainfall near the coast due to an increase in El Niño years since the mid-1970s. Extreme daily rainfall intensity and frequency have also decreased throughout much of the State.

The report predicted that by the year 2030:

- NSW is likely to become warmer than it was in around 1990.
- There will be more hot days over 35°C and fewer frost days below 0°C.
- Annual rainfall is likely to decline.
- Rainfall runoff and stream flows will be reduced.
- Droughts are likely to become more severe.
- The risk of bushfires is likely to increase.
- Extreme rainfall may become more intense in central and southeast NSW.

More detailed findings of the report are listed in Table 1 (below).

Table 1. Annual and Seasonal Climate Projections for New South Wales

Season	2030	2070
Annual	• Warmer by +0.2– +2.1°C • Rainfall change of -13 – +7%	• Warmer by +0.7– +6.4°C • Rainfall change of -40 – +20%
Summer	• Warmer by +0.2 – +2.3°C • Rainfall change of -13 – +13%	• Warmer by +0.7– +7.1°C • Rainfall change of -40 – +40%
Autumn	• Warmer by +0.2 – +1.9°C • Rainfall change of -13 – +13%	• Warmer by +0.7 – +5.6°C • Rainfall change of -40 – +40%
Winter	• Warmer by +0.2 – +2.3°C • Rainfall change of -13 – +7%	• Warmer by +0.7 – +5.6°C • Rainfall change of -40 – +20%
Spring	• Warmer by +0.2 – +2.1°C • Rainfall change of -20 – +7%	• Warmer by +0.7 – +7.1°C • Rainfall change of -60 – +20%

3.0 The Lachlan Catchment

The Lachlan Catchment covers an area of approximately 84,700 square kilometers in central NSW. It is flanked by the Macquarie and Bogan Catchments to the north, the Darling to the west, the Murrumbidgee to the south, and the Sydney/Shoalhaven Basin to the east. The catchment also encompasses 24 local government areas, and it falls predominantly within the Wiradjuri Aboriginal tribal area. The Lachlan Catchment has a population greater than 100,000 people and accounts for 14% of NSW's agricultural production.

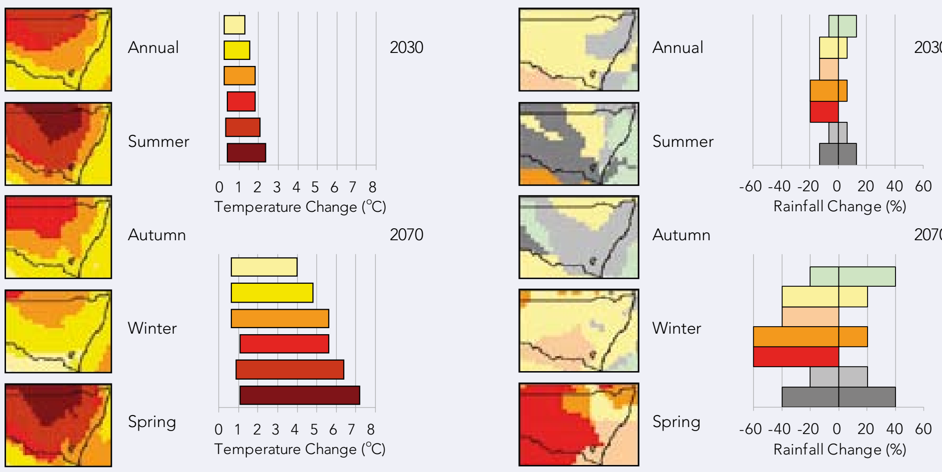
The Lachlan River rises near Gunning and terminates in the Great Cumbung Swamp near Oxley, 1,450 river kilometres to the west. Major tributaries of the Lachlan include the Abercrombie, Boorowa, Belubula and Crookwell Rivers. The main dam regulating flows in the Lachlan River is Wyangala Dam, which is located at the junction of the Lachlan and Abercrombie Rivers. In addition, there are numerous weirs along the length of the Lachlan River including: Nanami, Cottons, Jemalong, Booberoi, Lake Cargelligo, Lake Brewster, Willandra, Gonowlia, Hillston, Whealbah, Torriganny and Booligal. The geological formations throughout the catchment are quite complex and have a significant impact on salinity. The soil types throughout the catchment vary considerably ranging from very robust, durable soils to very fragile, naturally acidic and sodic soils. This variability requires effective management for erosion control as well as nutrient and salinity management.

