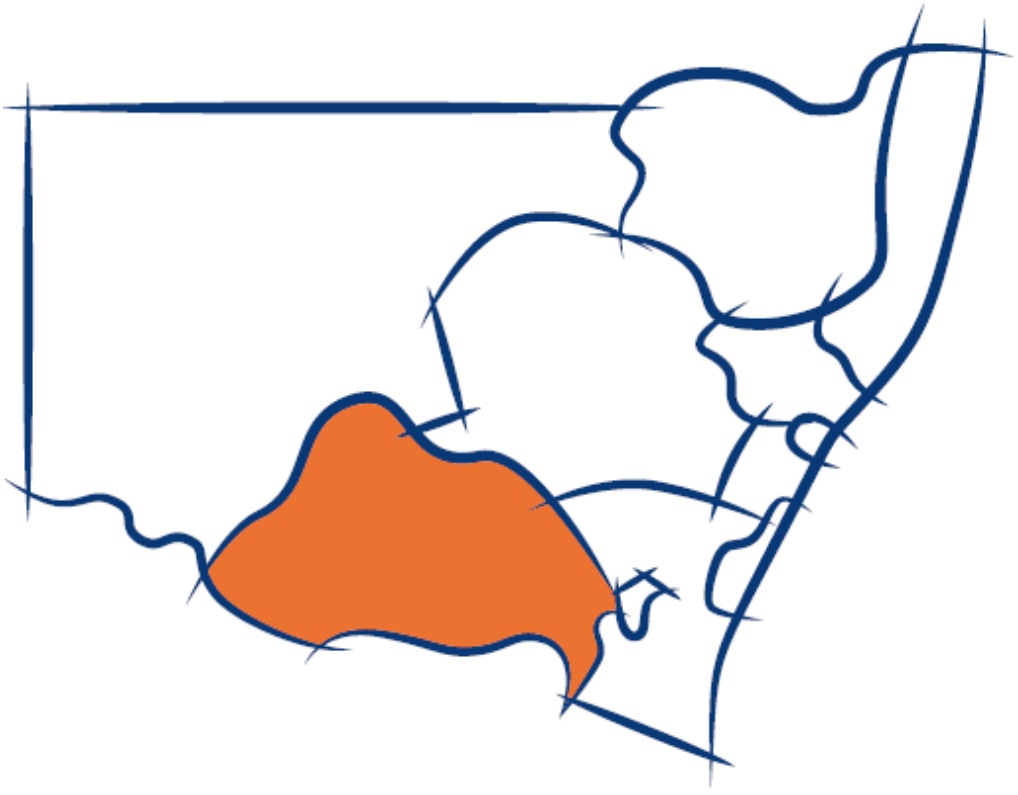
NSW GOVERNMENT Office of Environment & Heritage

AdaptNSW

Western Enabling Regional Adaptation

Riverina Murray region report



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The Office of Environment and Heritage (OEH) has compiled this report in good faith, exercising all due care and attention. The process seeks to describe factors that participants identified as contributing to sectoral and regional vulnerability, and the consideration of factors that contribute to regions' ability to cope with change, or "adaptive capacity". The participants draw on their experience as regional office bearers, multidisciplinary practitioners and members of the community. No representation is made about the accuracy, completeness or suitability of the information in this publication for any particular purpose. OEH shall not be liable for any damage which may occur to any person or organisation taking action or not on the basis of this publication. Readers should seek appropriate advice when applying the information to their specific needs.

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1 Introduction

The climate is changing and global modelling indicates that further change is already locked in. As a result, there is a growing risk of climate related impacts on our state's natural, social and economic systems. Regional administrators, businesses and communities need to identify their strengths and weaknesses in the face of climate impacts – deciding how they will act together to minimise the impact of climate change on their local economy, environment and society and identify opportunities for a sustainable future.

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. In partnership with leading researchers, the Office of Environment and Heritage (OEH) has developed and delivered regional scale climate projections and has facilitated the investigation of related impacts.

The Western Enabling Regional Adaptation (WERA) project builds on local knowledge to understand climate vulnerabilities in Western NSW and identify opportunities to respond, enabling regional decision-makers to enhance government service delivery and planning at a regional and subregional scale.

The WERA project will provide a structured process for participation by representatives of NSW Government agencies, local government and key regional stakeholders, using their tacit local knowledge to identify and capture opportunities to build regional resilience. By enabling participatory learning, the WERA process will aim to develop new and expanded professional networks which can be mobilised to respond to climate change. Operational knowledge of how regional systems interact informs the development of adaptation responses that are sensitive to the reality of local systems.

The WERA project has sought to:

- provide a credible evidence base for *Government adaptation planning* by developing a regional understanding of the impacts of projected climate change and vulnerability to the expected impacts for the Riverina Murray region
- build on the capacity of *regional decision-makers to undertake adaptation action* by improved understanding of regional climate change impacts, adaptive capacity, vulnerability and adaptation options, and
- strengthen *relationships between sectors across local and state government* in the four western regions, with a view to capturing opportunities for regional climate change adaptation projects.

This report presents the output from a series of workshops held in the Riverina Murray region during 2016. Workshop participants developed transition pathways for key regional systems, to build resilience to climate extremes and minimise impacts on their local communities.

The report also outlines the workshop process, and potential projects to activate the transition pathways and strengthen key regional systems in the Riverina Murray, and support improved government service planning and delivery now and into the future. The final chapter of the report gives proactive ways to turn the report's findings into action.

2 What needs to change in the Riverina Murray region?

2.1 Identification of vulnerable regional systems

The state's regions are subject to a broad range of drivers of change (economic, technological, social, and environmental). Regions such as the Riverina Murray are made up of many component parts (or systems) that all contribute to how the region currently functions (business-as-usual) and its trajectory of future development. A region's resilience in response to drivers of change relies on its capacity to adapt. For temporary drivers (such as fluctuations in agricultural commodity prices), basic alterations to business-as-usual may be an adequate response; however, for persistent and disruptive drivers such as climate change, more fundamental and transformative change may be required to adapt regional systems.

For the Riverina Murray, seven regional systems were identified by workshop participants as vulnerable to changes in climate, and in need of change to ensure effective ongoing government service planning and delivery:

- small communities
- land management
- riverine ecosystems
- river-based tourism
- mixed farming
- irrigated agriculture
- energy.

2.2 Transition models for key regional systems

For each of the key regional systems identified, a change model was developed to describe:

1. the regional system (or set its boundaries)
2. the most important drivers acting on the system, which currently may not be climate related; however, the impacts of non-climate drivers will likely be amplified by climate change
3. business-as-usual (or the way the system currently operates)
4. a series of transition pathways that emerge from business-as-usual in response to the need for change
5. a desirable future system, transformed by progress along the transition pathways.

The Riverina Murray region, as its name suggests, is strongly driven by natural resource-based industries which are themselves spatially organised by the availability of water both geographically and temporally. In the change models, the transition pathways of *riverine ecosystems* and *land management* are strongly interlinked with those of *mixed farming*, *irrigated agriculture* and *river-based tourism*, as can be seen by common or similar adaptation pathways. These include: development of accounting methods that encompass a broader range of (non-economic) water values; integrated regional planning to improve water, energy and natural resource management efficiency; the application of Indigenous knowledge to natural resource management; and the sharing of information across collaborative networks.

Small communities are more immediately affected by fluctuations in the natural and agricultural resource-based systems than are the regional centres. The *small communities*

transition pathways depend on developing new innovative business where leadership, human resources, social networks and infrastructure (especially telecommunications) exist to support this. This will be most likely to exist where the resource-based systems are prepared for climate change. In turn, the fluctuations of resource-based industries can be better managed where other diverse forms of income are available to a small community. For similar reasons the transition pathways in the *energy* system are shaped by the needs of the resource-based systems and small communities to be resource efficient and energy self-sufficient.

Small communities

The Riverina Murray region supports a range of sizes of human settlements from large regional cities such as Wagga Wagga (NSW's largest regional city), to small towns and hamlets. Small communities (Figure 1) were defined as those living in settlements of fewer than 7000 people, distant from regional cities, and that in the past would have provided services primarily to farmers, although this function has now often declined.

Workshop participants described government service delivery to small communities as coming under pressure from a range of drivers including: demographic change (both from ageing and drift or slow migration to larger settlements), increasing demand for primary health care and declining indicators of local community health, seasonal influx of transient populations (such as 'grey nomads'), an under supply of labour and a lack of jobs for youth, extreme climate events and their impact on emergency services, remoteness of some towns from service delivery hubs in larger centres, and the trend towards online retail diverting expenditure from the local retail economy.

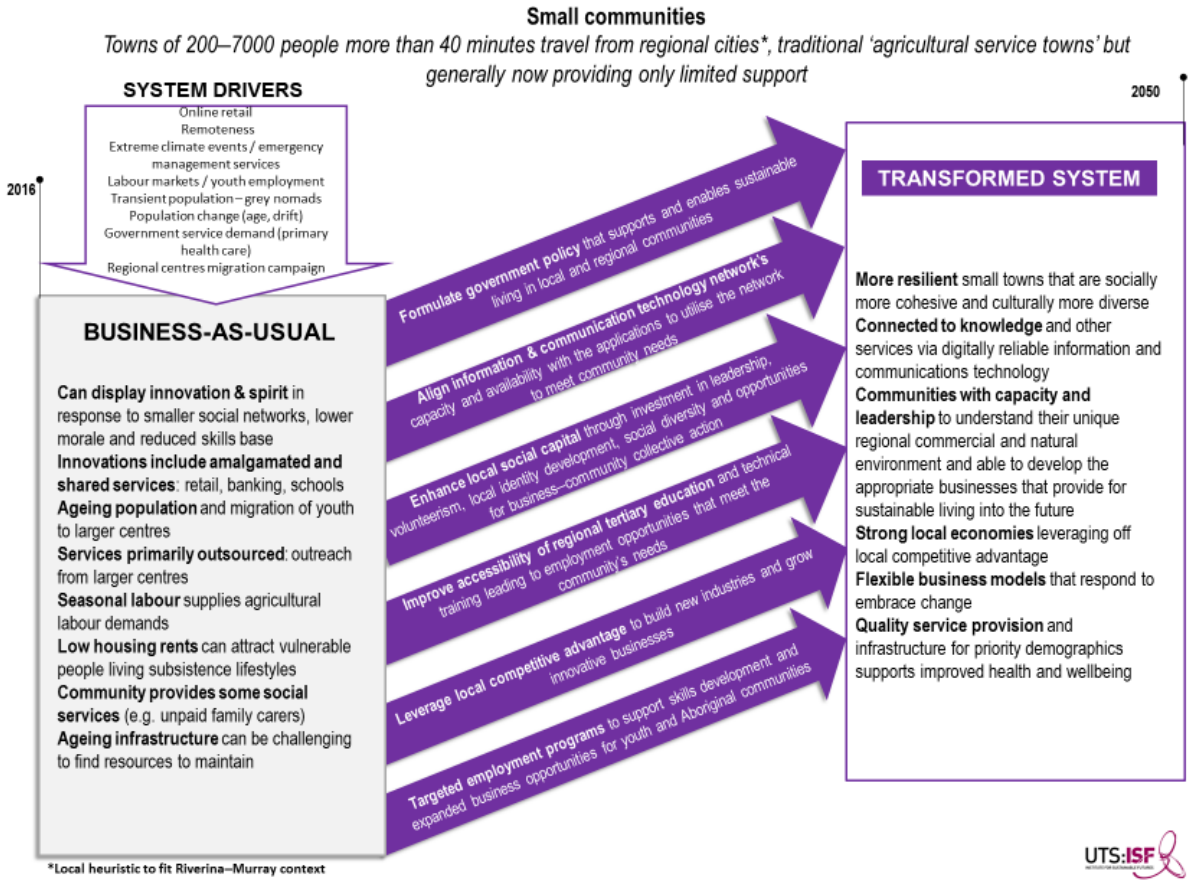

Figure 1: Change model for small communities in the Riverina Murray region

Small communities demonstrate tremendous spirit, and are the seat of local innovative responses to change. A statistical trend in population decline has narrowed the local skills base as population has migrated to the larger regional centres, and this has implications for how small communities access services and maintain their capacity. People living subsistence lifestyles in low cost rental housing may be particularly vulnerable to service accessibility and may not have access to funds to improve infrastructure. Innovation in the local presentation of services (such as retail, banking and education) has included amalgamation, cooperatives and sharing of infrastructure and access points.

Pathways for transition of small communities include a policy environment that enables sustainable living for small communities, and alignment of information and communication technology (ICT) networks with applications designed to better meet community needs. Improvements are needed in regional tertiary education and technical training linked to regional needs that develop the capability of communities to leverage local competitive advantage in business innovation. In particular, investment in leadership, local identity development, social diversity and business–community partnerships would promote collective action for change, provide targeted employment opportunities and arrest the decline in local social capital.

Future-cast: more resilient small communities with enhanced social cohesion, leadership and cultural diversity. Improved community connections to knowledge and services through reliable digital technology, supporting local capacity to develop businesses that provide for sustainable living and playing to community strengths of unique regional context both commercial and environmental. Stronger local economies have emerged that leverage local competitive advantage through responsive business models that contribute to providing quality services and infrastructure for sectors of the community most in need.

Land management

The Riverina Murray focus is on the creation of healthy, productive landscapes across public and private tenure (Figure 2). A feature of management is the integration of a range of land uses from traditional agricultural production to forests, reserves (national parks, Crown land and travelling stock routes), recreational areas and bushland.

Workshop participants identified a range of drivers acting on land management that include increasing landscape fragmentation and loss of biodiversity often related to rural residential subdivision around large population centres, the loss of cultural heritage and vulnerability of communities to natural hazards such as bushfire and flooding. Availability of funding and government policy are additional key influences.

Management of Riverina Murray landscapes was described as sometimes under resourced and reactive to specific issues. Where knowledge about resource management is held in policy silos this can limit collaboration with private land managers. Engagement with stakeholders should aim to foster a shared understanding of landscape value. Endangered species that are managed in situ could fare better if managed at a landscape scale.

