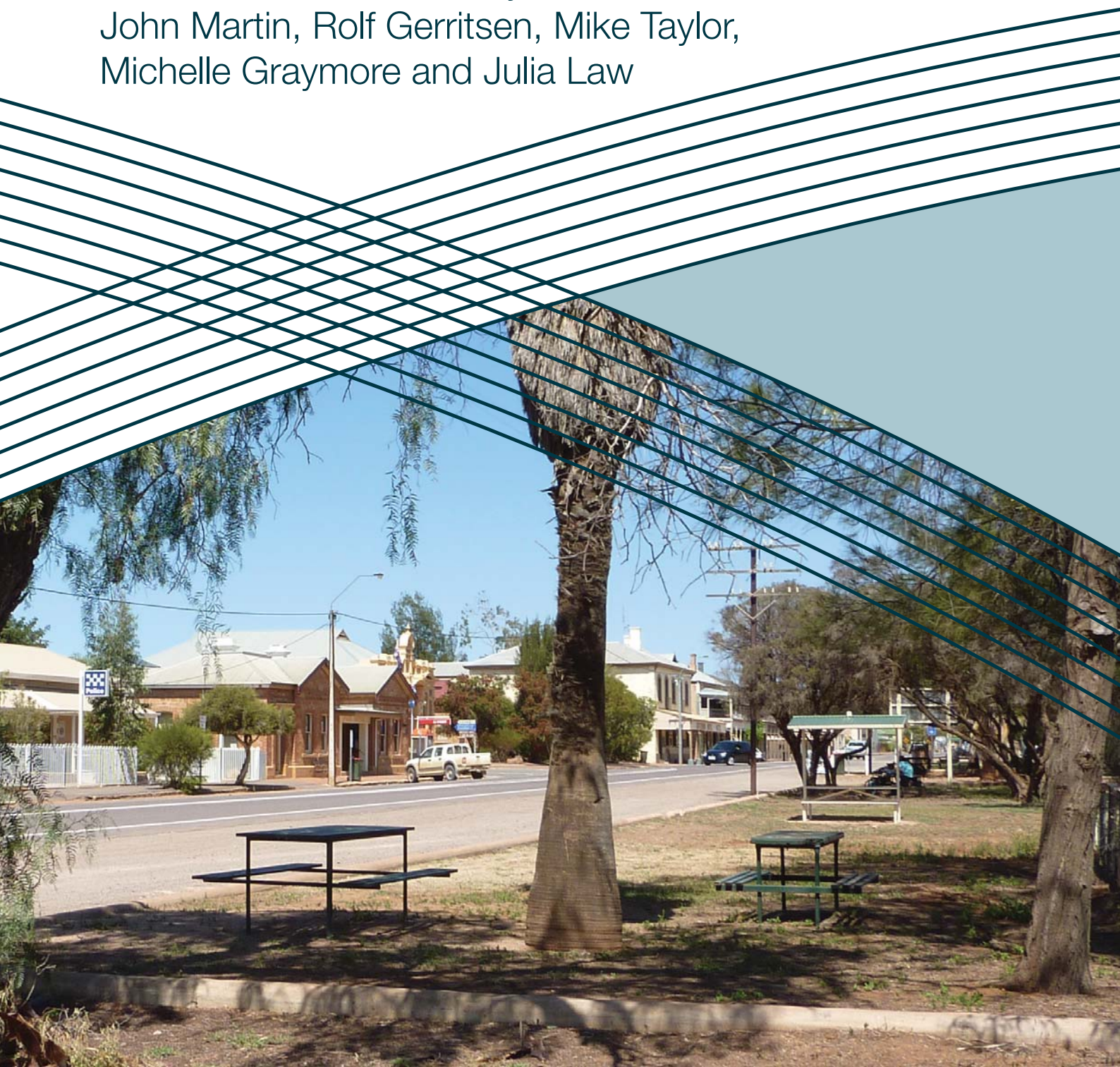


Australia's country towns 2050: What will a climate adapted settlement pattern look like?

Final Report

Andrew Beer, Selina Tually, Michael Kroehn,
John Martin, Rolf Gerritsen, Mike Taylor,
Michelle Graymore and Julia Law



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ABBREVIATIONS

ABC	Australian Broadcasting Corporation
ABS	Australian Bureau of Statistics
ALGA	Australian Local Government Association
ANU	Australian National University
APY	Anangu Pitjantjatjara Yankunytjatjara
CMA	Catchment Management Authority
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DCCEE	Department of Climate Change and Energy Efficiency
DEEWR	Department of Education, Employment and Workplace Relations
GDP	Gross Domestic Product
GHG	Green House Gases
GISCA	National Centre for Social Applications of Geographic Information Systems
GWMWater	Grampians Wimmera Mallee Water
IPCC	Intergovernmental Panel on Climate Change
MDBA	Murray Darling Basin Authority
WMSA	Wimmera Mallee Sustainability Alliance
NTG	Northern Territory Government
NTES	Northern Territory Emergency Services
NTICS	NT Incident Control System
NCCARF	National Climate Change Adaptation Research Framework
PMSEIC	Prime Minister's Science, Engineering and Innovation Council
PV	Photovoltaic
UCL	Urban Centres and Localities
UNDP	United Nations Development Programme
WebEOC	Web-based emergency operations network

ABSTRACT

This report considers the impact of anticipated climate change on Australia's inland towns and centres to the year 2050. It examines the ways in which non-coastal settlements will be affected by the primary, secondary and tertiary impacts of climate change, including the impact of extreme climate events, a warming and drying climate over much of southern Australia and increased costs associated with both structural economic change and accelerated degradation of infrastructure. The research finds that climate change is likely to have a wide range of impacts on Australia's system of inland settlement and that not all of these impacts are likely to be adverse. The published literature highlights the fact that some industries – including wool production, grains, viticulture and some grazing – are likely to benefit from climate change. While this is not the case in all instances, the fact that some industries will be enhanced runs contrary to both commonly held expectations and public discourse. In other sectors of the economy and society, technological change and/or investment in infrastructure will overcome many of the climate-change related challenges that have the potential to place the wellbeing of inland centres at risk.

This project found that rural and regional centres across Australia will be affected by climate change in different ways, depending upon:

- Their industry structure;
- Their geographic location, especially their degree of remoteness;
- Their climatic conditions now and in the year 2030; and,
- The resource endowments of communities – and especially their stock of human, social, physical, fiscal and economic capital.

The project reviewed the national and international literature on climate change adaptation to consider the vulnerability of individual inland centres. A vulnerability index was developed that was able to distinguish places that are more, and less, vulnerable to the negative impacts of climate change. This analysis was undertaken as a first step toward better understanding the differential impacts of climate change on the inland settlement system, and with a full awareness of the critiques of such approaches. The modelling highlighted that places that are remote confront some of the greatest risks from climate change, and that many – but not all – Indigenous communities are especially vulnerable.

Detailed field work was undertaken in five case studies across Australia – Alice Springs, NT; Junee, NSW; Horsham, Victoria; Waikerie, South Australia; Moura, Queensland – in order to understand the steps taken by inland centres to plan and prepare for climate change. The research found that many persons within rural and regional communities do not accept that human-induced climate change is a reality, and that in consequence preparations for change are patchy. However, in many rural economies contemporary 'good practice' in farming or grazing is entirely consistent with the measures needed to plan for climate change. The fieldwork also highlighted the fact that while it is possible to model the *potential* impact of climate change, such measures overlook the commitment and willingness of groups to address this challenge.

Finally, we conclude that climate change will contribute to the shifting nature of Australia's inland settlement system to the year 2050 but that it will be just one of a number of factors contributing to change. Other factors, including global markets, demographic change, the relative prosperity of individual industries, and the investment decisions of government will be important also.

EXECUTIVE SUMMARY

This is the final output of a project for the National Climate Change Adaptation Research Facility (NCCARF) on the impact of climate change on Australia's country towns out to the year 2050 and the capacity of this component of Australia's settlement system to adapt.

The report summarises the findings from all stages of the research. It does six things:

- first, it provides the conceptual foundation for the analysis of the capacity of Australia's country towns to respond to climate change. It considers adaptation and maladaptation, the project impact of climate change on Australia's ecosystem and the conceptualisation of vulnerability;
- second, it reviews the current literature on climate change and Australia's settlement system, with particular reference to country towns. It highlights the challenges country towns are likely to face over the coming decades and the importance of community action in preparing for this new future;
- third, the report considers the prospects facing the industries that support country towns currently and which will need to either survive or be replaced if these places are to have a future. It finds here that the evidence is mixed: climate change will have mixed impacts on rural and regional industries and that some industries that might be considered at risk are likely to thrive, at least in the short term. Adverse events, including major weather events, may have an impact on the viability of these industries but in many instances new technologies and management strategies will assist the adjustment process;
- fourth, it summarises the findings from the in-depth case studies of climate change impacts, vulnerabilities and responses in five inland locations – Alice Springs (NT); Horsham (Victoria); Junee (NSW); Moura (Queensland); and Waikerie (SA). The results of this component of the research show that in many ways inland settlements are lagging behind urban and coastal settlements in terms of adaptation. The case studies also show the varying capacities of settlements to respond to climate change and the need for more concerted action by a range of stakeholders, including all tiers of government, to support communities with risk identification, management and vulnerability. Currently, actions are very much still in the planning stage, and moving to the next phase in terms of setting goals and objectives for adaptation is crucial.
- fifth, the report presents the findings of the Delphi Analysis undertaken with key stakeholders in regional Australia, including representatives of state and local government, regional development agencies and academia. The results of this analysis shows a consensus around the complexity of challenges facing Australia's inland settlements and that climate change impacts are just one part of the challenges facing communities. Again, the results of this component of the research show the need for directing further resources to communities to assist with understanding climate change impacts and for assisting communities to develop their own adaptive capacities.
- sixth, the report presents the second iteration of an Index of Vulnerability for Australia's country towns. It concludes that the development of such an index is both practical and potentially worthwhile and that when mapped the results tell a compelling story about the distribution of country towns at risk. The preliminary results from the development and application of this Index for Australia's country towns, found that

- remote inland settlements are most at risk in a climate-change affected Australia;
- many of the most at-risk communities are Indigenous communities in remote locations;
- many parts of the established cropping lands in the south east of Australia appear to face a relatively muted risk, while settlements in Western Australia's agricultural lands appear to face a greater threat than those in South Australia or Victoria;
- the level of vulnerability appears high throughout NSW also, and this may partly be a function of the distance of many of these centres from Sydney or one of the other capitals; and,
- the least vulnerable inland centres tend to be located close to the capitals (for example, Crafers-Bridgewater and Summertown in South Australia) or larger settlements with diverse economies, such as Bendigo.

The report concludes that some of the implications of climate change for country towns are already evident. In many instances communities are already making investments in new infrastructure and facilities in response to events that can be linked to climate change. Examples include, the upgrading of fire fighting facilities and capacity; enhancing water supply or making provision for alternative sources of supply; better planning for flood risk; and, improving transport infrastructure, including roads and bridges. Critically, many of these investments are not placed within the context of climate change-related need, and therefore engagement with these issues tends to be *ad hoc* and sporadic, rather than systematic and strategic. The number and percentage of settlements with well-developed planning for climate change is small.

1. INTRODUCTION

1.1 Introduction

There is a growing consensus in the community around the certainty of human-induced climate change and its potential to significantly affect our economy, society and culture. The scientific and research communities achieved such consensus many years earlier and it has taken some time to move beyond the construction of a scientific evidence base to support the case for climate change and to move to understand its impacts. In this context, initiatives such as the extensive program of research funded by the National Climate Change Adaptation Research Facility (NCCARF) are critical for preparing Australia for the challenges of the next decades and beyond.

This report makes a contribution to this debate and this body of work. It considers the structure and functioning of Australia's country towns in the year 2050 in the face of on-going climate-driven change. The research recognises that the future of Australia's country towns is not simply a product of climate change and its manifestation in terms of altered rainfall patterns, an increase in average temperatures, increased extreme events – including heat, cold, flood and drought, as well greater challenges to infrastructure and social institutions. In large measure the future of Australia's non metropolitan places will be determined by their capacity to adapt, which in turn will be affected by their stock of community assets including social, economic, human and natural capital (Cocklin and Dibden 2005). Some locations will be more sensitive than others when exposed to climate change, one group of settlements will adapt well, while others maladapt or simply disappear.

The appropriateness of our infrastructure and buildings is an important part of the story of the adaptation of Australia's urban settlement pattern.

Understanding the processes that will affect Australia's country towns into the future is critical as:

- rural and regional Australia is the source of food production for the nation;
- regional communities are responsible for the majority of Australia's export earnings, with the mining sector alone accounting for 45 per cent of trade income;
- significant numbers of Australians may be at risk from adverse climate change impacts, simply because of their place of residence;
- the costs of economic dislocation associated with failed regional communities could impose a significant burden on national fiscal capacity;
- economic opportunities could be lost if we fail to recognise embedded opportunities to better adapt to a changing environment.

The focus of this report is inland centres across non metropolitan Australia. Other work funded by NCCARF considers the future of Australia's coastal towns. Inland centres, of course, face special challenges that may not be evident in coastal centres and are clearly less likely to be affected by issues such as sea level rise.

Understanding how country towns can better prepare for a climate changed future is a particular focus of this research project. The impact of climate change on Australia's settlement system is a priority research area for NCCARF. The impact on country towns is especially important because of the dearth of research on climate change-related impacts on Australia's inland settlements. This absence stands in contrast to the growing body of literature that examines the impact of climate change on Australia's metropolitan areas and some coastal settlements (see, for example,

Brunckhorst *et al* 2011; Bulkeley and Betsill 2005; CCCLM 2009; Gurran *et al* 2008; Hamin and Gurran 2009; Hughes 2003; Milne *et al* 2008).

The research is also important given that the impacts of climate change on inland rural, regional and remote settlements will differ from those experienced in the capital cities, and many of these places will have a different potential for adaptation when compared to metropolitan areas. Key changes in inland settlements include:

- shifts in agricultural productivity;
- the impact of extreme weather events; and,
- changing local environments and the diminution of resources, including major river systems.

These ecologically-driven changes will interact with long term demographic, economic and social shifts to produce complex outcomes. It is also important given that many rural and regional settlements and communities will be especially vulnerable to climate change because of an already marginal position within the settlement system, their dependence on agriculture, their economic reliance on natural resources, the impact of extreme weather events, and the need for infrastructure investment in excess of the capacity of governments or the community. Many parts of rural and regional Australia are already at risk and the process of adaptation to a climate change-impacted and -adapted economy is likely to result in significant disruption. The creation of an evidence base and suite of policies is needed to enable early planning and assist in minimising the costs associated with this change.

The research provides robust evidence on the economic, social and demographic characteristics of country towns and other inland regional settlements in a climate change affected world. The project as a whole produces an evidence base on the challenges confronting different settlement types across non-coastal rural and regional Australia. It documents the adaptation and resilience strategies currently being employed by rural and regional communities across inland Australia and uses that information to develop a 'tool kit' of strategies to be employed by policy makers at the national and state levels, as well as by local communities.

There is a pressing need to understand the processes driving action, change and the level of vulnerability within the economies of our inland settlements because on-going employment and economic activity will be fundamental to a successful transition to climate adapted settlement in inland Australia.

1.2 Project aims and methodology

This report is the final output of a research project for the National Climate Change Adaptation Research Facility (NCCARF) entitled *Australia's Country Towns 2050: What Will A Climate Adapted Settlement Look Like?* The project is specifically focussed on the future, fortunes and capacity of settlements in **inland rural, regional and remote Australia**.

The research sheds **light on the sets of processes – environmental, social, economic and demographic – that will reshape Australia's rural and regional settlement pattern as a consequence of global warming.**

The central hypothesis of the research is that many inland rural and remote communities are vulnerable to the primary and secondary impacts of climate change and that this varies by location, industry structure, environment, and remoteness. The project further tests the hypothesis that public sector and community planning and action can reduce the impacts of climate change on the sustainability of a settlement and that some forms of intervention will be more effective than others.

The research addresses a number of intellectual and policy challenges by examining:

- how vulnerable are inland Australia's rural and remote settlements to the first order and second order changes that will be ushered in by climate change?
- which centres and types of settlement will be most vulnerable as a result of climate change and how is that vulnerability affected by geography, economy, remoteness and demographic processes?
- how adequate are current measures for addressing the impacts of climate change and what constitutes 'best practice' in this area?
- what are the processes, mechanisms and sites (Pike et al 2010) that build resilience in Australia's country towns and other regional centres and how can they be further developed?
- what policies and strategies at the national and other levels will best enhance the resilience and adaptability of Australia's country towns and other regional settlements?

It has also been designed to shed light on two key issues. First it investigates whether:

- inland rural and remote communities are vulnerable to the primary and secondary impacts of climate change and whether this varies by location, industry structure, environment, and remoteness.

This question has been addressed through:

- an analysis of census data on industry structure, and the review of the projected impacts of climate change on rural and remote industries to develop and then refine an index of vulnerability;
- the review of the published and grey literature in this area;
- the use of a Delphi analysis to obtain the views of experts on likely outcomes; and,
- by ground truthing the predicted results in five case study sites.

The second question focussed on the capacity for public sector and community planning and to reduce the impacts of climate change on the sustainability of a settlement. Embedded within this question was the proposition that some forms of intervention would be more effective than others.

This question was addressed by:

- documenting existing climate change plans and strategies across inland rural and remote Australia and comparing them with international best practice;
- using case studies to identify how and to what effect climate change policies for the sustainability of settlements are being developed; and,
- developing a 'best practice' toolkit for use by inland rural and remote settlements and communities.

The work was undertaken in stages:

- Stage 1: Collection and analysis of Census and other relevant data sets (including DEEWR's small area labour market data, building construction etc) to identify the large scale trends affecting the settlement pattern in rural and regional Australia and vulnerability to climate change. Key indicators included population change, labour force by industry, age profile, educational attainment, and workforce skills. These data were collected and analysed at the ABS's Urban Centres and Localities (UCLs) level to produce a fine-grained picture of

change and construct a composite Index of Vulnerability to climate change for all of inland Australia.

- Stage 2: The researchers undertook the collection and analysis of the 'grey' literature produced by local governments, planning departments, state and Australian government departments and non-government organisations on the potential and extant strategies being used across rural and regional Australia to prepare for, and adapt to, climate change. This analysis was supplemented by the team's knowledge of the international and national academic literature in this area.
- Stage 3: Collection of data from relevant sources – government bureaux, industry associations et cetera – on the likely impact of climate change on individual industries in order to assess the potential impact of their decline or growth on Australia's rural and regional settlement system.
- Stage 4: Refinement of the Index of Vulnerability.
- Stage 5: Identification of five case study settlements for further in-depth analysis of climate change risks, vulnerabilities and sensitivities, and adaptation actions. The case studies chosen for this stage of the research represent a mix of inland settlement types and included Alice Springs (NT); Horsham (Victoria); Junee (NSW); Moura (Queensland); and Waikerie (SA).
- Stage 6: Application of the Delphi Analysis technique to relevant experts – those knowledgeable in the economic, social and demographic processes that sustain Australia's regional and rural centres. The Delphi Analysis was used to identify the broader trends affecting inland settlements, including information on the nature, direction and distribution of such impacts.
- Stage 7: Synthesis of the results into a Final Report.

Overall, the research contributes to ensuring economically and socially vibrant communities in rural, regional and remote Australia by developing fresh insights into the probable impact of climate change on both individual communities and groups of settlements. It also highlights effective strategies that can be implemented by individual communities and settlements.

1.3 Climate change impacts and adaptation in rural and regional Australia: an overview

Rural and regional Australia is often defined and characterised by its adaptability and innovation (Sorenson 2009; Tonts *et al* 2012). Rural and regional communities have demonstrated over many decades that they have the capability to respond to (albeit variably) the many economic, social and environmental challenges that have been encountered along their development trajectories. Such challenges include, for example, natural disasters, drought and the broad economic consequences of changing productivity and commodity market demands, globalisation and deregulation. **Climate change presents rural and regional Australia with an additional challenge. And, along with related and unrelated economic, social and environmental pressures, provides a new and more substantial hurdle that carries with it intergenerational impacts that could fundamentally change the way life exists in inland rural and regional Australia.** How rural and regional communities can and will adapt in the face of these challenges remains a public policy concern, underpinning the sustainability of Australia's country towns. Consequently there is an increasing need for Australian country towns to demonstrate their understanding of the impacts of climate change so their capacity for meeting climate

change impacts – known as adaptation – can be ascertained, harnessed and promoted.

As noted in the first output of this project, there is a small body of work specifically focussed on the impacts of climate change on Australia's inland settlements. This is in contrast to the much more substantial literature examining climate change impacts, risk management and adaptation for Australia's metropolitan areas and coastal settlements (see Brunkhorst *et al* 2011; Bulkeley and Betsill 2005; CCCLM 2009; Gurrán *et al* 2008; Hamín and Gurrán 2009; Hughes 2003; Milne *et al* 2008). This section briefly examines current practice with respect to climate change risk management and adaptation for settlements in inland Australia. It is argued that in many ways rural and regional Australia is lagging behind its metropolitan and coastal settlement comparators with respect to identifying and planning for climate change impacts, at least in terms of formal place-based plans. This is clearly an area of concern, given that a significant proportion of Australia's population live in these settlements and that the agricultural sector – one of the key contributors to Gross National Product – is the mainstay of many inland communities.

1.3.1 Moving to adaptation

Over recent years there has been significant high level policy action directed at climate change mitigation and adaptation in Australia. Driven by the Australian Government and through the Council of Australian Governments (COAG), climate change adaptation has been adopted as a universal policy aspiration. At a finer level of detail, across governments and in some communities, the move towards adaptation has been primarily about managing the risks of climate change. It has involved examination of the possible consequences of climate change across a range of sectors of the economy, as well as the community as a whole. In some places it has translated into discussions about what strategies can be put in place to avoid negative outcomes (Pittock 2005). In these instances the community and policy discourse exhibits a preference for a proactive approach, or planned or anticipatory adaptation, rather than relying upon a reactive approach, or autonomous adaptation. Anticipatory adaptation is considered most likely to achieve success in addressing the intergenerational impacts of climate change.

Adaptation policy at the national level has been guided by the National Climate Change Adaptation Framework (NCCAF) (Australian Government 2007), as part of the National Climate Change Strategy. This Framework supports decision makers to understand climate change impacts and incorporate actions for adaptation into policy and operational decisions at all scales and across all vulnerable sectors. It also provides a guide for state and territory government actions (endorsed by the Council of Australia Governments) over the five to seven year timeline from its release in April 2007. The Framework is structured around two key strategies (p. 6):

- building understanding and adaptive capacity, and
- reducing sectoral and regional vulnerability.

Building on the foundation for understanding and actions provided in the NCCAF the Australian Government's Department of Climate Change and Energy Efficiency has released two key documents outlining their efforts and focus in terms of adaptation. The first of these documents is an Australian Government Position Paper entitled *Adapting to Climate Change in Australia* (Department of Climate Change Government 2010). Again, this paper stands as a framework making the case for adaptive action. It centres on six key messages with regard to adaptation:

- some climate change is unavoidable;
- we need to pay attention now to our climate change adaptation needs;

- adaptation is a shared responsibility – governments, business and the community all have a stake and a role in responding to climate change impacts;
- sectors will be affected by climate change at different times and in different ways – so we need to identify some national adaptation priorities;
- some key changes can only be delivered by Governments working together; and,
- we need to measure how well we are adapting to climate change.

This document points to a range of actions being undertaken and funded by the Australia Government to promote the understanding of climate impacts regionally and across sectors.

The second key paper is a recently released short community discussion paper of sorts outlining the *Roles and Responsibilities for Climate Change Adaptation in Australia* (Australian Government 2012b). As with the NCCAF, this paper emphasises a risk management approach to understanding and addressing climate change impacts through adaptive actions. The document directs a broader community conversation about where the responsibility for addressing the impacts of climate change rest, as well as providing high level approaches to adaptation. The latter is focussed on the three tiers of government in Australia. Importantly the document emphasises the need for private interests to take responsibility for climate change risk management and adaptation as it affects them and their circumstances. As noted in the document,

For risk management to be effective in practice, risk bearers need to understand and accept their climate change risks and responsibility to manage them. Parties with a clear understanding of their climate change risks and responsibilities will be better placed to identify those actions that are necessary to manage these risks. Risk management approaches for dealing with these risks should best suit their specific circumstances and preferences of those affected.

It is not feasible, nor appropriate, for governments to bear all the costs of adapting to the impacts of climate change. It would also be inefficient and inappropriate for governments to make decisions on behalf of businesses and individuals that are better placed to understand and manage their own risks. Further, given that most of the assets and activities at risk from climate change are owned or managed by businesses or the community, it is reasonable to expect businesses and the community to manage their exposures.

Private parties should continue to take responsibility for their own actions, assets, investments and risks, while public actions and policies should be carefully targeted and should not undermine the incentives for, or capacity of, private parties to individually manage risk.

The basic principle of allocating the management of climate change risk should be as follows:

- private parties should be responsible for managing risks to private assets and incomes.
- governments – on behalf of the community – should primarily be responsible for managing risks to public goods and assets (including the natural environment), and government service delivery and creating an institutional, market and regulatory environment that supports and promotes private adaptation.

While government policies will influence private sector activity, much action in adapting to anticipated climate change in Australia will need to be undertaken by private parties who respond to climate change risks in the same way they respond

to other risks potentially affecting their livelihoods. Capacities of private parties and governments to adapt to climate change may differ depending on their exposure to risk and access to resources and knowledge.

(Australian Government 2012b: 1-2)

The document further notes that:

As with current risk management in Australia, local initiative and private responsibility will be at the forefront of climate change adaptation in Australia, with the most significant benefits flowing directly to those who plan well to adapt to anticipated changes.

Importantly, it also breaks down the specific roles and responsibilities for the three tiers of government in Australia. In short these are listed as:

The Commonwealth will:

- provide national science and information;
- manage Commonwealth assets and programs;
- provide leadership on national adaptation reform; and
- maintain a strong, flexible economy and a well-targeted social safety net.

The state and territory governments will:

- provide local and regional science and information;
- manage State and Territory assets and programs;
- work with the Commonwealth to implement the national adaptation reform; and
- encourage climate resilience and adaptive capacity.

Local Governments will:

- administer relevant State and Territory and/or Commonwealth legislation to promote adaptation as required including the application of relevant codes, such as the Building Code of Australia;
- manage risks and impacts to public assets owned and managed by Local Governments;
- manage risks and impacts to Local Government service delivery;
- collaborate across councils and with State and Territory Governments to manage risks of regional climate change impacts;
- ensure policies and regulations under their jurisdiction, including local planning and development regulations, incorporate climate change considerations and are consistent with State and Commonwealth Government adaptation approaches;
- facilitate building resilience and adaptive capacity in the local community, including through providing information about relevant climate change risks;
- work in partnership with the community, locally-based and relevant non-government organisations, business and other key stakeholders to manage the risks and impacts associated with climate change; and
- contribute appropriate resources to prepare, prevent, respond and recover from detrimental climatic impacts.

(Australian Government 2012b: 4-9)

Understanding this thrust is important for this research as it allows us to compare our findings on the ground with respect to community expectations with the policy position of the Australian Government. The document is also important as it highlights the broad remit assigned to local governments in terms of risk management and adaptation. Local government is identified as a key actor in bringing about strategies to address the impacts of climate change.

Local governments are at the coal face of addressing, understanding and directing the impacts of social, economic, environmental and demographic change for their communities. Moreover, climate change impacts reach across the full gamut of local government services. The development of plans to mitigate and outline adaptive responses to climate change require a strong commitment from local government as well as other key institutions within communities. Buy-in on issues such as climate variability and climate change impacts is crucial for securing the long-term sustainability, health, liveability and productivity of Australia's rural and regional inland country towns. For many residents of Australia's country towns the concept of climate change (and climate science) remains controversial and they prefer to think of observed weather conditions as climate variability, which may, or may not, be human induced. For them, changing conditions could be a consequence of variation in the natural climate cycle. Raymond and Spoehr (2012) – but see also Simpson (2011) – discussed this perspective in their research on grain and grape growers in South Australia and it represented a common theme amongst many of the stakeholders interviewed during fieldwork. Importantly, a reluctance to consider climate change a reality – now or into the future – can make planning for adaptation difficult, if not impossible. Such attitudes constitute a major hurdle to engagement with the challenge of adaptation, especially if such views are predominant on the local Council.

The Australian Government's *Climate Change Impacts and Risk Management: A Guide for Business and Government* has provided the catalyst for strategic planning for climate change adaptation in Australia (Australian Government 2006). This document uses AS/NZS ISO 31000:2009 to develop high level principles and guidelines to generate a tool for managing climate change risk within an organisation. According to recent research by Booth and Cox (2012) the Guide has been used extensively by local governments across Australia (Booth and Cox 2012). It is a practical guide, setting out a risk management framework to counter the institutional complexity associated with adapting to climate change, particularly given the broad range of organisations and individuals involved in adaptation to impacts.

The *Guide for Business and Government* strongly emphasises the need for adaptation actions to be context specific; taking into account the role of place or geography in determining climate impacts, as related to risks, sensitivities, vulnerabilities and exposure. Helpfully, it provides a schematic of the assessment process underpinning risk assessment for climate change (Figure 1). It also includes an extended version of this schematic, in the event of local government or business needing to undertake a more detailed assessment of a particular climate change impact or impacts (Figure 2). These schematics summarise the steps to be taken for adaptation, and also provide advice on fostering adaptive capacity within organisations, and by extension, communities.

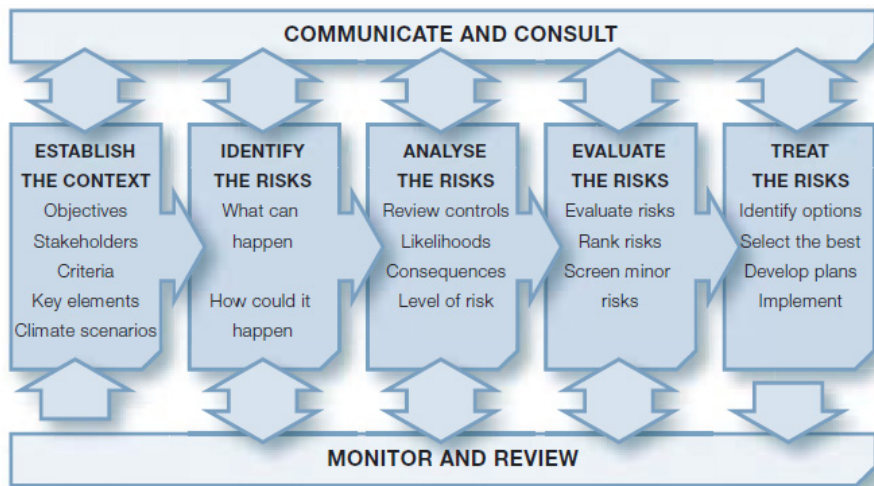


Figure 1: Climate change impact risk assessment process

Source: Australian Greenhouse Office 2006: 19.

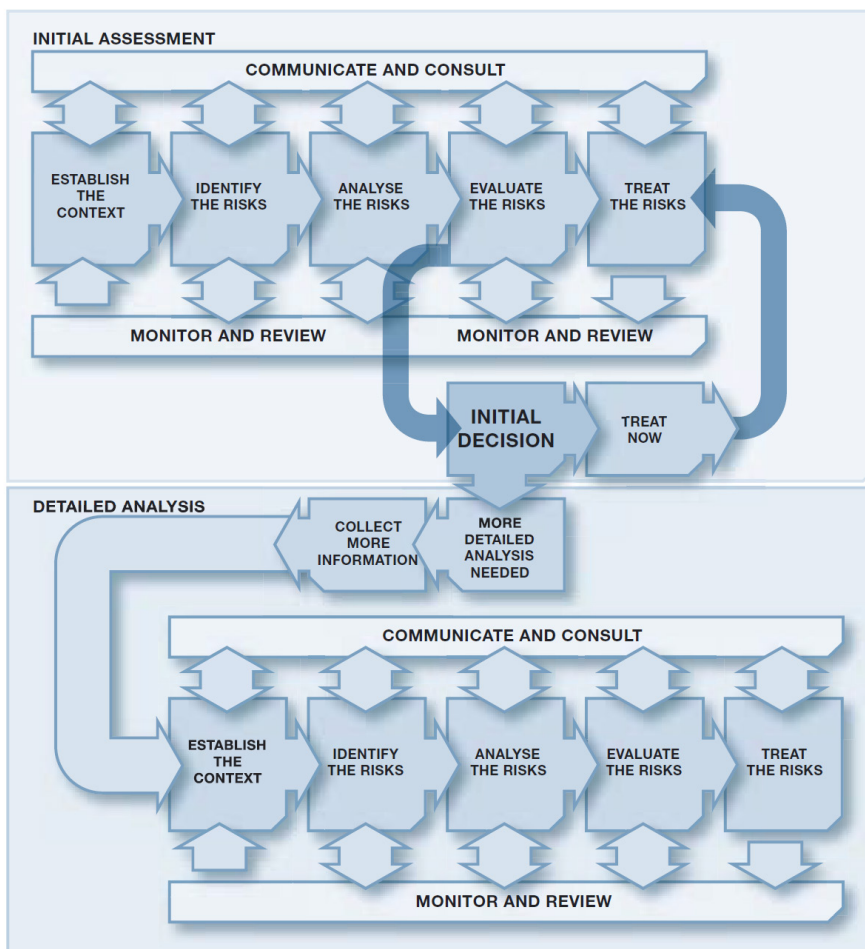


Figure 2: Detailed climate change impact risk assessment process

Source: Australian Greenhouse Office 2006: 21.

Alongside the key documents and the National Climate Change Adaptation Framework, local communities of various types have had access to financial support to identify and manage climate related risks. Such programs include:

- The Local Adaptation Pathways Program provided around \$2 million in funding to help local government build their capacity to respond to the likely impacts of climate change. Two rounds of funding were provided under the LAPP. The first round of the program provided seed funding for 33 projects across Australia. Of these projects six could be defined as inland settlements: Mansfield Shire Council (Victoria); Shire of Murchison (WA); Cradle Coast Authority (Tasmania); Shire of Wongan-Ballidu (WA); Campaspe Shire Council (with Shire of Moira, Victoria); New England Strategic Alliance (including the Armidale, Walcha, Guyra and Uralla Councils, NSW). The brief description of the first round LAPP programs notes the overrepresentation of funding for coastal and urban programs, and reflects the initial priority areas for local adaptation actions.
- Round two of the LAPP funded seven further projects – fundamentally to ‘help councils integrate climate change risk assessment into their broader decision-making processes’. These projects are described on the LAPP website¹ as covering ‘30 councils in regional and remote areas of Australia’. The majority of these councils however touch with coastal areas, rather than being wholly inland areas. The exception being the project by the Towong Shire Council, Alpine Shire Council and the North East Greenhouse Alliance to ‘build resilience to climate change in the community, risk management plans and develop adaptive actions’.
- The Integrated Assessment of Human Settlements sub-program, which has to date funded five projects to build the capacity of councils to identify climate change challenges and develop appropriate responses for councils. The five projects funded under the program are all coastal or urban.
- The Climate Change Adaptation Skills for Professionals Program an investment of almost \$2 million to fund tertiary education, training institutions and professional associations to revise or develop professional development and accreditation programs for architects, planners, engineers and natural resource managers.