3.1 The Climate of the Lachlan Catchment

Summers in the Lachlan Catchment are relatively hot, with average maximum January temperatures of 32–35°C at Forbes, Ivanhoe and Wyalong. However where the elevation rises in the catchment's east, the climate is more mild. For example, average maximum January temperatures at Crookwell are 27°C (Table 2). Based upon data from Wyalong, one would expect approximately 26 days above 35°C and 3 days above 40°C each year. Winters are cool to mild, with average maximum July temperatures of 14–16°C in Ivanhoe and Forbes, but only 10°C at Crookwell. Frosts are common in the catchment, particularly at higher altitudes. Annual rainfall ranges from about 300 mm/year in the more arid west to almost 900 mm/year further east. Peak precipitation occurs during winter, and the variability in rainfall from one year to the next is high.

A warming of 1.0°C and a 5% decrease in rainfall (a moderate scenario for 2030) would make the climate and Forbes similar to the current climate of Warren, over 200 km to the north west.

Figure 2. Climate Projections for New South Wales
(The coloured bars show the range of projected changes corresponding with the colours in the maps)



Since 1950, the region has experienced warming of around 0.8°C. This is likely to be partly due to human activities. Rainfall has declined by around 20–30 mm per decade. The contribution of human activities to this rainfall decline is hard to distinguish from natural variability.

The future climate of the Lachlan Catchment is likely to be warmer and drier (Figure 2). Such trends would also increase evaporation, heat waves, extreme winds and fire risk.

Nevertheless, despite this trend toward drier conditions, there is also potential for increases in extreme rainfall events. Further details about these changes are described in the following table (Table 2), which compares average conditions for the present climate with ranges of potential change in 2030 and 2070. These projections account for a broad range of assumptions about future global greenhouse gas emissions, as well as differences in how various climate models represent the climate system.

Table 2. Current and Projected Climate Change in the Lachlan Catchment			
	Present (1990)[1]	Projected Change	
		2030	2070
Temperature			
Average	Crookwell: 10 – 27°C[2] Forbes: 14 – 33°C[2] Ivanhoe: 16 – 35°C[2] Wyalong: 14 – 32°C[2]	+0.2 – +1.8°C	+0.7 – +5.6°C
No. Days below 0°C	Wyalong: 9	Wyalong: 2 – 7	Wyalong: 0 – 5
No. Days above 35°C	Wyalong: 26	Wyalong: 27 – 42	Wyalong: 32 – 93
No. Days above 40°C	Wyalong: 3	Wyalong: 4 – 9	Wyalong:5 – 35
Rainfall			
Annual Average	Crookwell: 860 mm Forbes: 527 mm Ivanhoe: 302 mm Wyalong: 481 mm	-13 – +7%	-40 – +20%
Extreme Rainfall[3]		-3 – +25%	-7 – +29%
Evaporation		+2 – +13%	+4 – +40%
No. Droughts per decade[4]	3	2 – 5	1 – 10
Extreme Winds		-5 – +8%	-16 – +24%
No. Fire Days[5]	Wagga: 50	Wagga: 53 – 57	Wagga: 58 – 72

1 Present day conditions for temperature and rainfall represent long-term averages from the Bureau of Meteorology. For extreme temperatures, the present average is based on 1964-2003. For fire danger, the present average is based on 1974-2003. For drought, the present average is for a period centred on 1990.

2 Range represents average July and January maximum temperature.

3 Defined as 1 in 40 year 1-day rainfall total. Values represent the range in seasonal projections from a limited set of climate models.

4 The values for drought represent average monthly drought frequencies, based upon the Bureau of Meteorology's criteria for serious rainfall deficiency (see also Burke et al., 2006).

5 Number of days annually with a "very high" or "extreme" fire danger index. Changes are for 2020 and 2050, respectively, as in Hennessy et al. (2005). Data from sites within the catchment were not available, and thus data for Wagga Wagga (an area with similar climatology) are presented.

