Integrated Regional Vulnerability Assessment: Riverina Murray

Volume 1: Regional vulnerabilities

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Glossary

Adaptation	Action taken to avoid actual or anticipated impacts from climate change, or to attain potential benefits arising from climate change. (IPCC, 2007a).
Adaptive capacity	The emergent property of a system to adjust its characteristics or behaviour to better cope with existing climate variability or future climate conditions. Adaptive capacity is expressed as actions that lead to adaptation that serve to enhance a system's coping capacity and increase its coping range, thereby reducing its vulnerability to climate hazards. Adaptive capacity also refers to the set of resources available for adaptation, and the ability of a system to deploy resources effectively in pursuit of adaptation (UNDP, 2005).
Climate	Average weather (or, more specifically, the mean and variability of variables such as temperature, precipitation and winds) over a time period ranging from months to thousands of years to millions of years.
Climate change	A statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period (typically decades or longer). Climate change may be due to natural internal processes or external forcings, or to persistent anthropogenic changes in the composition of the atmosphere or in land use.
Exposure	The degree to which a system or sector is exposed to climate factors, including in terms of the duration, frequency, and magnitude of changes in average climate and extremes.
Impacts (climate)	Consequences of climate change on natural and human systems.
Integration	The process by which separately produced components or assessments are combined, and incongruities in their interactions are considered and addressed.
Maladaptation	Any changes in natural or human systems that inadvertently increase vulnerability to climate variables; an adaptation that does not succeed in reducing vulnerability, but increases it instead.
Mitigation (emissions)	An anthropogenic intervention to reduce the sources or enhance the sinks of greenhouse gases.
Mitigation (natural disasters)	Measures to contain or reduce the severity of human and material damage caused by extreme weather events and natural hazards.
Region	The planning regions of NSW as depicted in *NSW2021 – A plan to make NSW Number 1.*
Resilience	Amount of change a system can undergo without changing state.
Sector	A part or division, as of the economy (e.g. the manufacturing sector, the services sector) or the environment (e.g. water resources, forestry).
Sensitivity	The degree to which a system is sensitive to change.
System	A population or ecosystem; or a grouping of natural resources, species, infrastructure or other assets.
Vulnerability	The degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude and rate of climate change, and variation to which a system is exposed, its sensitivity and its adaptive capacity.
Weather	Atmospheric conditions at a particular time, such as hours or days, as defined by variables such as temperature, precipitation and winds.
Weather extremes	Weather phenomena that are at the extremes of the historical distribution, especially severe or unseasonal weather.

Preface

The NSW Government's strategic plan *NSW2021* commits to assisting local communities to minimise the impacts of climate change and build resilience to future extreme events and hazards (NSW Government, 2011). Climate affects multiple systems and so risks from climate require a systemic, coordinated response. From a practical perspective, this requires input, agreement and collaboration of multiple stakeholders, amongst whom there may be no history of cooperation.

The Integrated Regional Vulnerability Assessment (IRVA) process allows NSW regions the opportunity to engage stakeholders, gain a holistic view and plan a collaborative response to the emerging risks from a changing climate. A cross-agency initiative, this innovative and rigorous intervention helps a region to:

assess the situation

- Identify local climate change vulnerabilities in vital sectors, and understand how these vulnerabilities influence other sectors
- Achieve a comprehensive understanding of the region's vulnerability, resulting from the interaction of each sector's vulnerability
- Gauge a region's capacity to adapt to climate change

mobilise industries and communities

- Increase stakeholder understanding of climate change issues and potential impacts – in the process boosting their capacity to respond appropriately
- Embed the importance of acting collectively – raising awareness that action by one sector may have adverse consequences in another
- Develop relationships among and within sectors, to support collaborative action

start planning a workable adaptation strategy

- Develop preliminary recommendations for reducing vulnerability in a systemic way
- Create a sound information base from which to prepare practical adaptation plans in response to local priorities, using a region's existing management and planning structures.

This report outlines the outcomes of the IRVA process undertaken in the Riverina Murray region of NSW. It describes the key areas of vulnerability to climate change identified by regional participants.

The Riverina Murray IRVA builds on the pilot NSW South East IRVA (OEH, 2012) undertaken in 2010, and furthers the framework from which other regions can begin the vital work required to prepare NSW for the impacts of climate change. This process has highlighted the depth and breadth of regional knowledge held by local officers, decision makers and community leaders. The IRVA process provides a system for accessing that wealth of information, and capturing it in a way that provides a basis for effective and collaborative regional planning for a changing climate.

1 How the IRVA overcomes the challenges of planning for climate change

1.1 Why do we need an Integrated Regional Vulnerability Assessment?

The NSW Government's strategic plan *NSW2021* commits to assisting local communities to minimise the impacts of climate change, and build resilience to future extreme events and hazards (NSW Government, 2011). For the Riverina Murray region, climate projections indicate that by 2050 there is likely to be hotter temperatures and a decline in total annual rainfall, with consequent impacts upon natural systems and the way communities and economies operate (DECCW, 2010a). Thus it is imperative that we begin to consider how our systems can adapt, to continue to function effectively and efficiently under these future conditions.

The Integrated Regional Vulnerability Assessment (IRVA) contributes to this commitment through a cross-agency initiative, which allows regional communities the opportunity to gain a holistic view of the emerging risks from a changing climate and plan a collaborative response.

By assessing regional vulnerabilities and undertaking adaptation planning, priority areas can be identified, and effective action implemented through coordinated and cooperative networks across groups and sectors. Such action will increase the resilience of the Riverina Murray's community, environments and economy to ensure that impacts are minimised and to capitalise on opportunities.

1.2 What is an IRVA?

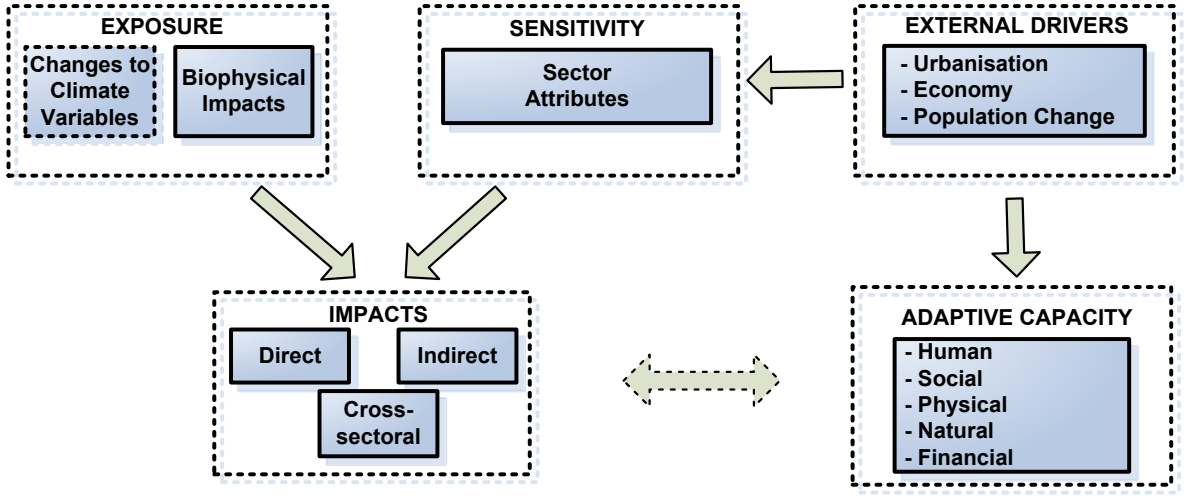
The IRVA process produces a qualitative assessment of the influence of climate impacts on a dynamic system. Through research and stakeholder workshops, an IRVA creates a sound knowledge and skill base from which regional managers and decision makers can develop adaptation responses for government services in the region.

The concept of vulnerability is key to the IRVA process. Vulnerability can be conceived of as a system's exposure to climate change impacts, sensitivity to those impacts and the capacity to adapt (IPCC, 2007a). Regional vulnerability occurs in the context of demographic and economic influences (external drivers) that influence the adaptive capacity and sensitivity of multiple sectors, as shown in Figure 1.

In undertaking an IRVA, participants consider the likely impacts of climate change within key regional sectors and how this may influence other sectors in the region. In addition, each sectors' capacity to adapt is discussed. In identifying sectoral and regional impacts and issues of adaptive capacity, the gaps or vulnerabilities can be identified, from which adaptation options to increase the region's resilience can begin to be developed.

Using this approach acknowledges the uncertainty in the impacts of climate change, and still allows identification of key vulnerabilities from which a regional adaptation strategy can be built. Most importantly, the IRVA uses a participatory approach that builds networks, empowers stakeholders to act on the results and promotes regional ownership (OEH, 2012).

Figure 1 Vulnerability model – integration of impacts and adaptive capacity for multiple sectors



1.3 The Riverina Murray Region of NSW

The Riverina Murray region covers an area of approximately 152,700 square kilometres in the south-western corner of NSW (Figure 2), and has a population of approximately 279,000 people that are mainly located at the major urban centres of Wagga Wagga, Albury and Griffith.

For the purpose of the Riverina Murray IRVA, the region is defined as the Local Government Areas: Albury, Balranald, Berrigan, Bland, Carrathool, Conargo, Coolamon, Cootamundra, Corowa, Deniliquin, Greater Hume, Griffith, Gundagai, Hay, Jerilderie, Junee, Leeton, Lockhart, Murray, Murrumbidgee, Narrandera, Temora, Tumbarumba, Tumut, Urana, Wagga Wagga, Wakool and Wentworth.

The region has two Regional Organisations of Councils (ROCs). The Riverina and Murray Regional Organisation of Councils (RAMROC) consists of 18 local councils, and Riverina Eastern Regional Organisation of Councils (REROC) is made up of 13 local councils and two water county councils[1].

The region spans a diverse range of ecological communities and environments, from the Australian Alps through to the arid landscapes in the west. Predominantly however, it is composed of the floodplains of the Murray, Murrumbidgee and Darling rivers.

The region is a major agricultural producer, with irrigated agriculture contributing over $900 million to the regional economy in 2006-7 and agriculture as a whole contributing 14 per cent to GRP and 28 per cent of exports from the region (ABS, 2007). The Riverina Murray is a key transport hub for distribution of goods across south-eastern Australia, with rail freight, roads and airport links within reach of major markets. It is situated to the south-west of the ACT and borders Victoria so has extensive commercial links to these regions, as well as Sydney and Adelaide. Recently, the regional economy has seen the rise of the services industry and tourism.

The region supports rich biodiversity, and much of the highest country in the very south east of the region is in conservation areas along with around 5 per cent of the foothills and lower

[1] Water county councils are organisations established under the *Local Government Act 1993* for the purpose of providing drinking water to the area they cover.

slopes of the Great Dividing Range including Woomargama National Park. Many of the ecosystems in the region rely on flooding, with the Riverina-Murray region accounting for a quarter of NSW's internationally significant Ramsar wetlands. The region also includes the World Heritage listed Willandra Lakes region and River Red Gum National Parklands (DECCW, 2010b).

More detail about the Riverina Murray region is in section 5.

Figure 2 The Riverina Murray region of NSW

2 Riverina Murray IRVA

The Riverina Murray IRVA sought to identify the region's vulnerabilities as a basis for developing approaches and actions that will build community resilience to a changing climate. The project aimed to:

- Establish an understanding of climate change impacts within key regional sectors, and how these impacts may interact between sectors
- Determine what sectoral stakeholders currently know, and plan to do, about climate change
- Assess barriers to adaptation in these key regional sectors, and the adaptive capacity of the region as a whole
- Identify the main sources of each sector's, and the region's, vulnerability
- Identify opportunities to reduce vulnerability and enhance regional resilience
- Continue to refine an IRVA methodology to be applied in other NSW regions.

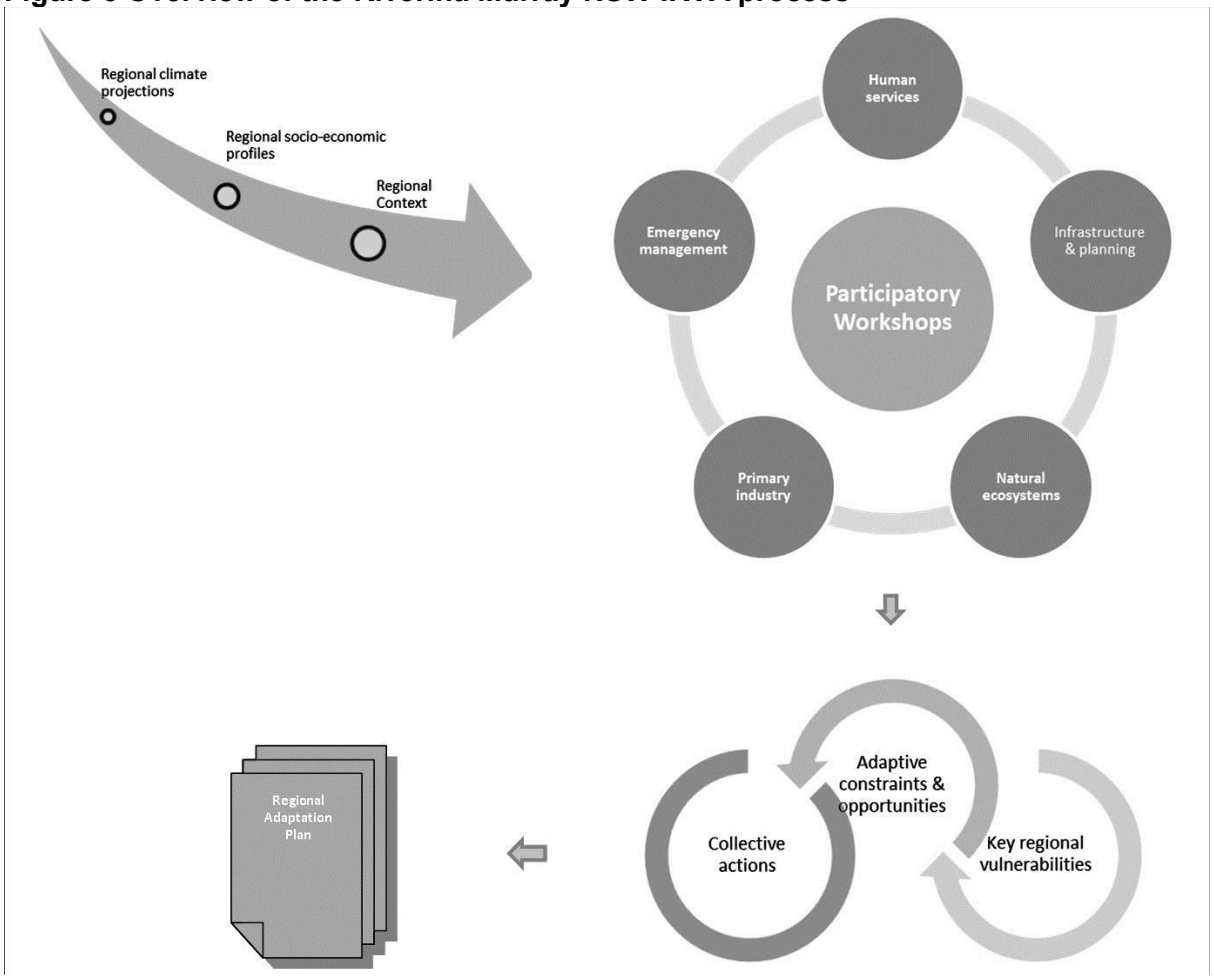
2.1 Process

The process involved the following stages:

1. Establishing project governance
2. Collecting and synthesising regional climate change and socio-economic information
3. Assessing sectoral impacts and adaptive capacity via sectoral workshops
4. Analysing and integrating sectoral workshop outcomes, to enable identification of regional vulnerability through an integration workshop
5. Synthesis of workshop outcomes with existing research into the social, economic and environmental impacts of climate change, to develop the Riverina Murray vulnerability assessment report

A simplified overview of the process is outlined in Figure 3.