(Australian Government 2012a)

Understanding the risks, sensitivities and exposure to climate change for a range of communities – again many of them coastal and metropolitan – has also been a focus of the research funded under the National Climate Change Adaptation Research Facility, funded under the Climate Change Adaptation Program. Significant work has been undertaken to advance understandings of risk, vulnerability, sensitivities and adaptation actions for coastal Australia. It is clear that this has been a priority area of inquiry. While the challenges facing coastal Australia are in many ways different to those facing rural, regional and remote inland Australia, there is a great deal to learn from the processes behind the development of the National Coastal Adaptation Agenda and other key strategies, policies, frameworks and discussions emanating from the work in this area.

While limited resources exist for understanding climate change impacts and adaptation actions for inland areas, a number of resources have been developed for local governments specifically – albeit mostly for councils to manage their own risks/shape their own procedures. These documents provide a useful starting point for identifying and managing risks for inland communities. For example, the report from the Federal

¹ See <http://www.climatechange.gov.au/government/initiatives/lapp/how-lapp-works.aspx>.

Department for Climate Change and Energy Efficiency *Climate Change Adaptation Actions for Local Government* – outlines the reasons for identifying, understanding and managing climate change impacts, particularly in terms of council operations and functions. The Australian Local Government Association (ALGA) and state/territory local government associations have also developed some informational and planning tools around climate change adaptation. Arguably the best developed of these are in Western Australia, Victoria and New South Wales. The Local Government and Shires Association of NSW toolkit, for example, provides a step by step guide to risk assessment and adaptation planning and action; a tool with widespread application for communities. The Victorian Centre for Climate Change Adaptation Research – a joint initiative of four Universities and the Victorian Government – also offers a range of useful resources for smaller and larger communities in understanding climate change and moving to adaptation. The publication, *Scenarios for Climate Adaptation Guidebook for Practitioners* (Wiseman *et al* 2011) outlines key steps in adaptation planning, including understanding, planning for and implementing actions, as well as building and refining scenarios for communities and organisations. It details a scenarios approach to climate change adaptation. Wiseman *et al* provide a number of real and hypothetical case studies of scenario planning.

VCCCAR also recently published a report entitled *Towards a Gippsland Regional Climate Adaptation Study* (Moore *et al* 2011), which details the processes undertaken in the development of the study, as well as setting key priorities for the region. Other VCCCAR publications and resources are equally detailed in terms of process, providing one of the much needed links between process and planning for adaptation that inland communities need. These include the reports of VCCCAR Think Tanks, some of which have occurred in regional Victoria, such as Horsham, (see, for example, VCCARF 2010). The recent work of the NSW Department of Environment and Heritage and key regional stakeholders involved in the South East of NSW Integrated Regional Vulnerability Assessment (including the Snowy Mountains, the Southern Tablelands and the South Coast) also offers an important tool for adaptation planning and documents the process involved in the development of the Integrated Regional Vulnerability Assessment.²

The other valuable resource developed recently for local governments is the working paper *Australian Local Government and Climate Change* by Stefanie Pillora from the Australian Centre of Excellence for Local Government at the University of Technology Sydney (Pillora 2011). The document answers a number of key questions for local governments in terms of climate change: relating to resources, impacts, existing initiatives, responses and gaps in knowledge and actions, needs and challenges. Importantly, the document maps the suite of programs, frameworks and reports (technical, practical and informational) available to assist local governments in their actions. It includes summaries of the key state government frameworks, strategies and key performance indicators, as well as the tools available to local government through the Australian Local Government Association and its state-based counterparts. It also points to some of the key areas of practical concern/actions for local governments that are drawn from the Australian Local Government Association's 2009 report *Towards a National Planning Framework for Climate Change Mitigation and Adaptation* (Table 1). In common with many of the key documents for local government there is a highly functional and service delivery approach to impacts, emphasising risk management in terms of litigation, asset management, natural resource and emergency management and minimisation of damage to infrastructure and the built environment inherent in these identified priority areas.

² See <http://www.environment.nsw.gov.au/climatechange/irvadescription.htm>

Table 1: Potential impacts of climate change on local government services, infrastructure and processes

Planning policy and development assessment	<p>Inappropriate location of urban expansion areas</p> <p>Increased uncertainty in long-term land-use planning and infrastructure design, i.e. location of future developments, suitability of infrastructure designs to cope with changing climate, etc</p> <p>Loss of private property and community assets</p> <p>Increase in insurance costs and public liability claims</p> <p>Increased pressure on disaster management and response resources</p> <p>Early retirement of capital infrastructure</p> <p>Cost of retrofitting of systems</p>
Litigation	<p>Potential legal challenges if it is argued that councils have unreasonably failed to take into account the likely effects of climate change in exercising a wide range of their service, planning and development activities</p> <p>Potential OHS and public liability claims</p>
Coastal infrastructure	<p>Increased coastal erosion and inundation</p> <p>Increased frequency, or permanent inundation of, coastal infrastructure and utilities e.g. water, sewerage, gas, telecommunications, electricity, transportation</p> <p>Destruction, damage and disturbance to council-managed marinas and boat ramps</p> <p>Increased erosion and/or exceeding of seawalls, jetties and other coastal defences</p>
Economic Development and Tourism	<p>Impacts on viability of industries</p> <p>Pressure on tourism activities (especially those relying on natural resources)</p> <p>Impacts on tourism/recreation activities along the coast</p> <p>Increased costs associated with operation and maintenance costs of public amenities/recreational sites due to climate variation</p>
Social and community planning	<p>Rural decline and climate impacts on the rural and regional sectors</p> <p>Increased population pressure on temperate zones</p> <p>Internal migration and accommodation of new migrants and climate change refugees</p>
Provision and use of recreational facilities	<p>Impacts on coastal recreational infrastructure</p> <p>Loss of existing public space in coastal areas</p> <p>Impacts on tourism/recreation activities along the coast</p> <p>Increased costs associated with operation and maintenance costs of public amenities/recreational sites due to storm damage</p> <p>Variation in landscaping design and plant species</p> <p>Needing to provide additional climate protective infrastructure for the young and elderly</p>
Maintenance of recreational facilities	<p>Reduced water quality and quantity resulting in less watering/irrigation of open space and sports grounds and closure of ovals</p> <p>Limited water for swimming pools, etc</p> <p>Beach and inland lake closures, e.g. due to <i>e.coli</i> levels after storms</p> <p>Limited water for swimming pools</p> <p>Need for more open space shelters</p>
Health services; Community/workplace health	<p>Milder winters improving communities' comfort levels</p> <p>Increase in geographical range and seasonality of vector-borne diseases and the possibility for an expansion of infect zones (eg, Ross River fever)</p> <p>Potential increased role in community immunisation</p> <p>High temperatures increasing incidence of food and water-borne diseases</p> <p>Risk of increased cryptosporidium infections during open water swimming in summer</p> <p>Health impacts due to exposure to extreme weather, eg, heat waves</p> <p>Extreme rainfall events transporting contaminants into waterways and drinking water supplies</p> <p>Increased pressure on drinking water supplies</p> <p>An increase in injuries due to increased intensity of extreme events, eg, storm surge and coastal flooding in coastal regions of Australia due to changes in sea level rise and human settlement expansion into coastal catchments</p>

Emergency/bushfire management	<p>Increased emergency response and recovery operations</p> <p>Risks to public safety and tourism and longer term impacts on regional economies</p> <p>Responding to flooding, drought, bushfire, cyclones/major storms, coastal inundation, heat wave, landslides, erosion</p> <p>Reduction in water availability for irrigation</p> <p>Changes in pest management</p>
Agriculture/biosecurity	<p>Changes in the type and viability of primary industries</p> <p>Loss of farming properties</p> <p>Reduction in water availability for irrigation</p> <p>Changes in pest management</p>
Natural resource management/coastal management	<p>Increased coastal erosion and inundation</p> <p>Loss of private property/community assets</p> <p>Loss of beach width</p> <p>Changes to wetlands due to sea level rise, shoreline erosion and saltwater intrusion</p>
Weed/pest management	<p>Changes in distribution of invasive species due to changes in climate and associated loss of biodiversity and changes to bushfire intensity</p>
Biodiversity Protection	<p>Shifts in distributions of plant and animal species</p> <p>Increased risk of population and species extinctions</p> <p>Reduced ecosystem resilience to stress</p> <p>Increased ecosystem and species heat stress</p> <p>Increased pressure on dunal systems</p> <p>Changes to mangrove habitats due to salt water intrusion</p> <p>Increases in ecological disturbances</p>
Water and sewerage services	<p>Inundation of storm water and sewerage systems</p> <p>Reduced security of water supply (depending on source)</p> <p>Environmental and supply contamination</p> <p>Increased peak flows</p> <p>Increased potential for erosion</p> <p>Changes in groundwater levels</p> <p>Changes in flood plains</p> <p>Reduced dry weather sewerage flows</p> <p>Reduced/unreliability of power supply for sewage pumping and treatment if existing electricity suppliers cannot maintain pace with long term changes in climate</p>
Stormwater and drainage	<p>More intense rainfall resulting in inflow and infiltration into wastewater networks</p> <p>Exceeding existing flood defences</p> <p>Exceeding drainage capacity</p> <p>Reduction in drainage capacity due to sea level rise and storm surge</p> <p>Changes in mean and peak stream and river flows</p> <p>Lower levels of rainfall, reducing pressure on storm water systems</p>
Wastewater	<p>Changes in intensity of rainfall events impacting inflow and infiltration to wastewater network</p> <p>Potential for blockages and dry weather overflows during dry spells</p>
Water supply	<p>Changes in mean and peak stream and river flows</p> <p>Uncertain water availability</p> <p>Insufficient water supply in some areas</p> <p>Increased potential for water contamination</p> <p>Salination of surface and groundwater supplies</p> <p>Changes in availability of groundwater available for irrigation</p>

Source: ALGA 2009 in Pillora 2011.

There are lessons from the international literature, though much of it is dominated by explanations of climate science and broad frameworks for adaptive actions, rather than the practical application of actions to specific places. Boxes 1, 2 and 3, provide three commonly referenced examples of principles for successful adaptation.

Box 1: United Kingdom Climate Impacts Programme Principles of Effective Climate Change Adaptation

Work in partnership – identify and engage your community and ensure they are well informed.

Understand risks and thresholds, including associated uncertainties.

Frame and communicate SMART* objectives/outcomes before starting out. (SMART objectives – specific, measurable, achievable, results-oriented, and time-bound objectives.)

Manage climate and non-climate risks using a balanced approach – assess and implement your approach to adaptation in the context of overall sustainability and development objectives that include managing climate and non-climate risks.

Focus on actions to manage priority climate risks – identify key climate risks and opportunities, and focus on actions to manage these.

Address risks associated with today's climate variability and extremes as a starting point towards taking action to address long-term climate change risks and opportunities.

Use adaptive management to cope with uncertainty – recognise the value of a phased approach.

Recognise the value of no/low regrets and win-win adaptation options in terms of cost-effectiveness and multiple benefits.

Avoid actions that foreclose, limit future adaptations or restrict adaptive actions of others.

Review the continued effectiveness of adaptation decisions by adopting a continuous improvement approach that includes monitoring and re-evaluation of risks.

Source: UKCIP 2012.

Box 2: Guiding Principles for Adaptation, White House Council on Environmental Quality

Adopt Integrated Approaches: Adaptation should be incorporated into core policies, planning, practices, and programs whenever possible.

Prioritize the Most Vulnerable: Adaptation plans should prioritize helping people, places and infrastructure that are most vulnerable to climate impacts and be designed and implemented with meaningful involvement from all parts of society.

Use Best-Available Science: Adaptation should be grounded in the best-available scientific understanding of climate change risks, impacts, and vulnerabilities.

Build Strong Partnerships: Adaptation requires coordination across multiple sectors and scales and should build on the existing efforts and knowledge of a wide range of public and private stakeholders.

Apply Risk-Management Methods and Tools: Adaptation planning should incorporate risk management methods and tools to help identify, assess, and prioritize options to reduce vulnerability to potential environmental, social, and economic implications of climate change.

Apply Ecosystem-based Approaches: Adaptation should, where relevant, take into account strategies to increase ecosystem resilience and protect critical ecosystem services on which humans depend to reduce vulnerability of human and natural systems to climate change.

Maximize Mutual Benefits: Adaptation should, where possible, use strategies that complement or directly support other related climate or environmental initiatives, such as efforts to improve disaster preparedness, promote sustainable resource management, and reduce greenhouse gas emissions including the development of cost-effective technologies.

Continuously Evaluate Performance: Adaptation plans should include measurable goals and performance metrics to continuously assess whether adaptive actions are achieving desired outcomes.

Source: EOoPUSA 2010.

Box 3: Key features and learnings from existing adaptation guidelines, for report Design of guidelines for the elaboration of Regional Climate Change Adaptations Strategies for the European Commission

Gaining political backing and managerial commitment: Since adaptation is a multidisciplinary issue that cuts across policy and service areas, gaining political backing and managerial commitment are crucial when developing an adaptation strategy. Gaining backing from politicians can help get buy-in from the various departments at a regional authority, whilst securing senior management commitment can assist in the development of adaptation responses and help secure funding to implement these actions.

Noted examples from the EU review include: Nottingham Declaration, UNECE guidance, ICLEI guidance, ESPACE.

Embedding/Mainstreaming climate change adaptation within existing plans, policies and programmes: Embedding or mainstreaming adaptation into existing and future plans, policies and programmes is considered by most of the guidelines reviewed to be an important step in reducing vulnerability to climate change in all sectors. It also ensures that climate change visions and targets are reflected consistently through all policy including sustainable community strategies, asset management plans, travel plans and procurement policies. In addition to having a stand-alone adaptation strategy, the necessary adaptation actions should be a feature of all policies to help avoid adaptation being viewed as an 'optional extra'.

Noted examples from the EU review include: Nottingham Declaration, ASTRA guidance, ESPACE guidance, UNECE guidance, UNDP guidance.

Developing an evidence base: A robust adaptation strategy will be based on sound science and the best available technology/information, for example climate change scenarios and risk assessments should be used to identify potential threats and opportunities of a changing climate.

Noted examples from the EU review include: UKCIP Adaptation Wizard, Nordregio guidance.

Identification of key vulnerabilities: Vulnerability assessment is a way of measuring the degree to which a community/sector or an asset/resource will be affected by adverse effects of climate variability and change. Issues to consider before conducting a vulnerability assessment include time available, priority planning areas, budget available and which scenarios to consider i.e. best case, worst case or business as usual.

Noted example from the EU review include: ICLEI guidance.

Selection and assessment of adaptation options: Adaptation options can be split into four categories: 'no regrets', 'low regrets', 'win-win', and flexible or adaptive management options. Noted examples from the EU review include: Nordregio guidelines, UKCIP Identifying Adaptation Options.

These actions can be further divided depending on whether they build adaptive capacity (planning, research and education) or implement physical measures such as flood and coastal defences (Australian guidance). Mal-adaptation can be avoided by not implementing adaptation options which are likely to increase vulnerability to climate impacts in the future.

Noted examples from the EU review include: ASTRA guidance, ESPACE guidance.

Stakeholder engagement and communication: This stage is considered a key to a successful strategy and should effectively engage stakeholders in order to maximise understanding and acceptance of the strategy.

Noted examples from the EU review include: Nottingham Declaration, UKCIP Adaptation Wizard, Alpine guidance, UNECE, USAID.

Monitoring, evaluation and review: The purpose of monitoring, evaluating and reviewing the strategy is to determine whether the project or activity delivers the intended benefits and/or creates negative impacts. Evaluation and monitoring activities should be conducted to verify the effectiveness of measures taken and to make adjustments if needed. In addition it allows you to keep up to date with climatic, scientific and technological developments.

Noted examples from the EU review include: ASTRA, ESPACE, UNECE.

Source: Ribeiro *et al* 2009, pp.13-14.

The key messages from these frameworks and principles are:

- partnerships;
- good communication (of what is generally complex information);
- prioritisation;
- tailoring approaches to geography and place; and,
- treating adaptation as an iterative and mainstream process.

These factors are also strongly emphasised in local documents, such as the *Victorian Climate Change Adaptation Research Facility Scenarios for Climate Adaptation Guidebook for Practitioners* (Wiseman *et al* 2011) and the more recently developed state/territory climate change adaptation frameworks which have been developed to advance national adaptation reform.

The recently released document *Prospering in a Changing Climate: A Climate Change Adaptation Framework for South Australia* (Government of SA 2012a) identifies a similar suite of guiding principles to those discussed above, adding the issue of scale – develop responses at the most appropriate scale – to the impact/adaptation picture (Box 4).

Box 4: Guiding Principles of Prospering in a Changing Climate: A Climate Change Adaptation Framework for South Australia

Recognise uncertainty and deliver adaptation actions where there is a plausible risk of harm

Prioritise actions based on careful assessment of risks, costs, efficacy and equity using the best available science to inform adaptation responses

Give priority to sectors likely to provide the greatest social, economic and environmental benefit for the state

Develop responses at the most appropriate *scale* to effectively address risks and maximise opportunities

Involve individuals, industry, business, academia and all tiers of government in developing responses using a coordinated approach

Build on, enhance and learn from the experience of communities, sectors and regions in developing adaptation responses

Plan for uncertainty and take action using an adaptive management approach to allow for readjustments as new information arises

Use the best available, most appropriate and locally relevant science based on good data and robust processes, to inform those best placed to deliver adaptation responses and manage risks

Take into account the need for flexibility to respond to emerging trends, including population projections and socioeconomic trends

Consider how best to **optimise and recognise the interconnections between social, environmental and economic systems**, and linkages between sectors in planning to adapt to climate change in a sustainable manner

Ensure responses avoid unintended consequences and do not undermine our ability to adapt over the long term

Take early action where there are demonstrated cost–benefits

Ensure that adaptation responses are appropriately **integrated and mainstreamed** into ongoing business.

Source: Government of SA 2012a: 17, emphasis added.

The SA Framework is also backed by a document clearly outlining the SA Government's roles, responsibilities and expectations for Government and other institutions. Importantly, they outline the path forward for developing regional adaptation plans across SA. The steps strongly emphasise the incorporation of adaptation actions in all activities of government, and the community, through partnerships between state agencies and local government, natural resource

management and Regional Development Australia boards, as well as local business and community leaders (see Box 5).

Box 5: Excerpt from strategies and actions for Government, Government Action Plan for the Climate Change Adaptation Framework in South Australia

Strategy 1.1 Lead South Australia's adaptation efforts

Action 1.1.1 **Establish Regional Agreements** under the *Climate Change and Greenhouse Emissions Reduction Act 2007* between the State Government and regional organisations including local governments, natural resources management and regional development boards and local leaders
Lead: Sustainability and Climate Change, Department of Environment, Water and Natural Resources (DEWNR)

Action 1.1.2 **Work with regional stakeholders to establish Regional Committees** that oversee implementation of the Adaptation Framework; coordinate funding submissions; oversee regional governance arrangements and the development of regional adaptation strategies and plans and engage with key stakeholders and lead the development of locally relevant adaptation responses. The Regional Committees will be established under the Regional Agreements
Lead: Sustainability and Climate Change, DEWNR

Action 1.1.3 **Conduct Regional Integrated Vulnerability Assessments** overseen by Regional Committees to assess the level of risk to business, communities and the environment
Lead: Regional partners

Action 1.1.4 **Establish a cross agency group** to deal with adaptation issues affecting more than one government agency, this includes issues that are identified through Regional Committees and Integrated Vulnerability Assessments and which fall within the State Government's responsibilities
Lead: Sustainability and Climate Change, DEWNR

Action 1.1.5 **Support the cross agency group** by committing one senior executive and providing ongoing support to its work programme
Lead: Sustainability and Climate Change, DEWNR supported by relevant agencies

Action 1.1.6 **Support Regional Committees** by committing one senior executive per region in geographic areas of particular relevance to the business of the agency
Lead: Sustainability and Climate Change, DEWNR supported by relevant agencies

Action 1.1.7 **Prepare whole-of-government responses** to climate change adaptation plans provided to Government by regional committees
Lead: Sustainability and Climate Change, DEWNR supported by relevant agencies

Action 1.1.8 **Hold an annual adaptation forum** to provide the opportunity for regional and state organisations to share information and experiences and to ensure common approaches and methodologies
Lead: Sustainability and Climate Change, DEWNR

Action 1.1.9 **Bring together a community of climate change adaptation practitioners** within the State and Local Government and academia to encourage the sharing of adaptation information and ideas by providing regular meeting opportunities and utilising appropriate communications technologies
Lead: Sustainability and Climate Change, DEWNR

Strategy 1.2 Build partnerships with the business community and non-government organisations

Action 1.2.1 **Engage with key business and non-government organisations** to identify key roles and responsibilities and adaptation activities
Lead agencies: Sustainability and Climate Change, DEWNR in consultation with DMITRE and DPTI

Source: Government of SA 2012b: 11-12.

Helpfully the report *Design of Guidelines for the Elaboration of Regional Climate Change Adaptations Strategies* for the European Commission (Ribeiro *et al* 2009: 15) identifies a series of gaps and in adaptation guidelines that have direct applicability in Australia. These include:

- lack of understanding of adaptation as a process and what it means in terms of outcomes;
- need for better direction in adaptation guidelines and toolkits regarding setting objectives;
- lack of data on climate risks and their impact(s) at the regional/local level;
- little or poor examination of sector impacts of climate change and adaptation;
- poor cooperation and communication between key actors and agencies in developing adaptation plans, communicating results and key information and reviewing activities, and poor communication/alignment of/about adaptation actions across regional and other jurisdictional boundaries.

At the more local level, Pillora (2011) points to some of the key gaps in information and process for adaptation by local governments. These include:

- the need for accessible and consistent information on 'effects, impacts and responses' to climate change and climate science, including within and between government departments;
- understanding of the long-term costs of/budgeting for adaptation;
- assistance to access the specialist advice needed to engage in adaptation and risk management planning;
- support from state/territory governments with enforcement of certain planning guidelines and regulations at the local level;
- assistance to set and prioritise actions for communities and local government operations;
- funding commensurate to responsibilities devolved to local governments, particularly for councils and communities with poor resources and most vulnerable to climate change and associated economic and social impacts;
- better sharing of institutional and organisational learning from adaptation planning trials;
- how to make climate adaptation the core business of relevant organisations;
- development of common metrics, performance indicators/targets and frameworks for institutions with common characteristics and facing similar challenges; and,
- different priorities and programs for adaptation between jurisdictions nationally, with implications in some cross-border regions, adding to confusion and potentially duplication of effort where climate impacts, effects and responses find expression across borders.

This last point is particularly pertinent in Australia where state borders (and in some instances local government boundaries) determine access to information, programs and other support, and where climate change impacts and therefore adaptation actions may need to cross boundaries. This is yet another argument for regionalisation of adaptation plans, in a similar vein to regional development organisations, natural resource management boards/catchment management authorities and the like. It also

shows out the importance of high level direction and coordination of vulnerability assessment and adaptation planning activities.

1.3.2 Climate adaptation in rural and regional Australia: current practices

The limited nature of the research around climate change in rural and regional Australia extends to our understanding of adaptation actions and strategies for settlements. On the whole few integrated climate change adaptation strategies exist for inland settlements or regions nationally. In some respects this is because such plans are in development, as they are in the more populated areas of the country, such as in coastal and urban settlements. It is therefore difficult to identify best practice in terms of local adaptation plans. Instead we can only identify the handful of plans in place; and most of these have been developed very recently, having received specific funding from the Australian Government under the Local Adaptation Pathways Program discussed earlier. There is not room here to discuss all of these initiatives and they are in varying stages of planning, development and execution. As an example of activity, Box 6 outlines the current state of adaptation planning in the Campaspe Shire, Victoria.

Box 6: Short case study – preparing for climate change in the Shire of Campaspe, Victoria

The Shire of Campaspe in Victoria has proposed a climate change action plan that integrates both mitigation and adaptation, using a risk management approach. The Plan is focussed on internal shire functions and also how this will impact the community they serve. It has been developed to link in with current risk management strategies, to be a bolt on to the Shire's current planning and strategic focus. The Shire has framed their actions around four key strategies which include:

- *Mitigation* of greenhouse gas emissions.
- *Adaptation* to the priority risks from climate change.
- Building Council's capacity to *adapt* to impacts from climate change;
- *Influence* the community's overall greenhouse gas emissions and their capacity to adapt to climate change

The shire was able to identify eight key areas through their assessment of risk that climate change could impact on the shire and their ability to deliver in their core areas. These eight key areas are: *Asset management, Biodiversity, Business and economic development, Emergency management, Parks and gardens, Public and environmental health, Service provision, Volunteerism.*

To achieve their objectives areas were identified within the Shire that would require adjustments to be made in terms of their capacity to deal with climate change. These adjustments would be additional resources, behaviour and technologies available to assist with implementing the action plan. These adjustments include:

- *strengthening internal and external communications on climate change;*
- *dispersing responsibility for action on climate change across Council departments, with coordination and integration provided by the Environment Department;*
- *develop regional governance arrangements for climate change;*
- *monitoring and review of this Plan and its activities and achievements, in line with Council performance reporting and Council Plan review processes.*

Source: Shire of Campaspe 2010.

The Mid West Regional Council (MWRC), Western Australia has embarked on a similar process of adaptation planning. In this instance planning has taken a more regional focus to risk management and adaptation planning, involving seven member councils working together to set adaptation strategies (Box 7). This regional approach is also evident in the structure and works of the Central Victorian Greenhouse Alliance, discussed in Box 8.

Box 7: Mid West Regional Council (MWRC), Western Australia

The Mid West Regional Council (MWRC) Climate Change Risk Assessment and Adaptation Action Plan Project was a collaboration of seven member councils (Carnamah, Coorow, Mingenew, Morawa, Mullewa, Perenjori and Three Springs) and was funded by the Australian Government Department of Climate Change and Energy Efficiency, the MWRC and member councils. Each member council received a tailored Climate Change Adaptation Action Plan.

Using a private consultant they engaged in a risk management process as outlined in *Climate Change and Risk Management: A Guide for Business and Government*. This centred on the five stages of the Guide's risk framework:

- Set the Context.
- Identify the Risk.
- Analyse the Risk.
- Evaluate the Risk.
- Treat the Risk.

The member councils came to agreement on addressing a number of climate change impacts and developed strategies for implementing adaptation actions. The key areas include:

- Bushfire management
- Improving the preparedness and resilience of the farming community
- Biodiversity
- Potable and non-potable water supplies
- Extreme events
- Health
- Coastal

The key to achieving a targeted risk assessment for the MWRC region stemmed from member councils allocating responsibility to the MWRC to undertake adaptation actions that delivered common benefits across the region. These actions focussed on:

- (i) lobbying on behalf of member councils to obtain support, or to engineer a change in the practice(s) of a government agency or management authority with statutory responsibilities within the region, or a non-government organisation active in the region; and
- (ii) to pursue funding on behalf of all member Councils and in some cases, to employ staff who may have a role across the entire MWRC region (Nash *et al* 2010, p. 91).

By undertaking a rigorous risk assessment process the MWRC were able to target a whole of region approach for developing adaptation actions. It is hoped this process will enable the councils and communities within the region to engage in and implement local responses.

Source: Nash *et al* 2010.

Box 8: Central Victorian Greenhouse Alliance

The Central Victorian Greenhouse Alliance (CVGA) was formed in 2000. It is a member organisation comprised of the 14 councils in Central Victoria, a number of businesses and services based in the region and some local environment action groups.

The Alliance's overarching remit is to use world's best practice to reduce CO₂ emissions within the region. It plans to do this by playing a key role in creating sustainable, climate-aware communities and profitable, climate-friendly economies in the region. The Alliance's key objectives are:

- to reduce Central Victorian Greenhouse Gas Emissions by 30 per cent below 2000 levels with the goal of achieving zero net emissions by 2020
- to promote sustainable development and sustainable economic growth throughout the region

The Alliance notes that their work is 'helping central Victorian communities to develop and utilize sustainable low emission and renewable energy options, to embrace and practice energy use behaviour change, and to be ready to capitalise on new jobs, new technologies and new markets in the emerging low carbon economy'.

CVAG's key objectives include:

- raising awareness of climate change, its effects and the solutions
- initiating, driving and coordinating projects
- facilitating networks, partnerships and cooperative ventures
- sourcing project funding, information and resources
- providing a forum for discussing opportunities and challenges

Most of the actions of the Alliance have a mitigation rather than adaptation focus, but Alliance members believe the knowledge gained from their actions will filter through to adaptation actions and strategies. Some of the successful action undertaken by the Alliance to abate greenhouse gases in the regional include:

- Central Victoria Solar Cities – part of the Australian Government's \$94 million Solar Cities program. It offers incentives to local residents and businesses to participate in a trial range of energy efficiency, local energy generation and demand management products and services. CVAG is a key player in the consortium delivering the Central Victorian Solar Cities programs, and was instrumental in winning this program for the Central Victorian region.
- *Refit n' Save* – The Refit n' Save project ran for 2011. It was a partnership between five community sustainability groups, co-ordinated by CVGA. It built and used a network of local businesses and service providers to make sustainable choices easier. The project assisted 800 households with sustainable water, energy, heating and cooling measures. It was supported by the Victorian Government Sustainability Fund managed by Sustainability Victoria. (See <http://www.refitnsave.org.au/>)

The Alliance has also successfully delivered sustainability projects on 'Reaching for Renewables' and aimed at household behaviour change. They have also commissioned a range of research into the competitive and comparative advantages of the area in terms of sustainability, as well as research into zero net emissions for small shires.

The Alliance also describes its role as:

- supporting energy efficiency in local government
- addressing regulatory barriers
- supporting new technologies, services and projects
- supporting and mentoring new climate change groups

The Alliance has brought together a range of stakeholders to create a forum for debate on climate change impacts and actions to address impacts. It uses a bottom up approach to assessing and addressing impacts.

Source: www.cvga.org.au.

These examples highlight that climate change risk assessment and adaptation planning is in its infancy in most of inland Australia. Moreover, for the most part, the actions being undertaken are being driven by local government risk and asset management. Accordingly, the focus of the adaptation plans centres on the operations of local government, rather than a whole of community approach to identifying, understanding and managing climate change impacts.

1.4 Structure of this report

The remainder of this report is structured as follows.

Chapter Two summarises the literature on Australia's country towns and climate change, looking also at the likely and varied impacts of climate change on different regions nationally.

Chapter Three extends the discussion in the preceding chapter, to consider the industry-specific impacts of climate change and sustainability, for those sectors underpinning Australia's rural and regional settlements.

Chapter Four presents the final Index of Vulnerability for Australia's country towns. This chapter revises earlier work presented in the first output of this project, showing similar concentrations of vulnerability – in remote communities and the south west of Western Australia.

Chapter Five summarises the findings from the case studies undertaken as part of this research.

Chapter Six summarises expert opinions about the future of Australia's country towns to 2050 – from the Delphi Analysis.

Chapter Seven synthesises the results from the whole project, pointing to key gaps and directions as well as eliciting distinct policy implications.

2. THE IMPORTANCE OF PLACE: CURRENT KNOWLEDGE ON AUSTRALIA'S COUNTRY TOWNS AND CLIMATE CHANGE

2.1 Introduction

Significant policy, research and community attention has been directed to the issue of climate change and its impacts over recent years. While debate about the cause and extent of impacts, certainty of climate modelling, and the shape and urgency of efforts to measure, mitigate and adapt to the impacts of climate change has ensued, it is clear that Australian communities cannot ignore this issue. This is true for all communities, regardless of whether they are urban, peri-urban, rural, regional or remote settlements.

This chapter presents the findings of a targeted review of the literature around climate change and rural, regional and remote Australia. The focus of the discussion is the extant literature on climate change and the role and functioning of country town in the Australian landscape. This literature review has been conducted to serve two purposes: first, to present what we know already in these arenas, and, second, given the still anticipatory nature of climate change-related impacts, what is predicted or likely to occur in Australia's country towns.

The literature reviewed here has been captured through a conventional systematic analysis of academic databases, examination of the relevant grey literature and the review of the plans and strategies by key institutions and stakeholders active in the climate change and settlements areas. Such institutions include the National Climate Change Adaptation Research Facility (NCCARF) and the growing body of work by the CSIRO, including that being undertaken by the CSIRO Climate Adaption Flagship. The review has also captured relevant documents from government agencies across all tiers of government, including Regional Development Australia agencies and local government plans for climate action and sustainability generally.

The discussion in this chapter focusses on the key themes emerging from the literature and is structured as follows. First, an overview of the state of the climate change literature is provided. This discussion highlights the complex and often confusing nature of what is a broad and ever-expanding body of work. Following this, the discussion outlines the likely impacts of climate change in Australia that are relevant to country towns – socially, culturally, environmentally and economically. This section of the chapter focusses on the impacts in a number of key areas:

- impact of extreme weather events;
- issues around water sources and irrigation;
- impacts on infrastructure and the built environment; and
- public health impacts and concerns

The predicted specific impacts of climate change on settlements in terms of their economic development and industrial bases is the notable omission in this chapter. However, this topic is the focus of the next chapter of this report.

2.2 Australia's country towns and climate change

Nationally the literature on climate change is well established with contributions from a range of different institutions and, increasingly, draws upon research that crosses traditional academic disciplines. It is also a complex body of work, with often confusing messages and outcomes. Accordingly, it is difficult to capture the breadth of experiences and knowledges within the climate science, climate variability and climate change debates.

When looking at the Australian (and international) climate change literature generally, there are three clear streams of analysis and argument:

- a body of work focussed on global and national contextualisation of probable and likely climate change-related impacts, risks and vulnerabilities;
- a literature around mitigation of such impacts; and,
- a literature on adaptation to impacts.

In looking at these works as a whole it is clear that each of these bodies of work represents a progression in our understanding of climate change, likely climate change-related impacts and the implications at the global level, for nation states, and regions and places within nation states. In many ways these literatures are an extension of past studies of the environment and the economic and cultural factors shaping human responses to climate. Seminal works here include Donald Meinig's *On the Margins of the Good Earth* (1962), Joe Powell's *The public lands of Australia Felix* (1970) and *An historical geography of modern Australia: the restive fringe* (1988) and the works of Les Heathcote over many years, including his posthumously published work *Drought and the human story: braving the bull of heaven* (Ashgate 2013), *Australia* (1st edn 1975; 2nd edn 1994), *Back of Bourke: a study of land appraisal and settlement in semi-arid Australia* (1965) and collections edited by Heathcote (and others) such as *The Australian experience: essays in Australian land settlement and research management* (1988), *Land, water and people: geographical essays in Australian resource management* (with Mabbutt, 1998). These works remind us to acknowledge changing patterns of land use and settlement over time, as well as the constant evolution of environmental understanding and environmental policy, changing views/contestations about the environment and the impact of social structures and institutions on the environment, economy and culture, including expression in policy spheres.