3.2 Impacts of Climate Change in the Lachlan Catchment

Although average changes in temperature, rainfall and evaporation will have long-term consequences for the catchment, the impacts of climate change are more likely to be felt through extreme weather events. Projections suggest there will be more hot days, bushfires, droughts and intense storms. These can all place human life, property and natural ecosystems at increased risk. Additional details regarding climate change impacts on various activities and assets in the catchment are discussed below.

Water

Changes in rainfall and higher evaporation rates are likely to lead to less water for streams and rivers in the Lachlan Catchment, which will have downstream consequences for storages and place strains on the catchment's water resources. For example, due to recent trends toward reduced rainfall, as of August 2006, the Wyangala Dam on the Lachlan River was at only 21% of capacity, and the Carcoar Dam on the Belubula River was at 20%.[1]

1 Data obtained from the Water Observation Network: http://wron.net.au/DemosII/DamData/DamMap.aspx

Various studies of stream flows in the Murray-Darling Basin indicate that climate change is likely to reduce flows in the future (Hassall and Associates, 1998; Jones and Page, 2001; Beare and Heaney, 2002; Bates et al., 2003). Under the National Water Initiative, the Commonwealth, State and Territory Governments have agreed that water users should bear the risk of such reductions in water availability. As a consequence, water users within the catchment may face long-term reductions in allocations and higher prices for water.

Lower flows and higher temperatures may also reduce water quality within the catchment. For example, low flows, higher temperatures and elevated nutrients create a more favourable environment for potentially harmful algal blooms. Greater fire activity could contaminate water catchments with sediment and ash. Salinity problems in the catchment may be exacerbated by changes in rainfall, temperature and stream flows (Beare and Heaney, 2002). Meanwhile, decreases in runoff due to climate change may reduce the extent and function of freshwater wetlands in the Lachlan Catchment that provide habitat for birds and other wildlife.

Farms

The farmers of NSW have developed useful adaptation skills that stand them in good stead for dealing with climate change, but they will need to plan for new climatic challenges and opportunities.

Climate change will have both positive and negative impacts on the types of crops that can be grown and on agricultural productivity. For example, higher levels of carbon dioxide in the atmosphere are likely to increase plant growth, but the protein content of those plants is expected to be lower. Low to moderate warming will also help plant growth and extend growing seasons, but a rise in the number of very hot days could damage crops. Dry land grazing (sheep and beef cattle) and broad acre cropping are also likely to benefit from higher carbon dioxide levels, but this may be offset by the effect of higher temperatures (Hassall and Associates, 1998). Furthermore, warmer temperatures will increase heat stress on livestock (Howden et al., 1999a; Jones and Hennessy, 2000), which may affect growth and productivity and, subsequently, livestock management.

Irrigated agriculture is very significant in the region and includes rice, cotton, horticulture and pasture. These industries are likely to be affected by reductions in water availability meaning that water efficiency will be increasingly important. Higher temperatures also may lead to inadequate winter chilling for some fruit trees, which could reduce fruit yield and quality (Hennessy and Clayton-Greene, 1995). It may become necessary to consider low chill varieties and alternative management options. However, higher temperatures are likely to reduce the risk of damaging winter frosts.

Climate change is also likely to affect viticulture in the catchment, which includes the grape growing regions of Young, Cowra, Orange and the northern part of the Riverina. Warmer grape growing regions (e.g., Riverina) will be affected by climate change differently than cooler grape growing regions (e.g., Orange). Although in the absence of adaptive strategies, grape quality has been shown to decline in response to rising temperatures, increasing yields may compensate for this effect, leading, in some cases, to a net economic benefit. This is true for the Orange region where a 6–12% increase in gross return is projected by 2030 (Webb, 2006). In the Cowra region and Riverina regions, however, the projected impact to gross returns by 2030 is negative (2–14% and 12–46%, respectively).

The key consequence of climate change on farming will clearly be rainfall. Any reduction in rainfall will place most farms under stress, particularly when linked to higher temperatures. For dryland cropping, reductions in rainfall and increases in evaporation directly contribute to reductions in soil moisture. Meanwhile, irrigated agriculture is likely to be affected by tighter constraints on water allocations and higher prices (see above). In this sense, the unusually hot droughts of 2002/03 and 2005/06 may be a sign of things to come. Indirect impacts due to changes in weeds, pests and international markets may also place farms under stress.