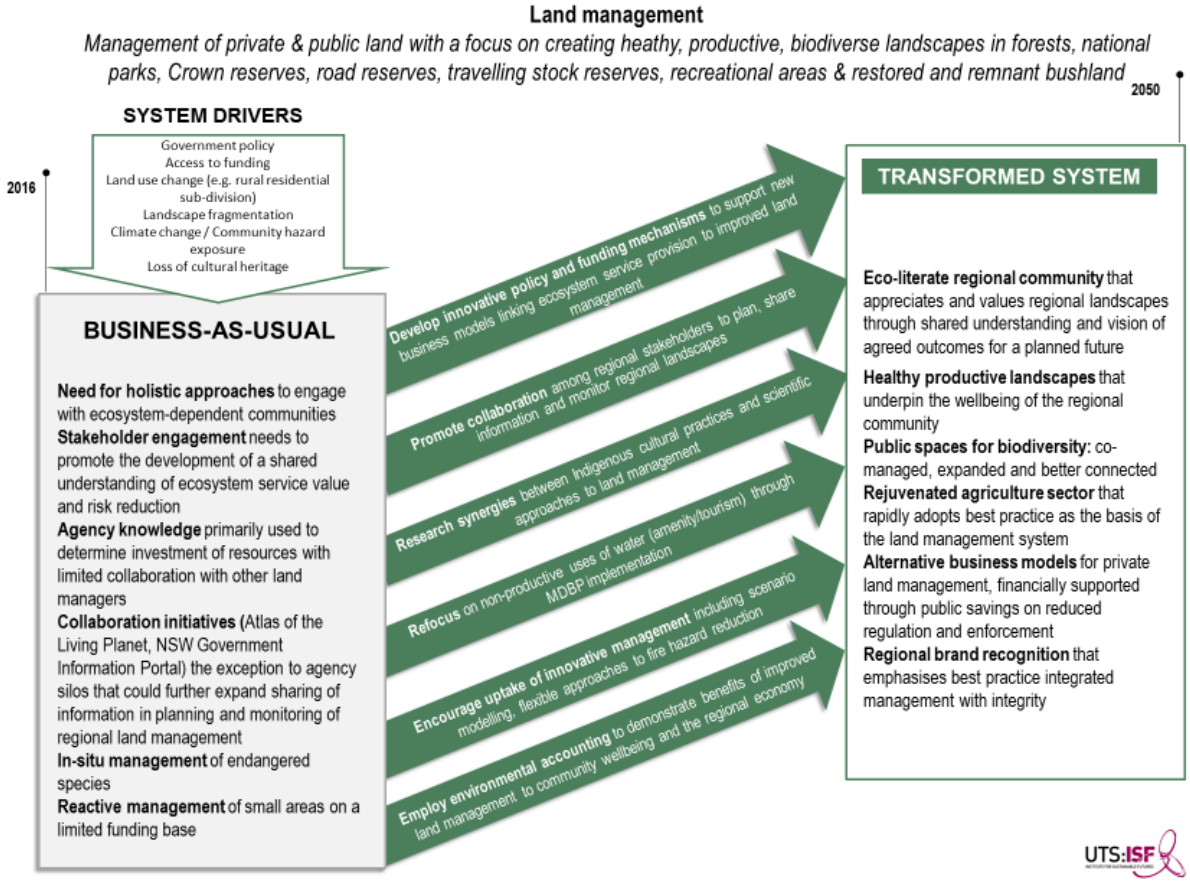

Figure 2: Change model for land management in the Riverina Murray region

Pathways that transition landscape management include policy development to support new business models that link ecosystem service provision to improved land management practices, and that balance agricultural production and landscape ecology. These business models would improve collaboration and information sharing to encourage innovative approaches to land management that integrate Indigenous, experiential and scientific knowledge. Implementation of the Murray–Darling Basin Plan (MDBP) will strike a balance between sustainable use of water for agricultural production and its other values in providing healthy rivers and wetlands, amenity and tourism. Environmental accounting will provide the evidence base to demonstrate the benefits of improved land management to the community and the regional economy.

Futurecast; healthy, productive, biodiverse landscapes are valued by regional communities that actively co-manage public and private spaces. Through the adoption of best practice and supported by new business models for private land management including carbon and biodiversity, the agricultural sector is more resilient to climate and commodity market cycles, strengthening the regional economy. The region leverages the benefits of excellence in land management to enhance its reputation as a healthy lifestyle destination for local communities and visitors.

Riverine ecosystems

The riverine ecosystems in the Riverina Murray encompass the water, soils and vegetation that contain the region's biodiversity, and that provide social, cultural and economic values for the region's communities (Figure 3). Riverine ecosystems are important for the regions tourism, agriculture, small towns and energy.

This system responds to a range of drivers, across river-dependent and rainfall-dependent ecosystems. The Murray Darling Basin Plan frames the balance for water allocation between users, and this seeks to establish a basis for sustainable regulation and use of water. Local drivers such as land-use change, emerging biotic threats, improvements in knowledge leading to technical innovations in system management and the costs of water infrastructure also affect these systems. Climate change-altered rainfall patterns are influencing the riverine environment and the patterns of availability of water for irrigation and the environment.

The workshops identified that currently regulated river systems in which water collection, holding (in dams) and release forms the basis of system management. River managers attempt to accommodate the interests of multiple water users and address declining water quality. The complex range of water users invariably leads to difficulties for system managers in balancing competing demands for water among producers and environmental water uses. Regulation of environmental flows and consumptive use is leading to innovative water management practices.

The Murray Darling Basin Plan seeks to establish a basis for sustainable regulation and use of water into the future that will underpin the value of agricultural goods and services marketed from the region, and the natural and cultural heritage of flow-dependent ecosystems. This careful management of a scarce resource will lead to innovative water management knowledge, technologies and practices. For rain-dependent ecosystems, new approaches to land management that recognise the value of stewardship and provision of ecosystem services and that build new markets for investment into land management can lead to more sustainable landscapes that are resilient to climate effects. Interflow of knowledge between managers across land tenures, and integration of experiential, cultural and scientific knowledge through local management of biodiversity will underpin this resilience.

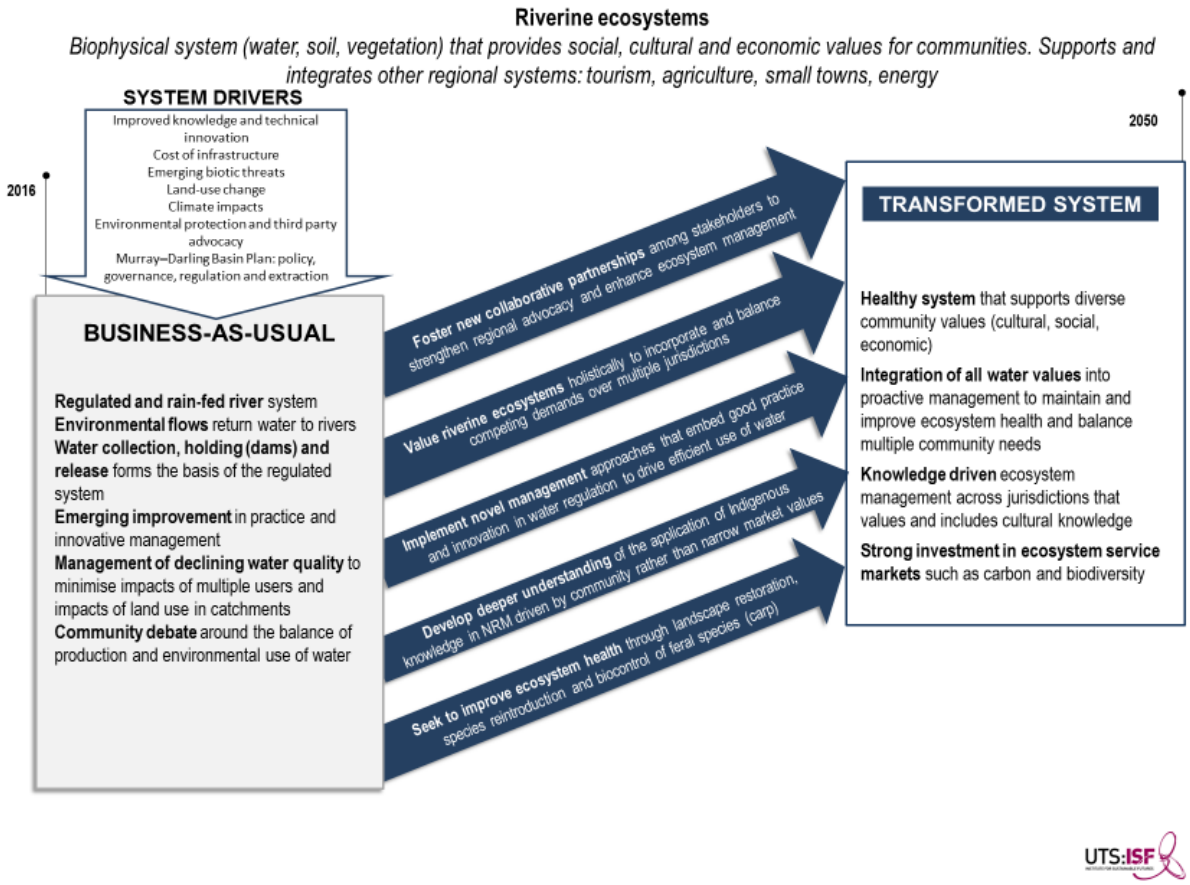

Figure 3: Change model for riverine ecosystems in the Riverina Murray region

Transition pathways to a transformed future centre on fostering new collaborative partnerships among stakeholders to strengthen regional advocacy and ecosystem management, and a more holistic valuation of riverine ecosystems to better balance competing demands across jurisdictions. Implementation of novel management approaches that embed best practice and innovation in the regulation of water is essential to drive more efficient use of water. As with land management, a deeper understanding of natural resource management that is community-based and incorporates Indigenous knowledge should complement market values surrounding consumptive water uses. Finally, improvements to ecosystem health will result from restoration of the landscape, species reintroduction and biocontrol of feral aquatic species, in particular carp.

Futurecast; transformed riverine ecosystems are healthy and proactively managed, drawing on a deep knowledge of ecosystem management that values and includes cultural, experiential and scientific knowledge and incorporates new markets to integrate ecosystem health and services with community and economic needs.

River-based tourism

River-based tourism for the Riverina Murray region is made up of regional tourism providers and businesses linked to water-based leisure activities (Figure 4). Activities include those broadly dependent on the river system (such as wine, food, golf, heritage, camping, fishing and events) and those that take place on lake, dam or river frontages.

Participants to this project described river-based tourism as dependent on local outcomes of management, policy and practice of water management in the major river catchments (e.g. Murray, Edward, Murrumbidgee, lower Lachlan) as these influence the nature and timing of access to water, bodies, healthy fish populations and opportunities for nature-based tourism. As the Murray River forms a State border resolution of differences in cross-border regulatory and policy regimes can facilitate better tourism outcomes. Within the region, an inconsistent perception across the community of the value of river-based tourism limits the prioritisation of water management for amenity purposes. The availability of infrastructure to support visitation is important locally as are linkages to related regional, non-river tourism markets. Extreme climate events, in particularly droughts and floods, influence visitation.

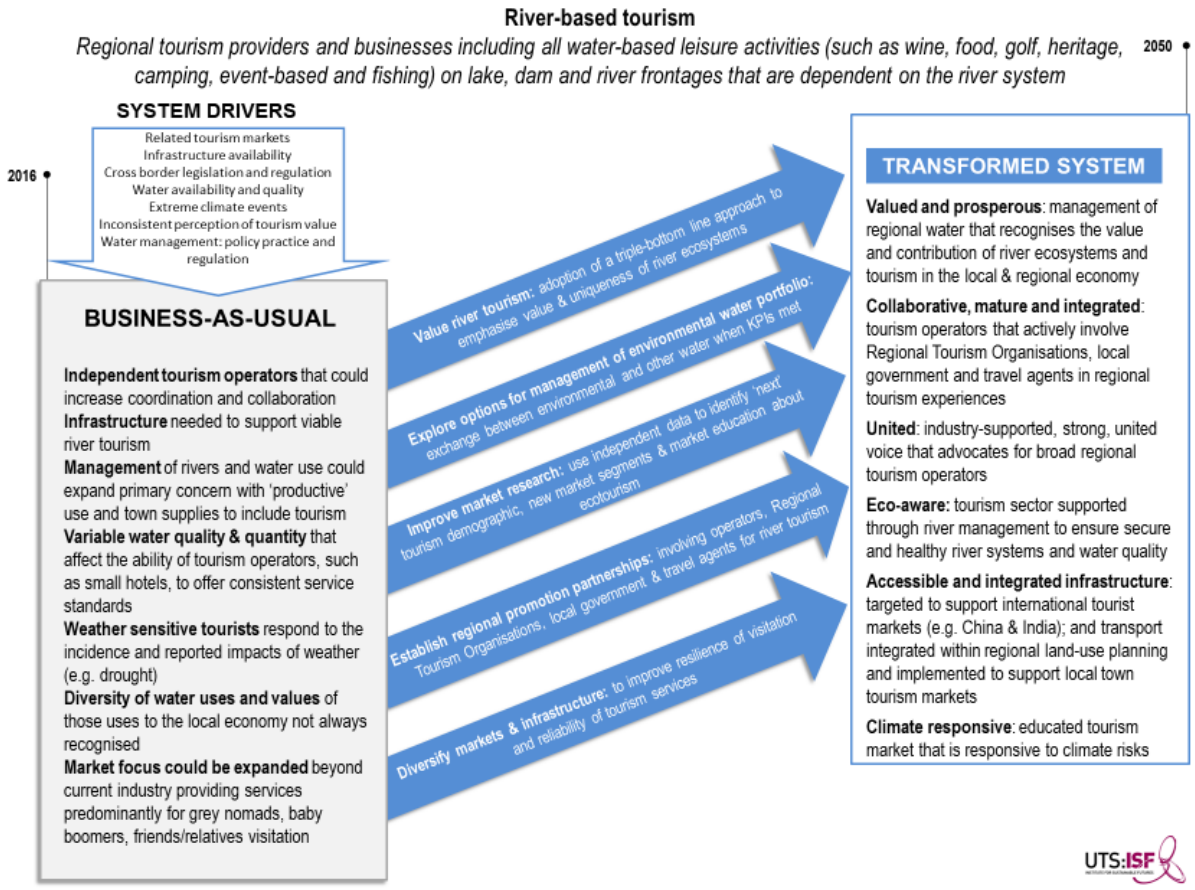

Figure 4: Change model for river-based tourism in the Riverina Murray region

There is potential to better coordinate and improve collaboration amongst independent tourism businesses, and to invest in appropriate supportive infrastructure. River management priorities can be better tuned to support consistent service standards desired by tourism operators. Visitors are highly sensitive to the reports of adverse weather (e.g. incidence and impacts of droughts). Improved recognition of the value of river tourism to local economies and integrated marketing to expand visitation into new market segments will build the future viability of river-based tourism.

In common with transition pathways in riverine ecosystems, the adoption of new approaches to value the uniqueness of river ecosystems would help to support the business case for river-based tourism. More flexibility in management of river flows may better support river tourism and other water requirements. Innovation in tourism marketing that incorporates improved market research, regional promotional partnerships among tourism stakeholders,

diversification into new market segments and enhanced infrastructure would increase reliability of tourism businesses and the resilience of regional visitation.

Futurecast; a more valued and prosperous river-based tourism sector in which stakeholders collaborate to create regional tourism experiences and are united in their advocacy for regional tourism operations. Infrastructure is in place to support international visitation and provide access to small rural towns to expand tourism experiences. The sector provides quality nature-based tourism products supported by river management that optimises water supply, river health and water quality to visitor experiences.

Mixed farming

Mixed farming in the Riverina Murray region is defined as the production of crops and livestock under non-irrigated (dryland) conditions (Figure 5).

Rain-fed mixed farming has been a long-standing and resilient presence in the mix of agriculture across the Riverina Murray region, generating quality animal and plant products. Farmers and the agriculture sector more generally have developed resilience against volatility in international commodity prices and declining terms of trade, and have responded to changing availability of labour with increased inputs of technology, flexibility in selected commodities, and improvements in genetics. The challenge of adjustment to global and national economic trends is being met by access to relevant financial products and services, and knowledge connection though producer groups and market networks. Young rural people are responding to a future in agriculture and associated value-adding industries, and regional capacity to provide relevant training, certification and education is increasing. This increase in on-farm capacity and viability will mitigate some of the demographic and social trends typical of rural populations. Government investment in regional infrastructure (particularly transport and communications) can further improve business viability and resilience to climate events, in particular drought.

The mixed farming systems of the Riverina Murray are currently undergoing considerable change. Family-owned enterprises that have well-defined, local, productivity thresholds for viability predominate. Farming landscapes are being reconfigured through changes in farm holdings, both amalgamations, and fragmentation near large regional centres. Rural communities are increasingly dependent on goods and service provided from larger regional centres. Adaption in response to climate and market volatility is characteristic of farming communities.

Workshops identified transition pathways that will continue to build resilience in mixed farming systems including a policy environment that supports adoption of innovative technology, better use of data in decision-making and novel business models. In addition, the inclusion of additional revenue streams from new service markets (such as solar and carbon farming, and low input farming systems) could be expected to complement traditional farming enterprises and consolidate viability by supplementing farm incomes. Ongoing support for the development of an educated, multi-disciplinary agricultural service sector that works in conjunction with a farming community that has ready access to ongoing professional development opportunities will enhance these outcomes.