While the three foci within the literature outlined above appear to be linear in progression, because of the complexity of climate science, improvements in modelling and data, significant inter- and intra-regional variation in impacts, resources and adaptive capacity, and the expected far-reaching impacts of climate change, significant work is *ongoing* in each of these three areas. These efforts will allow us to better understand climate change processes, impacts and vulnerabilities. Indeed, the climate change literature in Australia is being added to almost daily – reflecting the importance afforded to this issue by the research community, governments and, albeit to varying degrees, communities and individuals. With such rapid evolution in understanding, it is difficult to keep up with new understandings, predictions and messages. These facts add significantly to the challenges being faced at the local level in understanding, preparing for, and adapting to, expected climate change impacts.

This literature review summarises key findings for regional, rural and remote Australia from those bodies of research work that have considered contextualisation/predicted impacts, mitigation and adaptation. However, much of this discussion considers what we know and can expect from the context/quantification literature, and from the emerging body of *local-level* work in the adaptation literature.

The adaptation literature, in particular, is highly relevant to this project as adaptation recognises and emphasises the importance of temporal and spatial scales and the interdependencies of human and natural systems, particularly in terms of *addressing* the likely impacts of climate change. Adaptation has been variously defined elsewhere. In the context of this research, the key elements are captured in the following definitions by the IPCC and United Nations Development Program respectively:

Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (IPCC 2001).

A process by which strategies to moderate, cope with and take advantage of the consequences of climatic events are enhanced, developed, and implemented (UNDP 2005).

It would be remiss not to mention that 'Adaptation...can be considered an agenda still very much in its infancy' (Martens *et al* 2009: 16). Given this, it is unsurprising that much of the literature on adaptation is theoretical or quasi-theoretical in nature, emphasising the complexities driving, and to be taken into account in, adaptation.

Moreover, as Fünfgeld and McEvoy (2011) note:

climate change adaptation can be considered a **process of continuous social and institutional learning, adjustment and transformation**. Understanding adaptation as an ongoing process of learning is particularly relevant for local and regional scale decision making. (Fünfgeld and McEvoy 2011: 6)

This perspective on adaptation highlights the importance of human factors in responding to an environmental challenge. Places and individuals better able to adapt and adjust will have better prospects than those trapped in past production systems or ways of thinking. Critically then, factors such as educational attainment within the community, access to information and vibrant bridging social capital will contribute to the success of some communities and towns.

McEvoy *et al* (2010) have recently furthered these perspectives, considering adaptation frameworks from Europe. Their research noted that successful adaptation is affected by local institutional capacity, the 'inconsistency of regulations' and local economic difficulties, which may adversely affect the provision of resources to implement actions. Additionally:

Achieving a better understanding of future risk, and therefore how best to adapt, requires an integrated assessment of both climate and non-climate scenarios i.e. consideration of multiple stressors. In practice, the extent and exact form of adaptation will be further influenced by a complex array of interacting factors including the perception of potential risk by decision-makers, political and institutional context, issues such as cultural heritage, the availability of financial resources etc. (McEvoy *et al* 2010: 792)

The literature and evidence on climate change adaptation presents both conceptual and practical challenges for researchers, especially when considering something as concrete as a nation's settlement pattern. Preston and Jones (2006) noted that climate change carries the potential for both benefits and negative impacts, as 'economic benefits may occur for warming as high as 3-5°C, given sufficient rainfall' (Preston and Jones 2006: 20). But both the challenges and the opportunities presented by climate change will require significant planning and adaptation efforts in order to maximise the potential advantages and minimise the disadvantages. Howden and Jones (2001) for example, quoted research on the wheat industry in Australia that noted the possible increase in wheat yield associated with climate change could be offset by reduced production as a consequence of a greater incidence of pests and diseases.

Importantly, the published and grey literature in this area also generally concurs around a point succinctly put by Sposito (2006: 23.20), that:

The pathway to adapting to climate change is likely to be a series of shorter-term actions moving towards long-term strategic goals. Short-term activities, such as crop choice in agriculture, can be useful adaptation options that are implemented incrementally, so they can respond to climate variability on a seasonal basis. On the other hand, the impact of agricultural activities on landscape systems and its effects on processes, such as salinisation, will require long-term planning horizons.

Other literature and programs provide important learnings, also demonstrating the complexity, multiple actors and therefore complexities in framing and understanding climate change and its local level impacts. For example, a US based initiative – America’s Climate Choices Program – has generated a number of relevant findings on the nature of adaptation and its intersection with policy. This program identified a number of impediments to ‘adapting well’, including:

- climate change mitigation, not adaptation, is traditionally the priority;
- continued climate scepticism;
- the politics of climate change in the US – there are long term neoliberal trends to less government intervention, and smaller budgets;
- a current 'adaptation deficit' especially lack of maintenance of infrastructure and declining investment in research and development;
- US conventional economics discounts the future, and politics is short term;
- institutions lack mandates, resources, information and professional capacity;
- confusion or lack of agency responsibilities;
- maladaptive regulations and institutions; and,
- lack of research on adaptation (as opposed to other areas of climate science). (Liverman in Batterbury 2010: 6)

Liverman (in Batterbury 2010) noted that an effective National Adaptation Strategy can be sketched out and that it should be a multi-level strategy involving multiple actors, where the Federal Government:

- facilitates cooperation and collaboration across different levels of government and between government and other parties;
- provides technical and scientific resources to the local or regional scale;
- re-examines policies that may inhibit adaptation;
- supports scientific research in adaptation and climate change;
- practices adaptation in its own programs and lands. (Liverman in Batterbury 2010: 6).

Such broad-scale insights are helpful in beginning to flesh out the policy implications of research into the nature of Australia’s country towns in 2050 as informing policy is a key objective of this project. This research project seeks to make a contribution to this incremental and iterative process of adaptation by identifying the nature and level of risk confronting Australia’s country towns. Such knowledge will assist in developing better policies and processes.

The focus within this review on the context and adaptation literatures is not to downplay the importance of the mitigation literature. It is merely a question of temporal and

spatial scale. The mitigation literature generally centres on higher level actions to mitigate impacts. Accordingly, this literature is focussed on measures to reduce greenhouse gas emissions into the atmosphere, through:

- actions for carbon abatement – using carbon sinks and stores;
- carbon pricing as a mechanism for reducing Australia's dependence on fossil carbon for industry and regional economic development; and,
- development and promotion of low emissions energy technologies, so called 'green' energy alternatives, such as solar and wind power generation to reduce the nation's reliance on fossil fuels, particularly within the energy and transport sectors.

To date, this literature has also had the dual purpose of providing evidence for the need for high level political and community support for, and engagement with, global protocols for greenhouse gas emissions.

Much of the published research on climate change adaptation in Australia consists of local-level studies promoting place-based actions to adapt to current trends. Many such studies have been specifically urban in focus, or focussed on the priority areas identified by government and other key organisations. To date, these have been:

- The Murray Darling Basin;
- Coastal communities;
- South West Western Australia;
- Alpine regions;
- Rangelands;
- The Great Barrier Reef.

Understanding impacts at the local level (for communities, for settlements and for individuals) and promoting adaptation is the logical next step for climate change research. In part this reflects the priorities of governments and key organisations in the climate change field. It is also a priority area of action. The then Prime Minister's Science, Engineering and Innovation Council, for example, were explicit about the need for this focus in their report *Climate Change in Australia: Regional Impacts and Adaptation – Managing the Risk for Australia* (PMSEIC 2007), highlighting the following 'key areas for action':

- developing national, regional and sectoral adaptation plans;
- communicating information and educating the community about adaptation and adaptation responses;
- increasing the priority given to climate change adaptation research; and,
- removing current impediments to multidisciplinary collaborative programmes of research relevant to climate change adaptation.

And, further,

- knowledge about both future regional climates and the impact of these changes on local communities, economies, industry and infrastructure; and,
- research into and knowledge of the economic, social and health implications of climate change.

Along with the general literature on impacts, the mitigation and adaptation literatures then serve to help build a picture of global-, national-, regional- and local-level

implications of climate change. For the most part these implications are understood in terms of identifying and managing region-wide (defined in various ways) and place-based risks and vulnerabilities. And, as the Allen Group (2005: xi) provide in their comprehensive report *Climate Change Risk and Vulnerability*, addressing such vulnerabilities requires identifying and understanding exposure(s) and sensitivity(ies) within human and natural systems in a given place; how these interact and influence potential impacts from climate change locally; and how local adaptive capacity (including autonomous and planned adaptations) determine overall community and systems vulnerability. These relationships are summarised in Figure 3 (further discussion of the vulnerability framework is included later in this report).

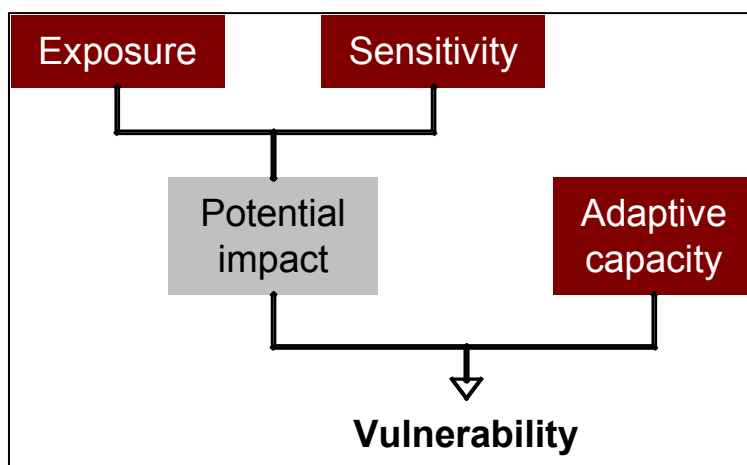


Figure 3: Key elements in assessing vulnerability to climate change-related impacts

Source: Allen Consulting Group 2005: 20.

2.3 Australia's country towns and climate change: broad impacts and vulnerabilities

Much of the literature on climate change to date has been about setting the global context of climate change. This literature is highly scientific in approach and presentation, and is focussed on understanding climate trends through mathematical models and replicating and predicting climate parameters, patterns and variables. The publications of the relevant Working Groups of the Intergovernmental Panel on Climate Change (IPCC) and the CSIRO are prominent among such work (see, for example, summaries of some of this work in Cleugh *et al* 2011).

The highly scientific nature of climate change research has been necessary to date, as climate change inquiry has been focussed on understanding the complex natural and anthropogenic influences on weather, climate and natural systems generally. Moreover, debate about the precise contributions of natural and human systems to *year-to-year climate variability* and *longer-term climate change* has required robust quantitative methods.

The voluminous works on global climate change impacts will not be summarised here. To do so would be to repeat work presented adequately elsewhere (see specifically Cleugh *et al* 2011; also Allen Consulting Group 2005; Commonwealth of Australia 2007; Department of Climate Change 2010; Hennessy *et al* 2007; Assessment Reports of the IPCC 2007, 2001, 1995, 1990). Instead, this research is framed against the clear and important finding of global level investigations of climate science around which most climate scientists agree: that the science around climate change is robust enough

to substantiate what most climate models show – the world has warmed significantly faster over recent decades than at any time in the past for which we have data, and this process has been influenced by human behaviours, particularly the release of high volumes of greenhouse gases into the atmosphere.

Figure 4 provides a simplistic schematic of the influence of human activities on the climate change cycle. Human-influenced actions known to influence this cycle include:

- the process of energy production (particularly the burning of fossil fuels) and consumption;
- emission of pollutants from industrial processes and increasing water consumption from such processes, such as manufacturing;
- the expansion of cities and the proliferation of industrial land uses that change natural systems, including water penetration (runoff, natural storage systems, environmental flows) and the ability of natural systems to act as a sink for carbon (Preston and Jones 2006).

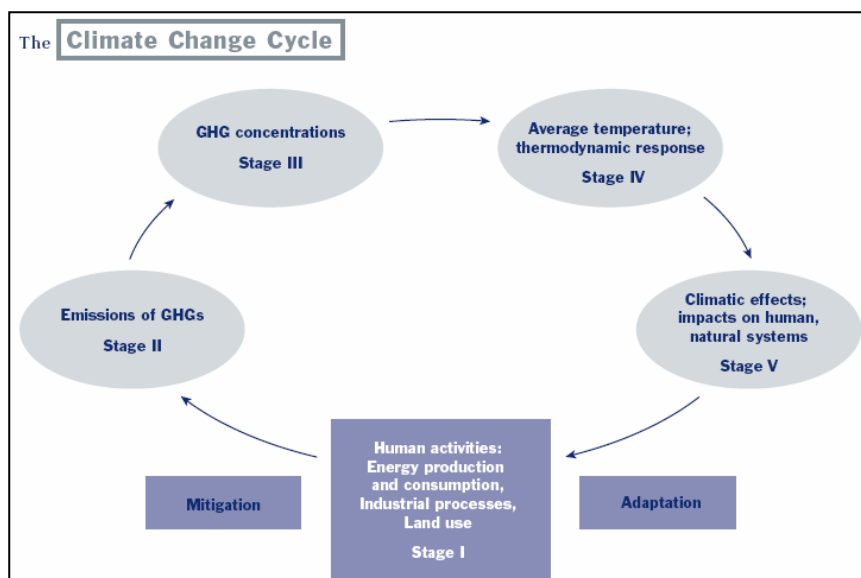


Figure 4: Schematic of the influence of human activities on the climate change cycle

Source: Preston and Jones 2006, 9 © CSIRO.

For the purposes of this research, the following key findings of the climate change literature provide the basis for a broad level understanding of climate impacts on Australia:

- projected average annual **warming** of around 1oC nationally by 2030 (above average 1990 figures), ranging from a warming of 0.7–0.9oC for coastal locations and 1–1.2oC for inland areas. And, best estimate projections of average annual warming by 2050 of 0.8–1.8 for a low greenhouse gas emissions scenario and 1.5–2.8oC for a high emissions scenario and for 2070 a warming range of between 2.2oC (low emissions) and 5oC (high emissions);
- anticipated increased occurrence of El Nino Southern Oscillation (ENSO) events, with associated characteristic **intense floods and droughts**;
- changes to the hydrological cycle due to **lower average rainfall** and therefore run-off across much of the continent, with implications for soil moisture and water supply for domestic, commercial and agricultural purposes; and,

concomitantly, more frequent and intense rainfall events in the tropical north of Australia, resulting in more frequent floods;

- exposure to **more frequent extreme weather events** including:
 - **more frequent and intense storms and cyclones**, with more intense storm surges predicted for coastal Australia as a result of anticipated rising sea levels and warmer air movements over coastal areas; and
 - **more frequent hot days** across southern Australia in particular, impacting on the frequency and length of heatwave events, the number of days of high bushfire risk and likely the frequency and intensity of bushfires.
- **fewer frosts**; and
- **decreased snow coverage** in alpine regions.

The PMSEIC Independent Working Group (2007) shows high levels of confidence in these climate change-related impacts and presents a number of dimensions of changing weather conditions (Table 2).

Table 2: Projected changes in weather and climate extremes

<i>Climate Extreme</i>	<i>Projected Change</i>	<i>Confidence in the Change Projected</i>
Number of hot days and nights	↑↑	Virtually certain
Number of cold nights	⇕	Virtually certain
Number of warm spells and heat waves	↑	Very likely
Number of heavy precipitation events	↑	Very likely
Extent of drought affected areas	↑	Likely
Intense tropical cyclone activity	↑	Likely
Frequency of extreme high sea levels	↑	Likely

Source: PMSEIC Independent Working Group 2007: 14

An overriding finding of the IPCC's Fourth Assessment Report (A4R) is important to reiterate here: that climate change-related impacts are already occurring.

Regional climate change has occurred (very high confidence).

Since 1950, there has been 0.4 to 0.7°C warming, with more heatwaves, fewer frosts, more rain in north-west Australia and south-west New Zealand, less rain in southern and eastern Australia and north-eastern New Zealand, an increase in the intensity of Australian droughts, and a rise in sea levels of about 70mm (Hennessy *et al* 2007: 509).

While the literature discussing broad climate change-related impacts has reached a general consensus around these trends, it must also be said that **a key feature of climate change is diversity of impact** – globally, nationally and regionally. And this is certainly the case within a country the size of Australia, where geography has long influenced the weather, climate, economic development and ultimately fortunes of

different states, regions within state and places (cities, towns, settlements, communities). Moreover, adding further depth to the impacts of climate variability and longer term climate change is predicted within-season and inter-decadal variability in weather events and particularly rainfall. These factors are a key concern for many communities, particularly those communities where reduced water availability is predicted, such as across much of southern Australia, for as Preston and Jones succinctly note ‘...changes in precipitation and subsequent water management are critical factors affecting the future productivity of the Australian landscape’ (2006: 5).

The impacts briefly outlined above are the key starting point for most of the literature in the climate change arena in Australia, including literatures around mitigation and adaptation. They also provide the premise from which most national, regional and local level investigations of risk and vulnerability to climate change and climate variability have been assessed and, where able, benchmarked (Cleugh *et al* 2011; the Allen Consulting Group 2005; Preston and Jones 2006; Commonwealth of Australia 2007).

The remaining sections of this chapter provide a brief summary of the implications of the anticipated climate change-related impacts outlined above at the local level for country towns in Australia. The discussions are centred around the key areas of concern raised in the literature generally – extreme weather events, water, public health, infrastructure and the built environment.

2.3.1 The impact of extreme weather events

The list of broad climate change-related impacts outlined in the previous section strongly emphasises the predicted increased frequency and intensity of extreme weather events in a climate change impacted Australia. These trends are arguably one of the most discussed consequences of climate variability and longer term climate change – with far reaching consequences for all settlements. This underlies the discussion in the remainder of this chapter – with such events affecting water sources and supplies, human health, infrastructure and the built environment of settlements, as well as the current and future industrial base and direction of economic development for country towns (discussed in the next chapter). Such events then, are crucial shapers of the fabric and fortunes of non-metropolitan communities.

A number of broad regional studies have discussed the impact of these trends. Some of the key predictions are presented in Table 3. Different impacts from each of these trends are discussed elsewhere in this chapter and the next chapter.

In discussing extreme weather events it should be noted that with the predicted increased intensity and frequency of events such as floods, droughts and bushfires, comes a substantial social and economic cost. This has been seen recently with the loss of life and damage to crucial infrastructures (towns, individual houses, farms, and community facilities such as schools) recorded in regional areas. The 2009 Black Saturday bushfires in Victoria, the NSW and Tasmanian fires of January 2013 and the floods of January 2011 in Queensland imposed a substantial impost on the economies and social fabric of affected communities, and indeed, the nation as a whole. The increased likelihood of these events has implications far beyond the affected areas, with the impact on household and business insurance, as well as public infrastructure a highly visible marker of the cost of climate change adaptation.

Table 3: Predicted climate change-related extreme weather events

<i>Projected impact</i>	
For <1°C change in temperature	70 per cent increased in frequency of droughts in NSW. 10-20 per cent increase in the intensity of rain in extreme daily rainfall events in NSW. Approximately 5 per cent decrease in extreme daily rainfall events in Victoria. Approximately 20 per cent increase in days above 35°C (so called 'hot days') in SA and 25 per cent increase in NT.
For 2-3°C change in temperature	5-10 per cent increase in tropical cyclone wind speeds and 20-30 per cent increase in tropical cyclone rainfall. Approximately 15 per cent increase in 100-year storm tides along the eastern coast of Victoria. 10 per cent or greater increase in forest fire danger index in many areas of southern Australia.

Source: See Preston and Jones 2006: 30.

2.3.2 Water sources and irrigation

One of the most discussed impacts of climate change within Australia generally has been the issue of changing trends in rainfall and associated run-off. Such change ultimately has an impact on the sources and supplies of water for human and natural systems. As noted earlier, such trends in rainfall are predicted to vary nationally and regionally, with the key trends of concern for inland communities being:

- increased frequency and intensity of drought in the temperate areas of the country such as southern NSW, Victoria, Tasmania, South Australia and Southern Western Australia; and,
- increased frequency and intensity of flood events across the tropical north, including most of Queensland, northern NSW and the far northern regions of Western Australia and the Northern Territory.

In terms of region-specific studies around water, extensive work has been completed in the Murray Darling Basin – covering significant areas of Queensland, NSW, Victoria and South Australia. Table 4 outlines some of these broad level trends.

Table 4: Predicted climate change-related impacts on water flows and sources in Australia

<i>Projected impact</i>	
For <1°C change in temperature	Possible 3-11 per cent decrease in water supply for Melbourne. 10-40 per cent contraction in snow-covered area in Australian Alps.
For 1-2°C change in temperature	Possible 7-35 per cent decrease in water supply for Melbourne.
For 3-4°C change in temperature	16-48 per cent decrease in flow in the Murray Darling Basin. 10-40 per cent contraction in snow-covered area in Australian Alps.

Source: See Preston and Jones 2006: 26.

Additionally, Preston and Jones (2006: 25) note that water quality in the major river systems is likely to decline under climate change, as there will be less water available for the dilution of saline base flows. CSIRO projections indicate a decrease in overall rainfall in the southern areas of Australia, especially in winter.

2.3.3 Public health impacts and concerns

... the crucial point underlying any description of current and likely future health impacts is that climate change will affect more than built infrastructure, environmental amenity, the economy and jobs. It will increasingly disrupt and deplete the natural systems that support and supply the processes of life. That threat is the one that embodies the greatest long-term danger posed by global climate change. Therefore, not only do we wish to avert risks to health, but the fact that such risks exist serves notice on us that global climate change is a greater danger than we originally imagined (McMichael 2009: 5).

A key area of concern within the climate change literature is the issue of climate change-related impacts on public health. While for the most part research in this area has been nationally or state focussed – reflecting funding mechanisms within the health sector and responsibility in terms of service delivery – there are clear place-based implications for regional, rural and remote settlements. These are discussed in the remainder of this section, with some of the predicted public health impacts of climate change for such settlements outlined in Table 5.

Table 5: Some predicted climate change-related impacts on public health in Australia

<i>Projected impact</i>
Increased rates of death and injury associated with (largely heat-related) extreme weather events such as heat waves, bushfires, storms, cyclones and storm surges.
Possible decrease in cold related illness and death – if the predicted decreasing frequency and intensity of cold weather events ensues.
Increased prevalence of certain diseases due to changing/changed weather events – for example: likely increased frequency of asthma and respiratory disease due to hotter weather and changed growing season and patterns for particular allergens.
Increased levels of mental health issues among particular population groups – due to impact on livelihood and farm profitability from severe weather events and repeated impacts of severe weather events.
Potential southward movement of vector-borne diseases, particularly those transmitted through ticks and mosquitoes (such as dengue fever, Ross River virus and potentially malaria).
Increased frequency of food-borne diseases such as salmonella – due to heat impacts on food preparation and storage.
Increased frequency of water-borne diseases – due to flooding and the impact of severe flood events of settlement infrastructures such as sewerage systems.
Increased prevalence of heat stress, particularly affecting the elderly, those with lower resources and those working outside during the heat of the day.
Potential increased demand on local level health services and infrastructures due to all/some of above.

Sources: McMichael 2009; Preston and Jones 2006: 27; McMichael *et al* 2003.

Five key points of concern for regional, rural and remote settlements stand out from the Australian climate change and public health literatures. Firstly, the literature is clear that public health impacts and concerns have a socio-economic and geographic dimension. Leading work in this area by Tony McMichael and colleagues at the Australian National University is notable in this regard. Such work highlights the following groups as among those most vulnerable to climate change-related impacts:

- residents of places where extreme weather events such as cyclones, bushfires, storms and storm surges are likely to be more frequent and/or intense;
- old and frail people living in southern Australia where the incidence of hot days, heatwaves and therefore heat-related deaths and diseases are predicted to increase;
- people with lower levels of resources affecting their ability to adapt to altered weather and climate conditions, for example, by using air conditioning to mitigate impacts of more frequent, intense or prolonged heatwaves; and
- rural communities and farmers exposed to more frequent droughts and floods (McMichael 2009: 13).

Secondly, the literature strongly emphasises that remote Indigenous communities are settlements of particular concern with respect to the public health impacts of climate variability and longer-term climate change. This is particularly the case for those communities facing hotter and drier conditions, resulting in pressures on the supply and quality of water and food (including traditional food sources). Commentators in this field also note further complexities and challenges relating to health in remote Indigenous communities because of the anticipated impact of changing weather and climate on cultural norms and practices as well as physical and social infrastructures within communities:

Indigenous communities face particular health risks from climate change and its environment consequences. Many indigenous communities will face extremes of heat, freshwater shortage, diminished supplies of traditional plant and animal foods, fires and other weather disasters, and erosion of parts of their cultural base. Displacement of some communities from high-risk areas (e.g. coastal sea-level rise and cyclone zones) may cause tensions and conflicts, especially if the environmental resource base is already under stress (McMichael 2009: 13).

It is clear from this literature review, that while some research is being conducted in this area, much more is needed at the local level in Indigenous communities to examine the adaptive capacity of communities, and how this can be augmented through the provision of monetary, physical and social resources.

Thirdly, in considering the impact of climate change on health outcomes and trends in regional, rural and remote Australia, it is imperative that the issue of mental health is given due attention. Recent studies point to the increasing prevalence of mental health issues, including depression, among individuals and communities suffering economically because of prolonged drought conditions, as well as floods, cyclones and severe storms. It is assumed that such trends will continue where climate change has an economic impact, for example by affecting farm production and profitability. Increasing incidences of post traumatic stress disorder are also likely among these populations, particularly where individuals and communities have suffered human, financial, or social losses from extreme events, or repeated exposure to these events and losses from them.

Fourth, the increased intensity and frequency of extreme weather events is predicted to influence the path, form and geographical/population reach of some diseases affecting

human (and animal) health. Here the concern is with changes in known distribution of some water- and food-borne diseases – due to floods and more humid conditions in southern Australia. It is also anticipated that respiratory disease frequency and heat stroke will increase because of sustained hotter weather.

Fifth, and positively, the consensus view of the literature reviewed here is that the impact of climate change on public health outcomes is anticipated to be moderate; largely reflecting the good general health of the Australian population and the strong adaptive capacity in public health arenas. Most commentators note that current disease and injury control measures can be reasonably easily adapted, intensified or extended to meet climate change-related impacts. Similarly, in most settlements, and particularly larger settlements, it is expected that health infrastructures will be able to respond to new/altered trends in illness, injury and disease.

It is worth noting that in terms of region- or local-level impacts some commentators emphasise that an important limitation is the capacity of already over-stretched and highly pressured public health infrastructures in smaller, non-metropolitan centres to meet changing demand for medical services. This concern extends to the physical infrastructures within towns and regions, as well as issues around attracting key workers in the health and allied health fields. In this respect, telemedicine technologies will need to increasingly play a role in service delivery to regional and vulnerable populations.

Of additional concern are the practical issues around the supply of volunteers to staff local emergency services (ambulance services, makeshift hospitals) during times of extreme crisis – particularly during extreme weather events such as bushfires. This is an area of ongoing future concern with the predicted increased frequency and intensity of severe weather events – floods, bushfires and storms. Importantly, this concern also extends to other emergency management services such as State Emergency Services and local level fire services, known, for example, as the Country Fire Service in SA, Country Fire Authority in Victoria and NSW Rural Fire Service.

Finally, in discussing the public health impacts of climate change, it is pertinent to also point out that

The health impacts of climate change will be strongly influenced by the extent and rate of warming, as well as local environmental conditions and social behaviours, and the range of social, technological, institutional, and behavioural adaptations taken to reduce the threats (McMichael *et al* 2003: 4).

And,

Assessing the implications of climate change for public health remains quite challenging due to the existence of complex interactions among climate, the environment, and socioeconomic factors (Preston and Jones 2006: 26-27).

For these reasons, local level studies of public health outcomes are important in considering the totality of the impacts of climate change on settlements and their futures.

2.3.4 Infrastructure impacts

Infrastructure plays a critical role in Australia. It supports economic activity, links people to services, helps improve productivity and enhances our lives. Notably, the initial investment in infrastructure is typically significant. In addition, major infrastructure often has a long lifespan. Therefore, it is imperative that our infrastructure is designed, built, operated and maintained in a way that enables it to withstand current as well as future impacts, including climate change (Maddocks 2011: xiii).

Within the broad climate change literature is an emerging body of work concerning the physical infrastructure impacts of climate change (for example, DPCD 2008; LGASA 2010; Barker McKenzie 2011). The relevant work in this field – much of which is highly urban-focussed³ – is concerned with impacts brought about by the predicted increased frequency and intensity of extreme weather events such as heat waves, storms (and storm surges in coastal communities), floods and, in southern Australia in particular, bushfires and prolonged heatwaves.

Reflecting the engineering perspective within this body of work, the literature emphasises the need to recognise weather-related impacts (from exposure to extreme heat, inundation due to floods and sea level rise, increasing humidity across broader areas *et cetera*) on new and existing transport infrastructures (roads, rail, ports, bridges), housing, commercial and industrial buildings, and energy infrastructure, including generation and distribution infrastructures and the sector’s extensive transmission networks. Additionally, the literature has noted the impact of other trends on the useful life, quality and demand for/on infrastructure because of population growth, including possible climate-related movement of people from certain unliveable or uneconomic areas to other more favourable places (see Austroads 2004; Philp and Taylor 2011). In saying this, we need to acknowledge that technological innovation will continue to play an important part in setting the standards for new and existing infrastructure and its management.

Table 6 below outlines some key predicted impacts for infrastructure in Australia. The peak electricity demand figures provided in the table are capital city focussed, reflecting the absence of similar information for regional cities and towns. Clearly there are major concerns for infrastructure provision and adequacy. For example, maintenance and repair costs for transport infrastructure are expected to increase with a 2-3°C increase in temperature (Preston and Jones 2006: 28). In addition, the settlement system will bear the cost of more frequent severe weather events.

Table 6: Predicted climate change-related infrastructure impacts, Australia

<i>Projected impact</i>	
General impacts	Increased degradation of concrete in moist areas. Climate change-related population movements impacting on use of/demand for infrastructure in some places (Brisbane, Sydney and Melbourne) and reducing demand in others (Adelaide and Darwin).
For <1°C change in temperature	Decrease in thermal efficiency of electricity transmission infrastructure of around 3 per cent. Decrease in demand for natural gas for domestic heating purposes in Melbourne. Up to 1 per cent decrease in peak electricity demand in Melbourne and Sydney. 2-5 per cent increase in peak electricity demand in Adelaide and Brisbane.
For 1-2°C change in temperature	2-5 per cent increase in peak electricity demand in Adelaide and Brisbane.
For 2-3°C change in temperature	Increase in maintenance costs for transport infrastructure. 3-15 per cent increase in peak electricity demand in Adelaide and Brisbane.

Sources: see Preston and Jones 2006: 29; also Austroads 2004.

³ See, for example, Li 2010; McDonald 2010.

Energy infrastructure impacts are important, although little is known at the current time about supply and demand concerns in regional, rural and remote Australia. This said, there are some clear trends from the largely-metropolitan focussed literature on energy demand that are noteworthy for inland country towns. For example, the impact on peak energy demand due to prolonged heatwaves and change in the sources of energy used to generate electricity may create new concerns, as non traditional sources may lack the ability to respond to peaks in demand. Notably also, not all places in Australia will see the same trends for energy infrastructure due to climate change. Some places will witness a decline in the demand for energy during winter, while elsewhere demand may grow in all seasons.

Electricity generation and energy needs are not the only way climate change will affect infrastructure in Australia's country towns. For example, Austroads (2004) notes that:

Large parts of Australia are affected by salinity, and this also has a known infrastructure impact. High water tables, for example, reduce the structural strength of pavements, and salt rusts the reinforcement in concrete structures. Climate change will have an impact on salinity because precipitation and evapotranspiration are the main determinants of surface and ground-water flows, which in turn affects salinity levels ...

...Another manifestation of the salinity problem is increased salt concentrations in rivers. Climate change may exacerbate this problem because, with less rain to dilute surface salt, surface waters flows are predicted to become saltier. Steel reinforcing in concrete structures in riverine environments may therefore be more prone to corrosion. Road agencies might consider ways to better protect reinforcing in saline environments (p.122).

A broad indication of the economic cost of maintenance and rehabilitation costs for the Australian National Highway road network is provided in Austroads 2004 (see Chapter Three), which loosely predicts a 30 per cent increase in road maintenance and rehabilitation costs in 2100 (assuming a 7°C increase in average national temperature) for the same road infrastructure against 2000 budget figures (p. 85). Notably, this modelling does not include impacts of severe weather events.

As noted previously, infrastructure tends to have a long economic life and the need to consider climate change through to 2050 raises questions about the adequacy of existing infrastructure, as well as the standards to which new infrastructure should be constructed. Many decisions about the location, adequacy and standards of infrastructure will be made over that time frame and it crucial that decision makers are appropriately informed.

2.3.5 Community engagement and resilience

Within the broader literature on settlements and climate change there is a small but growing body of work that examines the issue of community resilience in the face of climate variability and the sensitivity and exposure of particular places to climate variability. This literature crosses over significantly with that centred on local activism and community engagement; a literature suggesting strategies and approaches for understanding and promoting stakeholder involvement and ownership of adaptation planning and activity. This literature involves the direct application of learnings from the well developed local and regional economic development literature, much of which has emerged in the face of broader structural changes affecting regional and rural communities. It also highlights the importance of local social, political and cultural institutions, norms and actors in county towns in Australia; with these factors directly shaping, driving and impacting on local capacities to deal with significant environmental and other challenges. Looking to the regional development literature also reminds us

that regional and rural Australia is a series of places with different resources, different values and are often sites of contradiction and contestation.

Bond (2010) highlights three avenues to step up local climate action: first, there is a need to increase attention to adaptation efforts – something arguably in its infancy in Australia and elsewhere in the developed world. Second, Bond (2010) argues that there is a need to link climate change-related adaptation and mitigation efforts to other locally relevant ecological concerns, and frame these within a locally-focussed sustainable development agenda (see also Martens *et al* 2009). Thirdly, she argues that communities need to harness local resources, particularly those actors and groups active in sustainable development and environmental management broadly. There is some evidence of the take up of such ideas within Australia. Bond's (2010) ideas on the need to link climate change adaptation to other local concerns appear to have been adopted in the Sunraysia district of North West Victoria (George 2009). Critically, this perspective on community engagement with adaptation does not focus solely on governments; within this schema the role of government is to support not steer change, and provide resources, incentives, space and place for engagement with adaptation issues (Bond 2010: 220).

The literature on community engagement for climate adaptation, in common with much community development research, emphasises the importance of including 'non-traditional stakeholders' in community actions for climate change as all members of a town or region must be engaged if change is to be enacted. One key way of engaging with stakeholders at the local level is by presenting and discussing climate change as part of a sustainable development agenda focussed on reducing vulnerability by increasing community engagement with these agendas and building community resilience to the challenges ahead (Bond 2010). These principles of community engagement on climate adaptation as part of a wider discourse of sustainability have already found expression in a number of places across Australia (see Box 9).