Figure 3 Overview of the Riverina Murray NSW IRVA process



For the Riverina Murray IRVA a Steering Committee was established comprising regional representatives from a number of key government agencies to advise on and oversee the project (Appendix A).

The Steering Committee agreed that the Riverina Murray IRVA would consider five sectors, which are outlined in Figure 4.

Figure 4 Workshop sectors for Riverina Murray IRVA

Sector	Coverage
Landscapes and ecosystems	Natural resource management, biodiversity conservation, natural and cultural heritage, (water)
Industries	Primary industries, processing and manufacturing industries, tourism, (water)
Settlements and infrastructure	Transport, energy, communications, buildings and settlements, retail, water infrastructure
Human services	Employment, health, aged care, disability services, community services, education
Emergency management	Preparation, response and recovery to fire, flood, storm, drought and other emergencies

To inform the assessment, regionally-specific climate change information developed for the *NSW Climate Impact Profile* (DECCW, 2010a) and *Impacts of Climate Change on Natural Hazards Profiles* (DECCW, 2010c) was collated. Information on regional socio-economic and environmental trends was collated from socio-economic research, demographic data and other peer reviewed scientific research, to provide a snapshot of the current socio-economic and environmental conditions in the region. This background information, and professional knowledge and experience of the participants, provided the basis for analysis in the workshops.

Five sector workshops were held. Workshop participants were invited from NSW government agencies, State-owned corporations, local government and organisations involved in government service delivery to the Riverina Murray region. Over 40 organisations were represented throughout the Riverina Murray IRVA process (Appendix A).

The workshops were based on a participatory approach. In groups of 10-12, participants were first asked to collectively construct influence diagrams to show climate change impact pathways and relationships with other sectors.

Mapping the influences of climate change impacts to each sector provided the context in which adaptive capacity could be discussed using the 'five capitals' framework. The five capitals addressed were human, social, natural, physical and financial. For each capital indicators of adaptive capacity, were identified by asking:
Given what we know are the likely effects of climate change in this region, for your sector:

1. *What must change to service the community and why?*
2. *What is needed to enable change?*
3. *Where is change needed most / least?*

This discussion provided clear indications of adaptive capacity within each sector, identifying both enabling and constraining factors that influence overall adaptive capacity, and also the level at which these operate: local, regional, and/or state/national.

Following the workshops, the impact diagrams and adaptive capacity discussions were analysed by OEH project staff in conjunction with existing and projected regional dynamics. This identified:

- sectoral vulnerabilities, and
- cross-cutting issues and common themes of key regional vulnerability.

In a single integration workshop approximately 45 participants 'ground-truthed' the outcomes of the sector workshops, then prioritised the identified vulnerabilities within their sectors. Following this they prioritised these issues across sectors, to identify cross-sectoral or cross-cutting impacts, which provided the foundation for participants to think about regional vulnerability.

Participants were then allocated to cross-sectoral groups to discuss the identified themes of regional vulnerability. These vulnerability descriptors were discussed and validated, after which the cross-sectoral groups each selected one vulnerability from which they sought to develop adaptation actions. Each group then reported to the broader workshop in a plenary session.

Outcomes of this workshop were then analysed, to produce this final report on regional vulnerability.

A full explanation of the IRVA approach and process is available in the *Guide to Integrated Regional Vulnerability Assessment* (OEH, 2013). Full discussion of the outcomes of the sectoral workshops are provided in the sector summaries (Volume 2).

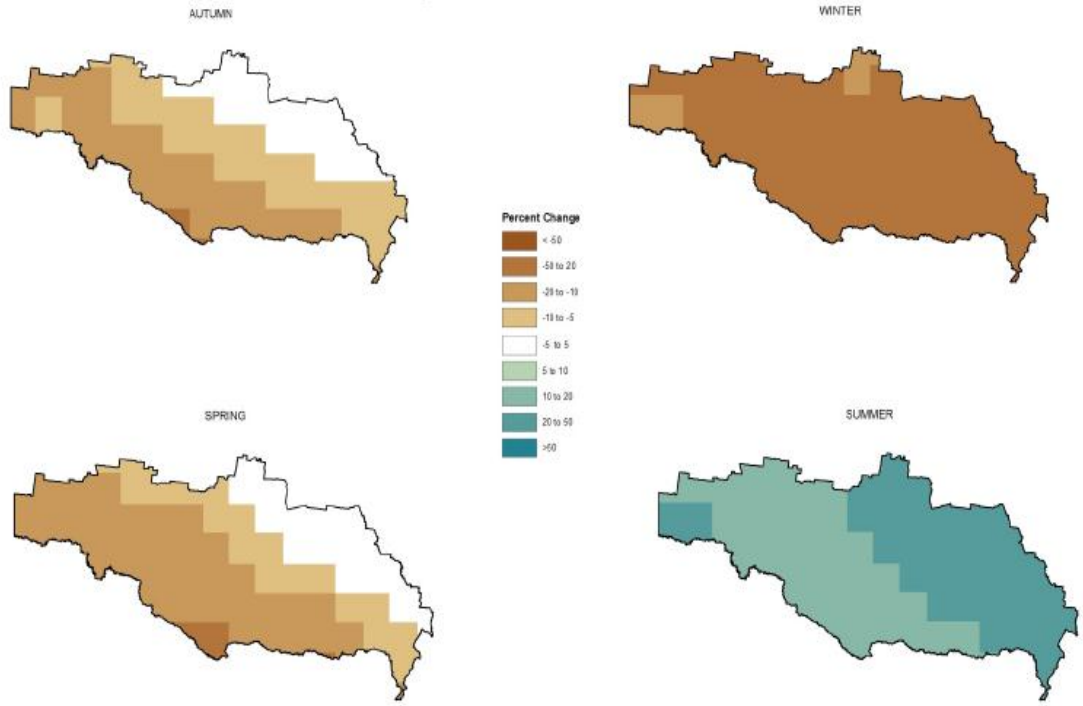
3 Climate change impacts in the Riverina Murray

The likely changes to the climate in the Riverina Murray include:

- Temperatures are virtually certain to rise by 1.5^{o}C – 3.0^{o}C in all seasons
- Rainfall is likely to decrease on average, due to a moderate increase summer, but substantial decline in spring, autumn and winter
- Evapo-transpiration is likely to increase in all seasons except winter
- The impact of the El Niño–Southern Oscillation is likely to become more extreme
- Frequency and intensity of heatwaves is virtually certain to increase
- Changes to fire frequency are uncertain, however weather conditions conducive to large, intense fires are likely to increase, and length and intensity of fire season is likely to increase
- The incidence of very high to extreme fire danger days per year is virtually certain to increase
- Incidence of flash flooding may increase
- Incidence of riverine flooding is likely to increase.

One of the key climate drivers for the Riverina Murray is the projected decline in average rainfall in the winter and a slight increase in average rainfall over summer (DECCW, 2010a) (Figure 5).

Figure 5 Projected changes to rainfall in the Riverina Murray in 2050



These changes will occur against the backdrop of climate variability, which is characteristic of the region. There will still be unusually wet or dry years, however the long-term climate trends projected in the models will lead to two key changes in the pattern of rainfall.

Firstly, because rainfall in the region is winter dominant (i.e. most of the year's rain falls in winter), the projected decline in winter rainfall, in combination with spring and autumn decline, is likely to result in an overall decrease in rainfall and water availability in the region. Secondly, current summer rainfall tends to fall in intense storm events, which can result in floods. An increase in summer rainfall may therefore increase the number and extent of extreme storm events and floods.

Research has shown that estimated stream flow in the east-central Murray Darling Basin could decrease by as much as 20 per cent by 2030, and as much as 45 per cent by 2070. Projections show substantial decreases to average run-off depth in spring and winter and moderate to minor increases in summer and autumn. Overall annual run off is about as likely as not to decline (DECCW, 2010a).

Further details of the projected changes to climate in the Riverina Murray are in Section 6.

4 Vulnerability in the Riverina Murray

This section reports workshop participants' informed understanding of the impacts and adaptive capacity issues of their region, with corroborating data supplied where available. The collated knowledge of regional officers and decision makers presented below is intended as an information base that can be used to inform future planning for adaptation action.

The vulnerability narrative in the Riverina Murray can be understood by looking at eight areas identified by participants in the Integration Workshop:

- Water resources
- Landscape function
- Infrastructure
- Viability of local government
- Demographic change
- Knowledge, skills, training and capacity within the region
- Regional networks
- Funding models.

These vulnerabilities summarise the ways in which the region is exposed and sensitive to climate change, through its water supplies, landscapes and physical infrastructure. The discussion also seeks to explore the limits and behaviours of human systems, which inform the region's adaptive capacity and how these systems interact dynamically with their physical context. Some areas of vulnerability will be clearly driven by climate change impacts, whereas other areas of vulnerability are due to existing pressures or trends, which are likely to inhibit adaptation in the future. In the latter instance, climate change creates a feedback loop where, by increasing these trends or worsening the pressure, vulnerability increases.

The following discussion of each vulnerability presents the main climate impacts and cross-sectoral impacts identified by participants. Factors affecting adaptive capacity of the region are also discussed. Where potential strategies to reduce vulnerability were highlighted in the workshops, these are summarised.

While these vulnerabilities have been identified for the region as a whole, there are differences in how they manifest at a local scale. The Steering Committee suggested that the region could be sub-divided into three areas, based on their landscape structure, predominant type of farming and population size. These sub-regions were far-west, mid-west, and uplands and slopes (see Figure 2). However through the course of the IRVA, it emerged that these divisions were not equally useful for understanding regional variability in each aspect of vulnerability. The following chapters include discussion of how subregional variations affect vulnerability.

4.1 Water Resources

> *Water is both a source of conflict and a provider of prosperity*.
>
> - Industry Sector Workshop

Changes to the volume, quality, seasonal availability and management of water resources in the Riverina Murray lie at the heart of the vulnerability narrative for the region. All sectors identified water resources as a critical area of vulnerability, caused by the interplay of changing climate conditions, environmental impacts, government policy and existing social, economic and environmental capacity. Water also links other areas of vulnerability, and highlights the risks that climate change poses for the region. The various elements that contribute to water being a key theme of regional vulnerability are summarised in Figure 6.

Participants identified that the regional economy, community and identity are tightly linked to agriculture and to the region's river systems. In considering the broad changes in water availability, and the range of impacts that these changes will have on agricultural production and management systems in the region, IRVA participants indicated that a decline in average yield was most likely with flow on to the viability of farms and supporting businesses.

Climate change impacts

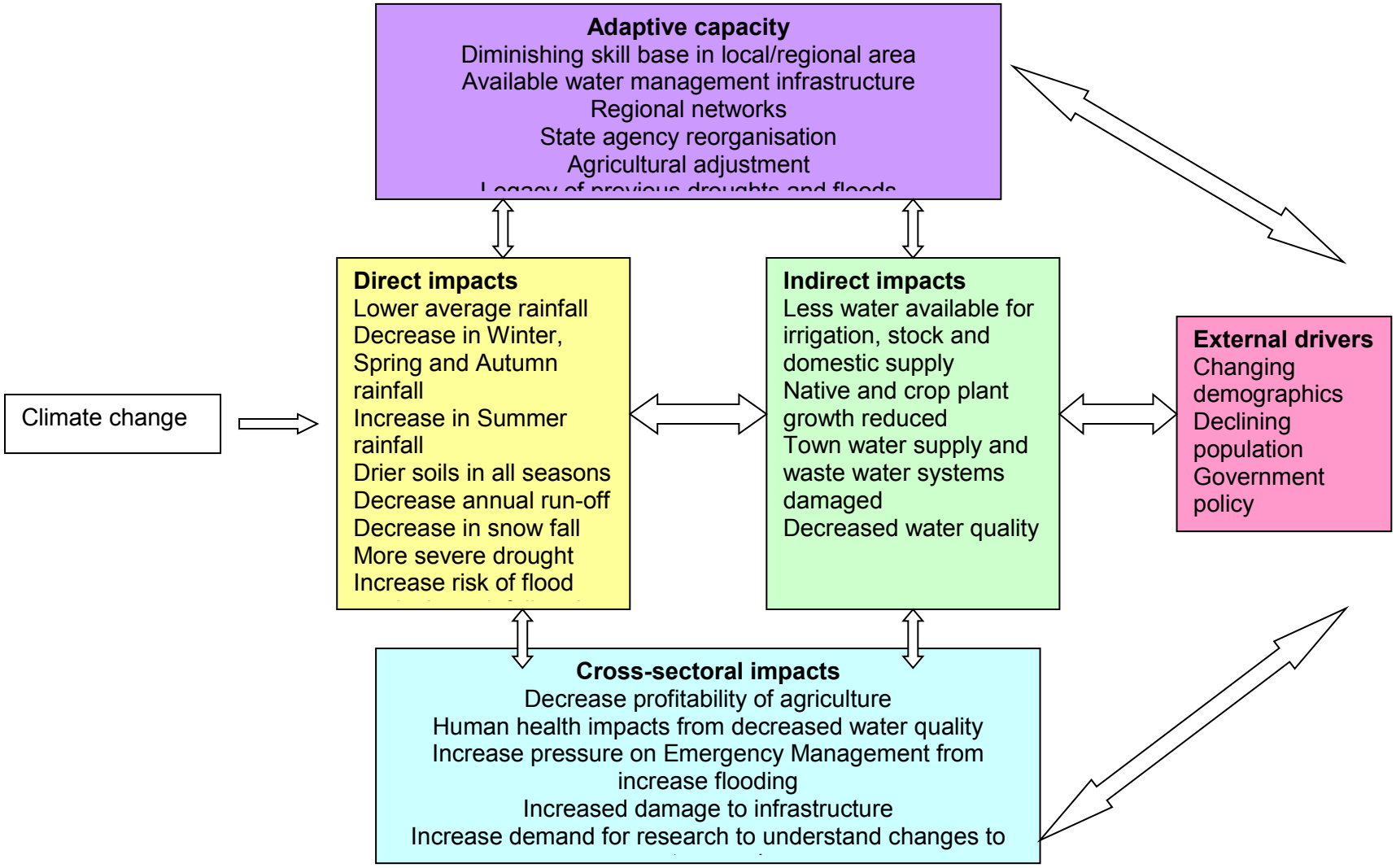
There are two main ways that climate change will impact the region. Firstly, because rainfall in the region is winter dominant, the projected decline in winter rainfall is likely to result in an overall decrease in rainfall and water availability in the region. Less average rainfall was identified as leading to a decrease in soil moisture, and an increase occurrence and duration of droughts.