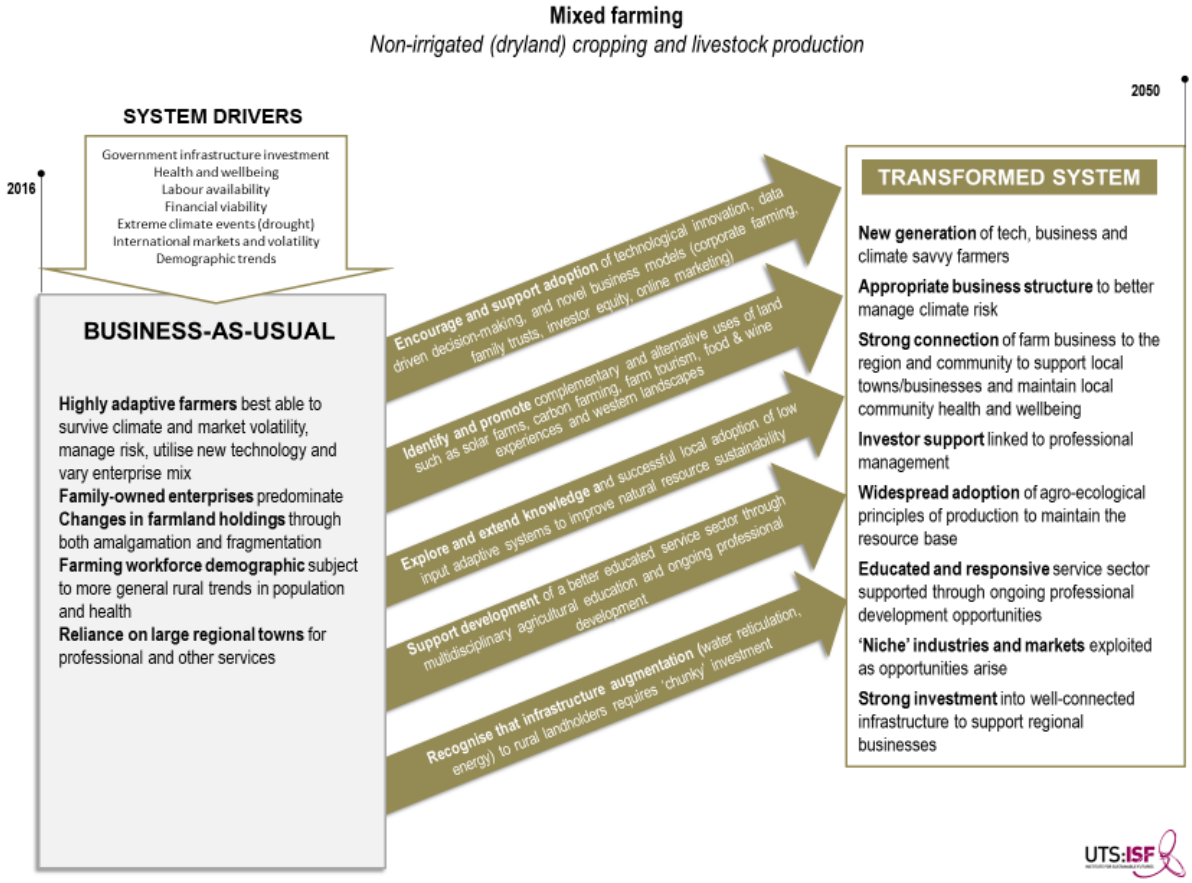

Figure 5: Change model for mixed farming in the Riverina Murray region

Futurecast; a new generation of professional farmers managing climate and other business risks through relevant and innovative business structures that enable improved access to investment in agriculture. Farming businesses will remain closely connected to the region, supporting local economies and will remain integral to the maintenance of local community health and wellbeing. The widespread adoption of agro-ecological production principles supported by a rich regional knowledge base will underpin natural resource sustainability. An agile farm sector will exploit market opportunities to establish a broad range of niche industries.

Irrigated agriculture

Irrigated agriculture in the Riverina Murray region is defined as the production of annual and woody perennial (trees and vines) crops in systems where rainfall is replaced or supplemented by irrigation to provide crop water requirements (Figure 6).

Workshop participants described irrigated agriculture responding to a range of water policy, management and market drivers including past water buy-back under the MDBP, with trust in 'the system' another contributor to outcomes. The separation of water and land titles to allow water trading has resulted in increased competition for water and speculation in the water market. This policy change has driven the continuing pursuit of improvements in water-use efficiency assisted by industry funded research and development (in particular enabled by new cropping options such as cotton production). Economies of scale for irrigation schemes are also a key influence.

The current system reflects the combination of rapid policy change and severe drought experienced by irrigators over the past 20 years. This change has produced irrigators with an enhanced ability to manage risk and adopt innovation in water efficiency measures (water delivery, irrigation layouts and moisture monitoring) in response to water markets and a decade of investment in water efficiency. Irrigators seeking to optimise water-use efficiency have changed to better water control infrastructure, and higher value, better adapted crop types. The Murray Darling Basin Plan frames the balance for water allocation between users, and seeks to establish a basis for sustainable regulation and use of water into the future that will underpin the value of agricultural goods and services marketed from the region, and the natural and cultural heritage of flow-dependent ecosystems. This careful management of a scarce resource has led to innovative water management knowledge, technologies and practices. Weed control in water storages is an emerging issue. The number of irrigators has declined due mainly to retirement and exit from the industry.

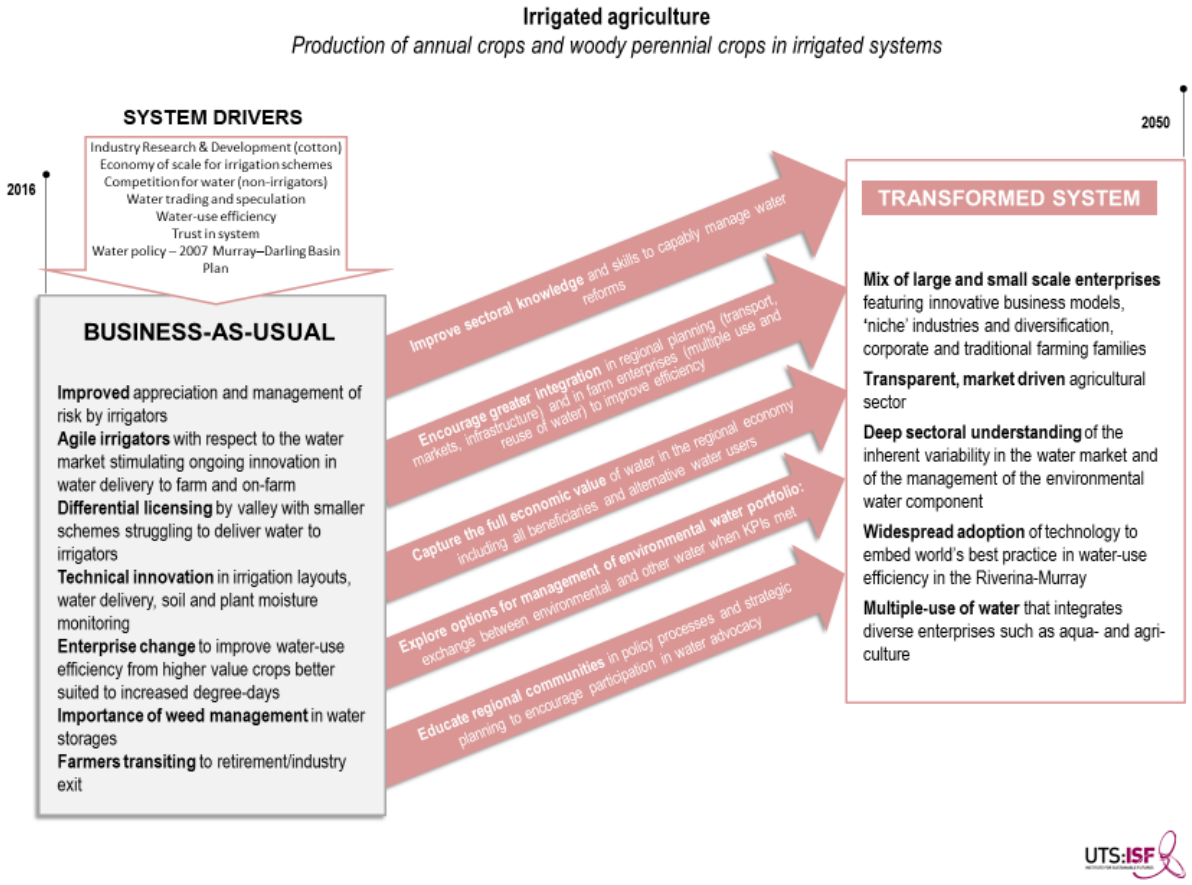

Figure 6: Change model for irrigated agriculture in the Riverina Murray region

Although currently dynamic, further transition in the irrigated agriculture sector will increase its capability to manage water effectively. Greater integration of transport and infrastructure planning with on-farm processes can enable multiple-use and reuse of water to improve system efficiency. Water management should be accounted holistically for the value of water to all users, social, economic and ecological, to improve understanding of its real value to the regional economy. Government can facilitate greater regional participation in water planning and management by improving opportunities for communities to better understand policy processes and participate effectively in strategic planning.

Futurecast: the industry is operating at two broad scales: large-scale enterprises featuring corporate-style management, and small-scale enterprises supporting more traditional farming families. The irrigated agriculture sector operates transparently in response to market forces through a deep understanding of water risk and an appreciation of the management of water for the environment. Technology adoption is rapid and widespread with water used multiple times across a range of diverse enterprises. The Riverina Murray region has established a reputation as an exemplar of world's best practice in water-use sustainability and efficiency, and this is reflected in market value advantage for its products.

Energy

The energy system in the Riverina Murray region includes domestic, industrial and transport needs and encompasses energy generation from a range of sources, and its supply, use and delivery (Figure 7). The system aims to embed resilience and low carbon emissions as essential features.

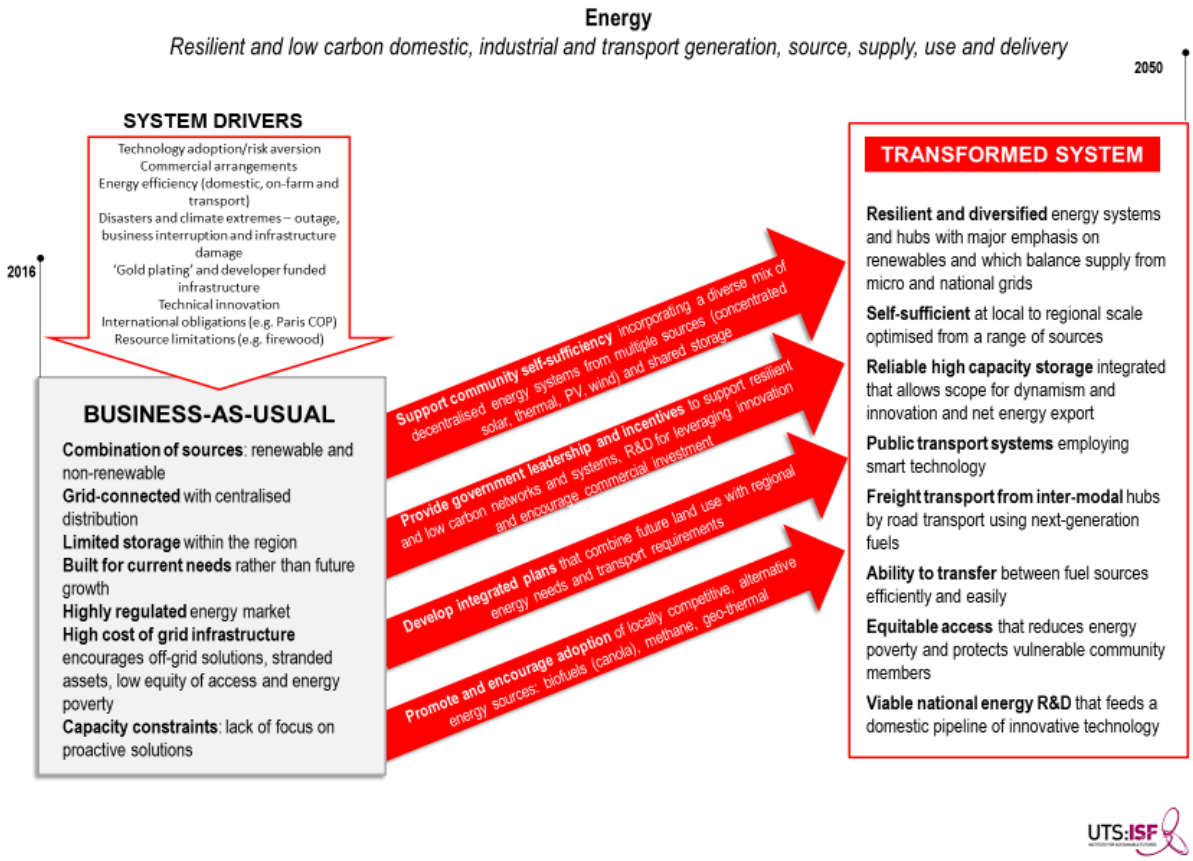

Figure 7: Change model for energy in the Riverina Murray region

Energy systems in general are undergoing rapid transformation in generation and distribution of electricity supplies in response to a range of drivers. Contributors to this project identified that in the Riverina Murray, drivers of system change include a significant improvement in the efficiency of energy consumption and international obligations under emissions reduction agreements (e.g. Paris Conference of the Parties (COP)). Other identified drivers included

the rapid pace of technical innovation in renewable energy generation, the growing demand for domestic, on-farm and transport energy efficiency to offset costs, and natural disasters causing business interruptions, reduced energy security and widespread damage to infrastructure such as electricity distribution networks. However, system change is constrained by existing commercial arrangements for power generation and supply, risk aversion to technology adoption among energy suppliers and consumers, and recent investment to 'gold plate' energy distribution networks that has increased energy costs. Currently new investment in energy infrastructure is paid for by developers so that overall system efficiency is not planned for.

The region is currently supplied with energy from a combination of renewable and non-renewable sources, primarily grid-connected with electricity distribution from a centralised source of generation, and operating in a highly regulated energy market. The system is constructed to supply current requirements rather than designed for future needs and adoption of distributed renewable generation of electricity is constrained by regional storage limitations and a lack of focus on proactive solutions. The high contribution of grid infrastructure costs to energy prices encourages 'off-grid' solutions which may lead in future to stranded assets, energy poverty (for those consumers with no choice but to stay on the grid or have no electricity) and low equity of access.

A transformed energy system for the Riverina Murray region will include support for community energy self-sufficiency that incorporates decentralised energy generation from a diverse mix of sources, and shared energy storage capacity. Leadership and incentives from government will support low carbon networks, expanded research and development into local applications of advanced energy, and encouragement of commercial investment. The development of regional plans that integrate future land-use, energy and transport requirements are essential to guide utilisation of a range of alternative energy sources that are locally competitive with traditional energy supply chains.

Futurecast; resilient and diversified energy systems that include renewable generation and balanced supply from micro and national energy grids. The region is energy self-sufficient through the integration of reliable, high capacity storage, and a net energy exporter. Energy for transport has also transformed with road freight primarily being to and from intermodal hubs. Vehicles can transfer between 'next-generation' fuel sources efficiently and easily. Regional public transport is cost effective using 'smart' technology. Access to energy is equitable reducing energy poverty and protecting vulnerable communities. At national scale, enhanced energy research and development feeds a domestic pipeline of technological innovation to ensure regional energy futures are secure.

3 How is the Riverina Murray vulnerable to climate change?

In partnership with regional decision-makers, the WERA process considers the climate vulnerability of regional communities in the context of biophysical impacts and socioeconomic change, with a focus on government service planning and delivery. By drawing on regionally specific data and local knowledge under the five capitals framework, an integrated understanding is developed of the relationships within key systems, and desirable adaptive responses and futures are identified. The following information was presented to workshop participants.