Box 9: The Mildura Eco-Living Centre, Sunraysia

The Mildura Eco-Living Centre is part of a program of environmental awareness actions by the Mildura Rural City Council and the community. It includes the provision of resources, spaces and places to raise community awareness. Actions include: construction and operation of the Mildura Eco-Living Centre within a Mildura Eco-Living Park (MELP) at the Mildura landfill site. The MELP is a demonstration site for sustainable living in the Mildura region, providing information to the broader community about carbon-neutral activities etc.

The MELP is being driven by Mildura Rural City Council as part of the Sunraysia Sustainability Network – a local network of stakeholders concerned with a range of issues including carbon emissions, climate change impacts and peak oil. The SSN advocates principles of a transition towns framework and in line with this has focussed the activities of the MELP on actions with specific local benefits. In addition to the MELP, the MRCC is driving action and learning around reducing environment impacts through use of solar, wastewater recycling and other soft infrastructure measures.

'Councils goal for this Green Precincts project is to stabilise (and even reduce) greenhouse emission and water consumption, raise community understanding of the issues of climate change and greenhouse and prepare the community for a future reductions goal' (p. 6)

Source: George 2009; Mildura Eco Living Centre Website 2012

Community is an important part of the adaptation equation across Australia and globally. Some places, and types of places, however may be better placed to meet the challenges of adaptation because of their size, economic base, or other characteristics. For example, Kiem *et al* (2010: 8) note that

For Mildura, the town's size and industry scope will provide some buffering from the rapid changes and impacts on farming in the region.

They also noted that service withdrawal and isolation will present on-going challenges to some rural settlements, especially those that are very remote or already in decline.

2.4 Conclusion

As the discussion in previous sections of this chapter shows, it is only relatively recently that studies of the impact of climate change and climate/weather variability have been undertaken at more localised levels. And, on the whole, the local level referred to here is what other areas of investigation, such as the regional development literature, would call region-based studies (eg the Sunraysia in North Western Victoria, the Hunter Valley in NSW or the Barossa Valley in South Australia). Case studies of impacts, adaptation and mitigation efforts at the level of a particular place are few and far between. This absence represents a significant challenge because while the regional scale may constitute an appropriate level for planning for climate change adaptation, many of the actions, consultations and public works will need to be implemented at the level of individual communities – including Australia's country towns. Without greater knowledge about preparedness for climate change at the township level, and the strategies that could and/or should be deployed, Australia's adaptation efforts will be hampered. As this chapter has noted, this is not a one-dimensional challenge, instead rural and regional towns and settlements will be confronted by multiple climate-related issues, including threats to public health, the potential deterioration of infrastructure, repeated, and possibly multiple, shocks as a consequence of extreme weather events, and social disruption as communities are confronted by the long term threats to their effective functioning and survival.

3. THE ECONOMIC AND INDUSTRY BASE OF AUSTRALIA'S COUNTRY TOWNS: CLIMATE CHANGE, VULNERABILITY AND ADAPTATION

Economic conditions have a fundamental impact on the functioning, social structure and wellbeing of all settlements, and especially country towns. Australia's system of country towns evolved from the late 18th Century and into the 20th Century as European colonisers appropriated Indigenous lands for agricultural and pastoral activity. While some country towns were established without forward planning, others were the direct product of deliberate attempts to 'open up' the country and establish an efficient system of agricultural production. South Australia is, perhaps, the best known example of such colonial activity, but similar schemes were evident across Australia. The national commitment to expansion of settlement effectively persisted into the 20th Century through 'Soldier Settlement' programs after World War One and Two, and the development of new lands for irrigated agriculture in North West Western Australia and the southern and northern parts of the Murray Darling Basin in the 1960s.

The history of urban settlement is significant because it is the country towns established through these processes that are now confronted by the need to adapt to a climate-change affected future. In most instances these are places whose economic foundation was firmly rooted on agriculture, and in many instances broadscale, dryland farming. While some country towns have grown over time and developed a mix of industries (Beer, Bolam and Maude 1994), others have not prospered and over the past 50 years there has been a noticeable decline in the number and economic vibrancy of some places, and especially smaller centres (Sorenson and Weinand 1991; Baum *et al* 1999). Climate change adaptation, therefore, will need to take place during a time when many country towns are already under some pressure. Some have already taken on new non-agricultural roles including serving as part of the commuter belt of the major metropolitan regions; through the development of service industries such as tourism, education or financial services; or by the large scale development of agribusiness or transport enterprises. Importantly, a considerable body of research has emphasised the highly differentiated nature of Australia's country towns and their labour markets, which suggests that the challenges of, and adaptation to, climate change will not be uniform (see Beer and Clower 2009). Agriculture, however, remains the fundamental economic pillar of many rural regions in Australia and the bedrock of town prosperity.

This chapter considers briefly the nature of economic activity in Australia's country towns and in particular it focusses on the prospects of a range of critical industries in a climate change affected world.

3.1 Australian agriculture and climate change

Agriculture lies at the heart of much economic activity in rural Australia. It remains an important source of export earnings and plays a fundamental role in ensuring food security for Australia and other nations. Agriculture, fisheries and forestry industries contribute to approximately three per cent of the Australian Gross Domestic Product (GDP) and 14 per cent (A\$31 billion) of Australia's total industry exports (CSIRO 2012). Related CSIRO work (Cleugh *et al* 2012) also notes that the expected negative economic impacts of climate change on primary industries are likely to be made worse by the positive impacts expected in many of our competitor trading nations, including

wheat producing nations such as the Ukraine and Russia and horticultural producers such as New Zealand.

A considerable volume of research has considered the likely impacts of climate change on agricultural productivity in Australia (see, for example, Steffen *et al* 2011; Jones *et al* 2010 and 2007; Preston and Jones 2006).

Steffen *et al* (2011) summed up the complexities associated with attempting to draw conclusions around the likely impact of climate change on agriculture. They noted that

First, for most types of Australian agriculture, water availability is a more important climate-related parameter than temperature, making temperature-based estimates of “dangerous climate change” based on scenario analysis less useful for Australian agriculture than for other sectors and other countries.

Second, because of Australia’s high natural climate variability, many producers and agricultural industries already have high adaptive capacity with regard to climate pressures.

Third, given that Australia is a large continent spanning tropical, sub-tropical and temperate climatic zones, there is enormous variability in the types of agriculture undertaken in the country, in the sensitivity of the various industries to a changing climate and in their adaptive capacity (p. s205).

Climate change, therefore, is likely to have highly variable impacts on Australian agriculture because some regions will experience increased rainfall; tropical, subtropical and temperate regions will be affected by climate change in different ways; and, Australian farmers appear to be ‘pre adapted’ for climate change.

Some risks for agriculture have been identified in the literature:

- the grains industry is potentially at risk because cereal crops are sensitive to the timing of frosts and because many wheat growing regions in southern Australia rely on winter-spring rainfall patterns that are predicted to decline over time;
- the dairy industry is one of the more vulnerable to rising temperatures due to the sensitivity of dairy cattle to heat stress (higher temperatures coupled with high humidity);
- horticulture may be affected because higher night temperatures are a risk for some late harvested varieties of fruit, maximum temperature limits exist for some varieties, and chilling requirements are common for many varieties (Steffen *et al* 2011, p. s207);
- the impact of some pests may increase as natural adaptation to new climates/environments may extend or redefine the natural areas pests can survive and operate within;
- irrigated agriculture in all forms may be affected as climate change models predict lower flows, which in turn means there will be less water to dilute saline base flows (Preston and Jones 2006: 25).

Preston and Jones (2006) estimated the likely impacts of climate change on key agricultural industries (Table 7) and showed that the impacts increased significantly with each degree of average temperature increase.

Table 7: Projective impacts to Australian agriculture, forestry, livestock

<i>Projected impact</i>	
For <1°C change in temperature	<p>\$4.4 million/year to manage southward spread of Queensland fruit fly</p> <p>\$1.1 million/year benefit with contraction in range of Light brown apple moth</p> <p>Increase in 'generic' timber yields (under wet scenarios)</p> <p>Decrease in 'generic' timber yields (under dry scenarios)</p> <p>25% of core habitat lost of Eucalyptus</p> <p>250-310 litre annual decline in milk production per cow in Hunter Valley</p> <p>8% reduction in native pasture growth (for 11% decrease in precipitation)</p> <p>13% reduction in livestock carrying capacity in native pasture systems (for 11% decrease in precipitation)</p>
For 1-2°C change in temperature	<p>12% change of decreased wheat production (without adaptation)</p> <p>32% chance of wheat crop value below current level (without adaptation)</p> <p>91% chance of wheat exports being below current level (without adaptation)</p> <p>\$12.4 million/year to manage with southward spread of Queensland fruit fly</p> <p>\$5.7 million/year benefit due to reduction of Light brown apple moth</p> <p>40% of core habitat lost for Eucalyptus</p> <p>38% increase in tick-related losses in net cattle production weight.</p>
For 2-3°C change in temperature	<p>31% reduction in native pasture growth (for 32% precipitation decrease)</p> <p>40% reduction in livestock carrying capacity of native pasture systems (for 32% precipitation decrease)</p>
For 3-4°C change in temperature	<p>32% chance of decreased wheat production (without adaptation)</p> <p>45% chance of wheat crop value being below current level (without adaptation)</p> <p>55% of core habitat lost of Eucalyptus</p> <p>25-50% increase in 'generic' timber yield in cool and wet parts of South Australia</p> <p>25-50% decrease in 'generic' timber yield in North Queensland and Top End</p> <p>6% decline in Australian net primary production (for 20% precipitation decrease)</p> <p>128% increase in tick-related losses in net cattle production weight.</p>

Source: see Preston and Jones 2006: 26

The impact of climate change on river flows will potentially have far reaching consequences for the viability of much Australian agriculture. Some 80 per cent of all profits in Australian agriculture are generated through irrigated activities and a reduction in the right – or the opportunity – to draw water may have significant impacts on some districts, especially those with substantial investment in infrastructure. The scale of this potential impact is considerable, with Preston and Jones (2006) citing research estimating that an increase in average temperatures of less than one degree will reduce flows in the Macquarie River basin by up to 15 per cent, while a 3 degree change would cut Murray Darling flows by between 16 and 48 per cent.

Extreme weather events will also have a significant impact on Australian agriculture, with Preston and Jones (2006) suggesting a wide range of adverse consequences (Table 8). Critically, many of these effects will be felt in other industries also, with tourism and other amenity based industries potentially at risk. The slow pick up in North Queensland tourism following Cyclone Yasi adds poignancy to this insight. Often it is these ancillary industries that generate significant employment in country towns and sustain them socially and economically.

Table 8: Implications of extreme weather events for key sectors

Phenomenon	Direction of Trend	Implications, by sector
Hot days and nights	↑	<p>Agriculture/forestry</p> <ul style="list-style-type: none"> • Moderate increase in crop yields in north-eastern Australia • In cooler Australian climates, warming likely to allow alternative crop varieties to be grown • Less cold-stress likely to reduce lamb mortality • Increase in potential distribution of exotic weeds and native woody species • Productivity of exotic softwood and native hardwood plantations likely to increase, although amount of increase will be limited by projected increase in temperature and reductions in rainfall • Temperate fruits and nuts production negatively affected. <p>Industry/settlement/society</p> <ul style="list-style-type: none"> • Reduced energy demand for heating, increased demand for cooling, declining air quality in cities • Some tourist destinations may benefit from drier and warmer conditions • Fewer days of snow cover per year, reduced area of snow cover and reduced maximum snow depth in south-east Australia. <p>Ecosystems</p> <ul style="list-style-type: none"> • Risk to survival of species in alpine regions, south-western Australia, coral reefs and freshwater wetlands.
Warm spells and heat waves	↑	<p>Agriculture/forestry</p> <ul style="list-style-type: none"> • Significant crop yield reductions in south-western Australia, compounded by reductions in rainfall • Increased heat stress on livestock • Impacts of cattle tick on the Australian beef industry likely to increase and move southwards • Reduced grape quality and value • Queensland fruit fly may become a significant risk to southern Australia. <p>Water resources</p> <ul style="list-style-type: none"> • Increased water demand, water quality problems – for example algal blooms. <p>Human health/mortality</p> <ul style="list-style-type: none"> • Increased risk of heat-related mortality and morbidity. • Warmer temperatures and increased rainfall variability likely to increase the intensity and frequency of food-borne and water-borne diseases. • Reduction in quality of life for people in warm areas without air conditioning, impacts on elderly and the very young. <p>Industry/settlement/society</p> <ul style="list-style-type: none"> • Increased peak and average temperatures likely to reduce electricity generation efficiency, transmissions line capacity, transformer capacity etc.

Phenomenon	Direction of Trend	Implications, by sector
Drought affected areas	↑	<p>Agriculture/forestry</p> <ul style="list-style-type: none"> • Cropping in southern Australia becoming non-viable at the dry margins if rainfall is reduced substantially. • Vulnerability of agriculture in south-west and inland Australia. • Water-logging, soil acidification, soil erosion and dryland salinity likely to be exacerbated. • Increase in potential distribution of exotic weeds and native woody species. • 20 percent reduction in rainfall likely to reduce pasture growth by an average of 15 per cent and live-weight gain in cattle by 12 per cent. • Land degradation, lower yields/crop damage and failure, livestock deaths. <p>Water resources</p> <ul style="list-style-type: none"> • Water resources becoming increasingly stressed, decline in runoff in southern and eastern Australia. • Reduced soil moisture over most of Australia, likely fall in annual stream flow in the Murray-Darling Basin. <p>Human health-mortality</p> <ul style="list-style-type: none"> • 50 percent chance by 2020 of the average salinity of the lower Murray-Darling Basin exceeding the 800 Electrical Conductivity unit threshold set for desirable drinking and irrigation water. <p>Industry/settlement/society</p> <ul style="list-style-type: none"> • Shortages, reduced hydropower generation potential. • Increased potential for population migration. <p>Ecosystems</p> <ul style="list-style-type: none"> • Increase in fire danger in Australia, reduced interval between fires, increased fire intensity. • Length of fire season extended, with the window of opportunity for control burning shifting. • Fire affected catchments leading to degraded water quality.
Intense tropical cyclone activity	↑	<p>Agriculture/forestry</p> <ul style="list-style-type: none"> • Damage to crops and trees. <p>Water resources</p> <ul style="list-style-type: none"> • Power outages cause disruption of public water supply. <p>Human health/mortality</p> <ul style="list-style-type: none"> • Increased risk of deaths, injuries, water-borne and food-borne diseases. <p>Industry/settlement/society</p> <ul style="list-style-type: none"> • Increasing coastal vulnerability for east Australian coast, south-east Queensland and north-east NSW. • Area of Cairns at risk of inundation by a 1 in 100 year storm surge likely to more than double by 2050. Coasts likely to be affected by changes in pollution and sediment loads from changes in the intensity and seasonality of river flows. • Queensland tourism likely to be negatively affected by more intense tropical cyclones and degradation of the Great Barrier Reef. • Withdrawal of risk coverage in vulnerable areas by private insurers. <p>Ecosystems</p> <ul style="list-style-type: none"> • Major impacts very likely for coral reefs, particularly the Great Barrier Reef.

Source: Commonwealth of Australia 2007: 16-19

Importantly, not all climate change impacts are likely to have a negative influence on the economies of country towns. Steffen *et al* (2011) noted that the Margaret River wine region may come under increased growth pressure as competing locations for agriculture, viticulture and tourism activities are going to be more adversely affected. In this sense the Margaret River region will serve as something as an refuge settlement, which in turn will place greater pressure on the management and regulation of urban development, infrastructure provision and preservation of the environment. Steffen *et al* (2011) argued that

There is a need for the acknowledgment that climate change adaptation may encompass the challenges of growth in some localities (vii).

Interestingly, Ward (2009) examined the potential impact of climate change on Western Australia's wine industries. She concluded that while climate change will have an impact, 'the major outcome ... was the indication that the wine regions of South West Western Australia (SWWA) will remain ideally suited to further viticulture development for the production of high quality grapes and wine' (p. x). While some new challenges would emerge, these could be dealt with via the selection of suitable varieties, vineyard water use, and the moderation of bunch temperatures via management techniques. Blackmore and Goodwin (2009) came to a comparable conclusion from their analysis of the risks confronting the Hunter wine region. They found that while viticulture and wine production faced some increased risks in the face of climate change, these risks fell within the already established tolerances of current management practices. Other research, however, has highlighted that different wine regions will be affected to very variable degrees by climate change. Webb *et al* (2005; 2006) concluded that there were significant varietal differences (with pinot noir most sensitive to temperature increases and chardonnay and shiraz relatively unaffected) and differences in both quality and quantity of production. They estimated that returns on grape production in the Riverina would decline by 16 per cent to 2030, but fall only 3.5 per cent in the Yarra Valley and 1.6 per cent in the Coonawarra.

The CSIRO (Cleugh *et al* 2011) argues that it is possible to adapt large parts of Australian agriculture to new climatic conditions. From the CSIRO's perspective, adaptation is a matter of changing management practices, technologies, institutions and expectations to fit the prevailing or projected climate (CSIRO 2012). Adapting primary industries effectively will not only offset negative impacts of climate change, but will allow producers to take advantage of opportunities afforded by our changing climate (CSIRO 2013). Harle *et al* (2007) noted that while climate change will have an impact on Australian wool production between now and 2030, it will not represent a major shock to the industry and this conclusion needs to be assessed in the light of the very major changes in the industry since the early 1990s when the wool floor price was abandoned. Ludwig *et al* (2009) found that climate change is unlikely to affect wheat yields in Western Australia under moderate climate change because both current and projected rainfall reductions take place in June and July, when rainfall often exceeds crop demand. Clearly then, there are a number of pivotal agricultural industries unlikely to be affected by reduced production levels in the near future, or at least not on a uniform basis.

Howden *et al* (2007) noted that there are a range of adaptation actions potentially available to Australian agriculture, with some strategies common across sectors – increased research and development, better training, the establishment of a framework to manage this transition and the development of appropriate policies – and others specific to individual types of agriculture. For example, some of the issues they identified for cropping included:

- species change, including a switch to summer growing grains and pulses;

- variation in planting time;
- better crop management, including the universal adoption of zero tillage, extended fallow periods and lowering plant populations;
- nutrient management; and,
- erosion management.

3.2 Mining

The mining industry is not a sector normally considered to be as vulnerable to climate change impacts as agriculture, but in its own ways it remains at risk. Virtually all mining activity in Australia takes place in a non metropolitan region and mines sustain many country towns. Indeed the very character of some rural regions – such as the Hunter Valley or the La Trobe Valley – have been defined by mining and associated activities.

The CSIRO (Cleugh *et al* 2011) suggests that the mining industry is likely to be confronted by a range of climate change impacts that will challenge existing production systems. These changes will include hotter, drier and more challenging weather (including storms and flooding). The most likely impact will be increased operational and maintenance costs. The CSIRO (2012) also notes that while every stage of mining is potentially influenced by climate change, the direct production stage is most at risk. The 2010-11 floods in much of Queensland highlighted this vulnerability, with many mines flooded as a consequence of this major weather event. Some mines were unable to produce for a number of months as the operators dealt with issues of flooding. The closure of some mines had a measurable impact on Australia's balance of payments for some months. Other research has suggested that all parts of the supply chain are at some degree of risk, with ports, rail lines, bridges and roads subject to the vagaries of extreme weather conditions. Some risks may be dealt with by simply strengthening existing infrastructure or building new infrastructure to a higher standard, while others may be an inescapable part of a climate change affected world.

Fly-in fly-out mining practices impose additional risks with respect to climate change. The absence of an *in situ* workforce carries with it the chance that extreme weather events may prevent workers attending the mine and/or impede workers leaving the mine in the case of flood, fire or cyclone. Moreover, the impacts of disruption in mine schedules may be felt throughout the settlement system, including metropolitan and non-metropolitan places distant from the areas of mineral production. Haslam McKenzie (2011), for example, has noted the prevalence of well paid miners amongst the second home owners of the Margaret River district. Fundamentally, a long term disruption to mining production may challenge the incomes of these and many other rural households, placing their economic sustainability at risk.

3.3 Tourism and climate change

Tourism is potentially very vulnerable to the impacts of climate change as much non metropolitan tourism relies heavily on both quality of life and natural amenity, which may be at risk as a consequence of climate change. Moreover, country towns may lack the financial and other resources to deal effectively with climate change via infrastructure investment or other adaptation strategies. The Department of Resources, Energy and Tourism (2008) examined strategies to prepare tourism for climate change and concluded that the sector as a whole needed to achieve five key outcomes:

- improve the understanding of the sector in terms of its vulnerabilities to the physical and economic impacts of climate change;

- develop a tourism industry that is prepared for a carbon constrained future;
- reposition tourism marketing strategies to tackle head on the challenges of climate change;
- fully inform the industry through outreach and communication; and,
- develop a nationally inclusive and consistent approach to implementation.

(DRET 2008: 5)

Jones *et al* (2010) considered the potential impact of climate change on the Margaret River region and concluded that local adaptations to climate change are not only necessary, but are often the only actions acceptable to local residents. The authors found that members of the Margaret River community had been affected by the Global Financial Crisis which in turn spurred them to look less to government and more to their own resources. They recognised that climate change may carry benefits for their tourism industry – primarily by enhancing the attractiveness of their beaches – but also carried risks, with respect to disaster/risk management, including fire and floods. In this instance, climate change was primarily seen as a local issue to be dealt with by the community and its members.

James and Liddicoat (2008) came to a similar realisation on the importance of local engagement for climate change adaptation in their study of the viticulture and olive industries in and around McLaren Vale. Critically, while olives and wine are agricultural commodities, they also serve as the focus of tourism.

One adaptation strategy many country towns may need to consider is the strengthening of local agricultural and environmental attractions as a way of ensuring a steady flow of tourists.

3.4 Conclusion

Climate change clearly represents a substantial challenge for the industry base of many country towns, but this challenge should be thought of as one of adaptation rather than survival. Even **agriculture**, which at face value would appear to be one of the most exposed sectors, **is confronted by both opportunities and risks in a climate change affected world**. Undoubtedly risks are not evenly distributed and some regions face potentially greater challenges than others. This said, the available evidence suggests that established industries will continue with the application of new technologies and management strategies. New agricultural industries will emerge and some will be unequivocally linked to climate change mitigation and adaptation (DCCEE 2012). Others will simply reflect shifts in opportunities and competitive advantage. The resilience of agriculture will sustain many country towns across Australia to the year 2050. Other industries are also important for Australia's country towns and less attention has been paid to sectors such as tourism, utilities and retailing. This absence is significant as both population size and diversity of employment opportunities will be important in determining which centres thrive and which centres decline in a climate change affected Australia.

4. DEVELOPING A VULNERABILITY INDEX FOR AUSTRALIA'S COUNTRY TOWNS

One of the over-riding concerns of this research is to understand the distribution of risk facing Australia's country towns as we move to the year 2050 and the certainty of human-induced climate change. Understanding which settlements are at greatest risk and why is critical if we are to better inform public policy and assist communities adapted for their future climate. It will also allow communities and society as a whole to make better decisions and take actions that are most likely to secure their future.

This chapter outlines a first approach to the measurement of vulnerability amongst Australia's country towns to the year 2050. The original goal of this chapter was to test the feasibility of developing such an indicator, but in this chapter we go beyond that to provide a first-run analysis of vulnerability for Australia's inland country towns. This is, of course, not the first attempt to model vulnerability to climate change for Australia's regions. The CSIRO's work in this area is well known, and indeed forms a key input into our own formulation. What is different, however, is the attempt to understand how discrete settlements will be affected by climate change and the ways in which social and economic characteristics will interact with a changing climate.

4.1 Conceptualising vulnerability, adaptation and change

Malone and Engle (2011) have noted that in discussing vulnerability and adaptation it is important to ask: who or what is vulnerable, what is vulnerability and what are they vulnerable to? As noted in Figure 2.1, the vulnerability of any place or region is a product of the level of exposure to change, the sensitivity of that place to either gradual or sudden shocks which together constitute the potential impact (see also, Preston and Stafford-Smith 2009). Potential impact works alongside adaptive capacity, which is a measure of a community's ability to adjust to change, and, in combination, potential impact and adaptive capacity determine vulnerability. Critically, vulnerability is a composite concept, with some of its constituents in turn shaped by multiple factors. Risk is the likelihood of a specified harm occurring, while maladaptation refers to an adaptation that does not succeed in reducing vulnerability but increases it instead (IPCC 2001: 990).

Unfortunately, vulnerability and risk do not arrive in linear and predictable bundles. Many climate scientists emphasise the importance of acknowledging the impacts of what they refer to as 'large-scale singularities' – or abrupt climate change-related impacts on the natural or human system. Preston and Jones (2006: 30-31) define such events as 'complex non-linear responses where systems switch from one state to another'. Frequently cited examples of large scale abrupt changes in Australia include the dramatic decrease in rainfall in South West Western Australia that occurred in the 1970s and from which the rainfall pattern have not recovered, and rapid coral bleaching occurring along the Great Barrier Reef in northern Queensland. While large scale singularities are unpredictable events, climate scientists remind us of their potential to disrupt systems significantly and instantly. Singularities represent a challenge for the modelling of climate future, especially at a regional or local scale, because they are almost impossible to incorporate into such analyses and introduce the potential for any model to be significantly mis-cued. Our analysis of vulnerability for Australia's country towns does not incorporate the potential impact of singularities, but instead represents an 'averaging' of likely climate impacts. Such an approach almost certainly underestimates the severity of some impacts, but does provide a justifiable basis for further action.

The modelling of the future of Australia's country towns is also made more complex by the need to incorporate both climate-induced and socially-driven change. Rosenzweig and Wilbanks (2010: 105) succinctly summarise this challenge:

For human and human-managed systems, projecting longer-term climate change impacts and costs is complicated by the fact that systems will be changing for other reasons as well (demographic, economic, technological, institutional), and climate change impacts will depend on interaction with these other changes.

Put more simply, the future of Australia's country towns to the year 2050 is not simply a story of a changing climate and its impacts. Instead, a range of demographic, social and economic changes will continue to reshape all of Australia's urban settlement system, with country towns likely to experience some of the sharpest change. This process of change will inevitably be affected by the decisions of governments and communities, with the public sector and individuals alike challenged to translate the scientific evidence into policies and actions on the ground (Martens *et al* 2009). We should acknowledge that many country towns currently extant are unlikely to survive to 2050, even in the absence of climate change. And those surviving to the year 2050 are likely to have taken on new functions, new methods of operating as a community and as an economic system, and be making use of infrastructure that differs from that currently on the ground.

4.2 Constructing the Vulnerability Index

4.2.1 Index construction methodology

This section sets out the processes undertaken to construct the Vulnerability Index for Urban Centres and Localities (UCLs) in rural and regional Australia. It explains how the Index was derived using the concepts of exposure, sensitivity, adaptive capacity, and how the variables for each were chosen. It also sets out how the variables were translated into numerical indices through normalisation for aggregation into sub-indices for each component of vulnerability. Finally the composite index is constructed and presented and the results presented.

This Index has been developed for all non-metropolitan UCLs in Australia more than 10km from the coast. UCLs are a standard unit of data collection and reporting for the Australian Bureau of Statistics (ABS) though not as commonly used as statistical divisions or statistical local areas. That said, there is a considerable body of work on Australia's urban system that has focussed on UCLs and the insights they offer into the nation's urban dynamics (see, for example, Beer and Clower 2009). Importantly, UCLs are the best approximation currently available for urban places. They are contiguous urban areas that have been identified by the ABS since the 1960s and they provide insights into how settlements change both independently of, and in conjunction with, their hinterlands.

4.2.2 Vulnerability defined

Vulnerability conceptual frameworks have been used extensively in analysing the adverse impacts of climate change and these frameworks emanate from an array of academic disciplines (Pearson and Langridge 2008, Nelson *et al* 2005). Preston *et al* (2011) note that there are a number of different frameworks for assessing vulnerability, including the use of risk-hazard models, social vulnerability models, pressure and release models and expanded vulnerability models. However Nelson *et al* (2005) highlight that whilst there is a diverse array of frameworks, there is a convergence in the generic attributes of vulnerability applied to climate change impacts. It is this

convergence of exposure, sensitivity and adaptive capacity that guides the model of vulnerability developed in this study.

The starting point for determining what vulnerability means in the context of *Australia's Country Towns 2050: What Will A Climate Adapted Settlement Pattern Look Like?* was identifying a working definition of vulnerability. The definition most commonly cited within the climate change vulnerability literature is that of the IPCC and its reports. Therefore we have used the definition from the Fourth Assessment Report, where vulnerability is understood as 'a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity' (IPCC 2007). This implies that vulnerability is determined by not only the direct impacts of the changing climate such as increased temperature and less annual average rainfall but factors such as the economic conditions of the study location, and also the social structure and political situation.

This general model of vulnerability uses the frameworks of Adger (2006), Smit and Wandel (2006), and Allen Consulting (2005) – presented in Figure 2.1 – that views vulnerability of a particular community as intertwined with the biophysical and socioeconomic conditions prevalent in that location. In rural and regional Australia primary production has underpinned the economy and social institutions that are active in these communities. Much land under primary production has had constant exposure to the vagaries of seasonal weather, commonly referred to as variable climate. Through these variable weather patterns, coping and adaptation has been a key feature of underpinning the productivity gains made for many locations over time, thus enabling such locations, as population centres and communities, to remain 'open for business' and viable.

Exposure and sensitivity are inherently linked and combine to affect potential impact. To assess the vulnerability of UCLs to climate change, we look at exposure to climate change, sensitivities to those changes and the adaptive resources and capabilities available. Therefore the key focus of this research was to develop a vulnerability index that integrates the three components by capturing measures pertinent to community functioning in rural, regional and remote Australia, including measures impacting on/determining climate change related vulnerability.

Exposure

Exposure is a measure of the direct impact climate change will exert on the conditions in a region and is assessed using change in mean surface temperatures and change in average annual rainfall (mm).

Sensitivity

Sensitivity describes the dependency of the location upon the element – industry or production systems – that is experiencing change. In this instance, a UCL that has no agriculture will be less vulnerable to drier or more unfavourable conditions. For the purposes of this analysis, sensitivity is assessed as a function of the percentage employed in agriculture and related industries and the degree of remoteness of the location.

Adaptive Capacity

The IPCC has defined adaptive capacity as 'the ability or potential of a system to respond to climate variability and change'. Within this Index adaptive capacity is assessed using the following indicators:

- percentage of total employed persons by highest year of school completed; percentage of employed persons by age by level of highest educational attainment; postgraduate (1); Graduate Diploma (2); and Bachelor Degree (3); and,

- population number (size) and percentage of the population with internet access.

4.2.3 Data sources

Data was primarily sourced from the Australian Bureau of Statistics (ABS). To qualify as a UCL in their own right each location must have a population of more than 200 persons. Very small locations then are excluded from this data measure. This is a prerequisite to be classified as a UCL by the ABS.

Accessibility Remoteness Index Australia (ARIA+) data was obtained from the National Centre for Social Applications of Geographical Systems (GISCA), while data for climate change scenarios were extracted from the OzClim Climate Change Scenario Generator of which there are a number of global climate models available for projections of future climates for Australia.

The degree to which there will be change in temperature and precipitation varies substantially by scenario or model, particularly when projected over long time frames. This variability guided the selection of the global climate model and we selected the CSIRO Mk3.5 model, which has an m-skill score⁴ which shows that it is a suitable and reliable predictor of the Australian climate (CSIRO 2007). The CSIRO Mk3.5 model is one of moderate – as opposed to substantial or muted – climate change and this middle road was selected in order to present a more likely set of outcomes. The CSIRO Mk 3.5 Model predicts annual average precipitation decreases across all of Australia, except for the east coast. The model also predicts that the annual pattern of temperature change per degree of global warming (PDGW) will increase across all of Australia. Many vulnerability indexes comprise averages of a large number of global climate models. This was outside the scope of this project.

In the first iteration of the vulnerability index the decrease in precipitation was measured as a percentage change predicted for 2050. However this measure does not draw out a relative sensitivity to changes in rainfall between the locations in the index. For example a 20% change in precipitation in location A (a low row rainfall area) could represent a more significant difference from historical conditions than that of location B (a high rainfall area). Similarly a warming of 1°C may be more drastic for certain locations than others. With Australia's diversity in climate conditions better climate predictions were assessed that reflected the climate variability for each location. This was done to better reflect the sensitivity of the location to impacts of global warming relative to other locations.

The climate projections used in this study are based on the A1B scenario for climate models. Assumptions in the A1B scenario include a future world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies. In terms of energy technology, the A1B scenario assumes a balance across all sources, where balanced is defined as not relying too heavily on one particular energy source, and that similar improvement rates apply to all energy supply and end-use technologies.

4.2.4 Index variable selection

Index variables were chosen after extensive consultation within the research team, the working group and analysis of the literature. The final selection criteria were based on the available data and how it captured the requisite impact on/for both the sub indices and the index overall. Data was not weighted as other research suggests no *a priori* basis for doing so (Nelson *et al* 2005; 2007).

⁴ A measure of climate model performance. (CSIRO 2007)

Exposure

Change in Total Rainfall (mm)⁵ – Total rainfall has broad influence on rural and regional locations. Primary production – both rain fed and irrigation, potable water and the local natural environment will be impacted by changes in total annual rainfall. With the predictions of precipitation decreases across most of Australia, and particularly inland Australia, rainfall variance was calculated to give more accuracy to each location in the index relative to other locations. With hotter and drier conditions projected for much of Australia, the greater the variance in rainfall decline for each location the more vulnerable the location.

Change in Mean Surface Temperature⁶

Mean surface temperature has an influence on local amenity and also on primary production. The higher the variance in increased mean surface temperature for each location the more vulnerable is the location.

Sensitivity

Percentage employed in agriculture related Industries – The largest industries in rural and regional areas of Australia are primary production based. Projections of less precipitation and increasing mean surface temperatures indicate that agricultural industries are vulnerable to the impacts of climate change. This will potentially affect rural and regional Australia at both an individual and location level, primarily because jobs will be threatened in those locations most at risk. The percentage of persons employed in agriculture is therefore used as a proxy for a location's long-term prospects. The higher the percentage of persons employed in agriculture, the more vulnerable the location. Data was sourced from ABS 2006 Census of Population and Housing.

Remoteness

Many locations in rural and regional Australia are remote from major population centres and residents of these communities have long distances to travel for services. The Accessibility Remoteness Index of Australia 2006 provides a relative measure of geographic remoteness in terms of the distance the population each town and locality must travel in order to access services. The higher the remoteness score the more vulnerable the location. Data was sourced from GISCA.

Adaptive capacity

Highest year of schooling completed – Having a well educated population has two key roles in boosting adaptive capacity within a location. Firstly, the ability to access information and distill relevant knowledge is critical for understanding the risks associated with climate change. Second, a better educated population also enhances the employment prospects of the individuals in the location. This has a positive effect in generating higher incomes which in turn enables the individuals to 'buy in' adaptation. The higher the percentage of persons who have completed high school the less vulnerable the location. Data was sourced from ABS 2006 Census.