Secondly, current summer rainfall tends to fall in intense storm events, therefore increased summer rainfall could result in:

- an increase in the number and extent of extreme storm events
- an increase in the number and extent of floods
- eroding topsoil, due to large downpours and loss of vegetative cover.

These impacts will vary by sub-region, as there are differences in landscape gradient across the region and water source and supply route. Some areas in the west of the region rely on the Darling River, which is fed by rainfall in northern NSW and southern Queensland. Northern NSW is projected to experience increases in summer rainfall and less severe decreases in winter rainfall compared with the Riverina Murray. So, although local rainfall is projected to decline in the west of the Riverina-Murray, the impact of climate change on water availability may not be as severe for those who have river access. Nonetheless, water availability is unlikely to improve in any part of the Riverina Murray region (CSIRO, 2008). In particular, areas that rely on local rainfall and/or rivers fed from precipitation in the Australian Alps are more likely to experience water shortages.

Figure 6 Water vulnerability issue summary



Cross-sectoral impacts

IRVA participants discussed how a decline in average rainfall could reduce water available for irrigation – particularly in the eastern and central parts of the region – and limit agricultural productivity and profitability through:

- restricting the area of irrigable land through reductions to water allocations
- increasing the cost of production due to high water prices, where it is accessed through a market
- reducing the quality of water available for crop and livestock watering.

Loss of water for irrigated agriculture is a concern for the region, as urban communities such as Deniliquin, Finley, Griffith, Jerilderie, Leeton, Moulamein, and Wakool have a high dependency on irrigated agriculture. Around 90% of businesses in these centres are directly reliant on irrigated agriculture. Irrigated livestock and cropping contributed over $900 million to the regional economy in 2006-7 (ABS, 2007). Given this regional reliance, participants identified that declines in profitability of irrigated agriculture could lead to issues across the entire regional economy. In combination with the Murray-Darling Basin Plan, the impacts are expected to be significant.

In addition to affecting irrigated agriculture, decreasing water availability was identified by workshop participants as causing a range of other negative consequences which will affect all types of farming, including:

- Sedimentation of waterways
- More algal blooms, due to lower flows and higher water temperatures conditions
- Insufficient moisture in the soil at the end of winter to finish winter crops
- Reduction of water available for irrigation and stock watering
- Stress on plants and animals
- Dust storms, with consequent air quality issues
- Changes, including possible decreases, to soil salinity and acidity risks.

Decreased water availability was therefore likely to have profound impacts on the local economy, both directly though the impact on agriculture, and indirectly through the large number of businesses – from agricultural suppliers to local grocery stores – that rely on agriculture and farming families to provide their customers. Participants emphasised that loss of agricultural productivity, and hence economic viability was very likely to contribute to a loss of people from the region and accelerated regional decline.

The Industries sector also identified that rivers, wetlands and riparian communities are important for tourism in the region. In the short-term participants identified that there could be changes to tourism within the Riverina Murray region, because as water dried from water recreation areas away from the river (such as dams) more tourist may visit the river, which will be slower to dry. In the longer term however, participants identified that reductions in water availability due to climate change are likely to affect the health of rivers and potentially reduce their tourist appeal.

Participants also discussed the impact that changes to the pattern of rainfall would have on ecosystems, which is outlined in section 4.2.

Increasing summer rain was seen by all sectors as likely to result in more flooding, as summer rain usually falls in high intensity events. This would:

- damage infrastructure and homes
- spoiling crops that are close to, or ready for harvest
- injure people and animals
- strain the economic and human resources of the region
- increase numbers of vector borne diseases, especially associated with mosquitoes

- cause 'burn out' of emergency management and human services volunteers and staff, which could leave the region more vulnerable to future events
- make it harder for water infrastructure managers to judge the levels that should be maintained in dams and weirs, in order to avoid flooding
- decrease the need for irrigation for summer crops such as cotton and rice.

However, participants also noted that following the floods in the region in March 2012 volunteers and staff had much better skills and knowledge to deal with flood events, and strong professional and personal relationships had been forged. It was hoped that this learning through experience may offset burnout among volunteers There are also likely to be issues caused by more fluctuations between very wet and very dry periods, both of which have implications for the management of infrastructure such as dams and weirs for water storage or for flood mitigation. This is discussed in more detail in Chapter 4.3.

BOX 1 Case Study: Climate Change Impacts on Agriculture

A range of research has been carried out in the Riverina Murray, which characterises the complex, and potentially dramatic, impacts of climate change on agricultural production. Impacts have been identified that include:

- Expected decreases in winter and spring rainfall in southern Australia will reduce annual pasture yield and the seasonal availability of pasture. This in turn is likely will reduce stocking rates, and decrease economic return particularly in areas of lower rainfall
- a 20 per cent reduction in rainfall at doubled CO_2 is likely to reduce pasture productivity by about 15 per cent in the rangelands, and live-weight gain in cattle by 12 per cent
- temperature increases exceeding 1.5°C would bring about warmer winters, reducing accumulated chilling required by some fruit trees and resulting in prolonged dormancy. This may be expected to lower yields and reduce fruit quality. Stone-fruit and apple production in southern Australia are particularly vulnerable (Passey, 2003).

Detailed research by NSW Department of Primary Industries has modelled crop growth, based on a range of different soil and climate types present in the Riverina Murray. The models showed that the impacts of climate change will be site and species dependent. Results indicated that in the short to medium-term wheat production is quite resilient due to the fertilizing effect of CO_2, whereas canola production may be more likely to suffer yield loss.

Factors affecting adaptive capacity

Participants identified the following factors as affecting the region's capacity to adapt to impacts of climate change.

- **Uncertainty in future patterns of water availability** – Participants identified uncertainty in how climate change will affect water availability at a local scale, making it more difficult to know which management strategies to use to capitalise on future climate regimes. It makes planning for planting and purchasing difficult, and can make it hard to secure finance or know how much water to buy. When conditions are difficult, this additional uncertainty could reduce levels of on-farm investment, cause people to leave agriculture or migrate from the region.
- **The complexity of climate change impacts** – It is currently not possible to know how climate change impacts will be experienced on the farm scale, and therefore it is very difficult to plan individual responses. Several sectoral workshops identified an impediment to local action in the lack of research on how decreasing water availability combined with other climate change projections, will impact agricultural production.

- **Existing infrastructure** – Farms in the Murrumbidgee Irrigation and Coleambally Irrigation may have some of their adaptation options limited, due to the relatively small farm size, the level of irrigation development and low rainfall (MDBA, 2010). These limitations will also be affected by soil types and current diversity of land use, which could offset these limitations. Farms in the Central Murray Irrigation area may have limited potential to transform in the area west of Deniliquin due to heavy soils, low rainfall and relatively small lot size; however, lot size has been increasing recently. Those east of Deniliquin have greater enterprise flexibility but are still reliant on irrigation for business viability.
- **Potential for water to cause friction in the community** - Sharpened competition under a future climate could result in more tension between groups who prioritise environmental uses of water, and those that prioritise use for agriculture. In the long-term, there may be tension between town water supply needs and agricultural and environmental needs. Participants felt that during the recent drought water competition led to heightened community tension in some instances, and undermined local social capital.
- **Water management policy** – Management of the impact of changes in water availability on agriculture could enhance or inhibit adaptive capacity. The current system for managing water involves a number of levels of government, different agencies and organisations (further details in Volume 2). IRVA participants identified the complexity of the system, and the competing priorities of stakeholders as impinging on the ability of the region to adapt to climate change. Water management policy will also affect where impacts of climate change are felt, for example policy allocating water for irrigation or environmental purposes.
- **Laser levelling** – Laser levelling to improve on-farm water management has changed where water courses flow and how the landscape floods, and leads to unexpected impacts on infrastructure and other assets.
- **Increasing urban development** – As larger towns develop (see section 4.4), there are more hard surfaces and run-off, which increases the flooding risk. This is further increased as development often leads to more people living close to rivers in areas at risk from flooding.

Potential regional strategies to reduce vulnerability

A range of options to address competition for water resources were identified in the workshops. These suggestions could be considered in an adaptation plan, where their appropriateness would be assessed in the context of other initiatives and priorities. Suggestions included:

- Research what the impacts of climate change will mean for water availability at a regional and local scale
- Investigate effective and innovative mechanisms for balancing environmental and economic outcomes
- Explore how water management policy can be best used to reduce impacts of climate change on regional communities
- Develop community capacity and understanding of how climate change may affect water availability
- Monitor the sustainability of groundwater development
- Simplify water management systems.

4.2 Landscape function

All sectors identified that climate change will affect native and productive systems upon which the communities and economy of the Riverina Murray are predominantly built.

Climate change impacts
Participants in the IRVA identified changes to timing and amount of rainfall and warmer minimum and maximum temperatures as likely to affect native and productive landscape function in the Riverina Murray region. This could lead to:

- Poor, or disrupted, plant growth and development
- Changes in the seasonality of flowering/pollination/breeding
- A disturbance of organic systems
- Shifts in species type and abundance
- Fragmentation or loss of habitat due to drought and increased frequency and severity of fire
- Loss of migration routes
- Changes in ground cover
- Aridification of landscapes
- More disease vectors
- New, or more, pests and weeds
- An extended fire season and therefore less time available for harvesting (machines not able to operate when they could start a fire)
- Increased erosion
- Stressed native fauna and agricultural stock.

These impacts also affect one another, and lead to feedback loops and flow on effects for other sectors (Figure 7). Examples of these interactions identified by participants include changes in the timing and duration of plant developmental stages. This can lead to a different environment for pests and diseases, resulting in plagues or outbreaks that directly impact on agricultural systems and quality of life for rural communities. In addition, Landscapes and Ecosystems workshop participants suggested that loss of a native plant and animal species could cause other native animals to turn to crops or stock as a food source.

BOX 2 Case Study Cross-sector impacts of climate change
Climate change can influence plant phenology Research has demonstrated that for *E. leucoxylon* (Yellow Gum), which occurs in the far-west subregion of the Riverina Murray, warmer minimum temperatures lower flowering intensity. During the recent droughts, Grey and Yellow Box changed the timing and density of their flowering, and this has possible implications for nectivores (particularly migrant species like Swift Parrot) (Hudson et al, 2010).

In addition changes to flowering intensity will increase competition amongst pollinators and species which depend on eucalypts as a food, such as the Swift Parrot. This may have flow on economic impacts as these pollinators contribute significantly to the honey industry (Hudson et al, 2010).

Cross-sectoral impacts
All workshops identified that the impacts of climate change on the natural systems will reduce their ability to provide ecosystems services on which Riverina Murray communities are reliant. For example, waterways support not only landscape health and biodiversity, but also human populations, agricultural production and tourism. Given this close relationship between landscape productivity and regional sustainability, this is a significant area of vulnerability for the region. The region's land use is dominated by agriculture, and any impact on agricultural productivity was seen as likely to result in flow-on effects, such as less custom

for businesses in the region. This could lead to lower profitability and financial stress, which could drive increased migration from rural areas and townships to regional centres (see section 4.4). Consequent issues arise, such as difficulty in attracting service providers like health care professionals, because of the lower employment opportunities for spouses or inadequate education opportunities for children (see section 4.4). Participants identified a range of changes to community profiles that may result from changes to landscape function including:

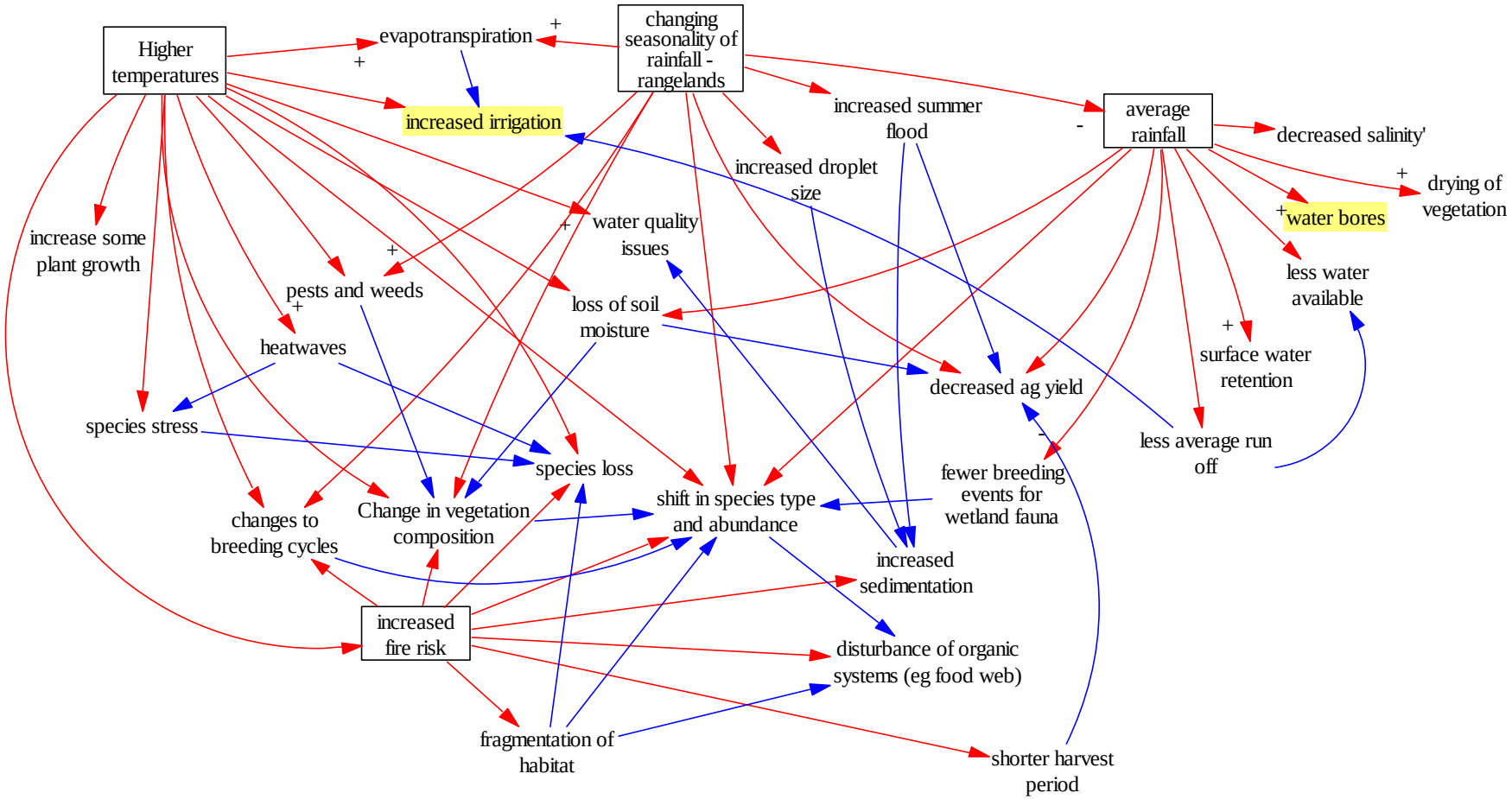
- Exacerbating regional and rural town decline
- Increasing fragmentation of productive land in the east, as higher land values make it more profitable to sub-divide properties into rural residential packages rather than continue to farm
- Amalgamations of properties in the west, as smaller holdings can no longer maintain profitability to achieve economies of scale (already occurring due to declining terms of trade in the sector)
- Higher competition for land use
- Declines in land management knowledge, as people leave the land and networks are lost
- Decreased community resilience, due to loss of people and networks
- Lower productivity of the agricultural lands, which may increase pressure to clear land, or alter native vegetation laws to maintain levels of agricultural production, leading to further impacts on biodiversity
- Loss of natural environments, which are important for recreational uses and community cohesion, health and well-being.