3.1 Social and economic

People

The Riverina Murray region encompasses the traditional lands of the Wiradjuri, Muthi Muthi, Wadi Wadi, Wamba Wamba, Barapa Barapa, Yorta Yorta, Ngarigo, Walgalu and Ngunnawal (NSW Government 2009).

The region's total population in 2011 was 266,350. Figure 8 provides a comparison of populations within each local government area (LGA) ranging from 61,800 people in the City of Wagga Wagga LGA to 1200 in the Urana Shire LGA (Department of Planning and Environment 2015).

The population of the Riverina Murray region is projected to grow by 3% over the next 17 years (to 2031). The rate of growth varies across the age profiles with the number of young people (less than 15 years old) declining by 10%, people of working age (15–64) declining by 8% and people 65 or older growing by 60%. This will see the proportion of people aged 65 years or over grow from 17% to 26% of the total population by 2031 (DPE 2015).

The labour force participation rate for the region in 2011 was 60.2% (NSW 59.7%) and the working age population (i.e. those aged 15–64 years) of the region comprised 63% (NSW 66%) of the total population (ABS 2013a).

The region generally has both a younger and an older population compared to NSW as a whole, with a pronounced difference in the working age population (Figure 9). The region has higher dependency ratios than the state overall, meaning that a smaller proportion of its working aged population is supporting a higher proportion of people deemed not to be in the workforce.

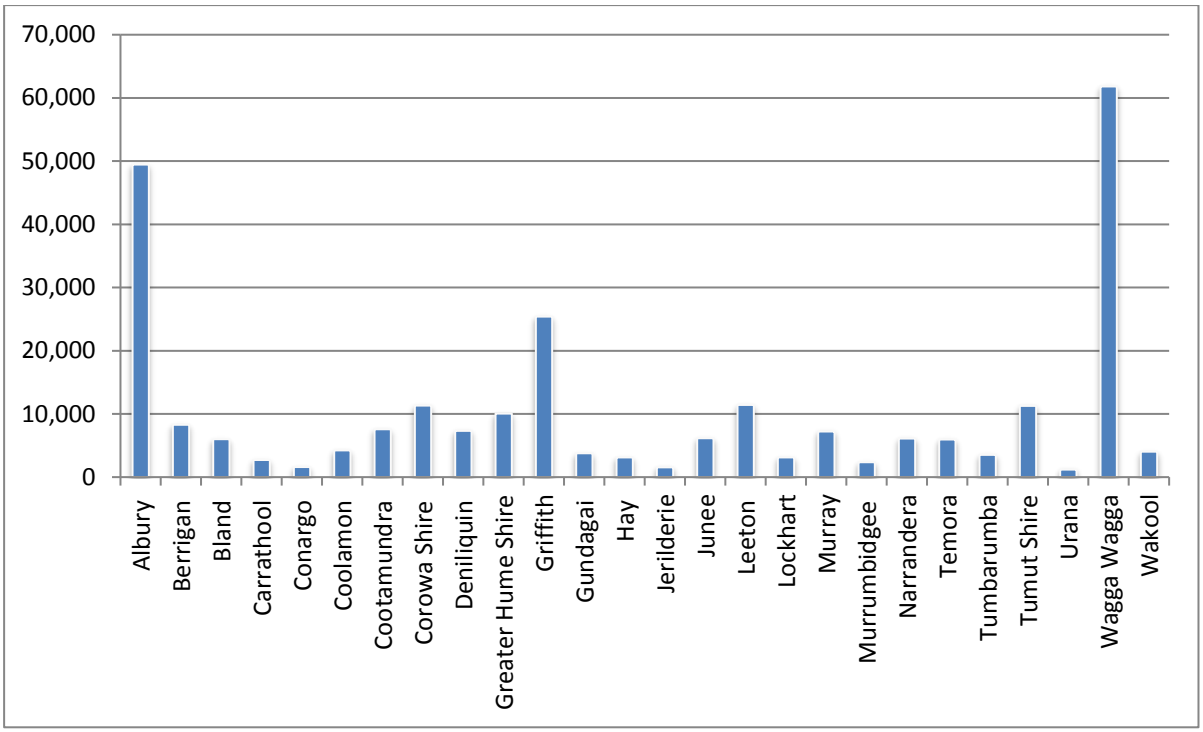

Figure 8: Local government area population statistics from 2011
Source: Department of Planning and Environment (2015)

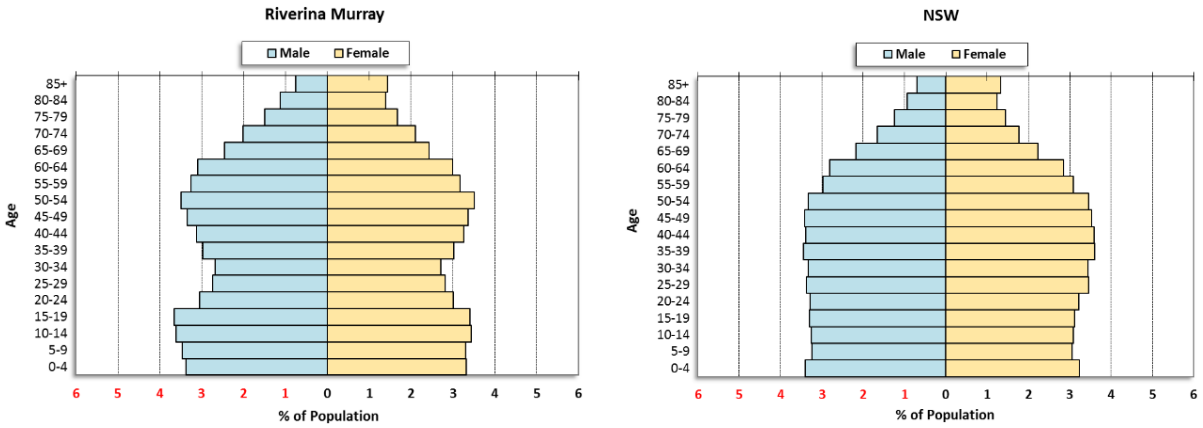

Figure 9: Age distribution in the Riverina Murray region (left) compared to NSW (right)
Source: Australian Bureau of Statistics (2013b)

The presence of the Victorian/NSW border along the Murray River on the immediate southern boundary of the region is an important influence. Population and regional production is distributed on both sides of the river with in some cases paired settlements either side. This southern part of the region effectively operates more in concert with these northern Victorian settlements, and the division created by the statistical and state boundary is somewhat artificial.

Human capital considers the skills, health and education of individuals that contribute to the productivity of labour and physical capability to respond to climate. Based on 2011 Census data key attributes of human capital for the region are:

- Compared to the whole of NSW, people living in the region were much less likely to have completed Year 12 education and more likely to have left school before or directly after Year 10. People were less likely to have a post-secondary schooling qualification above certificate level (ABS 2013a).

- Compared to the whole of NSW, the workforce had an under-representation of professionals and clerical workers and an over-representation of managers and labourers (ABS 2013a).
- Only one local government area was ranked in the lowest 20 for socioeconomic advantage and disadvantage (Narrandera) based on the ABS *Socio-Economic Indexes for Areas* (SEIFA). Conargo is the only LGA outside of Sydney or the LGAs adjacent to the ACT in the top 30 of this index (ABS 2013b).
- The region incorporates all or part of 19 Local Aboriginal Land Councils. Based on 2011 Census data, the Indigenous population of the region is estimated to be 11,708 people or 4% of the total population (compared with 1% for NSW as a whole) (ABS 2013a).
- In the region, there are over 7701 cultural heritage sites and 13 Aboriginal Places identified under and protected by provisions of the *National Parks and Wildlife Act 1974* (OEH 2016). Many of these sites are considered to be highly significant and include sites used for burials, ceremony and dreaming, and places that have social and contemporary usage for Aboriginal people today.
- There is one declared Indigenous Protection Area (IPA) in the region (Toogimbie IPA, near Hay, dedicated by the Nari Nari people), and a second one at Werai Forest (near Deniliquin) is in the consultation phase with the Wemba Wemba (also spelt Wamba Wamba) and Barapa Barapa (also spelt Perrepa Perrepa) nations. IPAs are recognised by the Australian Government as an important part of the National Reserve System.
-

Economy

The region has a strong and growing economy valued at over $13.6 billion in 2013 and supporting over 103,000 local jobs (Department of Industry 2015). Industry is quite diverse, with the major employment sectors being health care and social assistance; retail trade; agriculture, forestry and fishing; manufacturing; and education and training. The agriculture sector is the region's largest industry, with a 10.5% share of regional output and 11.4% of employment (Table 1).

Manufacturing is very significant in the region with an output of over $1.3 billion in 2013 and 10.4% of employment. Health care and social assistance is another of the largest sectors, with increased demand from a growing and ageing population likely to drive continued growth in this sector. The education and training sector is anchored by Charles Sturt University, the Riverina Murray Institute of TAFE and facilities including a commercial pilot training facility, an RAAF base and an Army Recruit Training Centre, and contributes around 6.4% to Gross Regional Product (GRP) and 8.8% of employment. Along with retail trade these three sectors make up around a third of total employment and contributed around $2.5 billion to regional output in 2013 (Department of Industry 2015).

Table 1: Top five industries by contribution to GRP and top five employers by industry

Industries by contribution to GRP in 2013	Employers by industry in 2011
1. Agriculture, Forestry and Fishing (10.5%)	1. Health Care and Social Assistance (11.8%)
2. Manufacturing (9.8%)	2. Retail Trade (11.6%)
3. Public Administration and Safety (7.1%)	3. Agriculture, Forestry and Fishing (11.4%)
4. Health Care and Social Assistance (7.0%)	4. Manufacturing (10.4%)
5. Education and Training (6.4%)	5. Education and Training (8.8%)

Source: Department of Industry 2015

Physical capital is the items produced by economic activity from other types of capital such as the built environment, infrastructure and equipment (houses, schools, clinics, roads, farm machinery, and producer goods accessible by the community). Separate occupied houses (91.3%) are the dominant dwelling type within the region. A small percentage of dwellings are flats, units (5.4%) and semi-detached (2.4%) dwellings (ABS 2013a).

3.2 Biophysical

The region includes a wide range of natural ecosystems ranging from alpine ecosystems in the highest altitudes of the Australian continent to semi-arid ecosystems in the south-west. Snowmelt and precipitation from the Snowy Mountains feed wetland communities across the region associated with the major rivers including internationally significant Ramsar listed sites (NSW Central Murray state forests, and Fivebough and Tuckerbil swamps). The region includes the NSW side of the Murray River above Wakool River, most of the Murrumbidgee River, and the lower Lachlan River.

The large range of precipitation and temperatures across the region gives rise to great diversity in flora and fauna. The most widespread species occur on the floodplains of the major rivers that dominate the region. Critically endangered ecosystems of the region include mallee and mallee-broombush dominated woodland and shrubland, lacking *Triodia*, in the NSW South Western Slopes Bioregion and Windswept Feldmark in the Australian Alps Bioregion. 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. A significant investment is being made under the NSW Saving Our Species program to recovery many threatened species.

3.3 Expected regional climate change

Information on projected climate for the region is in the Murray Murrumbidgee Climate Change Snapshot report on the AdaptNSW website (OEH 2014b), which provides near and far future scenarios (Table 2) based on a combination of four global climate models and three regional climate models using the A2 IPCC (business–as-usual) emissions scenario. These models do not include long-term feedback loops like significant polar ice or permafrost thawing.

Table 2: Climate change projections for the Riverina Murray region

Climate variable (average across the region)	Trend	Projections	
		Near future (2030)	Far future (2070)
Atmospheric CO_2	Increase	A2 IPCC emissions scenario	
Max temperature	Increase	0.4–1.0°C	1.6–2.5°C (2.4°C in summer & spring)
Min temperature	Increase	0.4–0.8°C	1.3–2.4°C
Hot days	Increase	5 – 13 (10–20 north of Hay)	16 – 28 (30–40 north of Hay)
Cold nights	Decrease	5 – 10 (10–20 in the mountains)	14 – 27 (20–30 in the mountains)
Heatwaves	Increase (frequency)	0.3 – 1.5 events	2.5 – 4.5 events
	Increase (intensity – amplitude [a])	–1.5 – 10.5°C[2]	15 – 27+°C[2]
	Increase (duration)	1.5 – 3.5 days	3 – 7 days
Annual rainfall [b]	Drying & wetting	–9% to +13%	–8 to +16%

Climate variable (average across the region)	Trend	Projections	
		Near future (2030)	Far future (2070)
Changes in average rainfall by season [b]	Drying & wetting	Summer –16% to +27% Autumn –13% to +57% Winter –9% to +4% Spring –26% to –1%	Summer –7% to +28% Autumn –5% to +69% Winter –18% to +16% Spring –19% to –8%

[a] Amplitude is the hottest day of the hottest heatwave of the year. Units are °C^2 because it is the product of two temperature anomalies.

[b] Negative values represent drying and positive values represent wetting under projections for annual rainfall and seasonality rainfall. Source: Office of Environment and Heritage (2014b)

In summary:

- The region is expected to experience an increase in all temperature variables (average, maximum and minimum), more hot days, and fewer cold nights for the near and far futures. Heatwaves are also projected to increase, be hotter and last longer.
- The region currently experiences considerable rainfall variability across the region and from year-to-year. This variability is reflected in the projections. All models agree that spring rainfall will decrease in future.
- Fire risk will increase, with projected increases in average and severe Forest Fire Danger Index values in the near future and the far future.
- Climate change will impact agricultural systems, (affecting crops, evaporation of surface water and stock), vulnerable groups within regional communities (such as the ill, very young and the elderly), natural ecosystems, regional infrastructure and fire management (see Appendix A: Expected physical responses for the Riverina Murray).

3.4 Vulnerability affecting government services

In 2012, local decision-makers identified eight factors that affect the vulnerability of the Riverina Murray region, which interact to set constraints and opportunities around the ability of government to service the community (OEH 2014a). Already influencing the region, the importance of these vulnerabilities is likely to be amplified by changes to climate:

1. **Water resources**: volume, quality, seasonal availability and management
2. **Landscape function**: changes to rainfall and warmer temperatures affect production
3. **Infrastructure**: critical to prosperity and adaptability
4. **Sustainability of local government**: pressure from various sources affects ability to deliver services
5. **Demographic change**: ageing population especially in rural areas and small towns
6. **Knowledge, skills and training**: capacity of workers is stretched, but climate change calls for new knowledge
7. **Regional networks**: facilitate transfer of information and skills to support adaptation; and develop collective visions
8. **Funding models**: strategic planning and funding to inform adaptation approaches.

Vulnerability

Regions in NSW vary in their vulnerability to climate change. Figure 10 shows a snapshot of vulnerability for the Riverina Murray region taken from data presented in the *Riverina Murray* *Integrated Regional Vulnerability Assessment* (IRVA) (Volume 1)

(OEH2014a). The snapshot draws on workshop activities, discussions and supporting literature and data to illustrate regional vulnerability as three components:

- **red boxes** – exposure to the range of biophysical and socioeconomic drivers that could potentially stress the ability of the region to function
- **orange boxes** – sensitivity to the diverse impacts that result from exposure to drivers of change
- **green box** – adaptive capacity represented by a set of attributes that act to determine how the region might respond to reduce future vulnerability. If present, these attributes can enable adaptation. If they are absent or negative, then adaptive responses will be constrained, and the region will remain vulnerable.