Highest level of educational attainment: Postgraduate; Graduate Diploma; and Bachelor Degree – Higher numbers of people with higher education levels indicates diversity in employment opportunities, particularly in the services sector. This indicates less reliance on industries susceptible to the adverse impacts of climate change for

⁵ Change in Total Rainfall (mm), in AUSTRALIA for the year 2050, Annual. Model: CSIRO-Mk3.5. Emission Scenario: SRES marker scenario A1B, Global Warming Rate: moderate.

⁶ Change in Mean Surface Temperature (°C), in AUSTRALIA for the year 2050, Annual. Model: CSIRO-Mk3.5. Emission Scenario: SRES marker scenario A1B, Global Warming Rate: moderate.

employment. The higher percentage of persons with a tertiary education the less vulnerable the location. Data was sourced from ABS 2006 Census.

Percentage of households with internet connection – information is seen as a critical element in guiding people and their communities to adaptation actions. However, Australia’s expansive landscape and remoteness generates barriers to accessing the internet and the benefits it provides. A higher level of household connectivity to the internet is a measure of access to knowledge in developing adaptive responses. The higher the number of households with internet connection the less vulnerable is the location. Data was obtained from the ABS 2006 Census.

Population – Social and human capital, alongside institutional strength and stability, are important for determining a location’s resilience. Places with larger populations will, *ceteris paribus*, have a larger pool of resources available for coping and adaptation. The additional services associated with larger populations – such as health, education and social supports – will all contribute to the adaptive capacity of the location thereby enhancing the location’s capacities to respond to climate impacts. Data was sourced from ABS 2006 Census.

4.2.5 Deriving the aggregate index values

To obtain variables insensitive to their various scale of measurement a minimum – maximum normalisation technique was used to construct the sub indices of each component of the vulnerability index. The following formulas were used in accordance with the variable’s functional relationship:

- $V_{ij} = (X_{ij} - \text{Min } X_{ij}) / (\text{Max } X_{ij} - \text{Min } X_{ij})$
- $V_{ij} = (\text{Max } X_{ij} - X_{ij}) / (\text{Max } X_{ij} - \text{Min } X_{ij})$

Where:

V_{ij} stands for the degree of vulnerability in location j , arising from X , which is one of the variables in the index;

X_{ij} stands for the value of the i th vulnerability variable, for location j ;

$\text{Max } X_i$ and $\text{Min } X_i$ stand for the maximum and minimum values of the i th Vulnerability variable for all locations in the index.

A composite index is, as its name implies, an average of a number of sub indices. The vulnerability index developed in this work is aggregated in three different components, so that the different dimensions of vulnerability are represented by a single value indicator. The sub indices were equally weighted and a simple average was then taken to compute the vulnerability scores for each location using the following formula:

$$VI = (A + S + E)/3$$

Table 9 below provides a schematic of the Indicators, Functional Relationship and Indicator Rationale.

Table 9: Indicators, functional relationship and indicator rationale

	Indicator/data	Functional relationship	Indicator rationale	Normalisation method used
Exposure	Change in Mean Surface Temperature, in AUSTRALIA for the year 2050, Annual	↑	The higher the projected change the more vulnerable is the UCL	1
	Change in Total Rainfall (mm) , in AUSTRALIA for the year 2050, Annual	↑	The higher the projected change the more vulnerable is the UCL	1
Sensitivity	% Employed in Ag related Industries	↑	The higher the proportion of people employed in Ag related industries the more vulnerable is the UCL	1
	Remoteness	↑	The more remote the UCL is the more vulnerable it is	1
Adaptive capacity	% of total employed persons by Highest Year of School Completed	↓	The higher the proportion of people in workforce completing year 12 the less vulnerable is the UCL	2
	% of employed persons by age by level of highest educational attainment; postgraduate (1); grad diploma (2); and Bachelor Degree (3).	↓	The higher the proportion of people in workforce with Tertiary education or equivalent the less vulnerable is the UCL	2
	Population number (size)	↓	The higher the total population the less vulnerable is the UCL	2
	% Population with internet access	↓	The higher the proportion of people connected to the internet the less vulnerable the UCL is	2

4.3 Results of vulnerability mapping for Australia's country towns

Development of the Vulnerability Index for Australia's Country Towns makes it possible to generate a standardised score for each of Australia's almost 2000 non-coastal urban settlements with a population of 200 persons or more. Figure 5 maps the scores for all of Australia while Table 10 on the following page lists the 20 most vulnerable centres according to this metric.

Both Figure 5 and Table 10 clearly show that remote inland settlements are most at risk in a climate-change affected Australia. Indeed, Table 10 shows that many of the most at-risk communities are Indigenous communities in remote locations. Nine of the twenty most at-risk settlements according to this index are to be found in the Northern Territory, a jurisdiction with relatively limited resources for climate change adaptation or implementation. No Tasmanian or Victorian community appears in the list of the twenty most vulnerable communities. Additionally, it is clear from this data that many parts of the established cropping lands in the south east of Australia appear to face a relatively muted risk, while settlements in Western Australia's agricultural lands appear to face a greater threat than those in South Australia or Victoria. The level of vulnerability appears high throughout NSW also, and this may partly be a function of the distance of many of these centres from Sydney or one of the other capitals. Table 11 shows that the least vulnerable inland centres tend to be located close to the capitals (for example, Crafrers-Bridgewater and Summertown in South Australia) or larger settlements with diverse economies, such as Bendigo. No Western Australian or Northern Territory settlement appears on the list of the twenty least vulnerable communities according to this index – and this reflects the apparently greater risk in these two jurisdictions when compared with southern and eastern Australia.

Comparable maps and tables can be produced for each of the States and Territories and are presented in the remainder of this section. Each of these tables and figures presents a state or territory based story of climate change vulnerability and its potential impact on country towns within a jurisdiction.

Importantly, at both the national and state levels, country towns that are already at risk because of economic restructuring, demographic change etc, appear to be most vulnerable to climate change. Climate change, therefore, may simply compound the difficulties facing such places and could serve to tip some settlements into a downward path. This has implications both for our understanding and interpretation of the impacts of climate change, and in the development of policy responses.

Unfortunately, data and maps cannot be produced for the ACT, as Canberra is the only UCL for the whole jurisdiction.

Vulnerability Scores Non-Coastal UCLs 2050

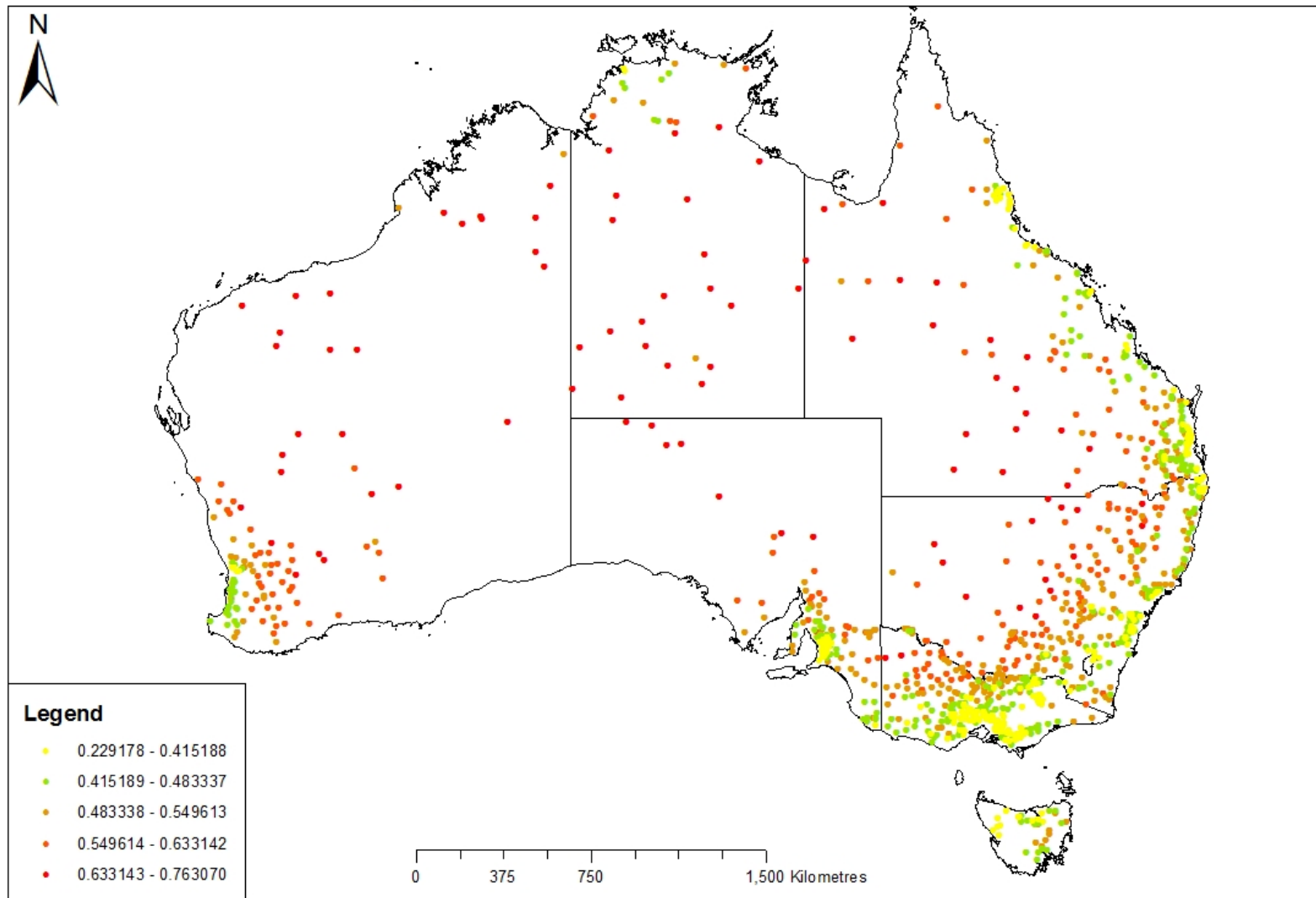


Figure 5: Distribution of vulnerability to climate change for UCLs in Australia for the year 2050

Table 10: Most vulnerable non-coastal UCLs, Australia with predicted increase in mean surface temperatures and decrease in annual average rainfall for 2050

<i>State</i>	<i>Location</i>	<i>Vulnerability Scores</i>	<i>Rank</i>
WA	Marble Bar	0.763	1
NT	Ampilatwatja (Aherrenge)	0.755	2
NT	Willowra	0.750	3
NT	Ali Curung	0.748	4
NT	Kaltukatjara (Docker River)	0.748	5
WA	Warburton	0.738	6
Qld	Boulia	0.737	7
NSW	Tottenham	0.734	8
NSW	White Cliffs	0.731	9
WA	Jigalong	0.729	10
Qld	Camooweal	0.726	11
NT	Alpurrurulam	0.726	12
NT	Kintore	0.722	13
NT	Nyirripi	0.721	14
NT	Titjikala	0.720	15
SA	Ernabella	0.719	16
WA	Balgo	0.714	17
Qld	Quilpie	0.711	18
NSW	Goodooga	0.708	19
NT	Yuendumu	0.707	20

Table 11: Least vulnerable non-coastal UCLs, Australia, with predicted increase in mean surface temperatures and decrease in annual average rainfall for 2050

<i>State</i>	<i>Location</i>	<i>Vulnerability Scores</i>	<i>Rank</i>
SA	Crafers-Bridgewater	0.229	1
SA	Summertown	0.254	2
SA	Oakbank	0.300	3
Vic	Beaconsfield Upper	0.300	4
Vic	Ballarat	0.304	5
SA	Hahndorf	0.305	6
Vic	Menzies Creek	0.305	7
Vic	St Andrews	0.307	8
SA	Mount Barker	0.310	9
SA	Uraidla	0.312	10
Qld	Mount Nebo	0.313	11
SA	Echunga	0.314	12
Vic	Emerald	0.314	13
Qld	Mount Glorious	0.317	14
Vic	Mount Macedon	0.318	15
SA	Balhannah	0.324	16
NSW	Gundaroo	0.325	17
Vic	Macedon	0.329	18
Vic	Greendale	0.330	19
Vic	Warburton	0.331	20

New South Wales

In NSW the most vulnerable settlements according to this index are to be found in the western parts of the state and in particular the remote northern and western districts (Figure 6). There are, however, exceptions to this general pattern:

- The far South Coast of NSW appears to have a higher level of vulnerability, and while the Bega itself is confronted by a low risk, nearby settlements, including those at the top of escarpment such as Nimitabel, Bombala and Delegate appear to be at risk;
- Parts of the Riverina – such as Wagga Wagga and Albury-Wodonga – appear to be confronted by a lower level of risk; and,
- This index suggests relatively little risk confronting alpine communities such as Perisher Village, Thredbo Village and Jindabyne, despite the published literature which suggests the ecology of these high elevation regions are at considerable risk in a climate change affected world.

Tables 12 and 13 detail the most and least vulnerable non-coastal settlements according to the Vulnerability Index for New South Wales.

Table 12: Most vulnerable non-coastal UCLs, New South Wales, Australia, with predicted increase in mean surface temperatures and decrease in annual average rainfall for 2050

<i>State</i>	<i>Location</i>	<i>Vulnerability Scores</i>	<i>Rank</i>
NSW	Tottenham	0.734	1
NSW	White Cliffs	0.731	2
NSW	Goodooga	0.708	3
NSW	Ivanhoe	0.680	4
NSW	Brewarrina	0.678	5
NSW	Wilcannia	0.674	6
NSW	Ungarie	0.667	7
NSW	Ashford	0.657	8
NSW	Gulargambone	0.650	9
NSW	Collarenebri	0.649	10
NSW	Lightning Ridge	0.642	11
NSW	Lake Cargelligo	0.637	12
NSW	Bundarra	0.637	13
NSW	Tullamore	0.635	14
NSW	Bourke	0.633	15
NSW	Baradine	0.629	16
NSW	Mungindi (Part)	0.626	17
NSW	Deepwater	0.626	18
NSW	Trangie	0.622	19
NSW	Nyngan	0.618	20

Vulnerability Scores Non-Coastal UCLs in N.S.W. 2050

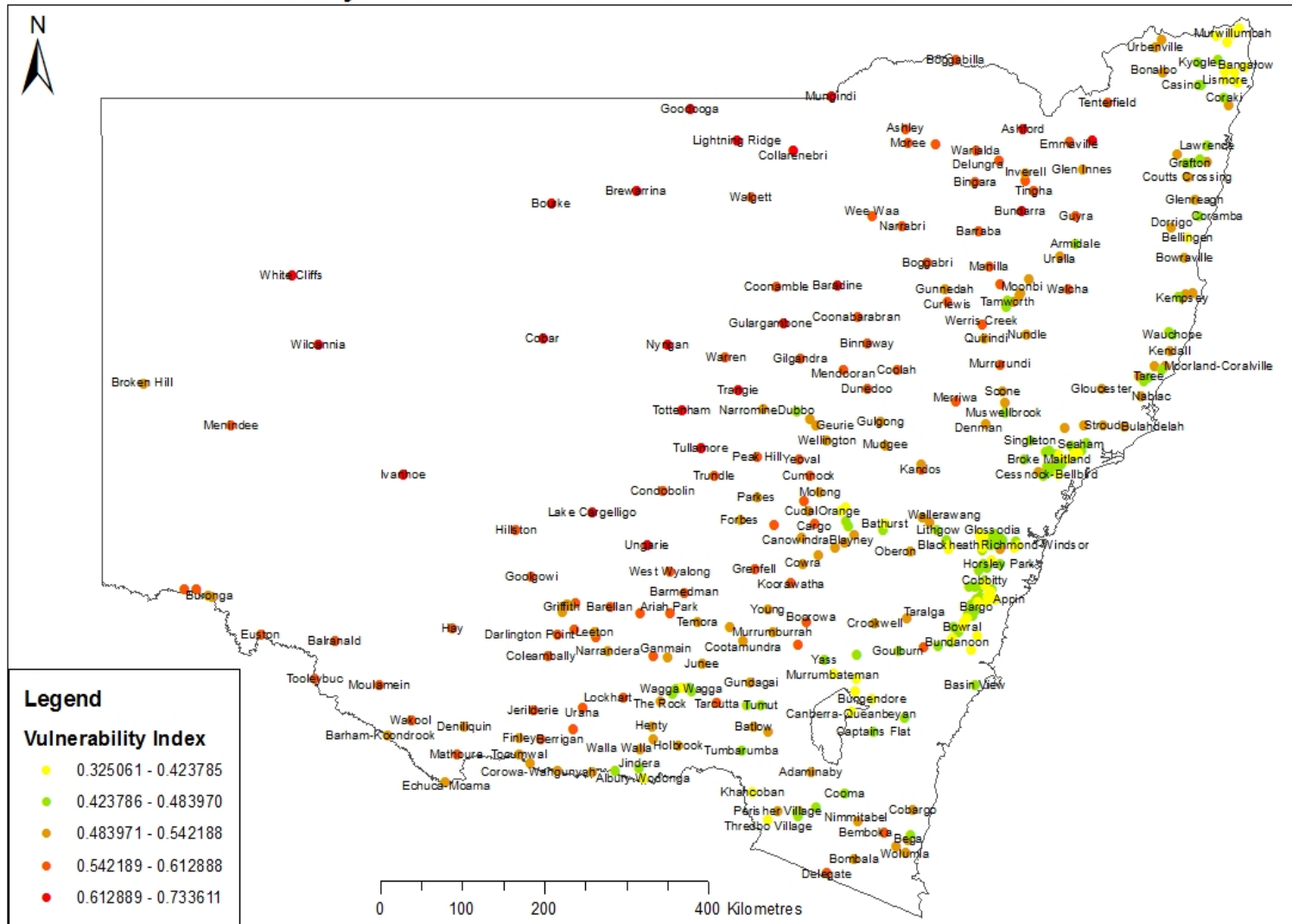


Figure 6: Distribution of vulnerability to climate change for UCLs in New South Wales, Australia, for the year 2050

Table 13: Least vulnerable non-coastal UCLs, New South Wales, Australia, with predicted increase in mean surface temperatures and decrease in annual average rainfall for 2050

<i>State</i>	<i>Location</i>	<i>Vulnerability Scores</i>	<i>Rank</i>
NSW	Gundaroo	0.325	1
NSW	Bangalow	0.334	2
NSW	Clunes	0.340	3
NSW	Murrumbateman	0.354	4
NSW	Kenthurst	0.355	5
NSW	Canberra-Queanbeyan (Queanbeyan Part)	0.370	6
NSW	Wollongbar	0.371	7
NSW	Sutton	0.372	8
NSW	Bowral	0.374	9
NSW	Alstonville	0.375	10
NSW	Thredbo Village	0.377	11
NSW	Albury-Wodonga (Albury Part)	0.379	12
NSW	Bungendore	0.381	13
NSW	Clifton Grove	0.384	14
NSW	Dunoon	0.385	15
NSW	Lismore	0.389	16
NSW	Maitland	0.391	17
NSW	Uki	0.392	18
NSW	Hawkesbury Heights	0.395	19
NSW	Brandy Hill	0.396	20

Victoria

As with the national pattern of vulnerability, settlements closer to Melbourne tended to receive lower index values and therefore can be assumed – according to this metric – a lower degree of climate change risk. It is important to reflect upon the fact that this is an outcome of both first and second tier impacts. Remoteness is an input into the model, though it would have a muted bearing in Victoria where few places can be classified as remote or very remote. Perhaps more importantly, places close to the major metropolitan centres tend to have more ‘urban’ economies – through commuting or the provision of goods and services to the capital cities – and are therefore less exposed to climate vulnerable sectors such as agriculture. The data for Victoria display a general south-north trend (shown in Figure 7), with country towns in the southern part of the state apparently less vulnerable to the impacts of climate change. This tendency is more readily evident in Western Victoria. In eastern Victoria the large area of national park associated with the mountains contributes to a more complex picture, but it is worth noting that in common with NSW, high elevation communities such as Falls Creek and Mt Hotham would appear to be less likely to be affected by climate change, when compared with settlements in the Mallee.

Tables 14 and 15 detail the most and least vulnerable non-coastal settlements according to the Vulnerability Index for Victoria.

Table 14: Most vulnerable non-coastal UCLs, Victoria, Australia, with predicted increase in mean surface temperatures and decrease in annual average rainfall for 2050

<i>State</i>	<i>Location</i>	<i>Vulnerability Scores</i>	<i>Rank</i>
Vic	Underbool	0.672	1
Vic	Murrayville	0.638	2
Vic	Beulah	0.613	3
Vic	Quambatook	0.609	4
Vic	Leitchville	0.590	5
Vic	Manangatang	0.589	6
Vic	Hopetoun	0.587	7
Vic	Ouyen	0.586	8
Vic	Nyah West	0.579	9
Vic	Gunbower	0.578	10
Vic	Goroke	0.574	11
Vic	Pyramid Hill	0.573	12
Vic	Robinvale	0.571	13
Vic	Sea Lake	0.566	14
Vic	Nyah	0.566	15
Vic	Wycheproof	0.563	16
Vic	Barham-Koondrook (Koondrook Part)	0.559	17
Vic	Minyip	0.558	18
Vic	Woomelang	0.557	19
Vic	Birchip	0.556	20

Vulnerability Scores Non-Coastal UCLs in Victoria 2050

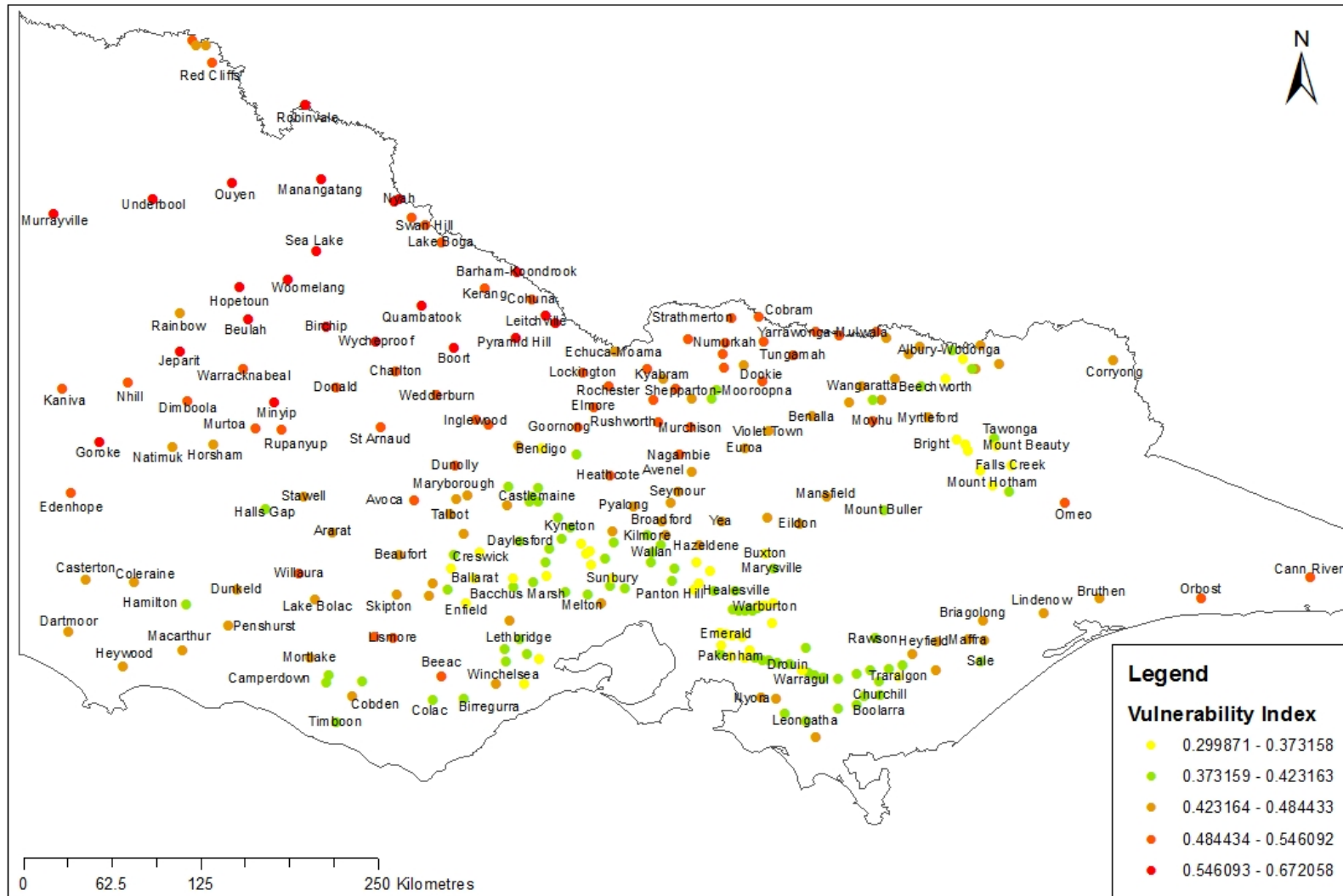


Figure 7: Distribution of vulnerability to climate change for UCLs in Victoria, Australia, for the year 2050

Table 15: Least vulnerable non-coastal UCLs, Victoria, Australia, with predicted increase in mean surface temperatures and decrease in annual average rainfall for 2050

<i>State</i>	<i>Location</i>	<i>Vulnerability Scores</i>	<i>Rank</i>
Vic	Beaconsfield Upper	0.300	1
Vic	Ballarat	0.304	2
Vic	Menzies Creek	0.305	3
Vic	St Andrews	0.307	4
Vic	Emerald	0.314	5
Vic	Mount Macedon	0.318	6
Vic	Macedon	0.329	7
Vic	Greendale	0.330	8
Vic	Warburton	0.331	9
Vic	Maryknoll	0.333	10
Vic	Falls Creek	0.335	11
Vic	Mount Hotham	0.339	12
Vic	Bendigo	0.341	13
Vic	Kinglake	0.342	14
Vic	Panton Hill	0.342	15
Vic	Gisborne	0.342	16
Vic	Pakenham	0.344	17
Vic	Cockatoo	0.348	18
Vic	Warragul	0.349	19
Vic	Moriac	0.355	20

Queensland

The distribution of vulnerability index scores for Queensland displays the same general trend evident nationally and in the other eastern seaboard states – with greater risk evident for the more remote western towns (see Figure 8 below, compared with Figures 6 and 7). Within this general pattern it is clear that there are clusters of low relative risk around a number of near-coastal regional centres, including Rockhampton, Mackay and Cairns. These larger, more urban settlements, would appear to generate resources and capacity internally and for nearby towns that should enhance their resilience in the fact of climate change. It is important to acknowledge also the limitations of this measure: some of the towns in the Surat Basin such as Surat and Chinchilla have relatively high vulnerability scores, but they do not reflect the emergence of coal seam gas as a major industry in this region. Such developments are likely to transform their economies and reduce exposure to the impacts of climate change

Tables 16 and 17 detail Queensland's most and least vulnerable non-coastal settlements according to the metric developed as part of this research.

Table 16: Most vulnerable non-coastal UCLs, Queensland, Australia, with predicted increase in mean surface temperatures and decrease in annual average rainfall for 2050

<i>State</i>	<i>Location</i>	<i>Vulnerability Scores</i>	<i>Rank</i>
Qld	Boulia	0.737	1
Qld	Camooweal	0.726	2
Qld	Quilpie	0.711	3
Qld	Cunnamulla	0.698	4
Qld	Alpha	0.692	5
Qld	Thargomindah	0.686	6
Qld	Augathella	0.686	7
Qld	Richmond	0.682	8
Qld	Dirranbandi	0.680	9
Qld	Winton	0.679	10
Qld	Blackall	0.675	11
Qld	Tambo	0.674	12
Qld	Julia Creek	0.671	13
Qld	Aramac	0.667	14
Qld	Mitchell	0.655	15
Qld	Normanton	0.652	16
Qld	Surat	0.646	17
Qld	Charleville	0.643	18
Qld	Doomadgee	0.642	19
Qld	Longreach	0.632	20

Vulnerability Scores Non-Coastal UCLs in Qld. 2050

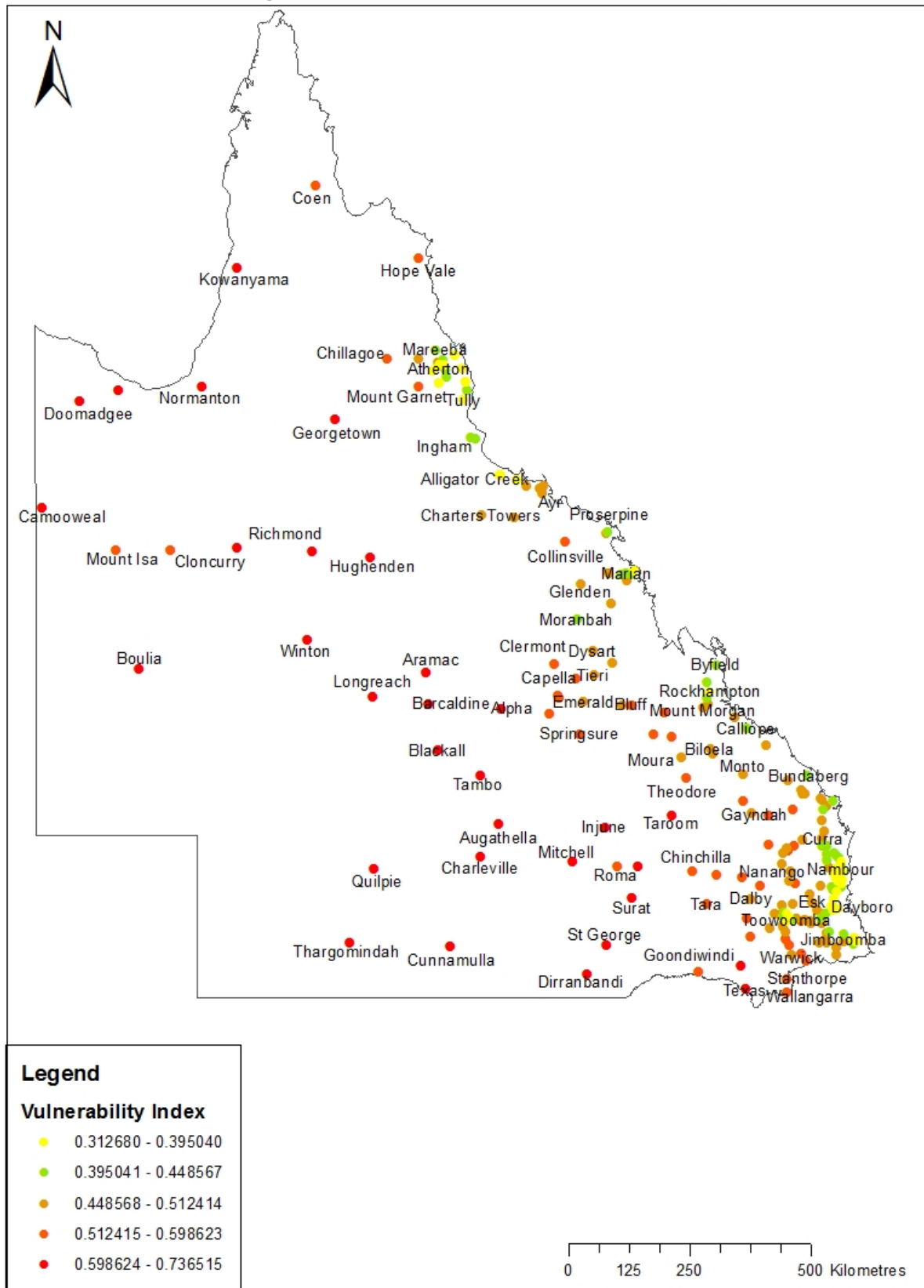


Figure 8: Distribution of vulnerability to climate change for UCLs in Queensland, Australia, for the year 2050

Table 17: Least vulnerable non-coastal UCLs, Queensland, Australia, with predicted increase in mean surface temperatures and decrease in annual average rainfall for 2050

<i>State</i>	<i>Location</i>	<i>Vulnerability Scores</i>	<i>Rank</i>
Qld	Mount Nebo	0.313	1
Qld	Mount Glorious	0.317	2
Qld	Toowoomba	0.337	3
Qld	Babinda	0.342	4
Qld	Rockhampton	0.347	5
Qld	Samford	0.347	6
Qld	Blue Mountain Heights	0.351	7
Qld	Palmwoods	0.355	8
Qld	Johnstone South	0.357	9
Qld	Mount Tamborine	0.361	10
Qld	Yungaburra	0.366	11
Qld	Tully	0.367	12
Qld	Herberton	0.368	13
Qld	Alice River	0.369	14
Qld	Nambour	0.369	15
Qld	Mooloolah	0.370	16
Qld	Peachester	0.370	17
Qld	Maleny	0.372	18
Qld	Mapleton	0.374	19
Qld	Woombye	0.375	20

South Australia

South Australia exhibits the same general trend toward greater levels of vulnerability to climate change evident in more remote towns than evident along the eastern seaboard. There are a number of features of the geography of South Australia that generate unique outcomes in this state. First, the highly concentrated nature of settlement in the state has meant that there is a cluster of towns in the Mt Lofty Ranges close to Adelaide – Crafers-Bridgewater, Mt Barker, Hahndorf *et cetera* – with low vulnerability scores. In large measure, these places serve as commuter suburbs for Adelaide and while geographically distinct from the capital, the social and economic structure of these places is tied to the metropolitan area. Second, Mt Gambier and the other settlements in the state's South East would appear to be at less risk as a consequence of the impacts of climate change – and this reflects climatic conditions. Third, the Riverland towns of Waikerie, Renmark, Barmera, Berri and Loxton all appear to be at relatively high risk. As is discussed in greater depth in the Waikerie case study in Chapter 5, many of these townships have already been challenged by significant change and in the long term their future will depend on the health of the Murray River and its flows. Figure 9 shows the distribution of vulnerability to climate change for the state.

The locations most and least vulnerable to climate change impacts as per our Vulnerability Index are given in Tables 18 and 19.