Factors affecting adaptive capacity

Participants identified the following factors as affecting the region's capacity to adapt to impacts of climate change:

- **High reliance on agriculture for regional economic prosperity** – As outlined in section 4.1, the Riverina Murray region is highly reliant on agriculture as a key part of its economy and identity. This reliance on agriculture means that the capacity of the region is tightly linked to the health and productivity on the landscape, which is in turn exposed to the impacts of climate change.
- **Limited remnant native vegetation** – Since European settlement large areas of the Riverina Murray have been cleared for agriculture. As a result, the native ecosystems are fragmented and struggle under current conditions to provide the ecosystem services that are vital to the region's prosperity. The additional stresses caused by climate change are likely to worsen the strain.
- **Highly modified river systems** – The rivers in the Riverina Murray are highly modified, with a large percentage of river flow used for irrigation and human consumption.
- **Existing weeds, pests and invasive species** – Climate change may amplify the already significant existing pressures from weeds, pests and invasive species.
- **National park expansion** –Increasing the amount of land managed as National Park increases the area that the Office of Environment and Heritage must manage actively for weed, fire and pest risk. This burden is likely to increase further due to the pressures of climate change, which may leave the region more vulnerable.
- **Existing soil salinity and acidity issues** – Existing soil salinity and acidity issues were identified by the Landscapes and Ecosystems workshop participants, and may limit the flexibility of land uses into the future, thereby limiting adaptation options.
- **Limited additional capacity of farmers** – Many farmers and land managers are already stretched managing their business, and have limited time, energy and money to take on additional natural resource management projects. This also affects their ability to prepare their land for future climate change, and to manage the additional impacts when they occur.

Figure 7 Summary of high level climate change impacts on landscapes and ecosystems identified in IRVA workshops



Potential regional strategies to reduce vulnerability

Options to reduce vulnerability due to landscape function issues were identified in the workshops. These suggestions could be considered in an adaptation plan, where their appropriateness would be assessed in the context of other initiatives and priorities:

- Encourage research and development of information or experience on how climate change is likely to impact natural and productive landscapes at a local scale
- Develop and maintain existing biodiversity corridors, to facilitate migration under changed climate conditions
- Understand likely changes to threats such as pests and weeds that may occur as the climate changes
- Continue to encourage variety amongst conservation areas

4.3 Infrastructure

The community needs to understand that there is no capacity to build "bullet proof" infrastructure. It will not last indefinitely without routine maintenance, particularly if climate conditions change.

Settlements and Infrastructure Workshop

Participants in all workshops identified infrastructure as critical to the region's prosperity and ability to adapt to climate change. Adequate, functioning infrastructure is important for community resilience as it:

- Affects the community's ability to manage scarce resources
- Facilitates economic activity
- Is essential for effective mitigation of, and response to, emergency situations
- Contributes to community building, health and wellbeing
- Will affect its ability to respond to and bounce back from extreme events.

For example, irrigation infrastructure, farm bores and dams and town water and sewerage supplies are all important assets for the region that allow efficient allocation of scarce resources or help ameliorate the hazards of dangerous flood waters. Transport infrastructure is vital to the economy and community and communication infrastructure is essential for maintaining community relationships, which can contribute towards regional resilience.

Climate impacts

The Emergency Management and Settlements and Infrastructure sectors identified infrastructure as potentially sensitive to climate change impacts, for example:

- More frequent and intense floods damaging roads, rail, settlements, industry and hospitals
- Extreme temperatures causing black outs which affect the running of households, local businesses, hospitals and other public infrastructure, especially where cooling is essential
- Extreme heat, fires and storms can interrupt telecommunications systems
- Water supply and sewage systems damaged by floodwaters and extended droughts
- Irrigation infrastructure damaged and/or silted,
- Farm infrastructure, often uninsured, such as fences and silos destroyed.

The Emergency Management workshop provided an example of how multiple extreme events can interact to cause new and unexpected challenges. Recent floods in the region had damaged fire trails through the state forest, and as a result when a fire broke out not long afterwards it was not possible to get the fire trucks to the critical areas to respond.

Cross-sector impacts
All sectors identified the link between infrastructure being damaged or destroyed, and effects on other sectors. There are clear links between the ability of sectors to adapt and the condition of infrastructure in the region. Damage to infrastructure was identified by participants as leading to:

- People cut off from food, medical supplies and care
- Animals and people injured or killed
- Increased costs on councils, governments and individuals for recovery
- Long-term disruption of transport links
- Loss of agricultural products and therefore revenue (as can't be transported to market)
- Health issues due to a lack of access to clean water, or exposure to polluted floodwaters.

In addition, repeated damage to infrastructure as a result of more frequent or intense extreme events due to climate change is likely to have substantial financial, as well as emotional, costs for individuals and the community. For example, the Industry workshop participants noted that if climate change results in transport infrastructure being destroyed more frequently, or falling into disrepair more quickly then this could make transport of agricultural produce, and access to goods and services even more difficult. This would have flow-on impacts on the economic productivity of the region.

A further example from the Industries workshop of the interaction between climate change and infrastructure was the siltation of ageing on-farm dams. Participants indicated that most on-farm dams are 70-80 years old, and are very shallow as a consequence of silting, making them prone to high evaporative losses. In addition, many dams are also gully control structures and can be destroyed in big rainfall events. This means erosion is then uncontrolled and stock water availability is reduced. Given likely increases in temperatures, decreases in average rainfall, and increase in extreme rainfall events these structures may not be well designed for water storage under future conditions. Participants questioned whether such dams would need to be modified or replaced to deal with the impacts of climate change.

Factors affecting adaptive capacity
Participants identified the following factors as affecting the region's capacity to adapt to impacts of climate change.

- **Competing infrastructure demands** - Hume Dam is a major regional water storage, however, there may be a public expectation that the dam could be used as a flood mitigation tool. Participants reported that in recent heavy rains in March 2012 the weir water level rose by up to 20 per cent. If dam levels were not already low at that time it may have spilled potentially exacerbating flooding downstream. Participants discussed whether such infrastructure may have to be managed differently in the future to use it for flood mitigation.
- **Changing use of infrastructure** - Use of the region's irrigation infrastructure is changing in places, and may be affecting the ability of the infrastructure to be used to assist climate change adaptation. In some locations, State and Federal governments are purchasing water rights from farmers in an attempt to reduce the amount of water taken from the Murray system for irrigation. As a result, channels are no longer being used to deliver irrigation water and therefore no longer being maintained. However,

management of the channels is likely to be important for climate change adaptation, due to their use to mitigate impacts during flood and distribute environmental flows.

- **Historical investment patterns** - Participants identified that in the west there has been greater investment in tanks and troughs to deal with recurrent droughts. This investment may mean that these graziers are better prepared for climate change. In the east of the region, they thought that stock watering hadn't been addressed as comprehensively and new infrastructure may be needed to improve robustness of water delivery.
- **Infrastructure built for 'gentler times'** - Participants indicated that many towns were built for unlimited availability of water. In times of drought, water restrictions mean that flow through the supply system is often very low, resulting in longer water retention in pipes. Coupled with higher summer temperatures due to climate change, this means water can become de-chlorinated, allowing the growth of human pathogens such as E. coli with potential impacts on human health. Most sewage treatment plants are designed for, and run best on, a constant volume of waste water. Large fluctuations in flow, such as in drought or flood, or system losses through extensive use of household evaporative coolers, may result in plant failure.
- **Funding changes** - The loss of the Country Towns Water and Sewerage Grants program means it is difficult to introduce any new water and sewage schemes in rural towns. Availability of alternative funding for these programs is very limited. Most investment in infrastructure is focussed on urban areas, because in rural areas there are additional costs due to less dense populations. In addition, across the region, rural decline is leading to an erosion of the rates base (see section 4.5). This in turn impacts on the ability of local government to maintain the infrastructure.
- **Limited infrastructure** - Participants identified regional road and rail transport infrastructure as inadequate. While there are good connections between the large cities and State capitals, lines such as the Griffith-Narrandera rail line are slow to be repaired after floods, and in some cases are never repaired. In addition, grain lines need to be supported by road networks, which require additional investment and maintenance.
- **Improved communications networks** - Participants reported that the community believes that the availability of access to high speed internet, anticipated through the roll-out of a National Broadband Network, offers great potential to the region as it may:
    - Improve communications, particularly in the west of the region, through access to tools such as video-conferencing
    - Provide basic health services to remote households
    - Increase business opportunities
    - Provide information and services in a manner convenient for stretched business owners and employees, or those in remote areas
    - Provide opportunities for education and training in remote locations
    - Provide older or less mobile groups with social networks and support forums, which are accessible from their homes
    - Help to gather information from rural communities on local scale changes to and responses in the landscape. For example during the recent floods, the CSIRO didn't have information on catchment flows and where water was going, but there were farmers who had local experience that would be invaluable in such events, if a system was available to access their knowledge and experience.

  There is however, a potential downside for local business through increased use of online shopping and other services. Improved internet access may also mean that individuals may not interact in person as much, thus reducing social networks. In addition, the complexity and regional specificity of climate change issues mean that the internet may not be the most practical format for delivering and sharing information.

Potential regional strategies to reduce vulnerability

A range of options to address vulnerability of services and infrastructure were identified in the workshops. These suggestions could be considered in an adaptation plan, where their appropriateness would be assessed in the context of other initiatives and priorities. Suggestions included:

- Build community understanding of the limits services infrastructure can provide under climate change, and of the costs of maintaining service
- Explore potential for infrastructure to be designed so that service may be lost during a flood, but the structure remains intact, so that it is usable after flooding subsides rather than needing to be rebuilt
- Pro-actively manage overland flows of water as a flood mitigation technique, rather than forcing it into pipes or canals
- Reform structure and use of dams to ensure they are fewer and deeper and explore potential to replace dams with pipe and trough systems for stock watering
- Encourage investment in road and rail infrastructure
- Focus on and encourage innovation in the region
- Balance regulation and development to allow innovation for adaptation to climate change e.g. through encouraging biotechnology or renewable energy
- Ensure infrastructure is costed for its entire lifecycle – including construction, maintenance, obsolescence and replacement
- Encourage regional businesses to make the most of the opportunities offered by new communication technologies
- Encourage the development of new communities and networks through the internet
- Develop a strategic plan to harness the benefits of the NBN.

4.4 Demographic change

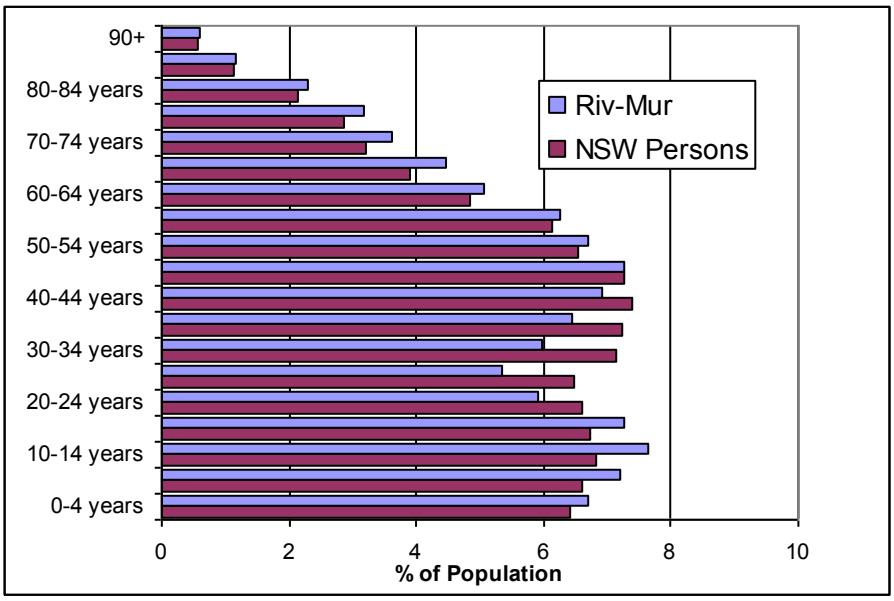
I estimate that the average age of RFS volunteers is 60, with some volunteers in their 80s. Older people are being asked to continue volunteering because of difficulty recruiting younger people.

Emergency Services workshop

Demographic change was identified by participants as a critical vulnerability for the Riverina Murray. On-going demographic change was seen as inhibiting the ability of the region to adapt. Participants were also concerned that climate change could accelerate many of the problematic demographic trends, creating a feedback loop that increases vulnerability.