Biodiversity

Changes to the climate will have significant effects on the catchment's plants and animals. Currently, 102 species, two populations and five ecological communities (i.e., a collection of species or habitat) are listed as endangered or vulnerable (DEC, 2006). Of particular concern are the endangered Box Gum and Grey Box woodland ecosystems, which represent critical habitat for some of the catchment's iconic species including the Grey-Crowned Babbler, the Superb Parrot and the Regent Honeyeater. Although current threats to the catchment's biodiversity are largely a product of historical alterations of land clearance, river flows and water extraction, climate change is likely to heighten the need for conservation efforts.

The geographic distribution of a species is often defined by its 'climate envelope,' reflecting species-specific tolerances to extremes of temperature and moisture. Climate change is likely to drive changes in the distribution of some plant and animal species, driving some species out of the catchment or enabling invaders to move in. Meanwhile, even those species capable of coping with climate change alone may succumb to the cumulative effects of multiple stressors.

Other risks to biodiversity in the Lachlan Catchment include:

- Reductions in stream flows are likely to have a negative impact on aquatic biodiversity and wetland ecosystems.
- Plants and animals may become 'stranded' in isolated remnants of vegetation as climate zones change, due to a lack of suitable habitat for migration.
- More frequent droughts and fires are likely to increase stress on plants and animals.

Forests

The Lachlan Catchment's forests and woodlands are a significant asset that is managed for timber production, biodiversity conservation, recreation and other purposes. Research and trial projects in the catchment indicate that farm-based forestry projects can aid in reducing land degradation from salinity and soil erosion (Latham, 2002).

Preliminary research suggests that temperate forests in Australia may increase in productivity with higher temperatures and increased concentrations of atmospheric carbon dioxide. However, these benefits may be offset by decreased rainfall, increased bushfires and changes in pests. Also the benefit of higher carbon dioxide concentrations may be limited over the long-term by the availability of nutrients (Howden et al., 1999c).

Climate change is likely to lead to changes in the distributions of tree species, possible increased invasion by pests, and changes to the habitat that these areas provide for local plants and animals. This will raise new challenges in managing forest areas for biodiversity conservation.

Climate change may also create challenges and opportunities for the plantation industry. Given appropriate selection of tree species and the availability of suitable land, it may be possible to expand plantation forestry within the catchment. However, increased risk of drought and wildfire may affect the feasibility of establishing successful plantations in some areas.

Communities

Warmer winters are likely to reduce cold-related illnesses, but warmer summers are likely to increase the risk of heat-related health problems, especially in the elderly (McMichael, 2003). Warmer temperatures may also contribute to the spread of infectious diseases, although the spread of tropical diseases such as dengue fever into the Lachlan Catchment remains unlikely.

The built environment is also vulnerable to climate change. As well as impacting on homes, climate change will affect infrastructure, commercial buildings and other physical assets. Changes in average climate will affect building design and performance, including structural standards and cooling and heating demand (PIA, 2004). Higher summer temperatures, for example, may induce the revaluation of building design and standards to ensure thermal comfort at minimal cost, while potential increases in extreme winds may necessitate more robust construction. In addition, a study by Austroads (2004) concluded that climate change would contribute to increases in road maintenance costs in NSW of up to 25% by 2100, largely due to assumptions about the effects of climate change and population growth on traffic volumes.

Increases in the intensity of the heaviest rainfall events would increase flash flooding and strains on water infrastructure such as sewerage and drainage systems, particularly in population centres. For example, a study by Minnery and Smith (1996) found that climate change may double flood-related damages in urban areas of NSW. Regardless of changes in such extremes, higher temperatures and lower average rainfall are likely to lead to increased pressure on urban water and energy supplies, unless moderated by demand management measures.

The risk of property loss due to bushfire is also likely to increase. As a consequence of these and other changes in extremes such as winds and floods (Table 2), insurance risk assessments and premiums are likely to be affected.

4.0 Adapting to Climate Change

Adaptation is a risk management strategy involving actions to reduce the negative impacts of climate change and take advantage of new opportunities that may arise. The types of adaptation measures adopted will vary from region-to-region. Because some of the decisions we make today will have lasting implications for future climate vulnerability, we must start planning our adaptive responses now. By doing so, we may help to lessen some of the environmental, economic and social costs of climate change.