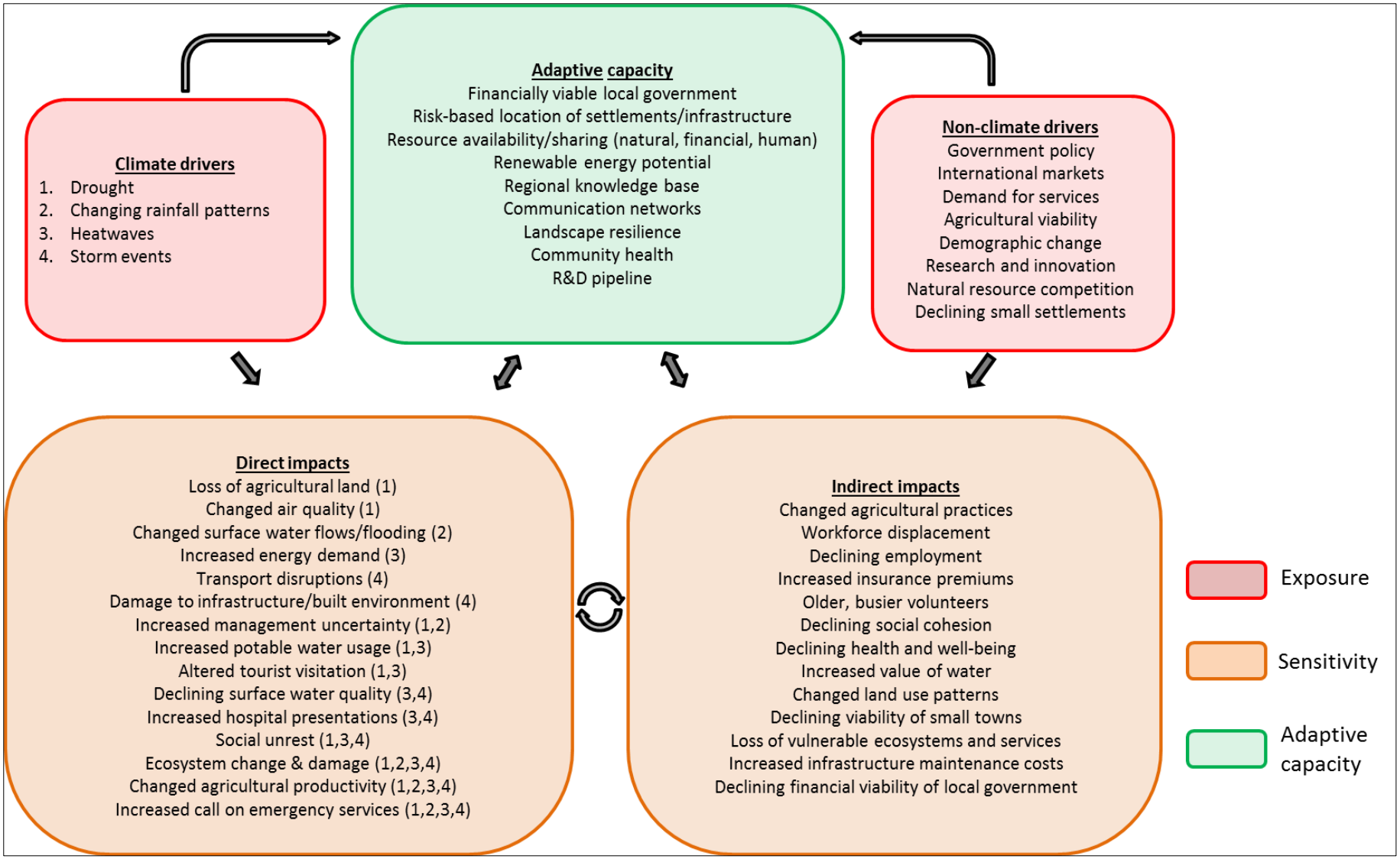

Figure 10: Snapshot of vulnerability in the Riverina Murray Numbers in brackets under direct impacts link the impact to the climate driver(s)

Exposure

Climate drivers

Based the Riverina Murray IRVA (OEH 2014a) workshops and supporting information, the main climate drivers of the Riverina Murray are drought, changing rainfall patterns (amount, seasonality and effectiveness), heatwaves and storm events. Of these drivers, drought, changes to rainfall and heatwaves are projected in the regional climate modelling; however, storm events associated with high winds have emerged recently as important regional climate events and are more difficult to predict.

Non-climate drivers

Non-climate drivers are drawn from the Riverina Murray IRVA (OEH 2014a) system transition models representing the range of socioeconomic and biophysical changes currently affecting the Riverina Murray. They operate at a range of scales from global (international markets) to national (demographic changes, research and innovation) to regional (natural resource competition, government policy) and local (declining small settlements). While they act independently of climate drivers, some are influenced by climate outside of the Riverina Murray region. For example, fluctuations in international markets for agricultural commodities influence the prices received by regional grain producers independently of climate variations experienced in the Riverina Murray. However, supply and demand in grain markets are strongly affected by natural disasters, such as drought, in the major agricultural regions of the world.

Sensitivity

Direct impacts

The impact of climate change in the Riverina Murray manifests through the effects of extreme events. These direct impacts, shown in Figure 10, summarise the initial interconnected impacts that ripple through the region's systems (see Figure 12). For example, the direct impacts of drought cause the loss of agricultural land and changes to air quality, changed rainfall patterns result in changing surface flows and flooding, heatwaves result in regional spikes in energy demand, and storm events cause damage to infrastructure and disrupt regional transport. Multiple impacts from individual climate drivers often converge at critical points of intersection. For example, impacts from drought and changed rainfall patterns converge to increase management uncertainty, particularly for farmers. Impacts of drought and heatwaves converge to alter tourist visitation. All four climate drivers intersect to damage ecosystems, change agricultural productivity and increase calls for assistance from emergency services.

Indirect impacts

These are the culminating impacts, which can 'snowballed' along the impact chains (Figure 12). They represent further socioeconomic and biophysical drivers of change that affect the Riverina Murray region, culminating from climate drivers, and are heavily influenced by non-climate drivers in complex ways. For example, non-climate drivers including government policy and natural resource competition contribute to enhancement of the value of water in the region. The value of water is also influenced by a combination of climate drivers through changes to surface water flows, increased potable water use and declining surface water quality.

Adaptive capacity

The attributes listed under adaptive capacity are largely aspirational. They represent a set of available resources, or changes to resource use, that provide options to act to reduce regional vulnerability to climate change in the face of future uncertainty, identified from data collected for the Riverina Murray IRVA (OEH 2014a).

For example, under the stress imposed by climate change, resilient regional landscapes assist natural systems to remain healthy and supply the ecosystem services that support

communities. A rich regional knowledge base combined with an effective research and development pipeline would assist local business innovation and adoption of new technology. Irrespective of impacts on the region, a healthy regional community reduces reliance on hospital and emergency services and the financial burden on local government of remote communities suffering from chronic illness. The transition pathways identified in the system transformation models (Chapter 2 What needs to change in the Riverina Murray region?) and the 'first steps' projects outlined in Chapter 5 (What can we do about it?) provide a mechanism to achieve regional aspirations for adaptive capacity.

Sectoral priorities

While sectors of the regional economy may prioritise differently the various aspects of vulnerability that affect their service delivery, there is considerable overlap among them. Table 3 lists the priorities for each of the sectors that participated in the Riverina Murray Integrated Regional Vulnerability Assessment (IRVA). For example, the establishment and maintenance of existing regional networks, considered a strength of the Riverina Murray, appears in the list of priorities for all sectors. In contrast, the impact on service provision of unmanaged land was a priority for the emergency services sector only.

Table 3: Sectoral priorities for adaptive capacity

Water	
Diminishing skill base in local/regional area	State agency reorganisation
Available water management infrastructure	Agricultural adjustment
Regional networks	Legacy effects of previous droughts and floods
Landscapes and ecosystems	
Regional knowledge base	Infrastructure sustainability – especially water and transport
Regional networks	High speed internet services
Climate change scepticism	Funding models and requirements
State government administrative churn	Agriculture and the regional economy
Landscape connectivity	Changing land use
Local community decline	
Regional river system	
Settlements and infrastructure	
Attract and retain skilled professionals	NSW Government restructures
Sustainable regional infrastructure	Land-use change
Community attitudes	Water
Regional networks	Regional investment
Local government funding base	Incentives for adaptation
Human services	
Attract and retain skilled professionals	Infrastructure availability and condition
Surge capacity	Access and resources for remote areas
Chronic disease	Housing
Community attitude to service delivery models	Funding models and financial relief
Regional social and professional networks	Equipment and IT
Emergency management	
Skill level of staff and volunteers	Unmanaged land
Declining human resources – including local council	Water – location, access, storage, availability
Decline in volunteerism	Maintenance of utilities and infrastructure
Resource sharing	Mitigation and response infrastructure
Professional and social networks	Budgets and funding models

Water	
Industries	
Diminishing skill base	Sustainable rural infrastructure
Regional networks	National broadband network
State government churn	Agricultural adjustment

4 How do we know?

4.1 Description of ERA process

The Enabling Regional Adaptation (ERA) process has been designed to develop a shared understanding among stakeholders of the likely vulnerability to climate change, and stimulate action to plan adaptation. To undertake the assessment, ERA engages state and local government participants from different sectors to ensure cross-sectoral and cross-scale operational knowledge and constraints are considered.

Sector	Scope
Emergency management	Emergency management (fire, flood, heat, bushfire), infrastructure and utilities, public health / disaster management
Human services	Education, health, senior, youth and child services, meals on wheels, library services, disability services, community services, health and education asset management and planning
Economy and industry	Business development, tourism, legal, professional services
Landscapes and ecosystems	Natural resource management, biodiversity, conservation, Aboriginal and historic heritage
Settlements and infrastructure	Regional and local strategic planning, local development, buildings and settlements, transport (rail, road, freight, buses) water (stormwater, sewer, water), energy, telecommunications, community infrastructure

Due to the complexity inherent in analysing adaptation at a regional scale, the approach uses both qualitative and quantitative techniques to integrate multiple lines of evidence gathered through subregional workshops, participant surveys, and shift-share analysis to identify locally competitive industries derived from ABS Census data.

ERA engages participants in cross-sectoral workshops where they are provided with regional climate projections, socioeconomic data and regional knowledge. Through a series of hands-on activities participants determine impact chains, adaptive capacity (in the Riverina Murray this was done as a separate IRVA undertaken in 2012 (OEH 2014a) and key regional systems. Final outputs of this process provide a description of regional climate vulnerabilities, system transition models and projects to activate pathways (Figure 12). An online survey was also undertaken before and after the workshops (see Chapter 6).

ERA has been carried out in such a way that it incorporates:

- a system thinking approach that acknowledges communities exist within human–natural (or social–ecological) systems
- participatory engagement in which stakeholders co-create an understanding of vulnerability through their deep understanding of the region
- a focus on developing an understanding of the constraints to adaptation, and on identifying opportunities for building adaptive capacity so communities can deal better with climate shocks regardless of their nature or timing
- qualitative analysis supported wherever possible with quantitative data, which acknowledges that societal interactions are complex and contradictory in nature, and not amenable to expert-led, reductionist approaches to problem analysis.

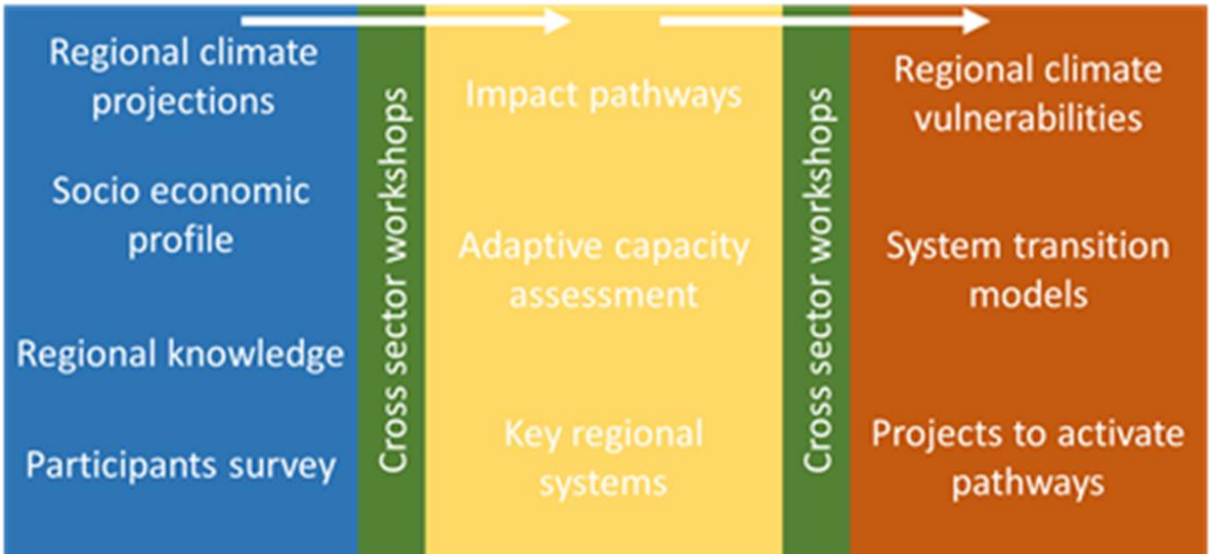

Figure 11: Enabling Regional Adaptation process

4.2 Riverina Murray regional workshops

In early 2016, OEH and the Institute for Sustainable Futures led a series of workshops in the Riverina Murray region as part of an ERA process for Western NSW (the WERA project). The workshops used participatory learning techniques to discuss, explore and gather information and data on the impact of climate change on regional systems and opportunities to respond. The workshops were held in two stages: the first workshops focused on validating regional climate vulnerabilities already identified through the 2012 Riverina Murray IRVA (OEH 2014a) and the follow-up workshops focused on developing regional change models.

Two workshops were held in February 2016 in Jerilderie and Wagga Wagga. The workshops facilitated a consultation with 60 decision-makers drawn from local councils, NSW state government agencies and federal agencies, including:

- Albury City Council
- Berrigan Shire Council
- Centrelink
- Charles Sturt University
- Cootamundra Shire Council
- Corowa Shire Council
- Fire and Rescue NSW
- Greater Hume Shire Council
- Greater Southern Area Health
- Griffith City Council
- Gundagai Shire Council
- Hay Shire Council
- Murray Darling Basin Authority
- Murray Local Land Services
- Murray Shire Council
- Murrumbidgee Local Health District*
- Murrumbidgee Primary Health Network
- Murrumbidgee Shire Council
- Narrandera Shire Council
- NSW Ambulance
- NSW Catchment and Lands
- NSW Department of Industry
- NSW Department of Justice
- NSW Department of Premier and Cabinet*
- NSW Department of Primary Industries*
- NSW Family and Community Services*
- NSW Office of Environment and Heritage*
- NSW Office of Regional Development
- NSW Office of Water
- NSW Planning
- NSW Police
- NSW Public Health

- NSW Roads and Maritime Services
- NSW Rural Fire Service
- NSW SES
- NSW WorkCover
- Prime Minister & Cabinet
- Regional Development Australia Murray
- Regional Development Australia Riverina
- Riverina and Murray Regional Organisation of Councils (RAMROC)*
- Riverina Eastern Regional Organisation of Councils (REROC)*
- Riverina Local Land Services*
- Riverina Water County Council
- TAFE NSW Riverina Institute*
- Temora Shire Council
- The Council of the Shire of Wakool
- Transport NSW
- Wagga Wagga City Council

Note: An asterisk denotes organisations represented on the project steering committee.

Workshops aimed to:

- validate, revise and enhance findings from the 2012 Riverina Murray IRVA (2014a)
- present the latest climate projections for the Riverina Murray
- present background socioeconomic analysis to inform workshop discussions of system changes
- construct a climate impact timeline to encourage consideration of climate projections in light of extreme climate events, regional socioeconomic trends and policy processes.

Two further workshops were held in late March 2016 with 39 participants (eight in Griffith and 31 in Wagga Wagga) to:

- develop qualitative, system change models that identify transition pathways leading to a transformed future
- prioritise regional adaptation actions (through discrete projects) to promote transition and limit maladaptation
- continue to build the regional capacity to deliver best practice adaptation.