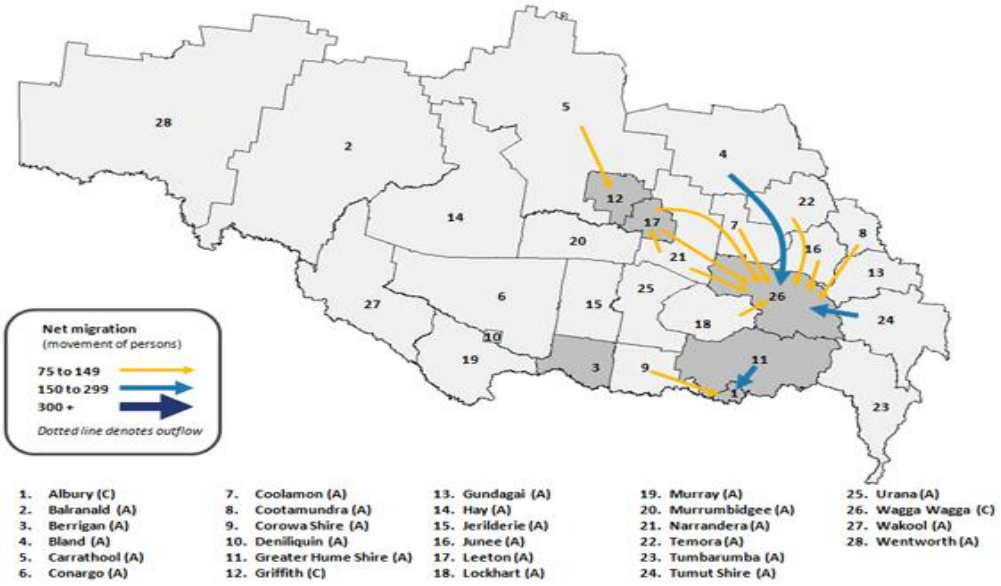
All sectors identified that the Riverina Murray has an ageing population, which mirrors the trend throughout regional NSW (Figure 8). However, the ageing population issues were identified as being more pronounced in rural areas and small towns than in regional centres. Participants felt that small towns were losing people, either to larger cities (such as Wagga Wagga, Albury and Griffith) or out of the region (Figure 9). This loss was focussed on people in their productive age range of 24-44 years old (Figure 11), and accelerates the ageing trend in the region's population.

Figure 8 Riverina-Murray Age Profile



Graph of the Riverina Murray Age profile showing that there is an ageing trend with higher shares in the 50 year age group and above relative to the broader NSW population.

Figure 9 Migration flows within Riverina cities



(Riverina Regional Cities Group, 2011)

Cross-sector impacts

Climate change was identified as likely to reduce agricultural productivity, and hence profitability, and thereby increase the economic hardship in the region. Several workshops identified declining farm income as making farming a less appealing career option, which makes it hard to attract and keep youth in the region. Participants worried that further decreasing the attractiveness of farming as a career is likely to drive more people to move away, particularly younger, more mobile groups. This has the flow on effect of damaging social networks, which are necessary to respond to or plan for impacts of climate change. It can also lead to social isolation of those remaining in increasingly remote locations, which may affect mental health and leave people with lower levels of capacity to deal with climate change.

Even before direct impacts are felt, the Settlements and Infrastructure workshop participants identified that negativity and uncertainty caused by *potential* impacts of climate change have caused people to sell their water and farm, and move away from the region.

Drivers of vulnerability
Participants identified some of the factors that they felt contributed to the declining populations in rural areas. Workshop participants, particularly in the Human Services, and Settlement and Infrastructure workshops, felt that in comparison to large regional centres, small towns and rural areas struggled to attract or retain younger people due to:

- Perception that government and other services are not of a sufficiently high standard
- Lack of education opportunities
- Lack of long-term career progression opportunities – the 'grass ceiling'
- Difficulty finding employment for spouses, particularly professionals
- Changing farming systems meaning the industry is dominated by more larger farms that employ fewer workers
- Budget and financial uncertainty
- Housing costs and availability
- Loss of services due to fewer resources in schools and hospitals
- Lack of social opportunities.

Long-term trends identified in the Settlements and Infrastructure workshop included the increasingly mechanised nature of farming requiring fewer people to work in the industry, and the increase in corporate farms rather than traditional family farms. As a consequence, this often means that one manager has responsibility for increasingly large tracts of land, and that this manager may not have the depth of local knowledge as in the past.

In contrast to the situation in rural areas and small towns, the larger cities of Albury, Wagga Wagga and Griffith have been growing in recent years. This development is not without challenges when confronted with climate change. It was discussed in the Settlements and Infrastructure workshop that there are risks to these towns stemming from increasing water demand, loss of agricultural land due to rural-residential development, and local loss of threatened ecosystems, particularly in areas such as Thurgoona in the development corridor to the north of Albury. They felt this development could leave the region less able to deal with water shortages as the conditions become drier, and with less arable land as other areas become more marginal.

Factors affecting adaptive capacity
Participants identified the following factors as affecting the region's capacity to adapt to impacts of climate change.

- **Increasing sensitivity of population to environmental factors** - As the population ages the number of elderly, who may be more susceptible to adverse health impacts from climate change, will increase. The Commonwealth Government's Intergenerational Report outlines that older people are more vulnerable to illnesses, especially climate related stress such as heat stroke (Commonwealth of Australia, 2010).
- **Greater demand for human services** – The increase in sensitivity to climate impacts means the demand for human services is likely to increase. However, an ageing population may mean that there are fewer people of working age to provide these services.
- **Fewer resources are available to provide services** - Council income is dependent on rates, which council levies on a per capita basis on only those residents who do not receive government support. So, those on an aged or disability pension are not levied. In addition, government services are often funded based on the number of people that are served, rather than the cost of serving them, which is generally higher

in remote and regional areas. This pressure on services in country centres is likely to leave them less able to deal with the additional stresses that climate change is likely to bring. There is further pressure as even if councils were able to collect more funds through rates, the community may not have the ability to pay more.

- **Losing productive capital** - Movement away from rural towns means towns lose productive capital (people of working age), and are left with a higher percentage of people who cannot, or no longer, work. The Human Services workshop highlighted that the ageing workforce is also an issue for the health sector. Participants estimated that the average age of nurses in the Riverina Murray is about 7 years above the NSW average, at 55. This was also felt to be an issue for volunteers.
- **Eroding the local knowledge and decreasing the ability to adapt to climate change** – Participants expressed concern that the ageing trend means knowledge, skills and people are being lost from the regional workforce as people retire and are not replaced. This may undermine the ability of regional businesses and organisations to adapt to climate change pressures. Participants were also of the opinion that it could be harder to engage or educate older population about climate change adaptation, due to higher levels of climate change scepticism in that age group and a general resistance to change. These issues were also felt by the Landscapes and Ecosystems sector to be reducing the ability to manage land for NRM outcomes, which may become more important and difficult as the climate changes.
- **Loss of community cohesion and identity** – Participants believed that the loss of youth from the region, and the declining population, mean that regional identity is being lost, due to the inability to pass traditions, knowledge and understanding to the next generation. In addition, community cohesion was felt to be threatened as populations in small towns are too limited to keep important social networks functioning (section 4.7), and people moving to larger towns are not adequately integrated into existing communities in those locations.

Potential regional strategies to reduce vulnerability

A range of options to respond to demographic change were identified in the workshops. These suggestions could be considered in an adaptation plan, where their appropriateness would be assessed in the context of other initiatives and priorities. Suggestions included:

- Investigate how, and develop programs, to build social capital in rural towns
- Research how to engage regional communities in climate change adaptation
- Provide targeted education and support for managing the impacts of heatwave and other climate impacts on elderly populations
- Evaluate what is a realistic population density for which adequate levels of government service provision are sustainable
- Promote youth connection to and within the region
- Monitor and respond to increases in demand for ambulance services
- Link benefits of adaptation to business development outcomes for farmers and small businesses.

4.5 Sustainability of local government

> Local government's finances are constrained by rate pegging…. This financial base does not allow for much other than operational priorities and climate change is not currently seen as core business.
>
> - Landscapes and Ecosystems workshop

Local government services and infrastructure assist to build a more robust community, which is then better placed to deal with the impacts of climate change, by providing:

- Maintenance and provision of roads
- Maintenance and provision of water supply and storm water infrastructure
- Delivery of health care services
- Delivery of child care services
- Provision of community centres, sports facilities and recreation grounds.

However, participants in the IRVA workshops identified pressure on local governments from various sources as affecting their ability to deliver these services, and climate change may further exacerbate this.

Climate change impacts

Climate change is likely to have a range of impacts on local government, which are outlined in more detail in other Sections. Workshop participants identified climate change impacts as likely to increase the need for some local government services, such as health care services for the elderly during heatwaves (see section 4.4). Climate change was also identified as being likely to cause more damage to infrastructure owned and operated by local councils (see section 4.3). In addition climate change is seen as likely to worsen demographic trends that are leading to declining and ageing populations in small towns, and which cause additional demand for council programs and infrastructure (section 4.4).

Factors affecting adaptive capacity

Participants identified the following factors as affecting the region's capacity to adapt to impacts of climate change.

- **Financial pressures** – At the workshops, participants raised the heavy constraint on local government finances as limiting the capacity to adapt. Generally, council income from rates charged to each resident is 'pegged' at 3 per cent per year in line with inflation. This means that council is restricted in the amount of income it can raise through collection of rates, particularly in areas with small or declining populations. There are unlikely to be increases in funding to accompany the increase in demand due to climate change (see section 4.4) and so council resources will be further stretched. In addition to having little extra money available to undertake specific adaptation projects, many councils are struggling to maintain current ageing infrastructure and there are infrastructure construction and maintenance backlogs. Increased impacts on infrastructure from climate change could amplify this problem (section 4.3). The ability of councils to adapt is further limited as costs cannot simply be shifted to local regional communities, as their financial capacity is already strained.
- **Service expectations** - While a lot of infrastructure provision has been privatised and is on a cost recovery basis, local government infrastructure is not. Nonetheless, the community expects that local government should provide services at the same level as those run on a cost recovery basis. Workshop participants felt that the level of service that has become traditionally expected of local government can't be maintained.

- **Fixed budgeting** - Many local government budget and works programs are fixed a year in advance, leaving little flexibility to take advantage when short-term or new funding opportunities arise, for example from CMAs with new project or program funding. In addition, what funding is available for climate change adaptation is hard for regional councils to access. Federal government funding to promote adaptation is limited, and accessing it requires completing highly competitive application processes. These favour larger councils that can demonstrate large benefits per dollar invested over the smaller projects put up by rural councils.
- **Regional approaches** - Participants identified the Regional Organisations of Councils as operating effectively at the moment to encourage sharing and a cooperative spirit among councils, and have achieved efficiencies. This model could be useful for adaptation in the region (see section 4.7).

Potential regional strategies to reduce vulnerability

A range of options to improve the sustainability of local government were identified in the workshops. These suggestions could be considered in an adaptation plan, where their appropriateness would be assessed in the context of other initiatives and priorities. Suggestions included:

- Facilitate partnerships between local councils, to identify efficiencies and leverage greater influence
- Explore new opportunities for revenue raising by local councils, including through public private partnerships.

4.6 Skills, knowledge, training and capacity

Climate change is scary and unknown and it is hard to understand how it will impact them [farmers]… They don't have the resources [and] they don't know where to go.

Industries workshop

As climate change puts new pressures on the region's systems, new and better skills, knowledge and training will be required. Emergency Management workshop participants argued that new skills would be needed as the climate changed, as there are likely to be bigger and more severe extreme weather events. However, a lack of skills, knowledge and training about climate change adaptation was identified as a key vulnerability for the region. For example, participants identified that for most professional organisations, climate change has been an issue for only the last 10 years. While drought and flood in recent times have helped highlight possible issues, and there is more information available, there is still a shortfall in skills and information. This shortfall is critical, as many all sectors identified that the capacity of regional workers is already stretched, and they may struggle to manage the extra workload and training requirements caused by climate change.

Participants in the Emergency Services and Industries workshops felt that the understanding of climate change and its local impacts, and skills in devising and implementing adaptation strategies, are not broadly available within the region. Participants worried that current government agencies' skills may not be applicable to new situations posed by climate change, and that building skills and knowledge in the region was impeded because regional training is unavailable, travel times made attending training unfeasible or individuals cannot

be spared. They felt that government will need to mentor the development of these new skills in order to facilitate change.

However, participants in the Industries, Emergency Services and Human Services workshops spoke about the resilience of the regional community, and that people in the region are very adaptive. Several participants identified adaptability as a strength of the region. Nonetheless, they suggested that the adaptation may lag behind the experience of impacts, and as a result there would be some trauma associated with the change. It was also noted that community resilience has limits, which might be tested by the impacts of climate change.

Drivers of vulnerability

It was noted in several workshops that within many businesses and government organisations, staff are experiencing increased workloads more time consuming travel demands and declining staff numbers. These drivers, partly linked to demographic change (see section 4.4) are reducing their capacity to deliver against existing demands and take on new skills, knowledge and training required for climate change adaptation.

The Landscapes and Ecosystems and Human Services workshop participants both spoke about the current strain that the workforce is experiencing. In the Landscapes and Ecosystems sector, it was felt that staff as being asked to do more with fewer resources. The skill and resources shortage in the Human Services sector was felt to be critical, with particular shortages in the numbers of nurses, allied health professionals and specialist doctors and difficulty recruiting to the region (see Section 4.4). These strains on staff mean that organisations are already on the back foot and are likely to struggle to deal with extra pressures from climate change, such as more frequent or extreme climate events, or decreasing water availability.

The large geographic area of the region, and limited staff, creates a further problem of 'patchiness' in the spread of skills and knowledge. Having access to the right skills and resources was identified as an issue in the Human Services, Landscapes and Ecosystems, and Industries workshops.

Participants were concerned that migration from the region is exacerbating the gaps in skills and knowledge, which may undermine efforts to effectively adapt to climate change. While the region has a number of higher education institutions (see Human Services Sector Summary), the regional presence of some research institutions has diminished. For example, the Landscapes and Ecosystems sector identified significant losses when the CSIRO research centre at Deniliquin moved to Canberra twenty years ago, and cut backs to the Griffith Research Centre. Landscapes and Ecosystems, and Industries sectors both felt that there has also been a steady draw down of technical support from the state agencies in the regions.

The Industries sector identified that while there are growing links between state government researchers and national research organisations such as the CSIRO, development of these links is driven by a lack of people. Participants observed that the NSW Office of Water now works with universities, because the agency has less capacity (skills and personnel) in house, and can leverage a small investment through such collaboration. The downside is that universities rely on postgraduate students for the bulk of their research effort, so that it may take about 4 years to obtain results and there is the risk that projects may fail due to non-completion of theses, or are not targeted as well as they could be due to 'academic freedom'.