Some examples of potential adaptation measures relevant to the Lachlan Catchment include:

- Improving water-use efficiency.
- Changing to crops that are more tolerant of heat and drought.
- Changing planting times and practices for crops.
- Providing more shade and cooling for livestock.
- Providing migration corridors for vulnerable animal species.
- Reviewing flood and fire management arrangements.

Making sure the catchment has the necessary capacity to implement such adaptation measures means continually expanding research, education and communication.

4.1 Adaptation in Action

Throughout much of Australia, users of the land have developed considerable experience in managing the high degree of variability that is characteristic of Australia's climate. However, many individuals and enterprises are recognising that they are contending not just with climate variability, but also climate change, and the past is no longer a reliable indicator of future conditions. In response, a broad range of adaptation actions are being implemented across Australia.

In 1999, the ***Masters of the Climate*** project collected information from more than 80 landholders on how they were using climate tools to better manage their land resources and farm businesses – 23 were selected as case studies. In 2004, those 23 landowners were visited again to see how they fared during the 2002/03 drought and to identify trends in the use of climate tools over the intervening five years.

Some of the observed trends included:

- Solid understanding of local climate history as the basis for greater understanding of climate variability and change.
- Growing use of weather and climate websites for both long and short-term forecasts.
- The application of sophisticated tools (such as software for tracking sub-soil moisture and wheat yields) for making full use of all available moisture.
- Shifts in the nature of crops and stock run on properties, with a movement away from riskier varieties and activities.
- Opportunistic decision-making – being ready to act on short notice to take advantage of weather conditions.
- In a few cases, deciding to leave the enterprise altogether.

All of the ***Masters of the Climate*** case studies from 1999 and 2004 are available over the internet at www.managingclimate.gov.au/information_resources.asp.

5.0
What is the New South Wales Government Doing?

The NSW Government is taking a leadership role in the responding to climate change. In late 2005 the NSW Greenhouse Plan was released, which outlines the NSW Government's response to climate change.

The NSW Greenhouse Plan outlines polices and actions in three main areas:

- Awareness Raising
- Adapting to Climate Change
- Reducing Greenhouse Gas Emissions.

Copies of the Plan can be downloaded from www.greenhouse.nsw.gov.au.

6.0
What's Happening in the Lachlan Catchment?

The following activities are currently underway within the Lachlan Catchment with the goal of improving both knowledge about climate variability and change in the catchment, and adaptation options to reduce the catchment's vulnerability:

- The Lachlan Catchment Management Authority (CMA) has developed a Catchment Action Plan and annual investment plan for improving the condition of natural resources through improved community awareness, education and land management.

- The CMA is involved in the development of macro water sharing plans that will govern the extraction and regulation of water based on sustainable yields that consider the economic and environmental constraints of the water source.

- The CMA is organising and supporting the Bureau of Meteorology and NSW Department of Primary Industry's (DPI) climate change and variability information sessions within the catchment. In addition, the CMA is supporting and promoting more detailed NSW DPI farmer workshops on climate change and enhancing climate change training for CMA staff and other stakeholders.

- The CMA runs Property Management Planning involving physical property planning, whole farm financial, enterprise evaluation and provides monitoring tools for improved matching of enterprise to land capability, water use efficiency, sustainability and profitability.

- The implementation of the Lachlan Remnant Vegetation Conservation and Enhancement Program to assist with the improvement of environmental services including the provision of clean air, clean water, mitigation of greenhouse effects, provision of food and habitat for insects, birds and other animals.

- The CMA is working with the community to conserve remnant vegetation, revegetate the riparian zones and over cleared landscapes, and encourage the connectivity of the existing large remnants within the catchment.

Want to know more about Climate Change?

A number of climate change studies relevant to the Lachlan Catchment are listed here:

Austroads. 2004. Impact of Climate Change on Road Infrastructure. Austroads Incorporated, Sydney, Australia, 124 pp.

Bates, B.C. Charles, S.P. Chiew, F., Harle, K., Howden, M., Kirby, M., Peel, M., Suppiah, R., Siriwardena, L., Viney, N.R. and Whetton, P.H. 2003. Climate Change Projections and the Effects on Water Yield and Water Demand for the Australian Capital Territory. Consultancy report for ACT Electricity and Water.