The workshop process acknowledged that understanding the current vulnerability of government service delivery in the region relies on assembling the tacit knowledge that resides in the collective store of experience of NSW public sector decision-makers. The aim was to gather information to inform future regional planning to enable regional adaptation to climate change.

Riverina Murray IRVA validation

Consultation for the Riverina Murray IRVA was completed in 2012. The report can be downloaded from: climatechange.environment.nsw.gov.au/Adapting-to-climate-change/Regional-vulnerability-and-assessment/Riverina-Murray.

The first step of WERA was to conduct a rapid validation process of the Riverina Murray IRVA findings to understand the current status of vulnerability in the region and document any changes that may have occurred in the period between completion of the IRVA and the commencement of WERA in 2016.

The validation was conducted as a world café in facilitated small group discussions. Each group was asked to review a summary of the Riverina Murray IRVA impacts (direct, indirect and cross-sectoral) and adaptive capacity and to consider the key changes in the region since the IRVA (see Vulnerability affecting government services).

Impact chains

Understanding how climate variability and extreme events will affect the region is a vital first step towards planning and implementing adaptation responses. In light of the regional climate projections and socioeconomic information, participants at the IRVA in 2012 constructed influence diagrams to illustrate impact chains and influence relationships stemming from each of the major climate variables (Figure 12). These diagrams allowed two types of impacts to be identified along impact chains: direct impacts were those that were directly attributable to climate change and appear on impact chains in close proximity to climate variables; indirect impacts resulted from the flow-on effects of climate variables and were also influenced by external regional drivers. Indirect impacts appeared further along the impact chains.

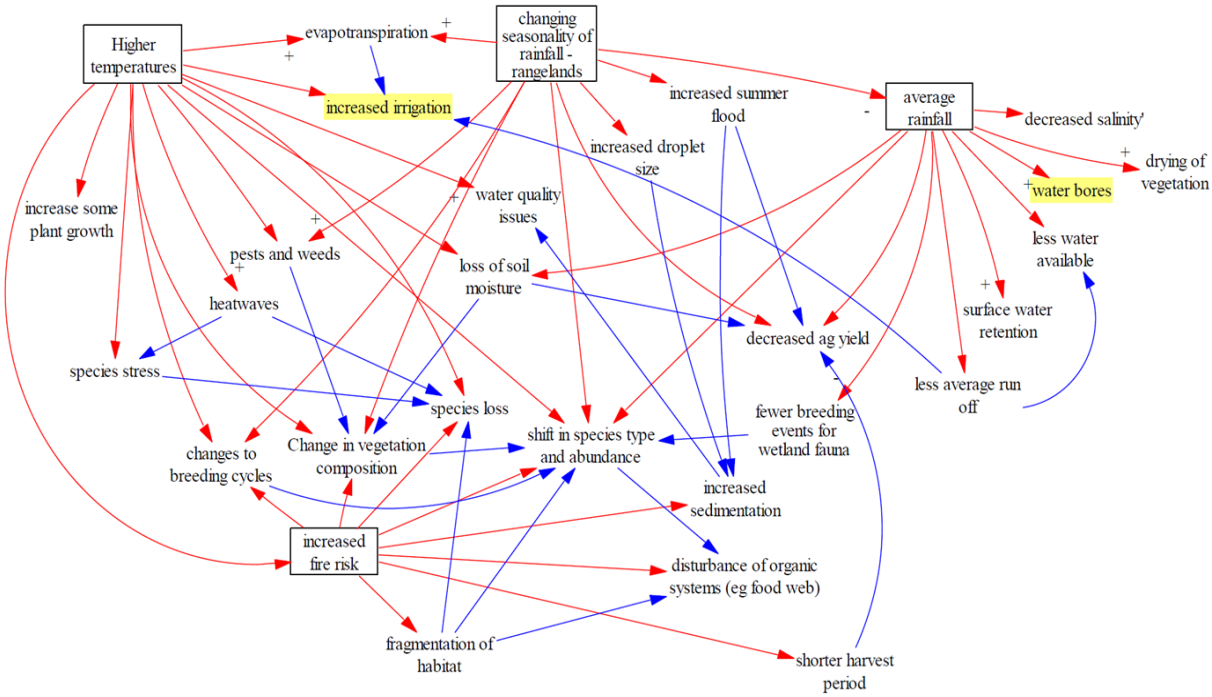

Figure 12: Landscapes and ecosystems climate impact chains

4.3 Key regional systems

Each sub-regional workshop identified the regional systems considered most in need of transformation to adapt to climate change. Four key systems were identified in the Jerilderie workshop and six in the Wagga Wagga workshop (Figure 13). These 10 systems were refined in the integration workshops to reduce redundancy and focus specifically on systems that could be influenced through action at a regional scale. This process resulted in the development of seven regional change models. The models are not intended to represent all aspects of the region; rather they reflect the expertise of workshop participants and provide a mosaic of the major systems of the Riverina Murray region.

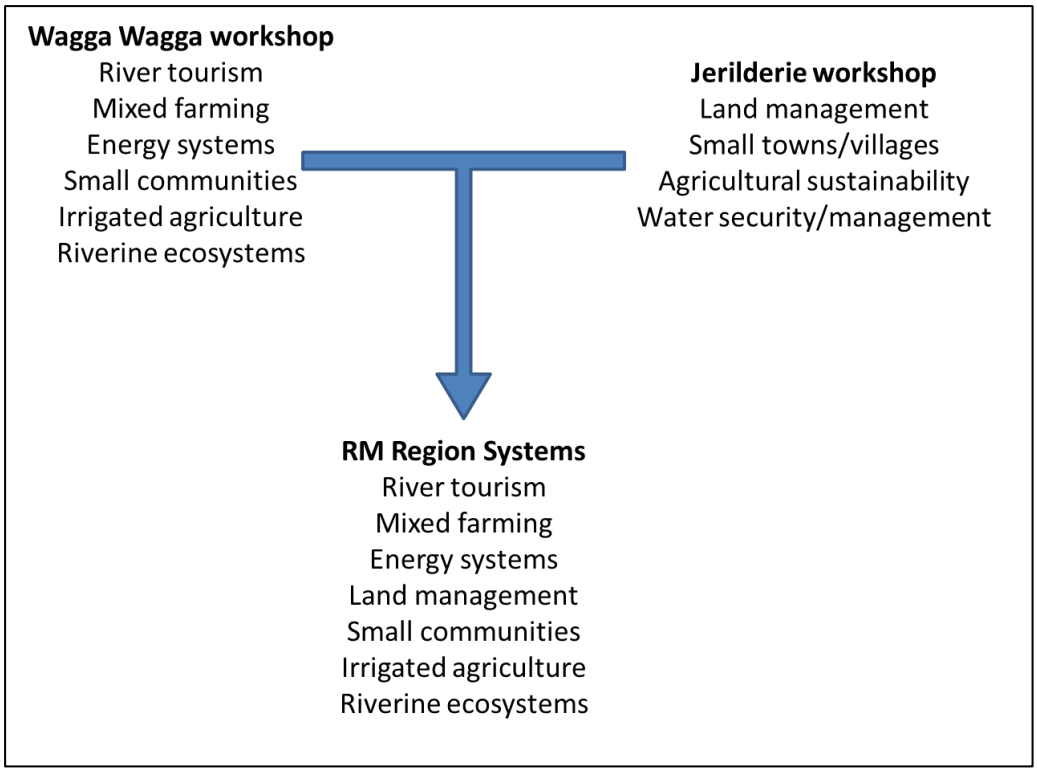

Figure 13: The key regional systems identified for the Riverina Murray region

4.4 System change models

Thinking of adaptation as a series of strategic pathways to transition away from business-as-usual was an effective technique to engage workshop participants in a discussion of system transformation in the region. The approach envisions transformational change toward a desirable future as a series of transition pathways that emerge from current practice either through existing innovations or because of new drivers of change (Figure 14).

For each of the selected systems the workshop participants discussed:

- business-as-usual (BAU) – what constitutes BAU in their service delivery area and what changes or 'tweaks' are being made to ensure resilience of the current system
- system drivers – the relative strengths of multiple drivers determine the extent and direction of change within the system. Drivers of change lead to the emergence of 'pockets' of innovation that offer transition pathways to a 'planned' transformation
- transition pathways – any new practices/changes/trends that may serve as an alternative to BAU that are emerging now or in the near future. These pathways could emerge from changes in the economy, society, the environment, technological development or politics
- barriers and enablers – for selected transition pathways participants identified the barriers to and enablers of change, who they need to work with, and any aligned processes or policies
- transformed system – participants were asked to identify their vision of service delivery in 2050 and articulate what the features of the transformed system would be.

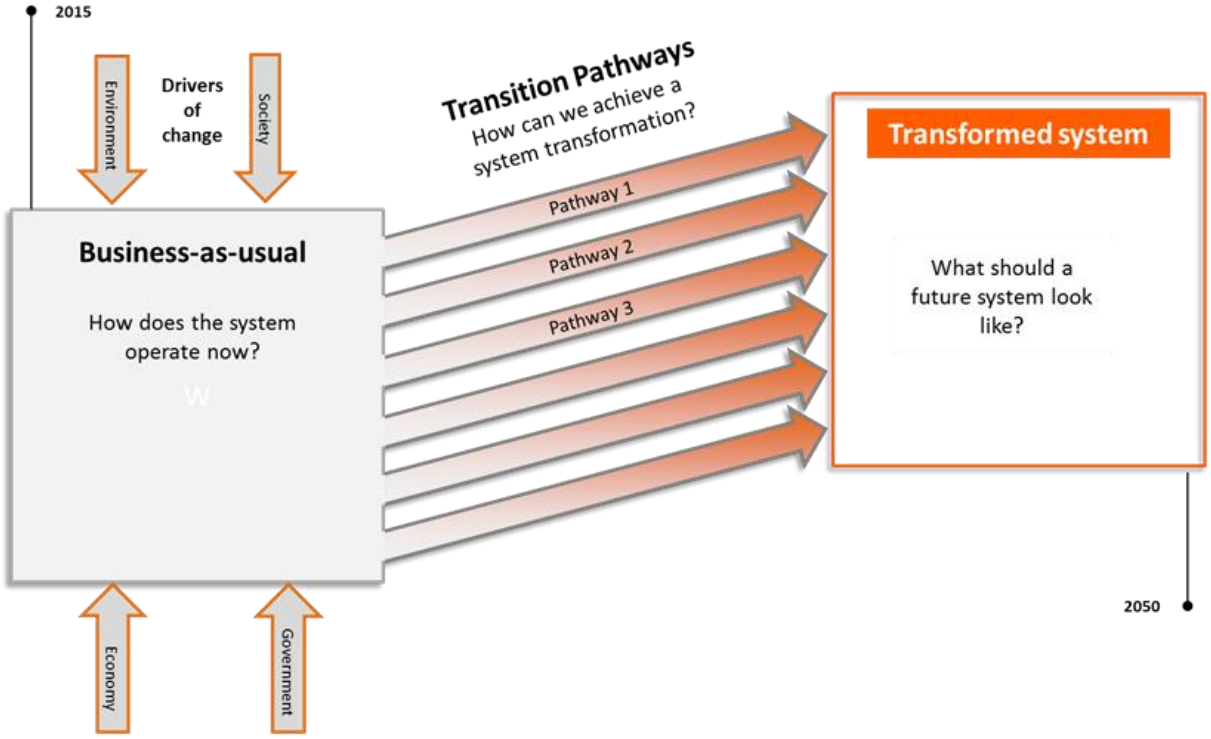

Figure 14: Conceptual model of transformative change Source: adapted from Jacobs et al. (2016)

5 What can we do about it?

5.1 Projects to activate pathways

Workshop participants voted on the various pathways for each of the seven regional systems to determine the key priorities for government from the range of transition pathways. The participants then worked together in cross-sectoral groups to identify potential transition projects to progress toward regional transformations to address climate vulnerabilities. Descriptions of these projects are outlined in Table 4. These projects illustrate the types of cross sectoral measures that may be undertaken, however are not endorsed regional projects at this time.

Table 4: Pilot projects to activate pathways

Pilot project	Description	System
1. RM adaptation network	A regional adaptation network to focus on key issues (e.g. river ecosystem resilience) for collaboration and information sharing	All
2. Central information portal	Government facilitated provision of consistent data to improve collaboration in planning, information and monitoring at a landscape level	All
3. RM triple bottom line	Regional indicators (including ecosystem services) for tracking a *shared* vision of the regional landscape, enabling the RLG to influence policy with Sydney decision-makers	River-based tourism, land management, irrigated agriculture, riverine ecosystems
4. JO working group on environmental water	Facilitate the development of aligned priorities across community and agencies ensuring triple bottom line impacts of climate risks are considered in the setting of regional priorities and collaboration in managing river ecosystems	River-based tourism, land management, irrigated agriculture, riverine ecosystems
5. River ecosystems survey	To promote better understanding of the different values to inform decision-making, such as that involved in water sharing plans	River-based tourism, land management, irrigated agriculture, riverine ecosystems
6. Integrated model Development Control Plan	A one-day cross agency workshop to formulate a model Development Control Plan focusing on capturing climate change opportunities, integrating planning for energy, transport and land use in the North Wagga area, but potentially applicable across the Riverina Murray	Energy, irrigated agriculture, mixed farming
7. Small Communities Leadership support	An audit of existing leadership programs, informing the design of an integrated program to meet unmet needs	Small communities

Pilot project	Description	System
8. Tech Access for Small Communities (C-TECH)	Connecting start-up ICT businesses with rural communities via an audit to capture existing innovation, opportunities and barriers to accessing digital communication facilities in small communities (including existing private networks)	Small communities
9. Renewable energy micro grid pilot	A proof of concept proposal for a micro grid in the Griffith region, to provide local energy security and a local income stream	Energy, small communities
10. Traditional ecological knowledge as adaptation	Research Indigenous land management practices and build a network of traditional ecological knowledge holders improving land and water management and Aboriginal employment in land management, training and partnerships	Land management, small communities, mixed farming, riverine ecosystems
11. Finding Plan B	Climate change risk management training for farmers (including impacts on insurance, finance and international trends) leading to better long-term planning and timely transition to alternative farm uses.	Land management, mixed farming, irrigated agriculture
12. Adoption of 'best bet' farming adaptation	Increased implementation of adaptation strategies from DPI modelling projects by better understanding and engagement with the end-user and/or client (may be different).	Land management, mixed farming, irrigated agriculture
13. Adaptive farm management data sharing	Farmers, farming consultants and funding partners to co-design and build a government provided data platform for the sharing of information around adaptive farm management	Land management, mixed farming, irrigated agriculture, riverine ecosystems
14. On-farm alternative fuels project	Establish trial site at Temora and partner with machinery supplier to trial alternative heavy vehicle fuels for farm machinery	Energy, mixed farming, irrigated agriculture
15. Future tourism market research	Establish an industry coalition around tourism outcomes to collect information on the target market demographics up to 2050 and enable open access, and quantify current and future tourism value	River-based tourism, riverine ecosystems
16. Government & Aboriginal community adaptation forum	Meet the need for government to engage and respectfully exchange information with the Aboriginal community and Aboriginal elders around climate change	Land management, small communities, riverine ecosystems
17. Strategic Framework for Regional Migration Planning	Strategic analysis of effectiveness of government service delivery and community resilience across the Riverina Murray to inform principles around future planning of government service delivery	Small communities

5.2 Actions underway

Since the inception of the WERA project in the Riverina Murray, a number of actions to enhance regional adaptation planning have commenced including:

- conferring of two regional scholarships for participants from the Riverina Murray to attend the Learning to Adapt accreditation course supported by the Environment Institute of Australia and New Zealand

- Wagga Wagga City Council in partnership with Edge Environmental have been awarded $58,756 from the Building Resilience to Climate Change program. 'Adaptation Action Plans for Priority Infrastructure and Vulnerable Communities' will develop an online interactive mapping tool that identifies priority infrastructure and assets based on vulnerable communities to inform renewal and maintenance schedules and prioritise funding of adaptation projects
- an innovative project to build disaster preparedness and resilience of culturally and linguistically diverse and refugee communities in the Riverina Murray has been funded under the Community Resilience Innovation Program (CRIP) 2015–17. This Red Cross project 'Harnessing the power of gender and language in emergency services' will be based in Leeton and Wagga Wagga and aims to extend a successful project already undertaken in Griffith to engage non-English speaking communities with the emergency services (particularly fire). The project will commence in mid-2017.
- approval by the Regional Leaders' Group (RLG) to extend the Riverina Murray Enabling Regional Adaptation Steering Group for a further two years in order to provide guidance and support to the development of multi-stakeholder climate adaptation projects arising out of the ERA process. A working group around 'Traditional Ecological Knowledge and Climate Adaptation' has been formed and the RLG and its steering group has accepted an invitation for an initial campfire discussion. Two other working groups are likely to be proposed around 'Adaptation for agriculture', and 'Community preparedness across the Riverina Murray'.
- inclusion of references to the WERA process in the Department of Planning and Environment Riverina Murray Regional Plan.