The Industry sector also identified that as regional branches of banks have closed, it has resulted in a loss of expertise in regional issues in the banking sector. They felt that this

reduced the ability of farmers and regional businesses to access finances as the conditions they face are not well understood, and there is misunderstanding and misinformation about the conditions in regional Australia.

Factors affecting adaptive capacity

Participants identified the following factors as affecting the region's capacity to adapt to impacts of climate change.

- **Lost communication channels** – In all workshops, restructures and staffing cuts within government were identified as meaning that official channels of communication have been lost, leaving only informal channels. Participants in the Industries workshop felt there used to be greater transfer of knowledge downward in government agencies however, integral parts of the system are no longer there. This loss of connection limits the flow-on of corporate knowledge, and the ability to share information about climate change impacts and how best to respond. Participants in the Emergency Management workshop thought it was important to construct a system that preserves corporate knowledge, and that will engage with people at all levels of government and the community. This need clearly requires the presence of extensive and effective regional networks, which are described in more detail in section 4.7.
- **Lack of specific, relevant information** – Industries and Landscapes and Ecosystems workshop participants felt there is a lack of information about local climate change impacts. Participants identified that there is some information about how some industries or parts of industries function now and might be affected by climate change. For example, the Commonwealth Government has released guidance for tourism operators on climate change adaptation measures (DRET, 2009). However, for other industries very little is known. For information to be useful it needs to be at a regional scale, targeted and simple, present the range of scenarios so that people can make their own decisions and cross-sectoral. However, government is providing much less research and development than 20 years ago, so industries are relying more on the private sector. Moreover, private research isn't increasing either as private companies are under more pressure to focus on product promotion rather than applied research. Finally, while the private sector will respond to demand, there is scepticism in the broader community and among farmers about climate change so demand for private research and development is likely to be limited.
- **Climate change scepticism** – Across a number of sectors Settlements and Infrastructure, Industries, Landscapes and Ecosystems and Human Services, community scepticism about climate change was identified as reducing the ability of the region to build knowledge, skills and understanding in relation to climate change adaptation.

Potential regional strategies to reduce vulnerability

A range of options to improve skills, knowledge, training and capacity were identified in the workshops. These suggestions could be considered in an adaptation plan, where their appropriateness would be assessed in the context of other initiatives and priorities. Suggestions included

- Engage with local research institutions, to tap into local expertise and active research on climate change impacts and adaptation
- Address scepticism within the community in order to promote demand for climate change research from private providers
- Development of local capacity and mentoring through collaboration between government, community and local business
- Engage industry in an IRVA-like process, to understand what research needs they

have
- Develop stronger links between academics and practitioners, to ensure that existing regional facilities target relevant research gaps, in particular issues such as climate risk management and planning for the Murray Darling Basin
- Funding bodies provide guidance to allow project planners to know if they are investing in the right areas and projects for climate change
- Work to construct a system that preserves corporate knowledge, and engages with people at all levels of government and the community
- Develop climate change information that is regional scale, cross-sectoral, targeted and simple, and present a range of scenarios so that people can decide their own actions based on their risk profile
- Use new technologies to facilitate training of regional staff, and ensure training of regional staff in new technologies
- Create regionally consistent, centrally supported messages to improve recruitment to and within regional areas.

4.7 Regional networks

Social cohesion enables communities to work together to build futures and adapt to changes.

Human Services workshop

Participants in all the sector workshops identified the strong networks in the region as vital for climate change adaptation as they can:

- Facilitate transfer of information and skills to assist with adaptation
- Make actions to respond to climate change easier, as communication channels and social contracts already exist
- Provide support networks to allow people to make personal and professional changes
- Create a stronger community, thereby making the region a more attractive place and reducing the 'push factors' to declining population, which affects vulnerability (see section 4.4)
- Maintaining personal health, particularly during stressful period such as natural disasters
- Build local collective visions.

For example, participants reported that during the recent drought, remote communities organised gatherings and were strongly protective of each other. They believed that this was important in allowing communities to cope with the pressure that the drought put on them financially and emotionally, and could therefore assist communities in dealing with the pressures of climate change.

Participants indicated that the region supports a number of healthy social, sporting, political and Landcare organisations, which provide social relationships that contribute to regional resilience. It was felt that increasingly younger people are using online networks, and there is potential to harness these new networks to assist adaptation to climate change.

Overlapping and complementing the region's social networks are its professional networks. Participants identified a range of networks operating both formally and informally:

- **Regional Organisations of Councils (ROCs)** - Settlements and Infrastructure and Industries sectors identified good horizontal networking between councils through ROCs. The ROCs are able to attract attention from state and federal governments,

and have recently successfully obtained grants in the range of $2.3 million for improving infrastructure in the region.

- **CMA – Local Government relationships –** The Landscapes and Ecosystems and Industries workshop participants thought Catchment Management Authority (CMA) [now Local Lands Services (LLS)] –local government networks were strong. LLSs and local governments are now talking as partners, and ensuring their activities are complimentary. For example, Murray LLS has developed a community committee which is linked to RAMROC and councils are looking to collaborate with LLSs on flood mitigation.

- **Regional Managers Network -** Within State Government, participants felt there is a strong state-wide Regional Managers' Network, and that the formal networks of Centre Link and Health are working well.

Not all networks were identified as operating well. The Emergency Management sector felt their connection with local government councillors could be improved. Officers felt that there were productive relationships between council officers and emergency management staff. For example, they felt they were often consulted in development of Local Environment Plans. However, the participants identified that planning requirements, or restrictions introduced to minimise risk from natural hazards, were frequently overridden at political level, perhaps due to a lack of exposure or understanding of the emergency management issues.

Factors affecting adaptive capacity

Participants identified the following factors as affecting the region's capacity to adapt to impacts of climate change.

- **Staff capacity** – For many organisations, the limited number of personnel (see section 4.4) was felt to constrain the development and maintenance of professional networks, as people could not afford to spend time on anything outside their core activities. This issue was identified for
    - LLSs (Landscapes and Ecosystems workshop),
    - Farmers (Industries, and Landscapes and Ecosystems workshops)
    - Small business owners (Industries workshop)
    - Research institutions (Settlements and Human Services workshops)
    - Nurses, allied health professionals, specialist doctors (Human Services Workshop).
- **Remoteness** – It was thought that linkages in the South West of the region may not be as strong, because the larger distances and smaller populations reduce staff's ability to attend events or meetings where networks can be formed.
- **Administrative 'churn'** – State agencies have had significant staff turnover and restructures in recent years. As a result, participants felt that relationships, knowledge and expertise has been lost or diverted. Restructures, and the creation of larger regions, also mean that it can be difficult to identify who to talk to in other agencies to address issues quickly. Churn is not only an issue within agencies but also for the community. Participants in the Industries workshop reported that the community finds working with government confusing, as they don't know how to access services and often have low confidence that government services are likely to be ongoing.
- **The 'sandstone curtain'** – Within the Emergency Management sector, participants felt that when natural disasters are elevated to being dealt with at a state scale, local knowledge and linkages can be underestimated, and undervalued. This feeling was echoed in other sectors, with participants referring to the 'sandstone curtain' (the Great Dividing Range). Participants expressed the sentiment that often decisions

were made in central agencies, which did not account for the different conditions – particularly larger distances and lower population density - beyond the Great Dividing Range.

- **Social pressures** – The Human Services sector identified issues such as double income families, increasing absentee landholders, reduced employment opportunities, declining populations, financial stress and greater demands on time, as limiting the amount of time for community engagement and contributing to a declining social fabric.
- **Unclear roles** – Participants felt that inaction in some areas was because social and professional groups are not sure how climate change will affect their communities so it is difficult for them to know what action to take of how to mobilise their members.

Potential regional strategies to reduce vulnerability

A range of options to capitalise on and develop regional networks were identified in the workshops. These suggestions could be considered in an adaptation plan, where their appropriateness would be assessed in the context of other initiatives and priorities. Suggestions included:

- Investigate how regional networks can be mobilised to assist with climate change adaptation
- Manage fracturing issues and pressures such as drought, to ensure the continuation of important social relationships and avoid social decline
- Facilitate inter-agency forums (similar to IRVA workshop) to enable communication across the service sector, and for providers to help build understanding and capacity
- Review the forums, groups and networks already in place
- Draw the private sector into new partnerships in the region
- Encourage champions and message bearers who are willing to go outside of their traditional comfort zones and engage with businesses to assist in adaptation. For example, the regional Chambers of Commerce and the NSW Business Chamber
- Use communication technology (e.g. participation by tele-conference and online forums) to encourage formation and maintenance of networks to assist in adaptation
- Showcase international examples of business opportunities that arise through adaptation
- Develop mentoring programs for smaller local councils to access adaptation knowledge and experience of larger councils
- Encourage national organisations to run specific adaptation programs for regional groups
- Provide information in short, sharp sessions, potentially outside office hours, that demonstrate the relevance of climate change to specific stakeholders and focus on opportunities, minimising businesses costs and customer demands
- Build local collective visions for an adapted community, to facilitate coordinated action across networks and across whole of government
- Develop communication and knowledge management systems that conserve corporate knowledge, especially related to managing climate extremes, and engage with people at all levels of government and community
- Improve government staff accessibility to the community to assist in managing issues with adaptation
- Encourage development of a more consultative approach to providing services among regional staff and departments, to assist in climate change adaptation.

4.8 Funding models

> *There are funds available for weed control but these funds are taken back if not spent in the financial year, regardless of the suitability of environmental conditions to carrying out weed control.*
>
> - Landscapes and Ecosystems workshop

The models used to fund projects and programs was another issue that ran through discussions by various sectors and was seen as influencing their ability to adapt. This affects regional resilience in several ways:

- natural resources and environment are not optimally managed now, so there is work to be done to improve their condition to deal with current conditions, let alone future climate conditions
- there is not time or money for strategic planning, and funding is not allocated in a way that allows development of the strategic approaches which are required for climate change adaptation
- Staff and corporate knowledge are lost, which could be used to inform adaptation approaches.

Factors affecting adaptive capacity

Participants identified the following factors as affecting the region's capacity to adapt to impacts of climate change.

- **Lack of sensitivity to conditions** - For a lot of work in the region, Emergency Management, Industries, and Landscapes and Ecosystems workshop participants felt that financial year deadlines do not work because environmental, or natural resource management, programs need to be able to be carried out when environmental conditions are suitable. For example, there have been instances where funding is available for tree planting, but the region is experiencing drought so planting trees would likely result in high levels of tree mortality and failure of revegetation projects. A similar issue exists where funds may be available for weed control, but these funds are returned to consolidated revenue if not spent in a financial year, regardless of the suitability of environmental conditions for carrying out weed control actions. Generally the regional managers felt that application for funding from regional bodies doesn't account for the complexity of natural systems planning.
- **Short-term funding cycles** - Many of the issues requiring attention in the region need to be worked on for several years. The participants felt that government organisations needed to be able to invest over longer timeframes.
- **Local discretion** - Participants felt that more discretion is required at a local level to allow funding to be independent of the political cycle. Currently, participants believed that funding programs follow 'fashions' of political interest e.g. salinity, biodiversity, carbon farming. This means that action is supported in the short-term, but long term programs are unable to continue. In addition, while there is often funding for programs, there also needs to be funding for staff positions to maintain works programs. CMAs often seek have to seek assistance from NGOs to get programs done within timeframes, because they do not have sufficient staff within the CMA to carry out the work.
- **Misdirected funding** – Participants in the Emergency Management workshop suggested that some communities can become conditioned to expect relief funding. Participants believed the reliance on disaster relief might mean that there is no driver to encourage changes in behaviour to develop resilience (moral hazard). Participants

expressed the sentiment that some disaster relief funding may actually be spending money to make the community less resilient.

- **All or nothing disaster relief** – Often relief from disasters is a small, set amount per household, which does not allow for differences in the extent to which people are affected. In addition funding for Emergency Management agencies to participate in disaster management and relief may only be triggered by certain events, which could prevent them contributing to smaller emergencies where they could nonetheless be useful. For example, the Ambulance service do what they can in an emergency, but if the Rural Fire Service Commissioner declares a localised "State of Emergency" they are able to contribute with much greater confidence.

Potential regional strategies to reduce vulnerability

A range of options to address vulnerability due to funding models were identified in the workshops. These suggestions could be considered in an adaptation plan, where their appropriateness would be assessed in the context of other initiatives and priorities. Suggestions included:

- Explore mechanisms to allow greater flexibility in funding of natural resource based projects, particularly where environmental conditions can be a significant determinant of success
- Evaluate potential benefits of allowing greater local and regional discretion in allocation of funds
- Provide mechanisms to ensure ongoing funding and adaptive management approaches, where it is required for program success
- Invest in building skills of local providers and community organisations, particularly in business skills, probity and monitoring and evaluation, required to manage government funding
- Ensure funding provided to manage and recover from natural disasters builds long-term community resilience, and is consistently and equitably distributed.

5 Riverina Murray regional context

The original inhabitants of the Western Riverina region area are the Wiradjuri Aboriginal people. European settlement dates from the 1820s, with land near the rivers used mainly for sheep and cattle grazing. Agriculture started to develop from the 1860s and the Murrumbidgee Irrigation Areas were established in 1912. The town of Griffith was laid out on a street plan by Walter Burley Griffin in the 1920s, and became a centre for the irrigation district. The district provides much of Australia's horticultural output.

5.1 Topography and land use

The Riverina Murray region covers an area of 152.700 square kilometres. It lies in the drainage basin of the Murray, Murrumbidgee and Lachlan rivers and their tributaries, and includes extensive floodplains and wetlands.

The Riverina Murray includes some of the most highly productive agricultural land in the Murray-Darling Basin (DECC, 2009). Agriculture in the region ranges from forestry and temperate fruit production in the east, through broadacre cropping and grazing, intensive irrigation to rangeland grazing in the west. Irrigated agriculture (cropping, horticulture, rice and dairy) is a key feature of the region.