Table 18: Most vulnerable non-coastal UCLs, South Australia, Australia, with predicted increase in mean surface temperatures and decrease in annual average rainfall for 2050

<i>State</i>	<i>Location</i>	<i>Vulnerability Scores</i>	<i>Rank</i>
SA	Ernabella	0.719	1
SA	Amata	0.706	2
SA	Mimili	0.693	3
SA	Indulkana	0.679	4
SA	Cooper Pedy	0.676	5
SA	Andamooka Opal Fields	0.670	6
SA	Leigh Creek	0.649	7
SA	Booleroo Centre	0.619	8
SA	Woomera	0.615	9
SA	Wudinna	0.603	10
SA	Pinnaroo	0.602	11
SA	Cadell	0.591	12
SA	Hawker	0.591	13
SA	Kimba	0.590	14
SA	Orroroo	0.580	15
SA	Lameroo	0.575	16
SA	Cobdogla	0.572	17
SA	Snowtown	0.570	18
SA	Owen	0.570	19
SA	Blanchetown	0.570	20

Vulnerability Scores Non-Coastal UCLs in S.A. 2050

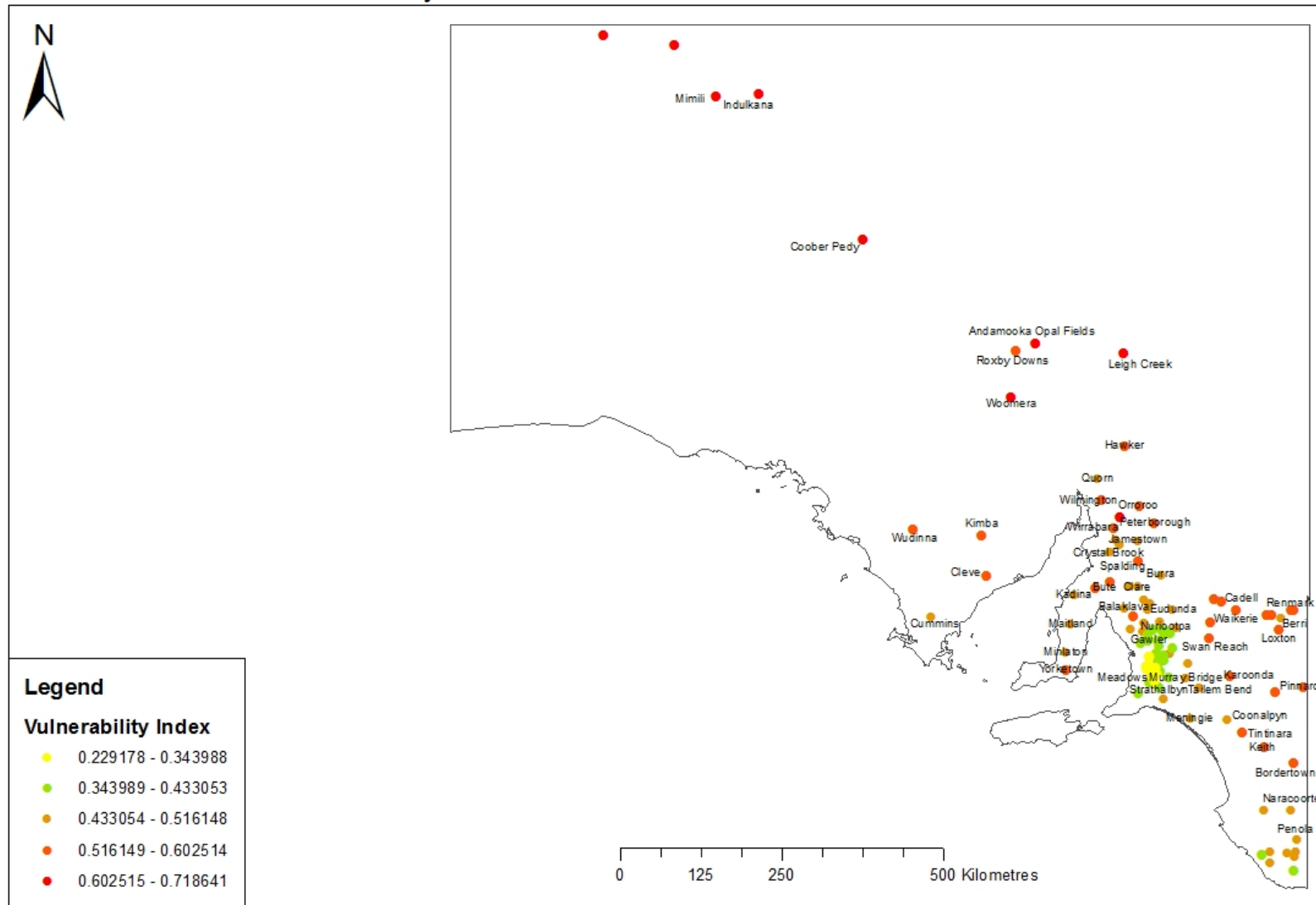


Figure 9: Distribution of vulnerability to climate change for UCLs in South Australia, Australia, for the year 2050

Table 19: Least vulnerable non-coastal UCLs, South Australia, Australia, with predicted increase in mean surface temperatures and decrease in annual average rainfall for 2050

<i>State</i>	<i>Location</i>	<i>Vulnerability Scores</i>	<i>Rank</i>
SA	Crafers-Bridgewater	0.229	1
SA	Summertown	0.254	2
SA	Oakbank	0.300	3
SA	Hahndorf	0.305	4
SA	Mount Barker	0.310	5
SA	Uraidla	0.312	6
SA	Echunga	0.314	7
SA	Balhannah	0.324	8
SA	Macclesfield	0.339	9
SA	Houghton	0.344	10
SA	Lobethal	0.359	11
SA	Mount Gambier	0.364	12
SA	Nairne	0.366	13
SA	Mount Torrens	0.366	14
SA	Meadows	0.367	15
SA	Kersbrook	0.367	16
SA	Woodside	0.374	17
SA	Birdwood	0.377	18
SA	Gumeracha	0.380	19
SA	Gawler	0.381	20

Western Australia

In common with South Australia, propinquity, or closeness, to Western Australia's capital appears to have a very strong impact on the distribution of vulnerability scores (compare Figure 10 and Figure 9). The lowest scores appear clustered around Perth. The geographic extent of low relative risk appears greater in Western Australia when compared with South Australia, extending down the coast to Mt Barker.

Interestingly, the gold mining city of Kalgoorlie-Boulder also recorded a low vulnerability score, as did Broome. Broome is differentiated by its strongly developed tourism and recreation industries, and rapid growth since the 1980s. The most vulnerable settlements in Western Australia have been associated with the mining industry, either now or in the past – for example, Cue, Marble Bar, Leonora, Meekathara *et cetera* – which goes some way to explaining their development in remote locations. Places such as Meekathara also continue to act as a service centre for pastoral industries.

A number of Indigenous communities are also ranked as being at a high risk from climate change.

Tables 20 and 21 detail Western Australia's most and least vulnerable country towns according to the metric.

Table 20: Most vulnerable non-coastal UCLs, Western Australia, Australia, with predicted increase in mean surface temperatures and decrease in annual average rainfall for 2050

State	Location	Vulnerability Scores	Rank
WA	Marble Bar	0.763	1
WA	Warburton	0.738	2
WA	Jigalong	0.729	3
WA	Balgo	0.714	4
WA	Bayulu	0.706	5
WA	Cue	0.705	6
WA	Yandeyarra	0.704	7
WA	Wiluna	0.703	8
WA	Meekatharra	0.696	9
WA	Mount Magnet	0.690	10
WA	Leonora	0.687	11
WA	Perenjori	0.687	12
WA	Koorda	0.686	13
WA	Laverton	0.683	14
WA	Looma	0.678	15
WA	Mindibungu	0.677	16
WA	Yungngora	0.669	17
WA	Halls Creek	0.667	18
WA	Warmun	0.665	19
WA	Paraburdoo	0.665	20

Vulnerability Scores Non-Coastal UCLs in W.A. 2050

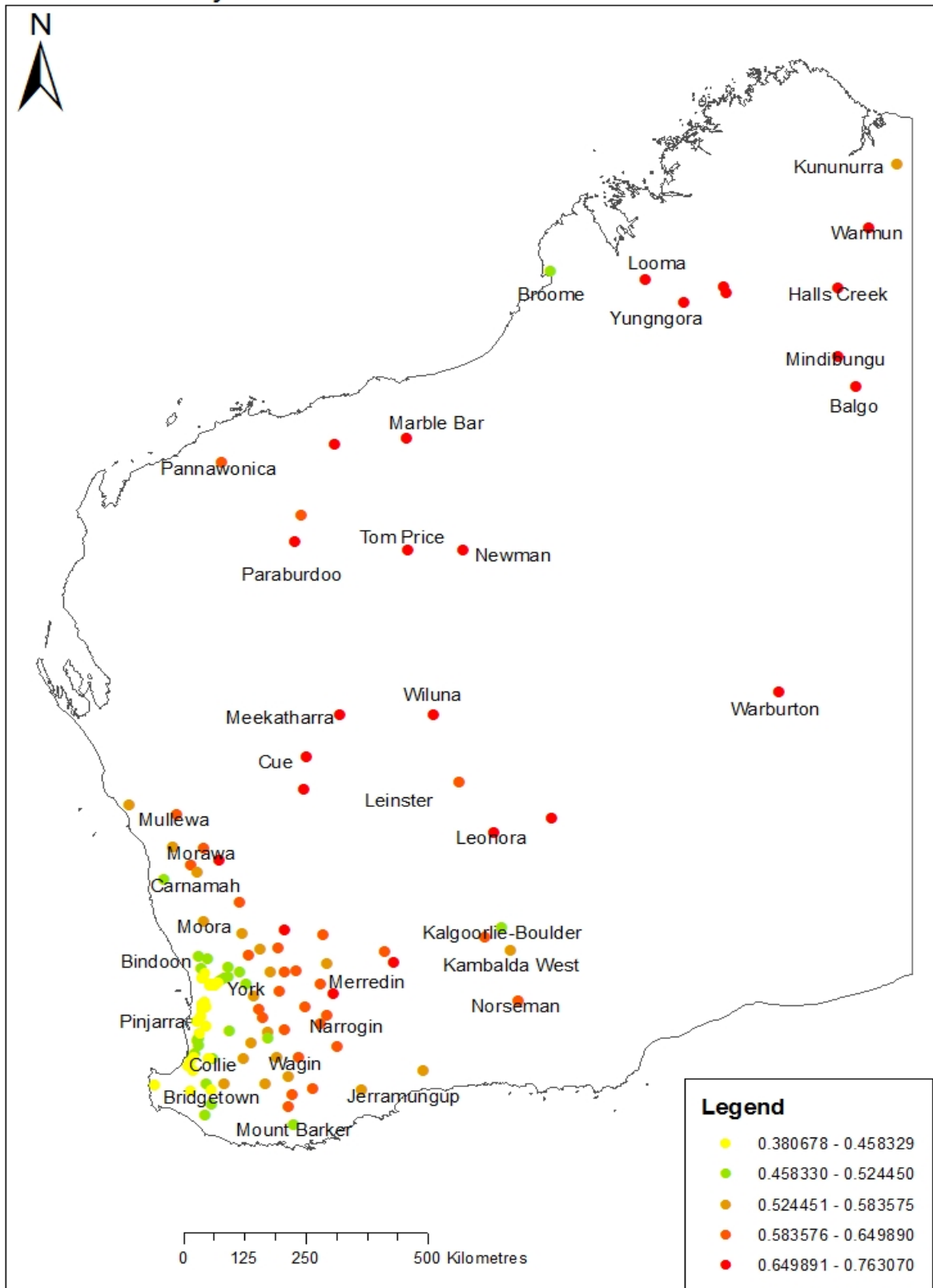


Figure 10: Distribution of vulnerability to climate change for UCLs in Western Australia, Australia, for the year 2050

Table 21: Least vulnerable non-coastal UCLs, Western Australia, Australia, with predicted increase in mean surface temperatures and decrease in annual average rainfall for 2050

<i>State</i>	<i>Location</i>	<i>Vulnerability Scores</i>	<i>Rank</i>
WA	Mahogany Creek	0.381	1
WA	The Vines	0.391	2
WA	Ellenbrook	0.392	3
WA	Parkerville	0.394	4
WA	Stoneville	0.402	5
WA	Mundaring	0.405	6
WA	Sawyers Valley	0.406	7
WA	Byford	0.418	8
WA	Mount Helena	0.426	9
WA	Dardanup	0.426	10
WA	Chidlow	0.436	11
WA	Burekup	0.437	12
WA	Allanson	0.441	13
WA	East Bullsbrook	0.441	14
WA	Jarrahdale	0.443	15
WA	Dwellingup	0.444	16
WA	Serpentine	0.445	17
WA	Cowaramup	0.446	18
WA	Mundijong	0.447	19
WA	Donnybrook	0.448	20

Tasmania

When compared with the mainland states, Tasmania's country towns present a slightly different pattern of vulnerability to climate change both geographically and in terms of the total quantum of risk. As noted earlier, no Tasmanian town was included in the national list of most vulnerable inland settlements and on the national scale the level of risk is muted. To place this into perspective, the most vulnerable town in Tasmania according to this index is Bothwell with a value of .542 (Table 22). Marble Bar in Western Australia, by contrast, is both that state's and the nation's most vulnerable settlement, with an index score of .763. Bothwell would not appear in the list of WA's 20 most at risk towns. In addition, as a sparsely populated island state with a strong maritime and fishing history, there are relatively few inland settlements in Tasmania. Within the state, the lowest scores are clustered in the west – including mining and tourism settlements such as Zeehan and Queenstown, as well as in northern part of the state around Launceston and the Tamar Valley (see Table 23). Higher index scores are evident in the southern part of the state in and around Hobart, as well as towards the state's centre and east (Figure 11). Both the relative remoteness of these places and their substantial workforces in agriculture and associated activities would have shaped this outcome.

Table 22: Most vulnerable non-coastal UCLs, Tasmania, Australia, with predicted increase in mean surface temperatures and decrease in annual average rainfall for 2050

<i>State</i>	<i>Location</i>	<i>Vulnerability Scores</i>	<i>Rank</i>
Tas	Bothwell	0.542	1
Tas	Ross	0.542	2
Tas	Campbell Town	0.541	3
Tas	Oatlands	0.506	4
Tas	St Marys	0.504	5
Tas	Ringarooma	0.503	6
Tas	Cressy	0.491	7
Tas	Kempton	0.484	8
Tas	Campania	0.479	9
Tas	Bagdad	0.477	10
Tas	Fingal	0.469	11
Tas	Railton	0.468	12
Tas	New Norfolk	0.460	13
Tas	Maydena	0.454	14
Tas	Mole Creek	0.450	15
Tas	Bracknell	0.448	16
Tas	Huonville-Ranelagh	0.446	17

Vulnerability Scores Non-Coastal UCLs in Tasmania 2050

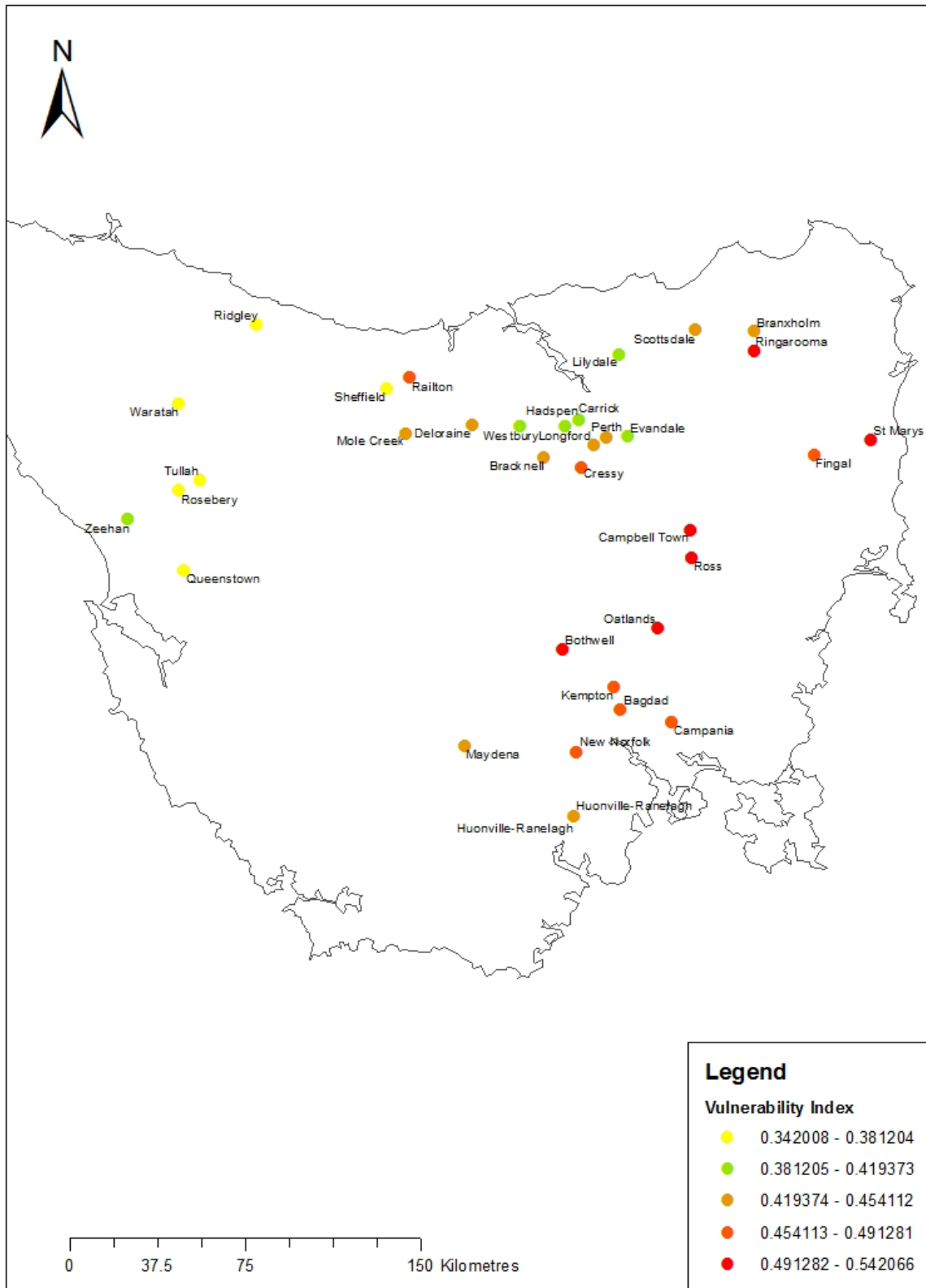


Figure 11: Distribution of vulnerability to climate change for UCLs in Tasmania, Australia, for the year 2050

Table 23: Least vulnerable non-coastal UCLs, Tasmania, Australia, with predicted increase in mean surface temperatures and decrease in annual average rainfall for 2050

<i>State</i>	<i>Location</i>	<i>Vulnerability Scores</i>	<i>Rank</i>
Tas	Queenstown	0.342	1
Tas	Rosebery	0.345	2
Tas	Waratah	0.354	3
Tas	Tullah	0.369	4
Tas	Sheffield	0.378	5
Tas	Ridgley	0.381	6
Tas	Lilydale	0.391	7
Tas	Evandale	0.396	8
Tas	Hadspen	0.404	9
Tas	Westbury	0.408	10
Tas	Zeehan	0.410	11
Tas	Carrick	0.419	12
Tas	Longford	0.434	13
Tas	Perth	0.434	14
Tas	Deloraine	0.436	15
Tas	Scottsdale	0.438	16
Tas	Branxholm	0.439	17

Northern Territory

There is an unmistakable north-south gradient to the distribution of index values in the Northern Territory, as seen in Figure 12. Many of the settlements with high index scores are Indigenous communities, especially those of central Australia. Alice Springs stands out as an outlier within that region, with a low apparent vulnerability to the impacts of climate change. This no doubt reflects its greater size, strong administrative and tourism industries and strong transport and communication links. Alice Springs is one of the field work sites discussed later in this report, and it is important to note that the case study considered both the township and the outlying communities in its region. Many of these settlements appear to be at greater risk from the impact of climate change.

Indigenous communities comprise approximately 25 per cent of the Territory's population and many Indigenous communities recorded high index values (see, for example, Yuendumu, Titjikala and Ali Curung). Table 24 lists the top 20 settlements most vulnerable to predicted change in mean surface temperatures and decreased annual rainfall – indicators of climate change.

Towns and other settlements close to Darwin and in other parts of northern NT recorded the lowest index values, with current and anticipated climate exerting a clear impact (Table 25).

Table 24: Most vulnerable non-coastal UCLs, Northern Territory, Australia, with predicted increase in mean surface temperatures and decrease in annual average rainfall for 2050

<i>State</i>	<i>Location</i>	<i>Vulnerability Scores</i>	<i>Rank</i>
NT	Ampilatwatja (Aherrenge)	0.755	1
NT	Willowra	0.750	2
NT	Ali Curung	0.748	3
NT	Kaltukatjara (Docker River)	0.748	4
NT	Alpurrurulam	0.726	5
NT	Kintore	0.722	6
NT	Nyirripi	0.721	7
NT	Titjikala	0.720	8
NT	Yuendumu	0.707	9
NT	Elliott	0.706	10
NT	Daguragu-Kalkarindji	0.703	11
NT	Papunya	0.692	12
NT	Santa Teresa	0.689	13
NT	Lajamanu	0.678	14
NT	Tennant Creek	0.663	15
NT	Hermannsburg	0.662	16
NT	Ngukurr	0.654	17
NT	Borrooloola	0.646	18
NT	Mataranka	0.642	19

Vulnerability Scores Non-Coastal UCLs in N.T. 2050

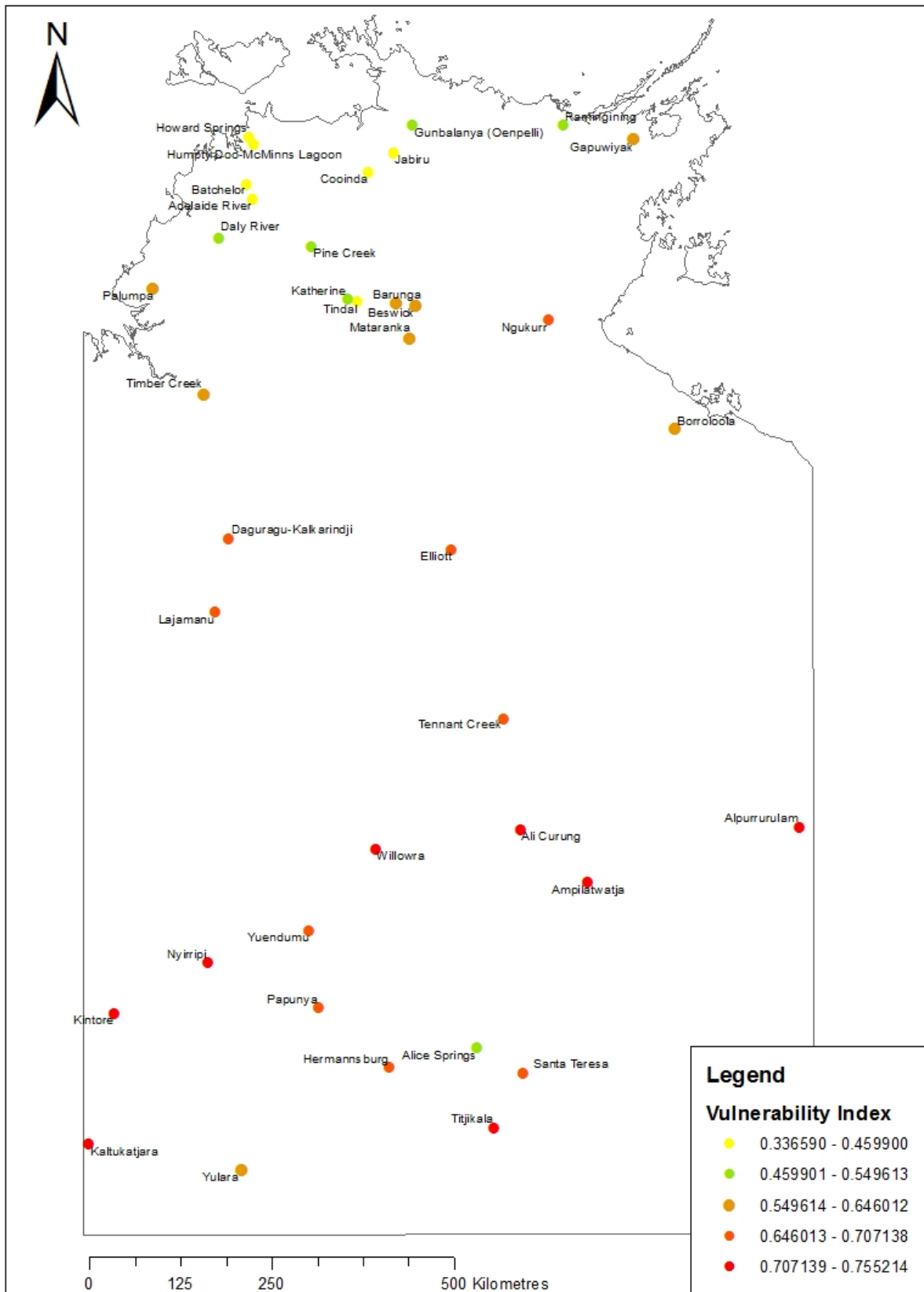


Figure 12: Distribution of vulnerability to climate change for UCLs in Northern Territory, Australia, for the year 2050

Table 25: Least vulnerable non-coastal UCLs, Northern Territory, Australia, with predicted increase in mean surface temperatures and decrease in annual average rainfall for 2050

<i>State</i>	<i>Location</i>	<i>Vulnerability Scores</i>	<i>Rank</i>
NT	Howard Springs	0.337	1
NT	Humpty Doo-McMinns Lagoon	0.352	2
NT	Jabiru	0.418	3
NT	Batchelor	0.426	4
NT	Tindal	0.439	5
NT	Adelaide River	0.444	6
NT	Cooinda	0.460	7
NT	Katherine	0.474	8
NT	Gunbalanya (Oenpelli)	0.511	9
NT	Alice Springs	0.524	10
NT	Pine Creek	0.529	11
NT	Ramingining	0.545	12
NT	Daly River	0.550	13
NT	Gapuwiyak	0.584	14
NT	Barunga (Bamyili)	0.586	15
NT	Palumpa	0.600	16
NT	Beswick	0.616	17
NT	Yulara	0.634	18
NT	Timber Creek	0.638	19

4.4 Conclusion

This chapter has considered the construction of an Index of Vulnerability for Australia's country towns. It has provided the conceptual basis for the formation of such a metric and discussed issues of scale and data availability. It has shown that it is possible to include measures of sensitivity, exposure and adaptation in a composite indicator of vulnerability. The chapter has also gone on to present an analysis of the outcomes of the Index of Vulnerability, showing that:

- remote settlements appear to be amongst the most vulnerable across the nation;
- many Indigenous settlements are to be found amongst the country towns most at risk;
- settlements with a lower vulnerability score tend to be located close to a capital city, are larger and/or do not rely on agricultural production for employment;
- some states (such as Western Australia) appear to have a higher proportion of their settlements vulnerable to the impacts of climate change and higher absolute index scores. Other states such as Victoria and Tasmania appear to have country towns with more 'protective' characteristics, such as closeness to a capital, more skilled workforces, and larger settlements.

The development and application of the Vulnerability Index is just one step in the larger project of understanding the potential impact of climate change on Australia's country towns. As with any index, the outcomes presented here reflect the values and metrics embedded in this measure and may provide a false sense of the true picture in any one place, or group of places, because of the failure to incorporate locality-specific factors. It has also been constructed as an indicator of long term social and economic sustainability or resilience, and does not necessarily include data on factors that we

might consider relevant to debates around Australia's pattern of settlement and climate change. There is not, for example, a measure associated with bushfire risk, because Australians, to date, have largely rebuilt in the aftermath of such events. However, as the case studies to be discussed in the next chapter show, managing bushfire risk is one of the key adaptations some towns have embarked upon over the past decade. Overall we would conclude that the Vulnerability Index is a useful starting point for analysis and debate.

5. CLIMATE IMPACTS AND ADAPTATION IN AUSTRALIA'S COUNTRY TOWNS: INSIGHTS FROM CASE STUDIES

This chapter presents the findings of the case studies used in this project to ground truth particular project findings and identify how, and to what effect, climate change actions are being developed to enhance the sustainability of settlements. These case studies are:

- Alice Springs (NT)
- Horsham (Vic)
- Junee (NSW)
- Moura (Qld)
- Waikerie (SA)

These settlements were chosen based on industry structure and population size; typifying a range of settlement types nationally.

The in-depth examination of actions in particular places sheds light on how emerging understandings and lessons about climate change are being translated and enacted on the ground. The case studies that comprise this report have been structured around the following framework:

- **Current industry structure, social, economic and governmental sustainability**, including demographics, known challenges and opportunities – economically, socially and environmentally
- **Risk and Exposure to Climate Change**, such as real and anticipated risks from climate change – sensitivities, vulnerability, the role of geography and what makes the case study location different (more or less exposed or sensitive) to climate change impacts?
- **Local Planning Processes** – Government and Industry. This includes the involvement of key institutions and stakeholders in regional economic development in face of likely and real climate change impacts and for/in adaptation; a summary of local plans and actions, including community awareness of issues; and links with regional and state priorities?
- **Discussion and Prospects**, including: adaption and mitigation plans and actions enacted and needed; economic, environment and social impacts and strategies for improving prospects/managing change/adaption; local resilience and how is it being fostered through leadership, community engagement strategies, community capacity building; what is seen as best practice locally in climate change mitigation and adaptation; and gaps in understanding or approaches around climate change impacts and their role in determining the future of the case study location.
- **Conclusions.**

This information has been obtained through:

- A desk-top literature and data review, examining key websites, plans and programs in each case study location; and,

- Interviews with key stakeholders in each case study location, including representatives of local government, business and industry associations, environment groups and other relevant organisations.

The findings of these elements of the research are presented in this chapter, commencing with a brief overview of current development in adaptation, and more specifically planned adaptation, to climate change related impacts in rural and regional Australia. It outlines some of the key strategies in place at the local level across Australia that aim to meet the challenges of climate change at the local level. This discussion provides the lead in to the five in-depth case studies. The chapter concludes with a discussion drawing together the insights from the case studies for the future of Australia's country towns to 2050. It highlights the key concerns for the settlements in this analysis, with obvious applicability to similar settlement types nationally.

5.1 Case study: Alice Springs

5.1.1 Introduction

This case study considers how Alice Springs will adapt to forthcoming climate change. In accordance with CSIRO modelling, climate change is expected to result in a rise in temperatures in Central Australia over the next 20-40 years, and most probably by at least 1.6°C (above 1990 temperatures) by 2050 (Whetton 2011). This is a serious predicted trend for Alice Springs, as Alice already has mean maximum temperatures of 35.5°C for five months of the year. Any additional temperature rise will provide challenges to human adaptability.

The climate change models for temperature generally have a higher degree of confidence than the predictions of rainfall, where there is less than 66 per cent agreement between various models (Black and King 2009: 33). For Central Australia these predictions are dependent on assumptions about the behaviour of the tropical monsoons. Depending upon the assumptions, you can predict the likelihood of less rain in Central Australia (Whetton 2011, Figure 3.2) or – as the geomorphologists would argue – more rain in Central Australia. For reasons discussed below it is assumed (with the geomorphologists) that Central Australia will have higher rainfall as global warming intensifies, a position that relies upon evidence of the rainfall consequences of past post-glacial rises in temperature and sea levels. Indeed some scholars (eg Hughes 2003, Webb 2006) argue that a wetter phase has already begun, a point that receives some (albeit not very conclusive) support from the fact that the period since the mid-1990s has been considerably wetter than 'normal' in Central Australia (Braganza and Church 2011, Figure. 1.2). Geomorphologists estimate that four of the largest seven floods in the last thousand years have occurred since 1921 (Thorley 2009, p.148). Central Australia may therefore already have begun to be impacted by climate change.

The notion of normal rainfall needs elucidation in the Centralian context. The 'average' rainfall for Alice Springs is usually given as around 200-250 millimetres per annum. But averages mean very little in a climate characterised by extreme variability (if not of temperature). The usual pattern is for several years of very little rainfall, say less than 100 millimetres, followed by a year such as 2010, where about 750 millimetres fell. In such years rain often falls not as gentle seasonal rain but in torrential thunderstorms that can easily cause flash flooding and make most of the roads in the region impassable. This phenomenon also directly threatens Alice Springs, which is very vulnerable to flooding being situated on the flood plain of the Todd River.

There is one caveat with respect to this case study of Alice Springs and climate change impacts. We do not address the issue of biodiversity. This is likely to be considerably affected by changed rainfall and higher heat profiles. Rapid biodiversity changes would produce, for policy-makers, a choice between preservation strategies or facilitative

change (Dunlop *et al* 2012). Given the sparse population and the Northern Territory Government's history of underspending on conservation (Gerritsen 2010) this is a problem that is difficult to address, with either strategy, until sometime after the full effects of climate change are obvious.

5.1.2 Alice Springs: a town in the desert

Alice Springs was originally a small township, established in the early 1870s about two kilometres south of the Overland Telegraph station, upstream on the Todd River and north of Heavitree Gap in the MacDonnell Ranges. Its establishment coincided with a final burst of exploration by Giles and Forrest designed to fill the gap between the Overland Telegraph and the settlements on the Western Australian coast (Madigan 1944: 29ff). The township, originally called Stuart, became a small service and supply centre for the policing of the new pastoral districts established in the region. Occasional mining 'rushes' brought miners into the region and confirmed Alice Springs' salience as an administration and supply centre. Supplies were brought in from Oodnadatta (then the railhead for the region) by camel trains until the railway was extended from there to Alice in 1929. The railway ensured that Alice Springs would replace Oodnadatta as the service centre of Central Australia; a position it has retained and consolidated since. Alice is now the major town in Central Australia.

Alice Springs' dominant service centre role was established by the end of the 1930s, when despite a population of just 550 people, it was the most significant town for 1,000 kilometres in any direction. The town featured a hospital (also the base for the Royal Flying Doctor Service from 1939), two hotels, a police post, courts and a prison, a post office, a school and a private airline (Connellan Air). It had a small diesel-fired power station. In addition, there were about 60 private and twenty or so government houses, as well as humpies and camps of varying permanency (Carment 1992). At this time the settlement also had two general stores, a saddlery and other service enterprises, such as a cemetery and an Australian Inland Mission church.

During the Second World War Alice Springs became a major logistical and troop transit base. Between September 1940 and October 1944, 194,852 troops transited through Alice Springs en route to Darwin (Donovan 1988: 188). The major legacies of the war were the establishment of a town water supply based on artesian bores, which replaced the private wells that had supplied this vital commodity (Madigan 1944: 75ff), and a new airstrip capable of landing large aircraft.

At the time of the 1933 Census there had been 526 people resident in Alice. By 1947 this had grown to 2,078. After this population growth was steady. New industries, in particular tourism and government services provided the impetus for growth, and a local ABC radio station and a library were established in the town.

The 1960s was Alice Springs' biggest growth decade; the population soared from 4,688 at the 1961 Census to 11,172 at the 1971 Census. This population growth was reflected in the rapid growth of public housing stock and the construction of hostels for single workers, such as teachers and public servants. In 1971 the Town Management Board (established in 1961) was converted to an elected Town Council with municipal powers; though not over planning and zoning. The tourism industry also grew rapidly from this period. In 1969 18,000 tourists visited Alice Springs. By 1984 this had peaked at over 600,000, a level at which it stabilised before going into gradual decline from the mid-1990s. Currently tourism numbers are about 350,000 per annum. The town has the usual panopoly of supermarkets, department stores and service and sporting clubs. Unusually for Australia, Alice has a large American population, a result of two joint US-Australian defence facilities. The Americans also distort the demographic profile by enlarging the proportion of graduates in the population.