5.3 Supporting processes

Climate Change Fund

In November 2016, the NSW Government announced an Environmental Future Funding package, which includes a Climate Change Policy Framework outlining the Government's ongoing commitment to action on climate change. It also included a Draft Climate Change Fund Strategic Plan, with priority investment areas and potential actions for up to $500 million of new funding from the Climate Change Fund over the next five years. The draft strategic plan proposes three priority investment areas that will form the basis of future action plans for:

- accelerating advanced energy
- national leadership in energy efficiency
- preparing for a changing climate.

Building Resilience to Climate Change program

The Building Resilience to Climate Change (BRCC) is a partnership between Local Government NSW and OEH to address identified climate change risks and vulnerabilities facing NSW councils.

The program was established to encourage:

- enhanced consideration of climate change impacts in local and regional decision making
- delivery of projects that minimise climate change impacts for local and regional decision-makers
- implementation of climate change adaptation beyond current projects and programs

- fostering of adaptive capacity in local government through a community of practitioners across professional disciplines with direct experience in implementing adaptation responses across NSW.

Community Resilience Innovation Program

The Community Resilience Innovation Program (CRIP) supports a broad range of community-led projects designed to increase all-hazard disaster preparedness and build community capacity and resilience. CRIP projects are based on collaboration and partnership between local community organisations and emergency services agencies. CRIP aims to:

- encourage local communities to engage in creative, community-focused activities that will enhance disaster resilience
- develop effective partnerships and build networks between local community organisations, councils, businesses and emergency services agencies
- foster ways to effectively engage the local community in emergency management and resilience building
- share knowledge and lessons learnt about new approaches and models through project evaluation
- support initiatives that can be integrated into current business and maintained in the longer term.

CRIP is a scheme under the Natural Disaster Resilience Program, funded by the NSW and Commonwealth governments through the *National Partnership Agreement on Natural Disaster Resilience*.

6 Measuring progress

6.1 Adaptation process

The ability to detect change is a critical component of any monitoring program because it facilitates adaptive management (Allan & Curtis 2005); however, issues associated with monitoring and evaluating climate adaptation are well-documented and include (Bours et al. 2013):

- measuring adaptation against a moving climate baseline
- consideration of avoided impacts through counterfactual arguments that are difficult to prove, such as 'if we hadn't undertaken this adaptation action the outcomes might have been much worse'.
- the difficulty with attempting to attribute an adaptation outcome to a particular course of action, as often multiple actions have contributed to improved climate resilience
- local adaptation actions can have outcomes that span multiple scales, sectors and responses
- the lack of a universal set of indicators against which adaptation can be measured.

Despite these difficulties, organisations (private and public) are moving from *awareness* about the need to manage climate change risks to *implementing actions* to manage them. This has led to the emergence of a common set of practices considered necessary to deliver effective adaptation to climate change: the adaptation process cycle (Figure 15). All the processes in the cycle commonly occur as part of action to adapt to climate change in NSW.

A well-defined process cycle is central to effective benchmarking. Benchmarking can be used to evaluate an organisation, business or process against external criteria. The objectives of benchmarking are to determine what and where improvements may be made, to analyse the ways in which other groups achieve high performance, and to use this information to drive improvements in performance. Benchmarking represents a 'soft policy' that encourages flexible planning, local consultation and incorporation of local context coupled with institutional support at higher scales of governance. Soft policy instruments can sustain proactive behaviour to achieve desirable outcomes that are embedded and accepted in everyday practices.

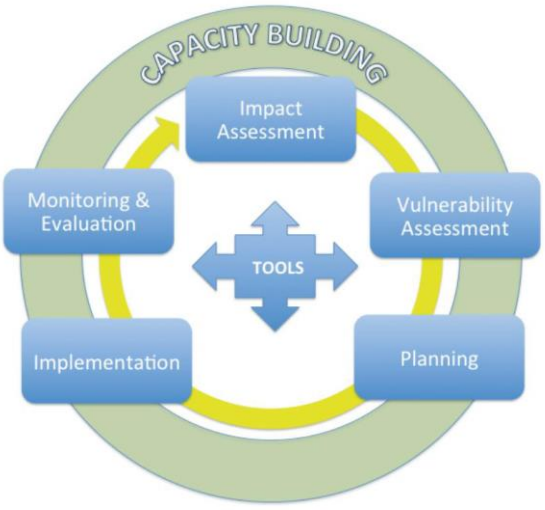

Figure 15: The adaptation process cycle Source: Hansen et al. (2013)

For climate change, benchmarking the adaptation process at the regional scale circumvents many of the problems with attempting to assess and aggregate local-scale adaptation actions. The WERA process focuses on assessing the degree to which organisations are employing an effective adaptation process rather than the effectiveness of government adaptation processes or interventions; the underlying assumption being that good process leads to good adaptation decisions. This type of approach was used by Hansen et al. (2013) in a national climate adaptation benchmarking exercise conducted across a number of sectors in the USA.

6.2 Adaptive capacity

One way to promote adaptation action is to build regional capacity to adapt (Jacobs et al 2015). Targeted capacity building requires an understanding of where the barriers to action lie in the region, which is generally related to the resources available for adaptation and the ability to use them. These resources commonly include awareness, knowledge and skills, and staff resources (human capital), engagement and networking with the community and other organisations (social capital), the formulation of strategic plans, and the financial resources to implement adaptation actions. Monitoring adaptive capacity over time can provide an additional measure of regional change.

6.3 Regional online survey

A qualitative survey was conducted to benchmark regional adaptation actions at the start of the project, to provide a baseline, and following completion of the WERA workshop process, as a preliminary assessment of change. The survey was available online for a period of four weeks between January and February 2016 (initial) and again in April 2017 for three weeks (post-workshops).

The response rate varied considerably between the two survey times. The results presented here will focus on the initial survey because the response rate was higher, and therefore, is likely to represent regional conditions more reliably. The change in response rate means that small differences in results between sampling times are difficult to attribute to any single factor. They may be the result of an altered sampling frame (for example, differences in representation across tiers of government or a change in the mix of agencies that responded to the survey) or to real differences in regional conditions. Despite this we will present differences between the two surveys in response to selected questions, particularly where they relate to identification of new, local adaptation projects.

In total 88 people from across all levels of government from the Riverina Murray region participated in the first survey. The representation was spread across NSW Government agencies (61%), local government (28%), regional agencies (8%) and Australian Government agencies (3%). About 4% (four of 88) of survey respondents identified themselves as being of Aboriginal heritage.

In total, 31 respondents completed the follow-up survey, representing Australian Government agencies (3%), NSW Government agencies (68%), local government (26%) and non-government organisations (3%). One respondent identified as being of Aboriginal heritage. More than half (61%) of the respondents had attended at least one of the OEH ERA workshops in 2016.

Perceived key climate change risks

In the initial survey respondents identified a number of climate related risks facing the Riverina Murray region. In the initial survey drought, heatwaves, changing rainfall patterns and intense storms with high winds were identified as the top four critical climate risks facing the region (Figure 16). In the follow-up survey flooding was also identified as a natural hazard affecting the region, reflecting a recent flood event. Increased hail events and frost were perceived as the least important climate related risks in the region in both surveys.

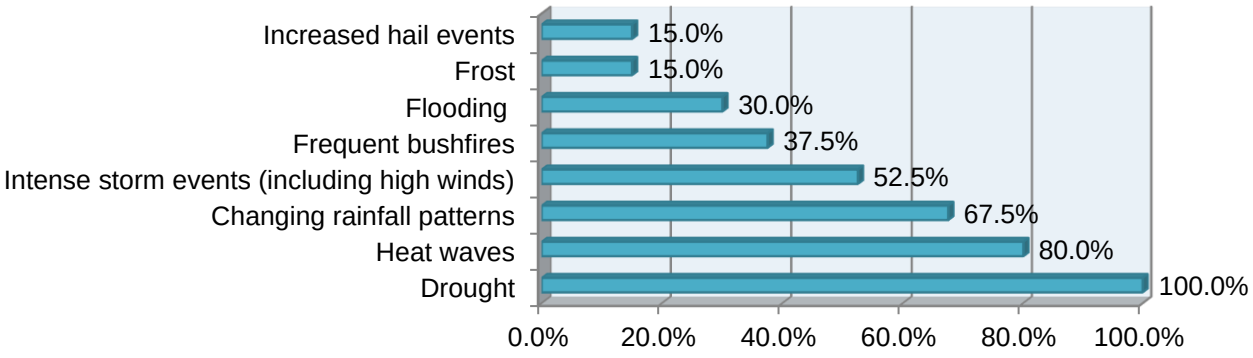

Figure 16: Climate risks identified for the Riverina Murray region

Importance of climate change

A series of questions was asked to ascertain the importance of climate change adaptation from individual and organisational perspectives. The initial survey showed almost three-quarters (72%) of respondents agreed that climate change adaptation is important to them personally and in their professional roles, 22% said it was slightly important and 5% said it was not important. Climate change adaptation was viewed overall as slightly less important for organisations, with (54%) indicating that it was a moderate to strong priority for their organisation, while 32% of respondents considered it a slight priority and 9% said it was not an organisational priority.

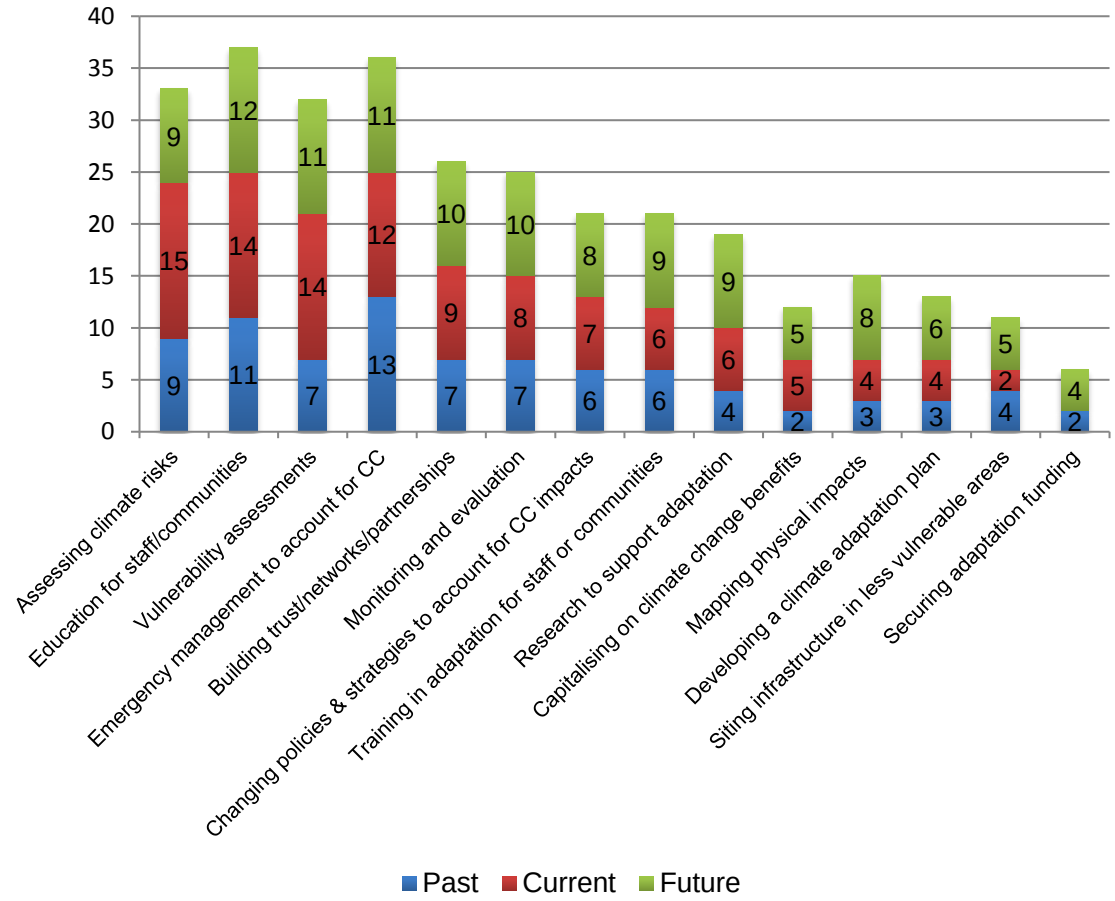

Figure 17: Adaptation actions across temporal scales

Adaptation action

The surveys explored the wide range of adaptation actions that organisations or individuals had been involved with in the past, action they are currently engaged in, and actions likely to occur in the future (Figure 17).

The top four adaptation actions from the initial survey undertaken either in the **past** or **present** included:

- assessing the risks posed by climate change
- awareness raising or education of staff and local communities
- conducing a vulnerability assessment
- building trust, networks and partnerships.

The most identified future adaptation actions included changing policies and strategies to account for climate change impacts; and assessing climate risks and conducting vulnerability assessments. In the follow-up survey securing adaptation funding was also identified as an important current and future action.

The development of a climate adaptation plan to guide organisational actions, building infrastructure in less vulnerable places, and capitalising on any benefits provided by climate change were the least pursued actions in the past or present, and the least likely planned actions for the future in both surveys.

Adaptation actions can span multiple scales, sectors and responses, as shown in Figure 18. Key adaptation actions conducted at a local or regional scale from both surveys included awareness raising or education of staff and local communities, building trust, networks and partnerships, and assessing climate risks, which provides the necessary evidence to inform climate adaptation planning. These assessments usually inform training in adaptation for staff and the emergency management sector. Changing policies and strategies to account for the impacts of climate change and initiating adaptation research were identified as actions most likely to be conducted at the state level.