Figure 10 Land use in the Riverina Murray Region

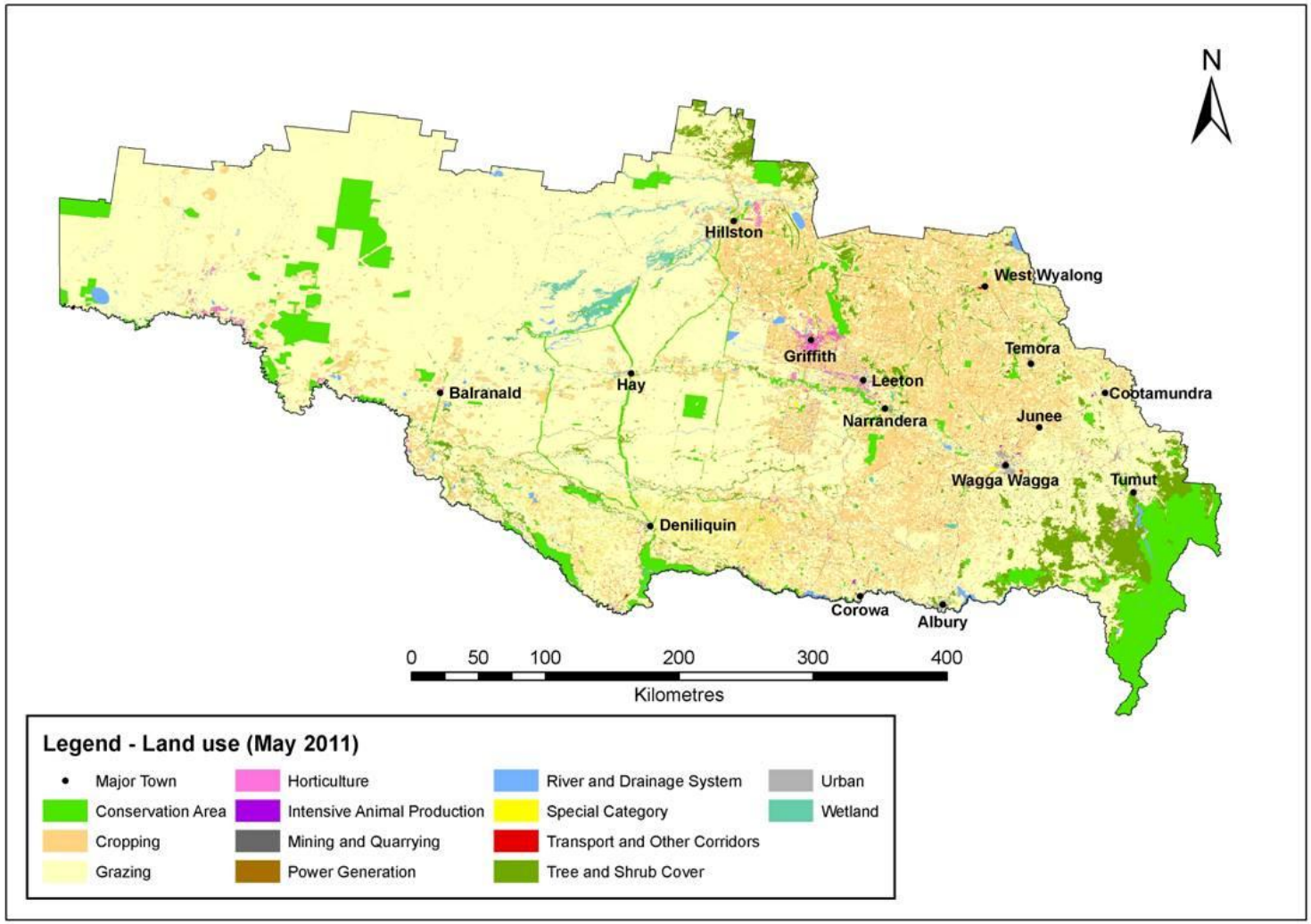


Table 1 Key land uses – Riverina Murray Region of NSW

Land use	Area (ha)
Grazing land	**10,193,268**
Fallow land	**344,720**
Crop land	**2,228,407**
Remnant vegetation (private land only)	**302,339**
Commercial forestry plantations	**126,000**

Source: ABS (2008), National Plantation Inventory (2008)

The region retains significant natural ecosystems, and significant areas in the south east of the region are managed as conservation areas. Many of the ecosystems in the region rely on flooding, including internationally significant Ramsar sites (NSW Central Murray state forests, and Fivebough and Tuckerbil swamps), and the World Heritage listed Willandra Lakes region. The region's biota is predominantly adapted to arid and semi-arid environments, with some eastern and cool-climate influences on the slopes and along major watercourses. Many of the region's plant and animal species are threatened by predation by introduced pests, competition with introduced herbivores, habitat modification for agriculture and altered river flow regimes.

5.2 Climate and hydrology

NSW has a very variable climate. The state experiences extremes of climate at seasonal, inter-annual, and multi-decadal time scales. This is mainly due to the combined influences on the eastern Australian climate of the El-Niño Southern Oscillation, the Southern Annular Mode and the Indian Ocean Dipole.

Rainfall throughout the Riverina Murray region is winter-spring dominated. Agriculture in the south of the state, around the Riverina Murray region, is dependent on regular rainfall from cold fronts and cut-off lows traversing south-eastern Australia during the winter growing season. These southern districts receive little rain in summer, however as winter approaches, the zone of high pressure shifts north, allowing westerly winds and rain-bearing systems from the Southern Ocean to affect southern Australia. Most of Australia's primary production occurs in these temperate regions of the south and east, and relies on this winter rainfall.

Average annual rainfall is lowest in the north-west of the Riverina Murray (240 mm) and highest in the south-east (nearly 1050 mm on the western edge of the Snowy Mountains). The highest run-off in the region originates from the Snowy Mountains and is winter-spring dominated, with high spring run-off relative to rainfall because of snow-melt. The more arid western parts of the region have a more uniform run-off pattern. Temperatures in this region have a strong seasonal cycle with cool-to-cold winters and warm-to-hot summers.

In the late 1990s and early 2000s, an extensive drought resulted in dramatic reductions in inflows to the Murray-Darling Basin and significantly reduced allocations of water through the irrigation systems. In recent years (2010/11 and 2011/12), there has been a return to higher inflows, however the 10 year average flows are still well below the long-term average as the preceding years had extremely low inflows.

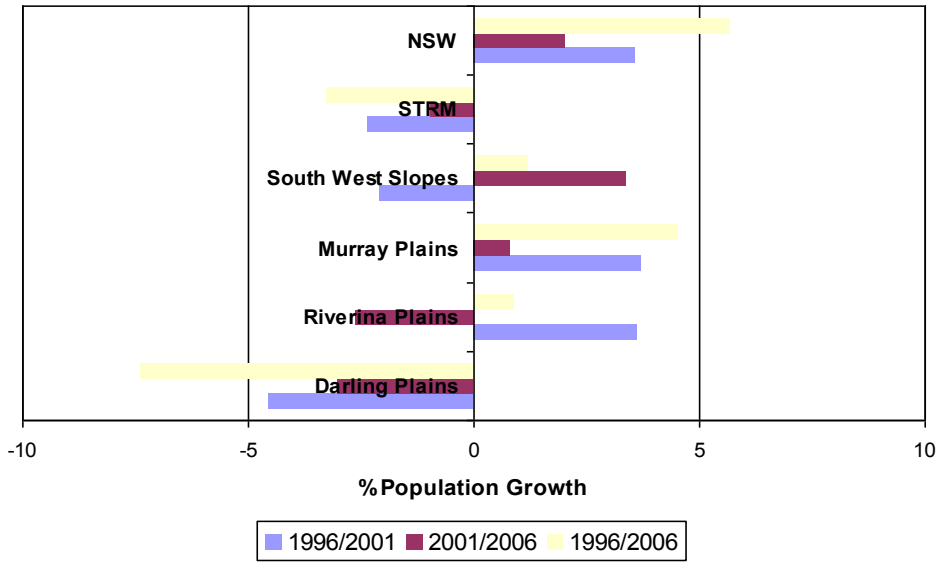
5.3 Population and demographics

The resident population of 257,817 includes 117,527 employed in Riverina Murray region workplaces. Over recent years those levels have increased slowly, at rates well below the average for NSW.

Although population has grown at a regional level, the pattern has varied at a sub-regional level. NSW on average shows an increase in population in 1996, 2001, and 2006, but both Southern Tablelands and Darling Plains show a decline in population growth rate in 1996 and 2001. In the South West Slopes, the population growth rate decreases from 1996 but increased from 2001 to 2006 (Figure 11).

While across the Riverina Murray the population in growing slowly, it is also ageing. The age profile of the Riverina Murray is shown in Figure 12. This shows that there is an ageing trend with higher shares in the 50 year age group and above relative to NSW. It is also a more fertile region, with higher shares in the age groups to age 19. There is a lower share in the age groups from 20 to 45. Figure 12 shows that at a sub-region scale the average age is higher than the NSW average in all regions, except for the Riverina Plains and the South West slopes. It appears the younger generations are in LGAs with higher population – in the case of the South West Slopes, the region has the closest age and sex ratio to the NSW average. This may reflect the presence of tertiary education establishments at Albury and Wagga Wagga. A further factor could be the diversity of industry in the regional centres, which offer a wider range of employment opportunities than are available in the other regional areas.

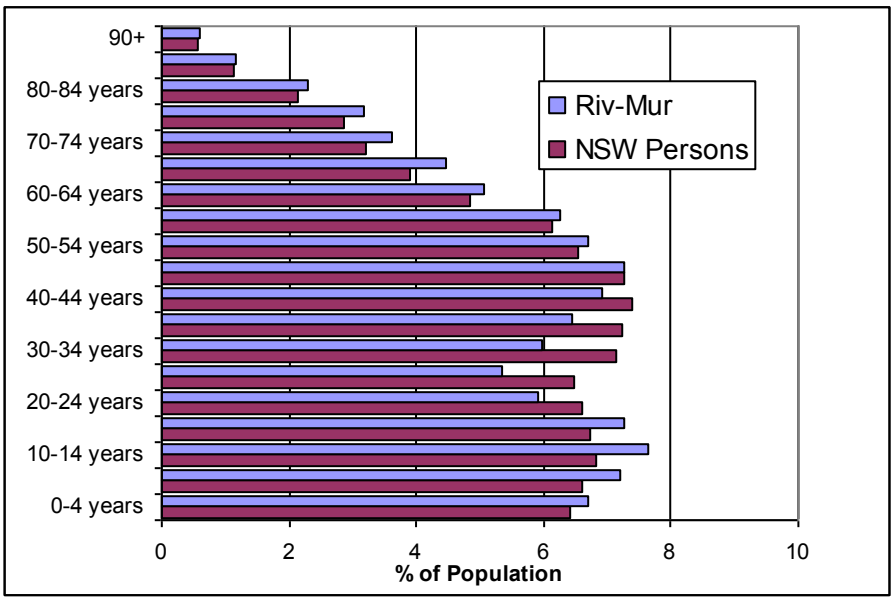
Figure 11 Riverina Murray Population Growth



The Department of Planning and Infrastructure notes that areas away from the main rivers and main towns, are expecting little development, and are expected to retain a stable or slightly declining population, with significant ageing over the period out to 2036 (DPI, 2009). In particular, Jerilderie, Urana, Conargo, Carrathool, Narrandera, Lockhart, Hay and Balranald are experiencing low levels of demand, and hence little development.

In addition, the Department of Planning and Infrastructure notes that some of the smaller towns along the Murray, such as Corowa, Moama and Barooga, have a significant tourism focus and are retirement destinations, particularly for people from Melbourne. As such, while they may not see a decline in population, these towns are expected to retain an older age profile (DPI, 2009).

Figure 12 Riverina-Murray Age Profile



In the Riverina Murray, employment has been growing since 1981 (Table 2). Employment growth has been about one-half of the rate of growth in NSW. However by 2006, 45.3 per cent of the population was employed, which was almost one per cent above the NSW average.

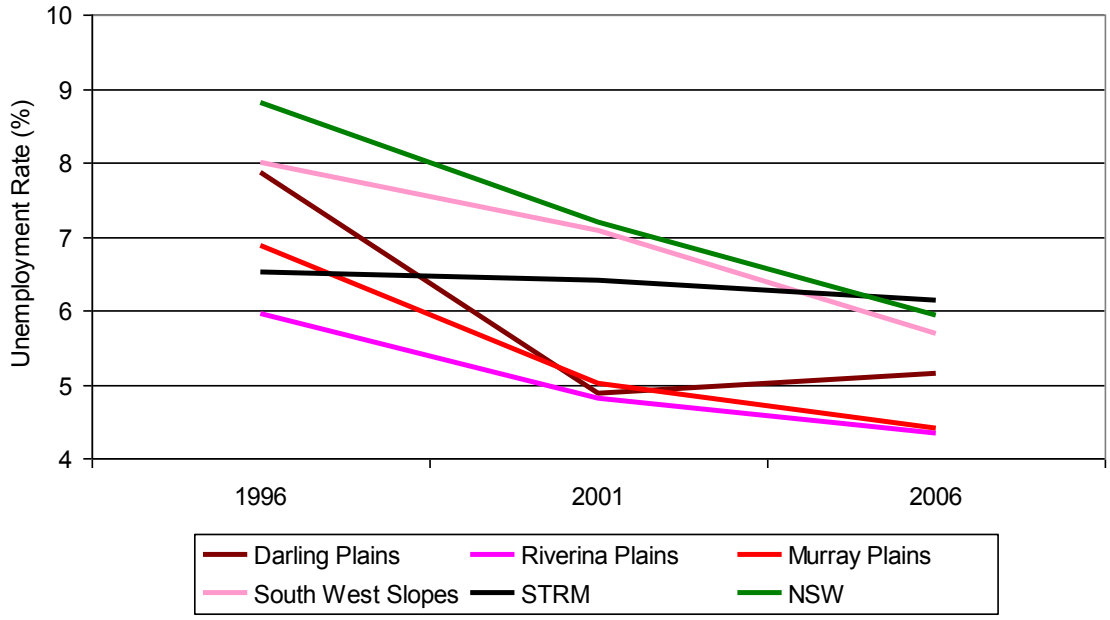
Table 2 Riverina-Murray Population and Employment Trends

Census Year	Total Employment	Total Population	Employment Share of Population	Average Annual Change Between Census Years		Total Change Between Census Years	
				Employmer	Population	Employmen	Population
			%	%	%	no.	no.
1981	103,526	245,100	42.2				
1986	100,507	248,520	40.4	-0.59	0.28	-3,019	3,420
1991	104,060	256,170	40.6	0.70	0.61	3,553	7,650
1996	107,341	260,032	41.3	0.62	0.30	3,281	3,862
2001	112,103	255,918	43.8	0.87	-0.32	4,762	-4,114
2006	116,803	257,817	45.3	0.82	0.15	4,700	1,899

The level of unemployment is also lower than NSW in 2006 for all regions except the Southern Tablelands. As shown in

Figure 13, the rate of unemployment in all regions, similar to NSW, has also been declining, except the Darling Plains, which showed a slight increase from 4.9 per cent to 5.2 per cent from 2001 to 2006.