By 2000 Alice Springs' population growth had stabilised. Its growth had slowed over past trends and the population inched upwards to just over the 28,500 residents the

town has currently. In most respects the town functions like any other large country service centre, with the amenities to match. In one respect it is radically different, because of the town's large Aboriginal population. Summary statistics for Alice Springs are presented in Table 26.

Table 26: Summary statistics, Alice Springs, 2006 and 2011

<i>Alice Springs</i>		
	2006	2011
Number of Persons	21,623	24,208
Median Age	32	33
Median Household Income	\$1,245	\$1,676
% Indigenous population	16.7	19.0
% Workforce in Agriculture	0.43	0.34
% Workforce in Mining	0.58	0.60

Source: ABS 2007, 2012a.

At any one time almost a third of the population of the town is Aboriginal. About half of this population are permanent residents. Many of the older generation of these residents remember the situation up to the early 1960s, when they needed a pass to be in the town outside business hours (Donovan 1988: 272ff.). The other half of the Aboriginal cohort are temporary visitors. They come to town for various reasons: to visit relatives, for shopping, to support relatives in hospital or receiving medical services. The duration of 'temporary' visits varies from a few days to months, even years. The visitors usually stay with relatives at one of the 21 town camps in and around the town (Foster *et al* 2005) or camp in the bush or the bed of the Todd River.

Aboriginal interests and services have become central to the development of Alice Springs. About 35 per cent of the cash spent in the town derives directly from Aborigines or their organisations (Gerritsen, Stanley and Stoeckl 2010). Aboriginal organisations are the major investors in the town and own the main shopping mall and several other major buildings. Aboriginal organisations also own real estate companies and car dealerships as well as other enterprises. Many service organisations represent communities far from Alice and may not even be based in the Northern Territory. These organisations service communities across the APY Lands (Anangu Pitjantjatjara Yankunytjatjara) in northern South Australia and the Ngaanyatjarra lands in the western desert in Western Australia.

The Alice Springs region, in any social, economic and services sense, ranges across the southern half of the Northern Territory and the central-eastern part of Western Australia, as well as across the northern half of South Australia. Events anywhere in that region impact across the region. Unrest or disputes in any community in that region could lead to 'refugees' fleeing to Alice Springs, as happens periodically. Consequently Alice Springs can be considered an integral part of a region probably at least equal in size to the state of New South Wales, although with a population of fewer than 40,000 people. Accordingly, any consideration of the impact of climate change on Alice Springs must take the whole of the vast Alice Springs region into account because responses anywhere in the region impact upon the town. This factor impacts considerably upon the vulnerability of Alice Springs to the effects of climate change. The town cannot be considered in isolation. For example, if there are flash floods that dislocate any Aboriginal settlement in the region, there is an impact on Alice Springs.

Since the 2007 Commonwealth 'Intervention' into the NT's Aboriginal communities, there has been considerable urban drift from a number of regional Aboriginal

communities to Alice Springs. The Central Desert and MacDonnell Shires (which cover the southern third of the NT), for example, have seen a decline in their Aboriginal population between the 2006 and the 2011 Censuses, the first such decline recorded and confounding the higher fertility rate of the Aboriginal population. Most of the Central Desert population loss can be attributed to about 400 people leaving Yuendumu (previously the largest settlement) because of internal disputes. Much of the broader region's Aboriginal population decline is because of urban drift to Alice Springs and elsewhere. Once in Alice Springs these 'migrants' contribute to overcrowded housing.

Some analyses of the risk associated with climate change for individual settlements rank remote Aboriginal communities as some of the most vulnerable places in Australia (Beer *et al* 2012). *Prima facie* they are. By standard measures they have poor health and education outcomes and poor economic resources; few of the positive quantifiable resources that feature in capacity measurement. However, there is growing evidence that Aboriginal people and their communities exhibit resilience in circumstances that would destroy non-Aboriginal communities. For example, in the 2000-02 floods, Kiwirrkurra (a settlement west of Alice Springs near the WA border) was inundated and evacuated. The residents adapted remarkably well in exile in Alice Springs (Thorley 2009: 109ff) and returned to their community once the floodwaters abated. Nevertheless the presence of a vast hinterland, with many, sparsely scattered and dependant Aboriginal settlements, amplifies climate change risks for Alice Springs because these risks are not confined to the town and its immediate environs, but occur across a much larger canvas.

5.1.3 Risk and exposure to climate change

The Vulnerability Index score for Alice Springs is in the moderate range, at 0.524. Risks and exposures for the town are discussed below.

5.1.4 Natural threats

A key threat for Alice Springs is flooding, and in Central Australia, floods eventually mean fire. And they may also exacerbate disease. Central Australia is usually arid or semi-arid. But floods do occur. Regionally significant floods occurred in 1922, 1953, 1974 and in 2000-01. Flooding, either local or regional, can easily disrupt Alice Springs' fragile transport links. The large scale rains of 1974 severed the rail link from the south and closed the Stuart Highway – literally the artery to the heart of Central Australia – in several places and for prolonged periods, leading to shortages in the shops in Alice. Airlifts were required to take food and fuel (for generators) to the Aboriginal communities in the region.

The possibility of flooding is ever-present in Alice Springs, as the Todd River passes through the middle of the town. Flood mitigation is a recurrent topic in the town's politics. New ratepayers are given a pamphlet with instructions to observe in the event of flooding and a map detailing the extent of floods of varying intensity. The pamphlet contains detailed instructions about how to react to a flood.

In 1981 the Northern Territory Government announced that it would construct a dam on a site above the Telegraph Station. Initially this was to provide a recreation lake for the town's residents. Following opposition to the dam by Lhere Aterpe, the organisation of the Central Aranda traditional owners (who were concerned that sacred women's sites would be inundated), the dam was 'converted' to a flood mitigation proposal. The Northern Territory Government determined to override the traditional owner's objections. The controversy dragged on until eventually in 1991 the then Federal Minister for Aboriginal Affairs, Mr Robert Tickner, disallowed the dam under National Heritage powers.

Flash flooding remains one of the greatest direct challenges faced by Alice Springs, particularly if the evidence of geomorphologists that past sea level rises were accompanied by higher rainfall in Central Australia. Under this scenario rainfall is likely to fall in an intensified version of the current rainfall pattern – with intense thunderstorms providing virtually the entire annual rainfall for Alice in a matter of hours.

In 1988, following 204 mms of rain in 48 hours, there was a flash flood in Alice Springs and the southern suburb of The Gap was flooded as the Todd backed up from Heavitree Gap (Thorley 2009: 89). This was a one-in-thirty years flood. A one-in-one-hundred years flood is expected to inundate two thirds of Alice Springs' residences. Severe flooding remains an ever-present possibility; arguably even inevitable. The last time temperatures were 2°C higher than at present, 10,000 to 5,000 years ago, Central Australia saw an age of 'superfloods', bigger than any observed since the European occupation of the region (Thorley 2009). At this time, Lake Eyre was 25 metres deep, as against maximum depths of six metres following the 1974 and 2001 floods. Alice Springs and surrounding communities seemingly face the certainty of major floods as a result of climate change. These may already have begun.

Serious fires are a recurring problem in Central Australia. They usually follow a season of intensive rain episodes, as in 1975 and 2002 (Latz 2007: 74). Following the 2010 heavy rains in Central Australia, the region was afflicted by bushfires engulfing large areas, fuelled by the abundant grasses resulting from the previous rains. The fires burnt out an area the size of Victoria and caused considerable damage to pastoral infrastructure. Following community criticism, an inquiry, known as the Eldridge Report (2012), found the official response was inadequate. Consequently the Northern Territory Emergency Service is being reorganised to better marshal resources regionally. There is no way large fires can be prevented as many of them are caused by lightning strikes but their impact can be better managed through more regular controlled winter cool burning and using technology such as satellites to discover potential problem fires in unpopulated areas before they spread and threaten infrastructure and community safety. Aboriginal Ranger groups (funded from Commonwealth programs and overseen by the Central Land Council) are gradually growing in number, and they will play an increasingly important role in controlled burning in future.

Each year some people die of exposure when stranded on isolated Central Australian roads (indeed while writing this report, one such instance occurred in the Simpson Desert). The numbers of people (including old people in settlements) who die from heat stress is likely to increase in the future. Although this is not likely to involve large numbers, it will be a growing and important risk for the region.

The Northern Territory is largely ready to meet any outside endemic disease threats. Routine medical entomology surveillance is already practiced in anticipation of vector-borne diseases, such as malaria and dengue fever. If climate change brings these into the 'top end' of the Northern Territory, they may also spread to Central Australia if it becomes wetter. Similarly, if it becomes wetter, Murray Valley encephalitis may spread to Central Australia. Where the conventional health literature addresses climate change it assumes a generalised pattern across Australia. (See, for example, Horton and McMichael 2008; Thomas and Capon 2011) Where this literature focusses upon arid Australia it assumes a drier future (Campbell *et a* 2008, Figure 1). We argue that such research should instead focus upon the implications of a wetter desert region.

Increased and more intense rainfall could also increase the currently high incidence of chronic disease conditions, such as giardia, virus-borne conditions such as viral gastroenteritis, or amoebas that provoke dysentery and meningoencephalitis. These micro-organisms would be assisted by poor maintenance of water sources and more free-standing water around the Central Australia region's Aboriginal communities. This

last point needs elucidation. Recent research by Roderick, indicates that evaporation rates in Australia are decreasing (Pockley 2009) and that, counter-intuitively, ambient temperature has less effect upon evaporation rates than declining wind speeds and solar radiation. So, even with higher temperatures following climate change, water will persist on the ground for longer, with obvious implications for public health.

Conventional research into the health impacts of climate change usually focusses upon those defined as most vulnerable – the young, the elderly and those with cardio-respiratory diseases (Campbell *et al* 2008; Horton and McMichael 2008). This analysis identifies current adverse Aboriginal health states and predicts these will worsen in degrees of incidence. That may be so, though it assumes steady-state medical services. In recent years, despite the general failure of the Commonwealth's *Closing the Gap* policies, there have been some noticeable improvements in Aboriginal health; the moot point is whether these will continue or be reversed by climate change.

5.1.5 Economic threats

Climate change will pose some threats to the Central Australian industries, especially the tourism, pastoralism and mining industries. As noted earlier the Central Australian tourism industry has been in decline for about a decade or so. There are various theories for this, market-based ones ranging from its failure to refresh or differentiate its product, to the high cost of air transport. Over the past two decades there has been a secular shift in Australian families vacation patterns, towards more, shorter, holidays; disadvantaging long haul destinations such as Alice Springs. Consequently, Alice Springs now has mainly 'time-rich' tourists, backpackers and 'grey nomads' hauling caravans on their post-retirement circuit around Australia. Nevertheless the tourism industry will be buffeted if temperatures rise even more. At best the shorter winter will reduce the tourism peak season. At worst climatic extremes could reduce tourist numbers dramatically.

Central Australian pastoralism features family-based operations rather than stations managed for large agribusinesses. That is because the difficult climate and low and uncertain returns require the type of close management that only an experienced owner will provide. These pastoralists are resilient and resourceful, which they will have to be in face of more climatic uncertainty with climate change. The likely intensification of an unpredictable pattern of torrential rainfall, followed some months later (unless there has been carefully controlled burning) by extensive hot bushfires, promises special challenges for Central Australia's pastoralists. Flash flooding can cause stock losses and infrastructure damage. Hot bushfires exacerbate erosion (Latz 2007: 76ff), thereby reducing the already sparse carrying capacity of the country. More frequent fires could also threaten soil quality (Latz 2007: 78ff). Pastoralists will have to persist in the face of even greater adversity than now. It is likely that impending climate change will affect the pastoral industry even more adversely than the tourism industry.

The mining industry faces increased production difficulties. This could be through pit flooding or rail and transport delays caused by torrential rain, as happened in Queensland's coal mines after Cyclone Yasi. Again this industry sector will have to factor such events into the cost of their operations. At present gold mining is concentrated to the north-east of Alice Springs, in the Tanami desert. It is already affected by increased rainfall, mainly through its effect on the (so-called) Tanami Highway, a dirt road from Alice Springs to Derby in the Kimberley region of WA. Much of the impending resource extraction in the region is focussed upon hydrocarbon extraction, which will be less affected by higher temperatures and more torrential rainfall than mining operations. At the margin some mining prospects could be uneconomic because of production and transport interruptions caused by climate change-induced increased/more intense rainfall.

5.1.6 Social threats

Central Australia has a peculiar demography. Not just because of the high proportion of Aboriginal people resident permanently and temporarily within the town. The non-Indigenous population of Alice Springs is also singular. For a start, rather than the usual description of them as 'settlers', they are more accurately characterised as 'expatriates' (Gerritsen 2010). They have careers in Alice Springs and then retire elsewhere, often to where they have come from, though a disproportionate number move to Queensland.

The non-Indigenous population 'churns' through the town. Each year about ten per cent of residents leave the town. They are replaced by a fresh cohort. This means that over the inter-censal period about 50 per cent of the population changes. Whether or not this is a disadvantage is debatable. Again counter-intuitively this churn means that older people are replaced by younger people. The fact that the social, sporting and service clubs in the town are quite vigorous offers indirect support for this hypothesis. Population growth in Alice is also changing in ways unusual for a country town. There is a growing proportion of immigrants to Australia (a 30 per cent increase between the 2006 and 2011 Censuses) to the point where the overseas-born constitute about 20 per cent of the town's population. Some of these are humanitarian refugees, the result of Federal Government resettlement policies. Some come seeking relative economic opportunity (thus the proportion of New Zealanders and Filipinos increased by over 40 per cent during the recent inter-censal period). But there is currently a significant influx of professional and semi-professional immigrants from India, and more recently Ireland. Between 2006 and 2011, the Indian proportion of the population increased by 445.6 per cent (ABS 2012b). They provide specialist medical and financial services of the type that most country towns are losing. The flow of fresh enthusiastic immigrants, from within Australia as well as overseas, maintains, if not augments, the social resilience of the town (and, indirectly, the region).

5.1.7 Local planning processes and responses

The responses of the Territory Government to climate change have been mixed. The previous Northern Territory (Labor) Government (2001-2012) actively adopted climate change policies (NTG 2009), even if these were inadequately resourced. The Northern Territory Government nominated nine goals and 40 targets in its climate change policy. Eleven of the targets had 2020 timelines. Some of the others had timelines beyond the next election, while a far greater number did not nominate specific timelines. Nonetheless the Government achieved some of its conservation policy aims. It banned plastic shopping bags and introduced a 'cash-for-containers' scheme (modelled on the South Australian container deposit levy scheme). The Government also made some progress in improving the energy efficiency of government buildings. And its Power and Water Corporation was an active supporter of the Alice Solar City project (see below).

The newly elected Country Liberal Government appears to be either unconcerned about climate change or to treat it as a minor priority. As part of its reorganisation of the public service it abolished the Energy Efficiency and Climate Change Research Unit in the Environment Department. Both the previous and the current NT Governments believe that by exporting liquid natural gas the Northern Territory will make a contribution to greenhouse gas reductions (NTG 2009: p.15).

In the respect of the institutional organisation of emergency/disaster response, the Northern Territory Government is much better placed. Procedures and plans for various contingencies have recently been overhauled and modernised (NTG 2012). It has formed an inter-agency Counter Disaster Emergency Response Group and developed a detailed set of protocols in an Northern Territory Incident Control System (NTICS). These include detailed flood plans for Alice Springs and vulnerable Aboriginal

communities in the region. They also include a web-based emergency operations network (WebEOC) that allows access by all government personnel and has detailed public health responses for emergencies.

Given that the Northern Territory is a jurisdiction with a small population scattered over a vast area, its institutional arrangements to deal with the type of emergencies that are likely with further climate change are sophisticated and to date have proven effective.

5.1.8 The Alice Springs Town Council

In 2006 the Alice Springs Town Council adopted a greenhouse gas emissions reduction plan (ASTC 2009). It implemented this policy with three initiatives:

- its new civic offices were designed on best-practice energy efficiency lines, including photovoltaic (PV) panels to put electricity back into the grid.
- it installed photovoltaic PV panels at all Council depots and carried out a major investment to solar heat the town pool with PV-derived electricity.
- in 2006 it sponsored an Alice Springs bid for Federal Solar City funding.

The last initiative has provided major energy efficiency gains for Alice Springs. The Alice Solar City project commenced in 2008. Within four years it had over-achieved on its aims (the details below are from Gerritsen, Zeng and O'Leary 2012):

- to increase the adoption of PV technologies. It increased the number of residential PV systems in the town from one in January 2008 to 277 in June 2011, providing a minimum 1,582 kWh/kW/yr to the grid. It also subsidised the installation of over 700 residential solar hot water systems, saving over 1,000 tonnes of CO₂-equivalent.
- to introduce a variety of Energy Efficiency Measures, such as energy efficient lighting, painting roofs white, Cost-Reflective Tariffs to achieve load-shifting, 'one-shot' hot water boosters, smart meters, etc. Businesses volunteered for energy audits, PV installation and other major energy projects.

In addition there were five 'iconic' PV projects. Four of these – the Airport, the Crowne Plaza hotel, the Aquatic Centre and the Araluen Cultural precinct – were designed to feed PV electricity back into the grid in amounts close to their electricity consumption. The fifth 'iconic' project, the Uterne Solar Power Station is a very large facility that generates a significant proportion of the town's peak load electricity supply.

In terms of climate change adaptation Alice Springs is relatively well prepared in the area of energy efficiency and the reduction of greenhouse gas emissions. The Aboriginal communities in the region are being assisted to install solar systems in residences, for street lighting and to generate power, via Federal funding for the Centre for Applied Technology's 'Bushlight' program. The region overall is gradually becoming more energy-efficient.

There are two other important conservation initiatives in Alice Springs worthy of mention; in the areas of water usage and recycling respectively. The 'Cool Mob' project was started to assist Alice Springs reduce its profligate use of water; average household consumption is about three times the national average. Since it was tapped in 1964 to supply Alice Springs, the Roe Creek borefield's water table has dropped by 45 metres; so future water supply may be more expensive as aquifers further afield are used. The Cool Mob is a similar partnership to the Alice Solar City, essentially between the Town Council, the Arid Lands Environment Centre and the Power and Water Corporation. Its Watersmart program, similarly, is using residential audits and subsidies to reduce over-consumption, in this case of water. The Council (in partnership with Watersmart) has also implemented water efficient irrigation systems in its 64 parks and reserves (Watersmart 2012).

The Town Council has been active in recycling to reduce waste to landfill. Currently it recycles wine and spirit bottles that are not covered by the Northern Territory Government's 'cash-for-containers' scheme. It crushes these bottles and uses the material in lieu of sand for concrete footpaths, kerbing and guttering, etc.

5.1.9 Prospects and conclusions

The discussion above leads us to be relatively optimistic about the capacity of Alice Springs and the Central Australian region of communities to adapt to a more extreme climate and its consequent challenges. This is partly because it is already beset with unpredictable weather-related events and its population is either resilient (in its currently popular usage – cf Walker and Salt 2012) or leaves Central Australia, to be replaced, presumably by younger and more adaptable immigrants. What will come with climate change is an intensification (of varying severity) of current problems, not particularly new problems. Our optimism then is based upon the fact that the institutional technology required for that response is rapidly being improved. This is particularly the case for emergency response and medical responses.

In the last few years the organisation of emergency responses to natural calamities has been overhauled, initially focussing upon flooding but recently also bushfires. There is a high level of awareness of the town and its region's vulnerability, a level of information that the research literature suggests is necessary for comprehending risk and preparing responses to that risk (for example, Preston *et al* 2008). In partnership with the Local Government Association of the Northern Territory, the NTES has developed Disaster Risk Management Plans for the Territory's remote Aboriginal communities (NTES, 2010).

In one respect – paradoxically considering the poor health status of Aboriginal Centralians – the Alice Springs region is medically well-equipped to deal with the increased risks of endemic disease arising from climate change. That is for two reasons: the quality of the hospital and the research infrastructure in the town. While it developed in a manner similar to most hospitals in large country towns (Cockrill 1999), since 2000 the hospital has become a teaching hospital of Flinders University. The hospital has access to a range of medical specialists that is unusual for a large country town. In addition the Baker Institute has a research facility in Alice Springs. Charles Darwin University and Flinders University also operate the Centre for Remote Health, another facility where researchers not only study epidemiology but also the social determinants of health. These facilities coupled with the Aboriginal medical service, the Central Australian Aboriginal Congress, mean that the town is relatively well-equipped to deal with the intensified medical challenges that climate change will bring.

The major private productive sectors of the Central Australian economy will face greater difficulties in future, in particular pastoralism and tourism. They will have to adapt.

The Northern Territory Power and Water Corporation sets uniform tariffs for all Territorians. So that ameliorates a problem that energy and water conservation policies pursued as part of a climate change response can have regressive distributional effects (Buchs *et al* 2011). Nevertheless, climate change will be a particular challenge for remote Aboriginal communities. They do not have the funds to run air conditioning on the extra hot days. They will have to persist with resiliently 'toughing it out', as they have done for millennia. In effect they will continue with the current practice of treating a house as a storeroom rather than a residence (Musharbash 2008), except when it rains.

It is conventional to assume that poverty equates to greater vulnerability in most societies (Lin and Chang forthcoming). Paradoxically, with Aboriginal people that may not necessarily be so. Generally they have different values from western capitalist values. Above all they value relatedness and sociality above material progress, even

comfort (McRae-Williams and Gerritsen 2010). This means that they can be, if not partly indifferent to, at least very resilient in the face of adverse circumstances; circumstances that might lead to 'expatriate' non-Aborigines departing Central Australia.

Archaeologists can provide us with supporting argument as to the resilience of Centralians to the rigours to be imposed by climate change. During the last glacial maximum (around 23,000-16,000 years Before Present) they continued to occupy refugia along the Central Australian ranges (Smith and Sharp 1993, Thorley 1998). These were not sites to which people migrated opportunistically, when temporary rainfall and resource conditions allowed, but permanent small scale occupations (Smith 1989). Here in conditions of extreme aridity unimaginable today, plus mean annual minimum temperatures much colder than today (Thorley 2009: 132), they survived and persisted until better conditions returned with rising sea levels (from ca 13,000 years Before Present). In the drier period 5,000 to 2,000 years BP they developed sophisticated, if simple, means to access, harbour and transport limited water supplies (Thorley 2009: 150-152). Centralians also developed elaborate and widespread ceremonial relationships (along what is popularly called 'songlines') to ensure that they had friends for assistance when local scarcity struck. Their survival was a monumental achievement of constant adaptation (Smith forthcoming).

Now Centralians have access to better technology to deal with disease, fire and flood. They have the institutional capacity to marshal that technology. And they have access to national institutions, such as military assistance capacity, to aid them in emergencies. Therefore we can be guardedly optimistic that Centralians and their capital, Alice Springs, will survive and adapt and persist in the face of climate change.

5.2 Case study: Horsham, Victoria

5.2.1 Introduction

The Horsham Rural City Council with around 20,000 inhabitants is the major regional centre in the Horsham Rural City. Located nearly 300 kilometres west of Melbourne in the dryland country known as the Wimmera, Horsham provides a range of services for people living in the town, as well as the surrounding region. Indigenous Australians have long used the banks of the winding Wimmera River as a place of shelter and ceremony. When Europeans came upon this land in the 1840s, as with other European settlement across Australia, there were numerous stories of both cultural clashes and cohabitation that defined the area's early history. From a climate change perspective this part of Australia has always been subject to significant climatic variability. The banks of the Wimmera River afforded both Indigenous people and European settlers a sanctuary from this climatic regime.

Prior to European settlement the Jardwa and Wotjobaluk people called the area that is now Horsham 'Wopetbungundilar', referred to as the birthplace of emu and Aboriginal legend. Other sources say this name means house of flowers, referring to the many wattles near the river (Brooke and Finch 1982). European settlement in the region around Horsham first started in 1842 with James Darlot naming his property 'Brighton' after the English seaside resort. By the time the Chief Constable established a presence there in 1847, Darlot had named the settlement Horsham after the town of the same name in West Sussex. New South Wales police troopers were responsible for keeping the peace in this remote region of the then New South Wales colony. Serving as a regional centre for early settlement, Horsham became well-established after the Victorian Government's Land Act of 1869. It became the centre for decision-making about land settlement in the Wimmera and to this day still plays an important role in the delivery of government services (Brooke and Finch 1982; Reid *et al* 1996).

While the Horsham Rural City Council today has 20,000 residents it is the regional centre for up to 52,000 people, covering five local government areas. The city of Horsham has major health and education services, as well as research facilities at the Grains Innovation Park (formerly Victorian Institute for Dryland Agriculture) and the new research facility at Longerenong College set up by Bayer CropScience. In addition, it hosts major recreational and sporting facilities such as horse racing, golf, velodrome cycling and basketball, as well as a refurbished and extended Art Gallery and new Performing Arts Centre. The city is the heart of a major agricultural centre on the Melbourne-Adelaide road transport corridor and at the junction of three major highways – the Wimmera, Henty and Western highways. It also hosts the Wimmera Intermodal Freight Terminal north of the city where rail and road connect to improve grain handling and export processes, including access to grain ports. Key statistics for Horsham are provided in Table 27.

Table 27: Summary statistics, Horsham, 2006 and 2011

<i>Horsham</i>		
	2006	2011
Number of Persons	14,124	15,262
Median Age	39	39
Median Household Income	\$788	\$923
% Indigenous population	1.4	1.7
% Workforce in Agriculture	4.1	4.1
% Workforce in Mining	0.59	0.85

Source: ABS 2007, 2012a.

The CSIRO has identified the change challenges facing the Wimmera through to 2030 (CSIRO 2011). These include: rural demographic shifts; water availability; changes in agriculture; increasingly competitive commodities markets; climate variability and change; and multiple uncertainties crossing all of these areas (CSIRO 2011: 3). These challenges are expected to continue beyond 2030 and well into this 21st century. The thinning out and ageing of rural Australia is expected to continue over the next few decades. As we have fewer but larger farms relying more on technology, there will be fewer people living and working in the rural environment. Commodity prices will continue to challenge farmers until world population swells to the point where food security is a very real issue in all corners of the globe. Climate change and variability – discussed below – is an important overlay on the social economic and technological aspects of the rural economy. As the CSIRO quite rightly points out, as these individual challenges combine to form multiple uncertainties the impact on rural towns like Horsham will be significant. Preparing for these futures is important and considered in this chapter (see TTM Consulting 2007 for discussion of growth management for Horsham).

5.2.2 Risk and exposure to climate change

This section considers current climate science and its predictions for annual weather patterns in the Horsham region in 2050, before discussing adaptation strategies appropriate for this predicted climate in subsequent sections. The Vulnerability Index score for Horsham is 0.439, a midrange score for vulnerability.

The Victorian government's Department of Sustainability and Environment (DSE) has published predictions for climate change in the Wimmera using CSIRO projections (DSE 2008). DSE conclude that the future climate of the Wimmera is expected to be

hotter and drier than today. By 2070 under a high emissions growth scenario they predict Horsham's temperatures would resemble those of present-day Wentworth in New South Wales, while rainfall would be similar to present-day Nhill. By 2030 average annual temperatures will be around 0.8°C warmer with the greatest increases expected in summer (0.9 °C). The number of hot days (over 30 °C) is also expected to increase from 51 to 58 days by 2030. Average annual rainfall reductions of around 4 per cent are expected especially in spring (7 per cent). As a result evapo-transpiration rates will increase (DSE 2008), reducing runoff to the Wimmera-Avon River system by up to 50 per cent. However, rainfall intensity is likely to increase with fewer days of rain, particularly spring, which may have impacts on farming, with storm events causing crop damage and soil erosion.

Climate change related impacts for Horsham and the surrounding region will be significant, but are not insurmountable. The impact on agriculture will be significant and, as farmers have always done, they will need to find innovative ways in which to farm in this changing environment. Equally people living in towns in the region have also dealt with climatic extremes in the past and will need to adapt to the heightened variation predicted for their future. The Horsham region has already seen the impact of drought. A range of actions have been taken locally to mitigate against the impacts of drought. For example, open irrigation channels have now been largely replaced by the Wimmera Mallee Pipeline system.

5.2.3 Local planning processes and responses

The Horsham Rural City Council, with its motto 'the rural balance', is already planning for an environmental future impacted by a changing climate. For example, in the Council's *Environment Sustainability Strategy 2010 – 2011 Action Plan* (HRCC 2010) the Council aims to, amongst other outcomes, assist the community to adapt to climate change. There is a strong focus on sustainability covering areas of leadership, energy efficiency, sustainable water use, solid waste management, transport, the built environment, the rural environment, the natural environment, community lifestyle, health and well-being; and extreme natural events. This is a comprehensive list demonstrating that the Council is already tuned in to questions of environmental sustainability.

The Strategy is backed by six key principles:

- lead by example;
- protect what we value;
- improve what we have;
- reduce what we use;
- minimise what we leave; and,
- share what we learn (HRCC 2010: 1).

These principles constitute criteria against which the council's performance can be measured and evaluated. The actions in the 2010 – 2011 Plan focus on specific actions Council can take to realise sustainable outcomes. What is not clear yet is how well the Council has performed against its aspirations.

Climate adaptation strategies are about whole of community approaches, as well as individual and sectoral approaches. In order to reflect this we will consider adaptation strategies related to various sectors in the Horsham city and region. There is a network of organisations in the Wimmera who are working together to ensure their communities and particular stakeholders are adapting to climate impacts: most notably, living and working in a drier and potentially more volatile environment. This network is the Wimmera Mallee Sustainability Alliance (WMSA) which involves the region's Councils,

water authority, Catchment Management Authority (CMA), waste management group, education institutions and Wimmera Development Alliance, aims to take a collaborative leadership role in the region to improve the sustainability of the region. Local governments are well represented in this organisation with the Horsham Rural City Council playing a leadership role with the adjacent rural shires.

The Victorian State Government's departments of Regional Development, Sustainability and Environment and Planning and Community Development are well represented in the region. Grampians Wimmera Mallee Water (GMMWater) also plays a vital role in the region, as it is the organisation primarily responsible for ensuring the continuing supply of water to the region. They work together with the Wimmera CMA and the Council not only to ensure water supply for communities and environment but to also reduce the impacts of flood and drought in the region. Wimmera CMA and Department of Primary Industries also play vital roles in land management and adaptation of landholders to changing climate. Department of Human Services also has a role to play with climate adaptation in the region with low income households, providing energy and water efficient housing stock and adaptation programs for these groups. Wimmera UnitingCare also has a role here. Wimmera Primary Care Partnership is focussed on helping community adapt from a health perspective, particularly to heatwaves and mental health issues. Finally, Grampians Regional Development Australia Committee and the Wimmera Development Association (owned by the local councils in the region) focus on economic and social development to ensure the long-term sustainability of the region. This diversity of public authorities with particular and overlapping roles contributes to the resilience of the region important in developing comprehensive adaptation strategies.

In the City Horsham many householders have adapted to living in a hotter and drier climate thanks to the recent long term drought (1997-2009/10), which raised people's awareness about the need to save water. An increasing number of homes now have rainwater tanks attached to them and gardens are changing from European style gardens to native Australian gardens, rock beds and artificial turf grass. It has also proven difficult for many households to maintain vegetable gardens. We observed in the city that a number of schools now have artificial turf, as well as significant sailcloth structures to protect the children from the sun's rays. It was also suggested that in the future, outdoor opportunities for children and sporting activities may be limited during days of excessive heat with a shift to indoor sports and changes to surfaces of playing fields to reduce heat exposure (i.e. bitumen tennis courts change to painted concrete).

Extensive research and development has gone on in Horsham and the surrounding region since cropping was introduced by the settlers. This work continues today as it does in private sector research and development laboratories in the region at Longernong College and the Grains Innovation Park. Successful farming is characterised by innovation, regardless of the climatic regime in which the farming occurs, and this is no less the case in the Wimmera where farmers and scientists work to identify climate adapted species that will ensure grain is supplied to global food markets. This is in addition to a focus on more efficient farming practices.

5.2.4 Discussion and prospects

Interviews with leaders from across the organisations mentioned in this report made it clear that the completion of the Wimmera Mallee Pipeline and its effective functioning was essential to the survival of people living in this region. In the *Western Regional Sustainable Water Strategy* (DSE 2011), making the best use of existing supplies, exploring the potential to use alternative, fit for purpose supplies, and making more water available for sustainable use were identified as important adaptation strategies surrounding this resource. Three key strategies were identified:

- first, continuing to promote water efficiency by urban, industrial and rural users includes cost-effective water efficiency options in supply, rebate programs for water efficient appliances for homes and small business, reviewing water savings rules, and, promoting best practice of management on farms.
- second, exploring opportunities to improve storage capacity by, for example using off-stream storages or aquifers including harvesting water in wet periods for use in dry periods when this can be done without adversely affecting existing users and the environment. Both aboveground storage and managed use of aquifers are considered here.
- third, encouraging water users to trade water with other users or carry over water from year to year. Importantly the strategy includes actions to increase the potential for trade such as continuing market development education, system specific rules to free up trade, adopting risk based trade approval processes, and allowing licensed water users to enter into multi-year transfer of all leases. As an adaptation strategy for the Wimmera making the best use of existing supplies through these programs, we believe, will be the most important approach to be taken.

The *Western Region Sustainable Water Strategy* also includes exploring the potential to use alternative, fit-for-purpose supplies, as well as making more water available for sustainable use. The latter being a contemporary public policy issue across the Murray Darling Basin. The Wimmera Mallee Pipeline offers the region 'growth water' in wetter years thanks to the water savings the pipeline provides to the region (TTM Consulting 2007; Van Veldhuisen 2001). This water is available to support economic development in the region, such as diversification of farming and businesses. Community leaders interviewed as part of this research all agreed that their combined efforts to ensure efficient and effective use of their declining water resources is the most effective adaptation strategy they can engage with.

Assuming long-term projections in declining rainfall across the region with significant impact on run-off, the Wimmera Mallee Pipeline is essential infrastructure in the long term. Long-term predictions are that global food demand will create opportunities for agriculture in the Wimmera and the pipeline will sustain farmers, their families and communities as they farm in what will be an increasingly variable climatic regime.

In addition to this major piece of infrastructure, organisations are working together to develop new ways of farming in a hotter, drier and more volatile environment. For example, agricultural industries developing new strains of wheat are setting up research and development operations in the Wimmera working with farmers to develop climate adapted crops. The council forecasts a significant increase in the number of people working in these science-based agricultural industries in the future adding to the innovative capacity of the city and its region. Organisations such as the Grains Innovation Park and the farmer led Birchip Cropping Group and the Victorian No-Till Farmers Association will continue to make significant contributions to research and development.