Beare, S., and A. Heaney 2002. Climate Change and Water Resources in the Murray Darling Basin, Australia: Impacts and Adaptation. ABARE Conference Paper 02.11, 33 pp.

Burke, E.J., Brown, S.J., and Christidis, N. 2006. Modelling the recent evolution of global drought and projections for the twenty-first century with the Hadley Centre climate model. Journal of Hydrometeorology 7, 1113-1125.

DEC (Department of Environment and Conservation) 2006. Threatened Species: Species, Populations, and Ecological Communities of NSW. Accessed October, 2006.

Hassall and Associates. 1998. Climatic Change Scenarios and Managing the Scarce Water Resources of the Macquarie River. Australian Greenhouse Office. Hassall and Associates, New South Wales Department of Land and Water Conservation, New South Wales National Parks and Wildlife Service, and CSIRO Atmospheric Research, Canberra, Australia, 113 pp.

Hennessy, K.J., and Clayton-Greene, K. 1995. Greenhouse warming and vernalisation of high-chill fruit in southern Australia, Climatic Change 30, 327-348.

Hennessy, K.J. Lucas, C., Nicholls, N., Bathols, J., Suppiah, R., and Ricketts, J. 2005. Climate Change Impacts on Fire-Weather in Southeast Australia. CSIRO Atmospheric Research. Consultancy report jointly funded by the Commonwealth of Australia and the governments of New South Wales, Victoria, Tasmania, and the Australian Capital Territory, 91 pp.

Hennessy, K., Page, C., McInnes, K., Jones, R., Bathols, J., Collins, D., and Jones, D. 2004a. Climate Change in New South Wales. Part 1. Past Climate Variability and Projected Changes in Average Climate. Consultancy report for the New South Wales Greenhouse Office by CSIRO and the Australian Bureau of Meteorology.

Hennessy, K., Page, C., McInnes, K., Jones, R., Bathols, J., Collins, D., and Jones, D. 2004b. Climate Change in New South Wales. Part 2. Projected Changes in Climate Extremes. Consultancy report for the New South Wales Greenhouse Office by CSIRO and the Australian Bureau of Meteorology.

Howden, S.M., Ash, A., Barlow, S., Booth, T., Charles, S., Cechet, R., Crimp, S., Gifford, R., Hennessy, K., Jones, R., Kirschbaum, M., McKeon, G., Meinke, H., Park, S., Sutherst, R., Webb, L. and Whetton, P. 2003. An Overview of the Adaptive Capacity of the Australian Agricultural Sector to Climate Change – Options, Costs and Benefits. CSIRO Sustainable Ecosystems, Canberra.

Howden, M., Hughes, L., Dunlop, M., Zethoven, I., Hilbert, D., Chilcott, C., and Crutch, G. 2003. Report on BDAC workshop on Climate Change Impacts on Biodiversity in Australia, CSIRO Sustainable Ecosystems and Environment Australia, Canberra.

Howden, M. and R. Jones 2001. Costs and Benefits of CO2 Increase and Climate Change on the Australian Wheat Industry. Australian Greenhouse Office, Canberra.

Howden, S.M., McKeon, G.M., and Reyenga, P.J. 1999a. Climate change impacts on heat stress and water requirements of cattle in Australia. In Global Change Impacts on Australian Rangelands. CSIRO Wildlife and Ecology,Working Paper Series 99/09, Canberra, ACT, Australia, pp. 38-51.

Howden, S.M., Reyenga, P.J., and Meinke H. 1999b. Global Change Impacts on Australian Wheat Cropping. Working Paper Series 99/04, CSIRO Wildlife and Ecology, Canberra, Australia, 121 pp.

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For the latest information on climate change, its consequences and tools for managing risk, visit the following web pages:

The NSW Greenhouse Office website:
www.greenhouse.nsw.gov.au
This site contains more information on what the NSW Government is doing to combat climate change, including downloadable copies of the NSW Greenhouse Plan.

The Lachlan Catchment Management Authority:
www.lachlan.cma.nsw.gov.au

This site provides the latest news on catchment management projects and programs, relevant policies, and access to brochures and publications related to management of the catchment.

The Australian Greenhouse Office's National Climate Change Adaptation Program:
www.greenhouse.gov.au/impacts/index.html#programme

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