Figure 13 Riverina/Murray Unemployment Rate 1996-2006



5.4 *Regional economy*

The Riverina Murray region is heartland Murray Darling Basin. Its Gross Regional Product (GRP) is estimated at $10.9b (3.6 per cent of the NSW economy), with $5.2b attributed as wage and salary income paid to households in the region. The overall industry structure is shown in Table 3.

Much of the regional economy is based on primary industries, notably the large irrigation areas based on the Murray and Murrumbidgee rivers, forestry in the river red gum forests and pine plantations, grazing and cereal cropping. Albury and Wagga Wagga also support mixed industries, and are the main regional services centres.

Table 3: Measures of the Riverina Murray Region Economy, 2005-06

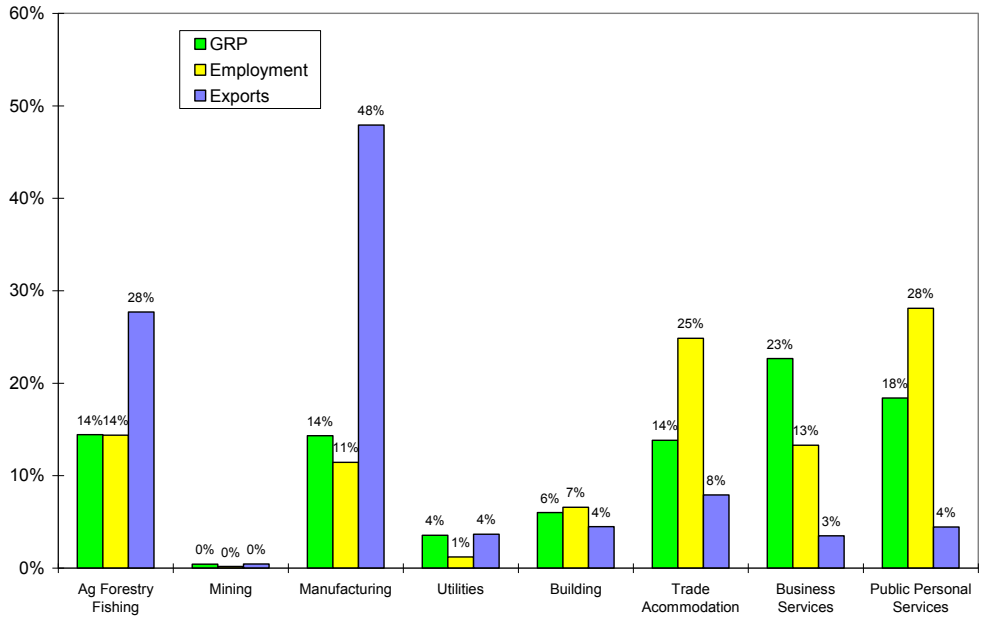
Measure	Region Value	Agriculture forestry and fishing	
	$m	Value $m	Share (%)
Resident population	257,817	na	na
Employment by workplace	117,527	na	na
Gross output	21,265	2,802	13.2
Gross Regional Product	10,918	1,575	14.4
Income from employment	5,172	526	10.2
Household expenditure	7,928	Na	na
Exports from region	5,625	1,565	27.8
Imports to region	6,832	432	6.3

Agriculture is a major contributor to the economy, with a direct share of GRP of 14 per cent and 28 per cent of exports from the region (Figure 14). That represents a substantial

dependence on agriculture for the Riverina-Murray region. This figure may be an underestimate, given the influence of drought and the limited access to irrigation water that existed in 2005-06. The drought over the decade to 2008 stressed all the agricultural industries directly, and through limited availability of general security water for irrigation. Across the Riverina Murray, many enterprises are reliant on irrigation including:

- rice, wine grapes, citrus, vegetables and other tree crops, grown the in mid Murrumbidgee and south west Murray sub-region (Griffith, Leeton, Coleambally and Barham)
- winter crops and annual pastures in the mid Murray sub-region (Finley, Deniliquin Wakool)
- a growing cotton industry around Hillston and Darlington Point
- livestock production and dairying in western parts of the greater region (MDBA, 2010).

Figure 14 Industry Structure of the Riverina Murray Region 2005-06



However, there is some close integration of production with processing, in terms of cattle feedlots and processing, pig production and processing, poultry production and processing, wine production, rice production and milling and between tree crops and processing.

Manufactured primary products contribute a further 27 per cent of exports, with processing of irrigated products from the Murrumbidgee Irrigation Area (MIA) and timber products based around Tumut.

The concentration of forestry plantations in the east of the region near Tumut is sufficient to support an integrated wood processing industry in the region, including sawmilling, fibreboard and cardboard manufacturing operations. These have expanded since 2005. There is also a paper processing facility in Albury and a range of wood processing operations throughout the western parts of the region, based on river red gum and cypress pine resources.

It is expected that the forestry industries in the eastern parts of the region will continue given the on-going supply of plantation timber.

Other processing activities are also concentrated in the MIA with wine production being the largest followed by meat production (especially poultry processing) and the processing of cereals including rice milling. Wine production will be spread over much of the region where there are vineyards.

According to Murrumbidgee Irrigation Ltd, the MIA, is one of the most diverse and productive regions in Australia, contributing over $2.5 billion annually to the Australian economy. Figure 15 shows the contribution of the MIA region to several industries.

Figure 15. Annual income and jobs from irrigated agriculture in the Murrumbidgee

Industry	Annual income (millions)	Notes	Jobs
Chicken	120	450,000 chickens/wk 60 million eggs / yr	950
Feedlot	450	75,000 cattle 150,000 through abattoir	800
Wineries	1,000	300,000 tonnes 13 wineries 60 containers exported / day	1500
Wine Grapes	147 (farmgate)	297,000 tonnes (60% NSW) 430 growers	*
Citrus	250 (retail)	185,000 tonnes 5 juicing plans 44 packaging sheds	1500
Rice	360 54 (farmgate)	500,000 tonnes ('normal' year) 30,000 tonnes 06/07	1200 600
Nuts	35	Expanding to 400 million in 10 years	*
Vegetables	79 (farmgate)		
Livestock^	347 (slaughtering)	650,000 head	*
Crops^	568	(excluding rice)	*

^ABS Ag commodities 06/07 Murrumbidgee Region. * Job figures not available
Murrumbidgee IL Company overview fact sheet:
http://www.mirrigation.com.au/AboutUs/fact%20sheets/1_Fact_Sheet_Company_Overview.pdf

A range of government centres located in smaller regional towns were closed during the mid 1990s, and elements of the Department of Water Resources were incorporated into locally run irrigation districts. This transitioned many administrative centres to service centres, consequently making them far more dependent on the region's agricultural economy.

Albury, Wagga Wagga and Griffith, as the main centres, attract most of the development in the area. Wagga Wagga and Albury both attract a younger population, due to large employment bases, particularly defence force employment, and the Charles Sturt University campuses. Wagga Wagga in particular has had strong growth, with new housing developments on the city fringes attractive to young families from the region (DPI, 2009).

5.5 Infrastructure and Emergency services

Water infrastructure
The Riverina Murray region covers the Murray, lower Darling, Murrumbidgee and Lachlan catchments, and includes extensive areas of irrigated agricultural land. The irrigation development along the rivers in the region has resulted in a large irrigated agriculture industry, but has come at a cost for river ecosystem health. In the middle of the drought in 2007, the Sustainable Rivers Audit reported that the Murray and lower Darling both had poor ecosystem health, while the Murrumbidgee had very poor ecosystem health and was the worst rated catchment in the system, along with Goulburn Valley river in Victoria.

Murray Irrigation Limited and Murrumbidgee Irrigation Limited are key irrigation entities in the region. Murrumbidgee Irrigation Ltd supplies water to farmland stretching from Narrandera through Yanco, Leeton, Griffith and west to the Lachlan River covering the area south of Goolgowi and Booligal, previously known as the Murrumbidgee Irrigation Areas and Districts (MIA). The MIA covers an area of 660,000 hectares, of which an average of 120,000 ha is irrigated.

Murray Irrigation Ltd provides irrigation water to over 2400 farms in an area of operation that stretches from Mulwala in the east to Moulamein in the west, taking in nearly 748,000 ha of farmland north of the Murray River.

Murray Irrigation Ltd operates over 3,500 km of supply channels and 2,160km of drainage channels, in what was previously called the Southern Riverina Irrigation Districts. Of the supply channels, 250km are cement lined, 100km are piped and the remainder are earthen channels. The integrated supply and drainage system gives the strategic advantage of being able re-use a majority of water within the area. The Murray Irrigation Ltd Integrated Horticulture Supply program is currently refurbishing 230 kilometres of open channels with a piped, pressurised system for improved water use efficiency.

Transport infrastructure
The Riverina Murray region is a key transport hub for distribution of goods across south-eastern Australia, with rail freight, roads and airport links within reach of major markets, and roads linking regional townships. The traditional transport hub for the Hume Highway is Albury, which provides transport, warehousing and logistics through facilities like the Ettamogah Intermodal Hub, and expansion of Border Express. In addition to road connections, there is a direct link to the Victorian and NSW rail networks, and air service to national and State capitals from Albury, Wagga Wagga, Griffith and Mildura.

There are good rail connections between the large cities and State capitals, and some additional grain lines line such as the Griffith-Narrandera rail line.

Communications infrastructure
Currently Wagga Wagga has an efficient ICT infrastructure, built around the high capacity fibre optic trunk link which runs through the city. The $200 million Royal Australian Navy Defence Communications Station also makes the Riverina home to some of the most advanced communication technology in the world.

The National Broadband Network (NBN) is scheduled for Wagga Wagga and Albury by 2014/15, but some areas of the region will get fixed wireless, and there is unlikely to be wide coverage in the region for some time. For example, Deniliquin will probably not receive coverage until 2020.

6 Climate change projections and biophysical impacts for Riverina Murray Region

Table A1: Climate Change Projections for South East NSW Region

Climate Variable	Trend	Projection
Average daily maximum temperature	Increase	Spring and Winter – increase 2.0-3.0 C Summer and Autumn - increase 1.5-3.0 C
Average daily minimum temperature	Increase	Spring - increase 1.0-2.0 C Summer and Autumn – increase 0.5-1.5 C Winter – increase 0.5-1.0 C
Average rainfall	Decrease	Details of projected changes in average rainfall are uncertain, and vary across the region – more details below
Rainfall seasonality	Rainfall is likely to increase moderately in summer but decline substantially in Spring, Winter and Autumn	Spring – Up to 50% decrease, more severe in the south and west Summer – 10-50% increase, higher in the eastern Riverina and south-west slopes Autumn – Up to 50% decrease, more severe in the south and west Winter – 20-50% decrease
Atmospheric CO2	Increase	A2 IPCC emissions scenario (DECCW, 2010a)

Table A2: Biophysical impacts and changes to natural hazards due to climate change in South East NSW Region

Biophysical Impact	Trend	Projection
Soil Moisture	Drier in all seasons across the region	Drying due to changes in precipitation plus evaporation changes: Spring – no change in south, grading to 10-50% increase in the north Summer – 20-50% increase Autumn – 5-20% increase Winter – 20-50% decrease in the south grading to 10-20% decrease in the north
Run-off	Annual minor decrease	Spring and winter – moderate decrease in average run-off depth Summer – moderate increase in average run-off depth Autumn – minor increase in average run-off depth
Snowfall	Decrease	More precipitation falling as rain due to higher temps, and reduction in rainfall in spring and winter likely to reduce snow cover
Soil erosion	Increase	Sheet and rill erosion are very likely to increase Gully erosion is likely to become worse on the slopes and plains Wind erosion is likely to increase
Ecosystem function	Decrease	Virtually certain to have major impacts on all natural ecosystems in the region. Wetlands and ecosystems that are already under pressure are likely to be most affected. Ecosystem productivity and nutrient cycling are likely to decline

Natural Hazard	Trend	Projection
Heatwaves	More intense and frequent	Heatwaves are projected to become more severe, because of higher temperatures as a result of climate change. They are also likely to become more frequent, but projections are dependent on mid-latitude circulation patterns
Bushfire	Change	More bushfire weather and longer fire season leading to likely increase in frequency, but uncertain changes to fuel availability
Drought	More severe	Short, medium and longer duration droughts are all likely to become more severe, due to a projected decrease in run-off during these periods. Model results nearly all indicate an increase in severity, with estimates predicting up to a 15% decrease in total run-off
Riverine flooding	Increase	Increase intensity of flood producing rainfall events, however preceding catchment conditions will affect degree of flooding
Flash flooding	Increase	The risk of flooding along urban streams is likely to increase, due to increases in rainfall intensities, especially during short storms. Floodwaters in these events are likely to rise more rapidly, potentially increasing the danger of these local floods to the community

Appendix A: Agencies and organisations represented at the sector workshops

Organisations marked with * were also represented on the Steering Committee.

1.	Agriculture NSW
2.	Albury City Council
3.	Australian Government Department of Human Services - Centrelink
4.	Berrigan Shire Council
5.	Carrathool Shire Council
6.	Charles Sturt University
7.	City of Wagga Wagga
8.	Cootamundra Shire Council
9.	Greater Hume Shire Council
10.	Griffith Base Hospital
11.	Griffith City Council
12.	GSAHS Health NSW*
13.	Lockhart Shire Council
14.	Ministry of Police and Emergency Services
15.	Murray Catchment Management Authority*
16.	Murrumbidgee Catchment Management Authority*
17.	Murrumbidgee Local Health District*
18.	Murrumbidgee Shire Council
19.	NSW Ambulance
20.	NSW Department of Education and Training
21.	NSW Department of Family and Community Services
22.	NSW Department of Planning and Infrastructure*
23.	Department of Premier and Cabinet*
24.	NSW Department of Primary Industries*
25.	NSW Environment Protection Authority*
26.	NSW Fire and Rescue
27.	NSW Office of Environment and Heritage*
28.	NSW Office of Water*
29.	NSW National Parks and Wildlife Service*
30.	NSW Rural Fire Service

31.	NSW State Water Corporation
32.	NSW Trade & Investment - Enterprise, Small Business & Regional Development*
33.	NSW Trade & Investment - State and Regional Development
34.	Riverina and Murray Regional Organisations of Councils*
35.	Riverina Eastern Regional Organisation of Councils*
36.	Riverina Environmental Education Centre
37.	Roads and Maritime Services
38.	State Emergency Services
39.	TAFE NSW Riverina Institute
40.	TAFE Leeton-Narrandera
41.	Tumbarumba Shire Council
42.	Tumut Shire Council
43.	Urana Shire Council
44.	NSW Volunteer Rescue Association
45.	Wentworth Shire Council

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