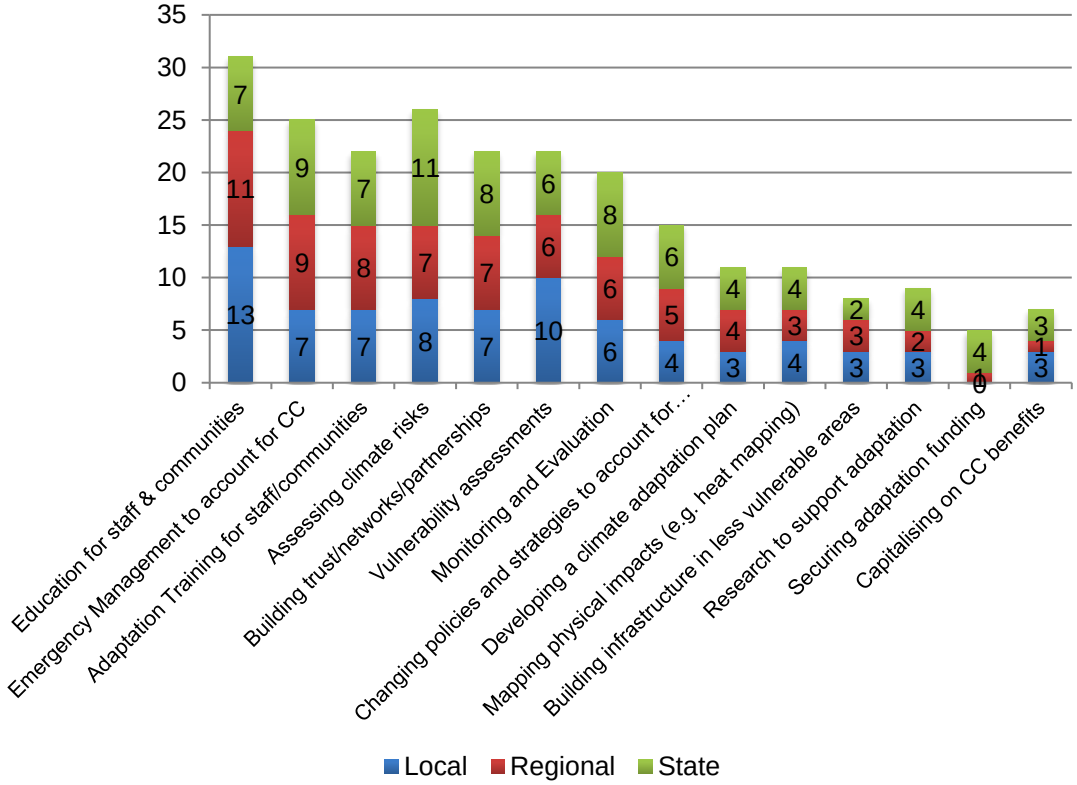

Figure 18: Adaptation actions across geographical scales

Organisational capacity to undertake climate change adaptation

The survey also explored organisational capacity to undertake regional adaptation actions. Organisational capacity can be broken down into seven key areas:

1. Awareness of the impacts of climate change
2. Knowledge and skills to adapt to a changing climate
3. Resources to undertake regional adaptation action
4. Engagement with the community and organisations within the region
5. Strategic planning
6. Funding for adaptation
7. Implementation of regional adaptation.

Median responses to the capacity assessment statements (Figure 19) indicated that the region is generally aware of climate impacts, is supported in knowledge and staff resources, and engages with communities and other organisations on adaptation. However, agreement with responses to capacity statements was more positive at the second survey than the first. The region's adaptive capacity appears to be constrained mainly by a lack of prioritisation of climate action in strategic plans, implementation of regional adaptation actions and funding dedicated to climate adaptation.

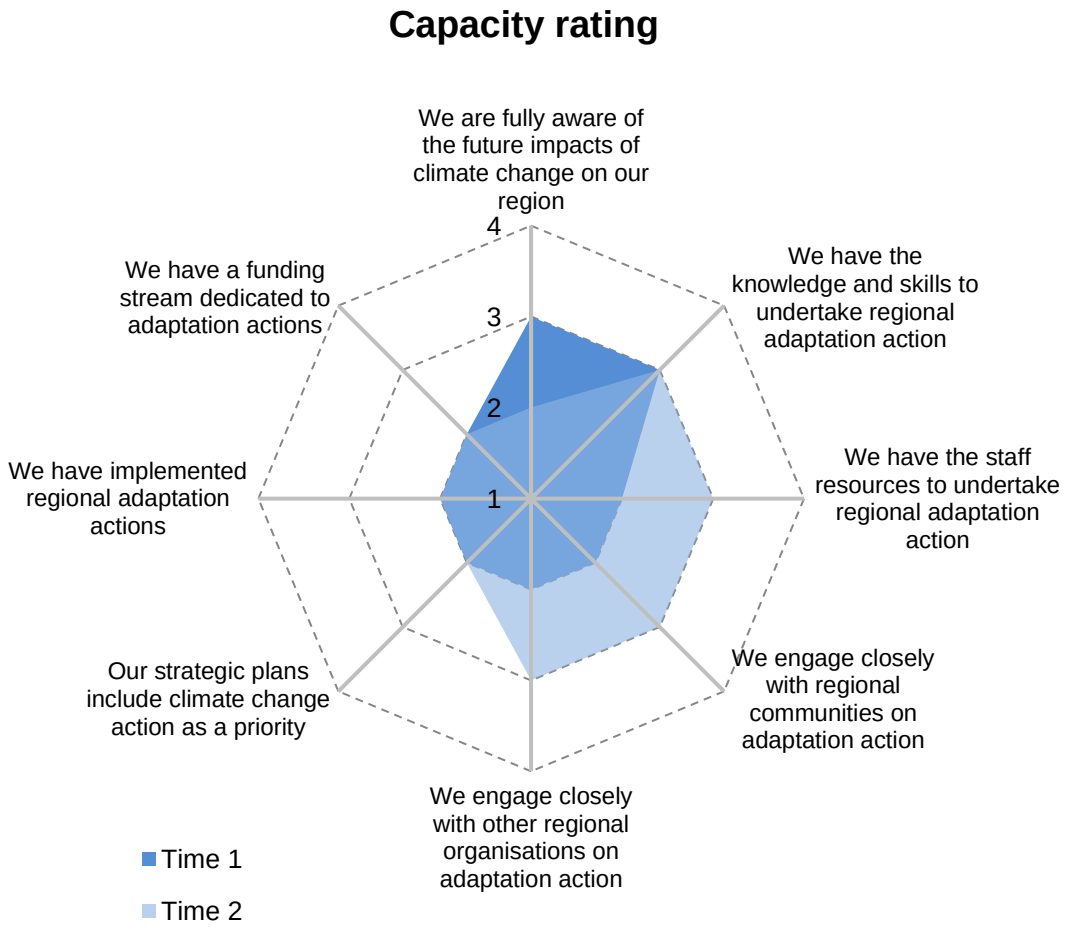

Figure 19: Adaptive capacity for the Riverina Murray Ratings are the median level of agreement with each statement where 1 = strongly disagree, 2 = disagree, 3 = agree, 4 = strongly agree; N = 21

Regional adaptation initiatives

The surveys aimed to gain a deeper understanding of the specific types of adaptation actions that had taken place in the region. Some of the adaptation actions identified focused on key areas of importance to the region such as adapting and managing essential services; mental health; agricultural education and disaster preparedness and recovery.

Adapting and managing essential services

The projections show that climate change will most likely impact regional water availability now and into the future. Therefore it is important to identify and plan for alternative solutions to cope with rainfall variability, for example using groundwater to provide an alternative town water supply when rainfall is low. Other actions focused on installing water infrastructure to deliver environmental water efficiently and effectively to maintain the health of water dependent ecosystems.

The impact of heatwaves on IT equipment is managed by retrofitting IT outposts that are used by Albury City Council and by the airport to cope with high temperatures.

Mental health

The Rural Adversity Mental Health Program (RAMHP) works with local communities to prepare for and deal with rural adversity, including drought, bushfire, etc. The program evaluation concluded that RAMHP has been very successful. A key strength lies in the collaboration with key local organisations and government agencies that deal with health and rural resilience. DPI Water has, in the past, supported small communities at times of drought and flood, dependent on the specific needs at the time. This assistance was not provided with a view to dependency during difficult times but with a view to ensuring those communities took action to reduce their vulnerabilities.

Agricultural Adaptive Capacity

Farmers are naturally adaptive and well attuned to weather and climatic changes. Extreme weather events such as drought can provide a window of opportunity to raise awareness and disseminate information about climate change, especially as they can generate media coverage and attention beyond regional boundaries. Some successful adaptation actions can be seen as ‘normal business’ activities that emphasise greater variability, e.g. risk management in drought. However, challenges remain in encouraging investment in longer-term measures when landholders are dealing with short-term issues and financial cycles while trying to remain productive. Other initiatives include working with farmers and local food economies in developing strategies to improve operational readiness and community resilience.

Disaster preparedness and recovery

An important component of adaptation is preparing for and recovering from disasters. In the Riverina Murray, adaptation actions have aimed to increase the level of understanding of the impacts of climate change on emergency management planning at local and regional levels. Local organisations are starting to focus on recovery such as assisting small businesses to recover from a disaster, for example following a major storm event.

Biodiversity planning

Adaptation actions that are currently being implemented or have recently been completed have focused on biodiversity through the implementation of two initiatives: establishment of biodiversity corridors and the dissemination of information from flora and fauna benchmarking studies.

Remote housing

The Aboriginal Housing Office and the Land & Housing Corporation are reworking existing policies around heating, cooling and energy management for tenants, in response to the extreme temperatures experienced in remote communities.

Adaptation challenges

At the time of the survey participants indicated that adaptation in the Riverina Murray is being hindered by the lack of:

- clear state government policy on climate change which in turn hinders implementation of adaptation measures
- community acceptance of climate change
- adaptation funding.

5.3 Supporting processes describes NSW Government policy addressing these concerns that has been put in place subsequent to this survey.

Monitoring and evaluation of adaptation actions

Programs, research and recommendations require continual monitoring, evaluation and adjustment to ensure they meet the needs of the regional communities in a dynamically changing environment. The final survey question asked whether monitoring and evaluation (M&E) of adaptation initiatives are undertaken on a regular basis. Only 20% of respondents confirmed that adaptation is being regularly monitored by their organisation, while a further 20% said that monitoring and evaluation occurs infrequently. However, 44% of respondents answered that M&E is not being undertaken or they did not know if it is (16%).

7 How to turn these findings into action

This report contains a collective understanding of the likely vulnerability to climate change of government service delivery in the Riverina Murray region and aims to stimulate action to plan adaptation. It documents regional challenges and actions identified by local decision-makers as critical to their community's prosperity and endurance. Local councils and state agencies will need to continue to collaborate and look for opportunities and policy windows to enable transformation of the eight systems identified in this report.

To address the region's vulnerability to climate change, begin by pursuing the following opportunities and be on the lookout for new ideas as well:

- **Understand regional vulnerability** – Table 3 of the report lists the priorities for adaptive capacity identified by each sector. It provides a lens through which the specific attributes of the region can be viewed as a means of addressing threats. It can also help to identify what attributes are absent or negative, highlighting which adaptive responses will be constrained, leaving the region vulnerable.
- **Understand the flow-on impacts of climate shocks and stressors across the community** – The impact chains in Figure 12 show how climate variability and extreme events will affect landscapes and ecosystems of the region and illustrate the complexity of consequences from the four main climate drivers that were identified.
- **Assess climate change adaptation progress in the region** – The survey results in Chapter 6 outline the key climate risks and the status of adaptation currently underway. This provides a benchmark against which future action can be measured.
- **Embed the transition models into regional and local strategic plans** – The transition models look at key regional systems that will need to be significantly different in the future due to climate change, and other specific regional drivers of change. Embedding the actions in the transition pathways into project and program development will aid cross-sectoral adaptation and support regional efforts to transform to a desirable future. This can be achieved through strategic planning or operational opportunities.
- **Seek funding to activate transition pathways** – The assessment method used to identify the regional vulnerabilities is a peer reviewed methodology, meaning it provides a robust and scientifically rigorous way to prioritise adaptation projects and responses. It provides a sound evidence base to support adaptation projects and justify subsequent investment.
- **Communicate the expected physical changes** – Table 2 and Appendix A summarise the changes to climate variables that can be expected in the future and also the likely impacts across different sectors. Community education and staff training will help the whole region to increase its preparedness.
- **Leverage existing cross-jurisdictional leadership groups** – These groups are central to coordinating and driving climate change adaptation in the Riverina Murray region and are a valuable resource to help build momentum.

Appendix A: Expected physical responses for the Riverina Murray

Physical response	Trend	Projection	Implications
Heat	Increase	Heatwaves are projected to occur more often, be more intense and last longer. Across most of NSW there will be more days over 40°C. For further information refer to the *Heatwaves* and *Urban Heat Climate Change Impact Snapshots*: climatechange.environment.nsw.gov.au/Impacts-of-climate-change/Heat	• Human health • Urbanisation • Biodiversity • Fire weather • Agricultural productivity
Soil erosion	Increase	Areas which already experience high erosion rates are projected to see increases in erosion. For this region, soil erosion is projected to increase by 1.4% in the near future and 13.5% in the far future. For further information refer to the *Soil Erosion Climate Change Impact Snapshot*: climatechange.environment.nsw.gov.au/Impacts-of-climate-change/Soil/Soil-Erosion	• Water quality • Agricultural productivity • Biodiversity
Soil properties (SOC, pH and sum of bases)	Increase – decrease	The projections across this region of soil organic carbon (SOC) are complex, with most of the Riverina Murray experiencing a loss in SOC in the far future (up to 20t/ha in the top 30cm in the alpine regions), but other parts of the region projected to increase SOC in both upper and lower soil depths. pH is projected to experience only marginal change with the exception of the north Griffith area which is projected to become slightly more acidic. Sum of bases are projected to increase in both upper and lower soil depths for both the near and far futures with the exception of a small area in the north-east of the region. For further information refer to the *Soil Properties Climate Change Impact Snapshot*: climatechange.environment.nsw.gov.au/Impacts-of-climate-change/Soil/Soil-Properties	• Agricultural productivity (+ and –) • Natural ecosystems
Rainfall erosivity	Increase	In the region rainfall erosivity is projected to increase in autumn and decrease in winter and spring in the near future. However increases are projected for all seasons except spring (for most of the Riverina Murray) by the far future. For further information refer to *Rainfall erosivity* in the *Soil Erosion Climate Change Impact Snapshot*: climatechange.environment.nsw.gov.au/Impacts-of-climate-change/Soil/Soil-Erosion	• Water quality • Agricultural productivity • Biodiversity

Physical response	Trend	Projection	Implications
Rainfall extremes	Increase	Rainfall extremes are projected to increase in the near future and far future. The state planning regions with the most frequent significant increases in extreme rainfall indices in the far future are the Far West, Riverina Murray and New England North West. For further information visit the Adapt NSW website: climatechange.environment.nsw.gov.au/Impacts-of-climate-change/Floods-and-storms	• Flooding • Agricultural productivity • Increased demand on emergency services • Local government
Hydrology (surface flow/ runoff and recharge)	Increase – decrease	The projections of future surface runoff are spatially variable across the Riverina Murray. In the near future there is a mix of projected increases and decreases in runoff with the western part of the region generally increasing and the alpine area decreasing. In the far future the whole region is projected to increase in runoff with the exception of the alpine areas which continue to decline, particularly in spring. Decreasing recharge of groundwater is likely across much of the region in the near future. Projections are spatially variable in the far future, with some higher and some lower recharge in different parts of the region. Reduction in recharge in the far future is particularly significant in the alpine region with up to 100mm reduction in average annual recharge compared with the baseline period (1990–2009); again this is most significant in spring. For further information refer to *Hydrology Climate Change Impact Snapshot*: climatechange.environment.nsw.gov.au/Impacts-of-climate-change/Water-resources/Groundwater-recharge-and-surface-runoff	• Councils' stormwater infrastructure • Town water supplies • Agricultural productivity
Flood		For further information visit the Adapt NSW website: climatechange.environment.nsw.gov.au/Impacts-of-climate-change/Floods-and-storms	• Urban and rural properties • Agricultural productivity • Emergency services • Local government
Fire weather	Increase	Average daily forest fire index is projected to increase in summer and spring in the Riverina Murray for both near and far futures. It is important to note that fire weather has been defined using the Forest Fire Danger Index and so for areas that are predominantly grasslands in the region fire risk may be more accurately assessed using the Grass Fire Danger Index. For further information visit the Adapt NSW website: climatechange.environment.nsw.gov.au/Impacts-of-climate-change/Bushfires	• Fire regimes • Emergency services • Hazard reduction

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