Other prospects that could help Horsham and its surrounding communities better adapt to changing climate include the current bid that many organisations in region have supported for a weather radar in Horsham to increase the predictability of weather and extreme localised weather events. This will lead to improvements in efficiency and productivity of farming the region. The University of Ballarat will continue to support Horsham's research needs around climate change adaptation and water management, and has already provided invaluable research into adaptation behaviours and climate knowledge of farmers. This information was used by Department of Primary Industries in their farmer adaptation programs.

Other opportunities for Horsham include a number of potential sources of renewable energy such as bioenergy using waste straw and green waste from residents, as well as solar and wind opportunities. Planning documents are being revised, such as the Wimmera CMA, where recent extreme events are being used to develop new upper limits for flood planning.

One thing commonly noted by those interviewed for this project, is that climate change is not the only driver of change in the region, with an ageing population, peak oil and oil prices, cost of energy and water, market values and food prices all major drivers of change. This provides an opportunity for adaptation programs to be wider than climate, as it will ensure more people will be involved.

Despite the prospects and opportunities in Horsham for a climate adapted 2050, there are some barriers that could impede adaptation. These include the general resistance to change rural people have, the ability of socio-economic disadvantaged families to adapt, the lack of concern in the community around climate change at the current time and other competing issues that draw away from adaptation. For example, when we approached community leaders in the health sector asking to meet with them about this project they did not believe that they were able to contribute in any meaningful way. In their view, concerns about funding, cost savings and human resources were far more critical than contributing to climate change adaptation. Thus, it will take the collaborative effort of many organisations and community members to overcome these and other barriers to adaptation in the region.

5.2.5 Conclusions

The ten years of drought to 2010 focussed community attention on the need to find better ways of capturing and using water. Ensuring that the community and policy makers beyond Horsham and the Wimmera maintain this focus is recognised by community leaders as an essential role for them. Since the breaking of the drought attention has shifted. Citizens are much less concerned about adaptation strategies for water for the agricultural economy and the urban community since ‘the drought broke’. For many people differentiating between long-term climate change and its impacts and climatic events – such as the floods experienced in 2011 – means that the challenge for community leaders is even greater if they are to ensure that the adaptation strategies put in place are followed through with appropriate outcomes. Many things may help refocus the attention of the Horsham community on climate change adaptation, including the Local Government Change Agents project being undertaken by the University of Ballarat in collaboration with Horsham Council and other regional councils. This project is designed to help council staff feel empowered to help their communities change behaviour, and adapt to climate change and other sustainability issues.

5.3 Case study: Junee, New South Wales

Located in the Riverina region of New South Wales 470 km south west of Sydney and 510 km north west of Melbourne, the town of Junee originated from the cattle station Jewnee Run. Surrounded by prime farming land, Junee has been able to develop a mixed economic base with industries such as rail transport, light industry and in more recent times, correctional services. Its population grew rapidly in the mid 1800’s when gold was discovered in surrounding areas and in the late 1870’s the opening of the railway line and station at Junee helped fuel the prosperity and expansion of the town. Junee remains an important production centre for canola, wheat, sheep and beef, but also plays a major role as a lower level commercial and administrative centre within an otherwise relatively sparsely populated region. Junee is situated approximately 50 km north of Wagga and 60 km to the west of Gundagai. The former is important as the commercial and service hub of the region, while the latter sits on the Hume Highway,

one of the nation's most important road transport links. Junee itself is an important junction within the NSW rail network, with a considerable volume of rail traffic passing through the town.

5.3.1 Current industry structure, social, economic and governmental sustainability

Agricultural industries remain the core of Junee's economy, with the region highly productive for both cropping and grazing industries. Whilst the rural industries still play a major role in the town's economic base, other industries such as tourism and hospitality, manufacturing, transport and specialised professional services have expanded and major employers in the town include Junee Beef, Charles Sturt University and correctional services facility. The town is also the administrative centre of its township, the Shire of Junee. Public sector employment is therefore an important part of the town's employment structure. The town also features several prominent tourist attractions, with Monte Cristo house and the Junee Liquorice and Chocolate Factory located in the old flour mill. Both serve as major drawcards for regional tourism. Once regarded as one of the most prosperous settlements in New South Wales, Junee's history of affluence is still visible today with many historic buildings dominating the town's main street. It is important to acknowledge that some of the older buildings do not simply attest to the prosperity of the past, some reflect the closure of industries that would have been important sources of employment in the past.

Junee received its first economic boost with the relocation of the railway repair facilities from Wagga Wagga. This made Junee one of the most important railway centres in the state and evidence of this is still visible today with the Junee roundhouse built in 1942, the largest facility of this type in the Southern Hemisphere. The railway infrastructure provided the impetus for another economic boost as the investment in transport infrastructure improved the capacity of the region to send primary produce to markets in both Sydney and Melbourne. This advantage was further cemented in 1952 when the largest grain terminal in the Southern Hemisphere was built in Junee. At various times in the past, the town has sought to attract manufacturing enterprises to diversify the region's economy and boost earnings. Prospective industries have included a range of agri-processing businesses which could be attracted by proximity to raw materials, including grains and other biomass for ethanol production. In large measure such efforts have failed because of limited water supplies, or more precisely, the relatively high cost of the water available in Junee. The town largely depends on bores to the south, with the high cost of provision a concern for a number of informants.

With a population of just 12 in 1866, Junee has a current population of 4,400 (ABS 2012a). The population has steadily grown in the last decade from 3,592 in 2001 (ABS 2002) and 3,745 in 2006 (ABS 2007). Despite its expansion, Junee remains a relatively small township that is largely dependent upon agricultural industries and public sector employment. Critically, while Junee is growing, many of the surrounding settlements have lost population over the last two intercensal periods, an outcome local informants attribute to consolidation in agriculture as family farms sell up to agri-businesses and as continuing family-based enterprises grow in order to achieve scale economies. Demographically, Junee is a relatively old town with a median age of 38 in 2011 (Table 28). While this is close to the national average, many regional settlements are much younger than the picture for Australia overall. There is a significant number of retirees living in Junee, a reflection of the quality of life that it offers and its relative proximity to a range of services. The available evidence suggests that Junee may be developing as a 'sponge' city: soaking up population from its surrounding districts as they experience both demographic and economic change. If this is the case, the township's ability to continue to provide a high level of amenity and good quality services will be pivotal.

Table 28: Summary statistics, Junee, 2006 and 2011

<i>Junee</i>		
	2006	2011
Number of Persons	3,745	4,400
Median Age	38	38
Median Household Income	\$726	\$837
% Indigenous population	3.3	8.4
% Workforce in Agriculture	3.2	3.1
% Workforce in Mining	0	0.3

Source: ABS 2007, 2012a.

5.3.2 Risk and exposure to climate change

In common with much of southern Australia, the most commonly cited climate change models suggest that Junee will become both warmer and drier over the period to 2050. The Vulnerability Index score for Junee (0.512), like Horsham and Alice Springs, places the town in the midrange for vulnerability.

Over recent years Junee and its hinterland have experienced a number of the phenomena predicted by climate change: this has included significant bushfires, drought and the impacts of flood. It is also worth noting that as the centre of a major agriculture producing area, Junee is vulnerable to long term declines in the productive capacity of agriculture. A number of informants in Junee felt that the town and the region were vulnerable to the second and third order impacts of climate change, with investors potentially reluctant to commit to the region if they believed climate change would reduce its productivity.

In 2006 Junee was affected by significant bushfires that closed some of the roads to and from the township and destroyed property, including some businesses. Interviewees acknowledged that bushfires were a substantial risk to Junee, although often not considered in the context of climate change. Some climate change projections suggest an additional 10 high fire risk days per year in the region by 2050. Junee has responded by upgrading its capacity to fight fires through investment in new infrastructure and training, and also in the stocking practices of farmers.

In common with most parts of the Southern Tablelands/Riverina, Junee was affected by drought through much of the first part of this century, resulting in poorer harvests and the associated loss of economic activity. However, drought was seen to be part of an on-going set of challenges for farmers in the region, with one respondent noting that

... there is certainly no feeling that the sky is falling.

Within Junee there was a strong sense that farms and farmers would continue adjust to changing conditions as they had in the past. As one person observed of the agricultural sector 'We will continue to adapt' and 'they are so innovative, our farmers, that they do this stuff for themselves' and 'they treat this as normal, they treat that as moving forward'. Recent innovations in response to the drought had included investment in precision agriculture, in-ground water storage and zero tillage – all of which could be thought of as part of good practice in contemporary farming.

In terms of Junee itself, one of the consequences of the drought was the need to drill deeper bores to secure the town's water supply, although the supply of water was never at risk. From late 2010 to early 2012 La Nina conditions returned to the eastern seaboard of Australia, resulting in heavy rains and flooding in some locations. Albury and especially Wagga Wagga to Junee's south, were affected by flooding in the Murrumbidgee River and there was some localised flooding in Junee. Most importantly,

several key roads – to Gundagai to the east and Wagga to the south – were affected by flooding, with some of the long term impacts still evident. Junee was not cut off as it sits on a crossroads, but the loss of access was significant.

5.3.3 Local planning processes – government and industry

Planning for climate change has occurred on a relatively small scale in Junee. The NSW Government has been active in planning for climate change, with a number of information resources made available to local government.

The Shire of Junee has undertaken a number of actions in anticipation of climate change and its likely effects. It undertook a study entitled 'World with Less Water' that sort to examine scenarios for the future. The Shire has also undertaken flood mapping, using state and Federal Government funding. Such initiatives have been important in planning for storms with the township of Junee. At a more fundamental level few of the approval processes administered by the Shire have an overt focus on climate change issues, with the major exception being the application of the Basix system to the development approvals. It should be acknowledged, however, that such adherence is mandated by state government policy.

It is important to recognise this case study – as with the other case studies – the ability of the council to undertake effective action and planning is limited by its restricted resource base. One interviewee noted that Junee Shire is 'a strapped for cash council' and therefore had little capacity to engage with climate change adaptation. As noted previously, Junee has upgraded its fire fighting capacity in response to recent events. It has also improved its in-town drainage infrastructure, both to better deal with high rainfall periods and provide an alternative water supply for council use. Its reuse of effluent also delivers 0.5 ml a day for use on sporting fields and other council-owned gardens. The development of stormwater harvesting and wastewater reuse is a logical first step in climate change adaptation.

The Shire made use of Australian Government monies to repair road infrastructure destroyed by flooding from 2010 to 2012. Several respondents noted that there had been four flood events in three years, which had resulted in considerable Federal funding for road repairs and reconstruction. While acknowledging the importance of this assistance, local government also noted that it was disappointing that funding was only available to repair roads to their previous state, rather than improve them to a more robust condition and effectively future-proof them from comparable events into the future. It is worth noting that in one part the road to Gundagai is still washed out, as undercutting of a bank by the Murrumbidgee River will require extensive investment rather than a simple 'patch'. One section of the road has been reduced to one lane for more than two years but at this stage, most floods have a very short term impact.

5.3.4 Discussion and prospects

There does not appear to be a high awareness of climate change issues within Junee. While the issue is acknowledged by local government and included in the forward plans of the NSW Government, it does not appear to be prominent within the thinking of the broader community. Several organisations contacted to participate in the case study declined to do so because of limited awareness and/or engagement with the issue. In part this reluctance to engage with adaptation planning reflects a number of factors:

- first, scepticism about climate change remains a feature of many rural communities, particularly amongst farmers used to dealing with the exigencies of a highly variable climate;
- second, there are a number of other processes – including the consolidation of agriculture, demographic change, and structural adjustment within a range of

industries – that are also reshaping country towns, and in many instances doing so on much shorter time frames; and,

- third, as a relatively small town Junee has a limited capacity for the community and public sector agencies to deal with all issues. The community is active in a number of environmental areas – including land and water management – and supports a range of social infrastructures. Climate change adaptation is a longer term challenge that in many respects requires higher order capacities not found in small country towns.

Centres such as Junee are likely to require substantial external inputs – in the form of advice, information and potentially resources, in order to adequately deal with the challenges of climate change. There is no doubt that Junee has many of the necessary features to deal with the challenges of climate change – with high levels of social capital, strong community groups and an engaged local government – but will require assistance to develop appropriate responses. One of the informants in this case study argued that while climate change adaptation was not a priority

... we are doing a lot of things that need doing anyway and they will help us adapt to climate change ... by 50 years we will have adapted.

5.3.5 Conclusions

Junee is, in many respects, a classic country town that is typical of much of the southern part of Australia. It is relatively small, and is neither inaccessible nor on a major road transport route. It has good access to services and in large measure depends for its wellbeing on the success of its agricultural industries. It has managed to attract significant public investment over a number of decades, including rail infrastructure and the establishment of a correctional facility. The town, via the Shire of Junee, has already taken a number of measures that are consistent with adaptation to climate change – including localised water harvesting and improved fire fighting capacity. But it is important to acknowledge that these are, in large measure, reactive measures brought about by events that have already taken place. There is limited engagement within the community around long term planning for climate change, and this reflects the capacity constraints confronting both local governments and community organisations.

5.4 Case study: Moura, Queensland

5.4.1 Introduction

Moura is a small rural town in the Banana Shire on the Dawson Highway surrounded by agricultural activities and open cut coal mining. It is located in central Queensland and is 180 kilometres south-west of Gladstone and 600 kilometres north-west of Brisbane. The town was first surveyed in 1836 and within a year a number of businesses were established to support farming activities in the Dawson Valley.

Originating as the service centre to Moura station, it has now grown and features a diverse economic base including cattle, wheat, sorghum, sunflower, cotton, nitrate, gas and coal production. A grain storage facility is located in Moura and has a dominant position on the town's landscape. When built it was one of the largest facilities of its kind in the Southern Hemisphere. Moura has been a coal mining town since the first half of the twentieth century, with early production dependent upon underground mining. In the early 1960s the economic base of the town underwent a radical transformation when the open cut Kianga – Moura coalfield began operations with what was then the largest dragline in the world – capable of moving 200 tonnes of coal at a time. There are now several large industries with operations based in Moura including Queensland Cotton's Gin Plant, Queensland Nitrate Pty Ltd's ammonium nitrate plant

plus mining operations to support the Seam Gas and Moura Coal Mine operations. These operations are reliant on access to rail and port infrastructure which are well developed with the nearest port being Gladstone. Moura became well known for a series of mining accidents in the underground mines and in 1994 underground mining ceased with all coal mines now open cut operations.

Moura has a current population of 1,704 (ABS 2012a). There has been a steady decline since 2001 when the population was 1,802 (ABS 2002) and in 2006 (ABS 2007) when the population was 1,774. The decline in population can be attributed to a number of economic processes: first, the coal industry slowed in the late 1990s because of falling world demand and mining at Moura came close to ending. However, booming demand from China from the start of the 21st Century reversed that trend and total production has increased. However, the threat to the town's industry precipitated exits that have continued to have an impact. Second, fly-in fly-out mining has grown in Queensland for a range of reasons, such that total volumes of production have risen while the resident workforce has declined. Thirdly, as a capital intensive industry, open cut coal mining is not dependent upon a large workforce. Even the associated ancillary industries – such as power generation – do not necessarily require a substantial workforce. The relatively high household incomes and low median ages in Moura reflect the impact of the coal and associated industries (40.4 per cent of the labour force, Table 29), with good wages and the capacity to attract new staff a feature of employment in this sector.

Table 29: Summary statistics, Moura, 2006 and 2011

<i>Moura</i>		
	2006	2011
Number of Persons	1,774	1,704
Median Age	32	32
Median Household Income	\$1,709	\$1,827
% Indigenous population	4.7	6.3
% Workforce in Agriculture	2.2	2.8
% Workforce in Mining	40.5	38.2

Source: ABS 2007, 2012a.

5.4.2 Risk and exposure to climate change

Moura has a Vulnerability Index score according to our matrix of 0.476. And climate change predictions for Moura and associated regions in north/central Queensland indicate a warmer future, potentially affected by stronger weather events and greater variation in climatic conditions. As the Queensland Government has noted, models of climate change suggest that Central Queensland will experience an average annual temperature increase of up to 4.5 degrees by 2070. There is the appearance of less certainty with respect to change in rainfall patterns, with some models suggesting an increase of 17 per cent in annual rainfall, and others indicating a fall of 35 per cent (Queensland Government nd). 'Best estimate' models suggest a fall in rainfall under all emission scenarios. Storm tides are also expected to become more common, which may have an impact on critical port activities. There is also an expectation that the primary regions for cyclone development will shift southwards, which could result in a greater cyclone impact on the Central Queensland region.

As will be discussed in greater depth later, state and local government agencies are aware of this predicted scenario but fieldwork with community members found a great deal of scepticism around climate change. A number of informants considered recent

weather events were a consequence of long-established climate variability, while others felt that they needed more detailed, regionally-based information before they could either plan or take action. For this latter group, the degree of uncertainty perceived to be associated with published climate change scenarios – including scientific adherence to a discussion of probability rather than certainty – appeared to cloud their response to this issue.

Moura and its districts have been affected by substantial climate events in the recent past. In 1993 and again in 2009-10 the township came close to losing its water supply as the Dawson River lost flow. The breaking of the drought and the arrival of La Nina conditions from late 2010 resulted in significant flooding which isolated farms and smaller communities in the region and resulted in the destruction of infrastructure. Some roads were washed out for more than six months. Mining activity has also been affected by major weather events, with Cyclone Yasi affecting coal exports from Gladstone harbour for some time.

5.4.3 Local planning processes and responses

Moura is part of Banana Shire, which is headquartered approximately 100km to the east at Biloela. Banana Shire is a relatively small local government, with just 15,000 residents. The capacity to plan for and integrate climate change adaptation in the day-to-day activities of the councils is therefore quite limited.

While mining is important in and around Moura, much of the remainder of the Shire is agriculturally based and much of the planning for climate change is focussed on the potential impact on agricultural industries, which include cotton, citrus, grapes, beef and grain production. Tourism is an important industry also, especially along the coast and there has been some planning for the potential impacts of climate change on this sector. Both an Environmental Management Strategy has been developed by the Banana Shire, and includes consideration of climate change. To date, however, the documentation simply reflects on national and global initiatives, and reports on the council's steps towards improving the energy efficiency of its vehicle fleet. It does not represent a comprehensive statement on climate change adaptation or mitigation (Banana Shire 2010).

There are few staff devoted to climate change issues within the Shire and cut backs within the Queensland Government has reduced the presence of state government agencies. The Queensland Government has prepared information sheets for the region (Queensland Government nd) that seek to inform landholders, residents and business about the likely impact of climate change on their region. This response is important within the region as there is a demand within the community for additional, and more detailed, information. The Queensland Government has also funded a number of projects that have addressed climate change in Central Queensland, including initiatives on risk management and scenario planning.

The potential impact of climate change on infrastructure was recognised as critical by a number of interviewees. The anticipated increase in the number of days above 35° and the probability of greater variability in rainfall – including flooding – was seen to represent a major challenge for transport infrastructure in particular. To date this issue does not appear to have been addressed systematically by government processes. Flooding is a major threat to a number of townships in the region – including Theodore and other river towns – but to date strategies have not been developed to address this issue in a comprehensive way.

5.4.4 Discussion and prospects

Moura's fortunes appear to be tied to the future of the coal industry, and more specifically current and prospective mines in its region. There appears to be little

planning for climate change in the region, and none noticeable in the township itself. As one interviewee noted,

... there is no sign of adaptation planning in the region, it's a reactive place.

The same informant noted that while climate change is likely to have an impact on regional businesses in the near future, the fundamental cause is unlikely to be obvious to residents and therefore will not initiate a more pro-active position. There was a very strong sense within the community that more information was needed before action could be taken to address climate change. Some respondents felt that some of the information provided to date on climate change had been 'tainted' by partisanship. In many instances, interviewees felt that local government would be the most appropriate source of more authoritative information, given its commitment to the region, awareness of local conditions and its substantial standing amongst the community.

As with the Alice Springs case study, the highly mobile nature of the workforce and population may add resilience to the town in the face of climate change, with new residents potentially cycling in and out of the town for employment. On the other hand, the highly mobile nature of Moura's population may serve as an impediment to adaptation. A number of interviewees noted that there was not a strong sense of community in the town, with many households moving into and out of the region with fluctuations in the coal industry. There are few locally based community or other groups that could serve as a conduit for local level action.

5.4.5 Conclusions

In a number of ways Moura is especially vulnerable to the impacts of climate change. Its location on the floodplain of the Dawson River and its position in Queensland's tropical north means that it is liable to be affected by cycles of drought and flood. The former is likely to affect the agricultural component of its economy – which is modest – while the latter will affect both agriculture and mining – which is substantial. Moura faces an indirect economic challenge associated with climate change: as a major producer of coal moves to reduce the use of fossil carbon as an energy source on a global scale are likely to exert an adverse impact on its future. Changes in production systems and an increased use of fly-in fly-out have already contributed to a fall in population in Moura, and it is relatively simple to imagine further falls in the face of adverse economic or climatic conditions. Its pre-mining industry – commercial activities associated with agriculture – is not a major employer and would not have the capacity to fill any gap if mining was to be terminated. Overall, Moura and the wider region are unlikely to engage in substantial climate change adaptation without considerable external assistance and encouragement. The township is poorly equipped to address adaptation on its own, while the local council is both distant and yet to make a significant commitment to addressing climate change.

5.5 Case study: Waikerie, South Australia

5.5.1 Introduction

Waikerie is a town in the Riverland region of South Australia, about 180 km (or two and a half hours travel time) from Adelaide by the Sturt Highway. The town is located on the south bank of the Murray River, a short distance off the highway, and in a region of the river famous for its cliffs. The region is a major irrigation district in the lower Murray-Darling Basin, and Waikerie's main industry is horticulture, traditionally citrus fruits and grape vines. Indeed Waikerie has long seen itself as the 'citrus capital of Australia'.

The first European settlement at Waikerie occurred in the 1880s, with the township of Waikerie being created in 1894 when, in response to the economic depression of that time, the colonial government established a village settlement (SA Government 2012).

Sixty five unemployed men from Adelaide were relocated to the village in April 1894, to work in a cooperative farming system. Within 12 months only 27 of those men remained there. Those 27 went on to form the core of the township of Waikerie which was surveyed as an irrigation settlement in 1910. By 1914 the Waikerie Cooperative Fruit Company (later to become the Waikerie Producers' Cooperative and then Nippy's Waikerie Producers) had been established, and in 1917 land in the Waikerie Irrigation Area was allocated to the soldier settlement scheme under the Commonwealth Government's Discharged Soldiers Settlement Act (1917). The town then grew into the modern and pleasant township of today. By the mid 2000s Nippy's Waikerie Producers was one of the largest fruit processing operations in the southern hemisphere.

In the 2011 census the Waikerie 'state suburb' had a population of 2,715 (ABS 2012a). This represented an increase (from 2465) in the 2006 census. This recorded population for the town (and its hinterland) may be contrasted with the demographic analysis provided by UrbisJHD (2007) in its report to Loxton-Waikerie District Council on the economic profile of Waikerie, which indicated a population growth rate of 0.3 per cent pa (or ten people per year) for the town since 1991, with a forecast zero per cent growth rate from 2006 to 2016. Key statistics for Waikerie are provided in Table 30 below.

Table 30: Summary statistics, Waikerie, 2006 and 2011

<i>Waikerie</i>		
	2006	2011
Number of Persons	1,745	1,633
Median Age	44	47
Median Household Income	595	\$666
% Indigenous population	2.5	1.9
% Workforce in Agriculture	15.6	14.8
% Workforce in Mining	0.9	1.3

Source: ABS 2007, 2012a.

The basis of Waikerie's economy has always been agriculture. In the face of many pressures, both external and internal, local businesses have shown themselves to be innovative and competitive (UrbisJHD 2007). The sector is diverse in its produce, growing citrus, grapes, nuts and stone fruits as well as vegetables and other fruits, with this diversity increasing in recent years as the citrus industry has declined. Value adding operations are significant in the area, in the forms of processing and packaging as well as storage and distribution. UrbisJHD described the skill set of locals combined with the land and climate as the key strengths of the local economy, and the Riverland region as a whole has shown itself to be innovative and flexible, introducing new varieties of produce and methods of production.

Waikerie has a key role as a service centre for the agricultural sector. Whilst it is part of the Riverland, and therefore closely tied to the other main regional towns of Renmark and Berri in particular, its location makes it more oriented towards the Mid Murray area and Adelaide. Waikerie provides a sufficient and appropriate level of services within the town, but residents must travel to these larger centres for their higher order requirements. Ongoing investment in the provision of services, including range and quality of retail, commercial, education and health services as well as utilities, tourism infrastructure and general amenity, was seen by UrbisJHD (and the Loxton Waikerie District Council) as important in improving the town's economic sustainability.

The recent drought and attendant problems with both the supply and cost of water for irrigation, decreasing demand for Waikerie's traditional produce (viz citrus fruit, especially oranges) – or perhaps an increasingly uncompetitive market for that produce (eg through a high Australian dollar and the availability of cheap imports as alternatives), and a concern about the emigration of young adults to other regions represent the primary challenges facing Waikerie. The actual or potential impacts of climate change on these issues and the economic, environmental and social sustainability of the Waikerie community have yet to be studied.

To shed some further light on the issues, challenges and opportunities facing Waikerie in 2012, a series of interviews with prominent local stakeholders was undertaken in August 2012. These stakeholders included an officer of a local conservation agency, a prominent local citizen interested in the future development of the town (and who regularly acted as a media spokesperson on community issues in the Riverland), staff members from local primary and secondary schools, and a senior officer from the Loxton Waikerie District Council. The outcomes of discussions with these stakeholders, along with a site inspection, form the basis of the material provided in the remaining sections of this case study chapter.

5.5.2 Risk and exposure to climate change

On the eastern approach to Waikerie, just inside the 80 km/h speed zone on the Sturt Highway, is a substantial if not expensive 'gateway' heralding arrival at the town. The gateway is illuminated at night using energy from a solar panel, and the structure indicates something of local pride and belief in the town and its community.

Figure 5.6 shows this structure as it was in August 2012, the victim of a collision by a motor vehicle. This perhaps provides a pertinent metaphor for Waikerie as it is at present. A proud and still prosperous community, if perhaps less so than a decade or two ago, as it has taken a buffeting in recent years from environmental and economic forces. There is resilience in the community, but future directions have still to be mapped out. The Vulnerability Index score for Waikerie is 0.525, the highest vulnerability score for the five case study locations included in this report.

Waikerie along with the rest of the Riverland suffered badly in the drought of the 2000s. The traditional irrigation industry that has long provided the backbone of the local economy was deeply troubled, through both lack of water and then the cost of the available water. A farming community that prided itself in its efficiency and ingenuity in the use of its natural resources was brought to the brink of despair, and some local producers did indeed surrender to those pressures and move away, or at least remove or abandon substantial parts of their plantings and orchards. Relief from the drought has come, but with it other perceived malevolent forces, represented by the high value of the Australian dollar, consequent shrinkage of international markets for the area's traditional produce (e.g. oranges) and indeed competition in the domestic market place by cheap foreign imports of that produce. Local costs of production are on the verge of exceeding prices, if they have not already done so. Some citrus growers have been prepared to leave their crops unharvested and rotting on the ground. Local economic activity, e.g. retailing in Waikerie's main street, has suffered – empty shops and boarded up shop frontages are stark illustrations of this. Waikerie has these, but it must be said not to the same extent as nearby downstream towns (e.g. Morgan) or some towns in the mid north of SA (e.g. Jamestown). But the immediate and obvious comparison is with how things used to be in the place, not how they are with other places.



Figure 13: Sturt Highway ‘gateway’ to Waikerie on the Sturt Highway eastern approach to the town – August 2012

Picture: Michael Taylor 2012

The ongoing debate about water allocations for irrigation, domestic and environmental water flows in the Murray-Darling adds to a sense of despair. Psychological factors can have major impacts on economic performance and on community wellbeing. Fear of returning to drought is foremost among many local people, especially farmers. The psychological wellbeing of the farming community, with concern about the mental health and wellbeing of farming men as one group, is a major issue and is leading to the uptake of the ‘Menshed’ initiative in Waikerie.

Where does climate change fit into this picture? The Waikerie community has varying shades of opinion on this, and especially on the perceived role of climate change on the length and intensity of the recent drought. If there is one widely held view in that community, it is that overall environmental sustainability is the key to the area’s ongoing future and prosperity, and that community and individuals must strive to attain the environment sustainability from which will come economic sustainability. The latter would be seen as the most important factor for the future wellbeing and development of the Waikerie community. Some see climate change per se as but one factor at work in this equation, others in the community would not recognise it. There is among some a local view that climate undergoes cyclical change, a not uncommon tenet in rural communities. Yet there is also a view that ‘something is different’ about present circumstances, and these two views coexist. A deep concern about the need for conservation of the natural environment is also apparent throughout the community, and is certainly not in conflict with perceptions of cyclical climatic behaviour among members of that community.

What is also true of the Waikerie community is its strong interest in adaptation. Individuals, businesses and local government agencies are looking for new or alternative ways to do existing activities, at new crops and farming systems, and at new industries and employment generators. ‘We have to do things differently’ was a catch cry used by a majority of the Waikerie stakeholders interviewed in this study. How water and power are used was a key concern in this.

Thus some primary producers are taking up dryland farming, while others are trying new crops such as avocados and dates, and with some success. Others see the future development of Waikerie in terms of quite different industries. Tourism is one (Urban and Regional Planning Solutions 2007). The 'retirement industry', i.e. providing for retirement communities, is another. A pleasant climate and surroundings, good town facilities and services, and enhanced accessibility to Adelaide⁷ are seen as providing Waikerie with the necessary features to encourage such developments⁸ and draw a new pool of residents from across South Australia.

The main thrust of community interest on environmental questions, seen both in the local schools and in the local Landcare (Riverland West Landcare) office is in broad based environmental sustainability and in specific initiatives in biodiversity – with a current focus on removal of exotic species and pests – and water conservation. Waikerie Primary School has been recognised at state and national levels for its 'Carbon Kids' initiative, in which students are encouraged to seek the means for conservation of natural resources in all aspects of their daily lives, including their families as well as school pursuits. The local community has given strong support and recognition to this initiative, a clear sign of its local importance.

Thus Waikerie is a town and community aware of environmental issues and concerned to see these addressed, with recent experiences of environmental problems and their consequences for the town and its surrounds. Climate change is, however, at best seen as one aspect of environmental management, and for some there is scepticism about it.

5.5.3 Local planning processes and responses

Local planning processes are managed through the Loxton Waikerie District Council. The council was formed in May 1997 with the amalgamation of the previous District Councils of Loxton, Waikerie and Browns Well. The council has an area of 7 957 km², and a total road length of 2 235 km.

While one or two stakeholders interviewed were not convinced of the merits of the amalgamation that led to the present administration and would have preferred retention of a separate Waikerie council, the broad view was that the council was doing a good job in local planning and oversight for the town.

In recent years council has put considerable efforts into infrastructure improvements, such as recent flood mitigation and urban drainage in Loxton, and more broadly in systems for environmental protection. The council is currently implementing a new system for waste management and recycling, in which environmental concerns have been a driving influence. The council has also willingly participated in and supported a number of environmental research projects, including a current 'Sustainable Communities' study being undertaken by a consortium of universities, including ANU, Flinders University and the University of Canberra, as well as a current SA Premier's Science and Research Fund project⁹ on climate change adaptation. The council sees participation in these projects as an important means for the two way flow of information on sustainability issues.

⁷ As a consequence of recent improvements to the Sturt Highway, including duplication of the road from Gawler to Tanunda, and construction of the Northern Expressway in the northern suburbs of Adelaide.

⁸ The population statistics on the numbers of senior citizens in Waikerie, as discussed earlier in this chapter, suggest that the town is already seeing the advent of that retirement industry – although the protagonists for this are keen to see an influx of younger retirees into the Waikerie community.

⁹ This is the PSRF 'Human dimensions of TREND' project led by Professor Andrew Beer of the University of Adelaide, and involving researchers from the three South Australian universities.

The thrust of the Loxton Waikerie District Council's planning strategy, directions and processes are outline in its 2010-2015 Strategic Plan (LWDC 2010). Council's statement of future directions in that plan is as follows:

The District Council of Loxton Waikerie is committed to improving the quality of life through the maintenance and development of a vibrant and prosperous community by:

- facilitating a strong regional economy which encourages development opportunities
- effective, open and accountable governance and leadership
- maintaining appropriate and sustainable community infrastructure
- preserving and enhancing the natural environment
- recognising our heritage and cultural diversity
- providing a comprehensive range of quality services.

The strategic plan then outlines six community goals for the realisation of the future direction:

- sustainable economic development
- visionary community leadership
- provision and maintenance of infrastructure
- recognition and protection of the environment
- provision of cultural and community services
- delivery of relevant services through responsive corporate management.

The plan then describes the strategies developed for each of these community goals to achieve its stated objectives. In terms of the community goal for recognition and protection of the environment, the objective is to ensure the importance of the environment spaces is recognised and protected for the enjoyment of future generations. Realisation of this objective is intended through the key strategies listed in Table 31.

It can be seen from this table that the planning emphasis is on conservation of energy and conservation and recycling of materials, primarily in council operations and activities, but also in the wider community. Climate change is specifically identified in key strategy 4.3.5.

Table 31: Loxton-Waikerie's key strategies for community – Goal 4 'recognition and protection of a sustainable environment'

4.1 Water resources management	
4.1.1	Identify and pursue opportunities for the development and upgrading of sustainable methods of water and waste water management and disposal
4.1.2	Encourage/advocate sustainable use of water by households, industry and schools
4.1.3	Review development controls to ensure sustainable water management practices are reflected or encouraged
4.2 Waste management	
4.2.1	Encourage waste minimisation and resource conservation through the promotion of regional best practices in recycling, reuse and minimisation
4.2.2	Seek to avoid or minimise waste in council operations
4.2.3	Work regionally to secure cost efficient long term disposal options for waste
4.2.4	Take a leadership position in regional waste management initiatives

4.3 Sustainability	
4.3.1	Adopt practices in the management of council's assets and operations that support the sustainable use of energy and natural resources
4.3.2	Encourage business and the community to adopt the sustainable energy and natural resources
4.3.3	Promote the use of renewable construction materials to business, the community and in council activities
4.3.4	Incorporate opportunities for energy saving and environmentally sensitive principles of development in the Development Plan
4.3.5	Work constructively to ensure the community is informed and can respond to the impact of climate change
4.4 Environmental management	
4.4.1	Implement the Public and Environment Health Plan
4.4.2	Identify and support opportunities for low impact development of ecotourism ventures as a method of increasing awareness and appreciation of the environment
4.4.3	Develop a Heritage Plan which identifies those building and places of interest that contribute to the character of the district
4.4.4	Protect, enhance and actively manage the natural and built environment

Source: extracted from LWDC (2010).

5.5.4 Discussion and prospects

Waikerie is a town characterised by strong feelings of community and a history based on endeavour and innovation that have previously led to success and prosperity. There is a strong sense of place and belonging – for instance many young men who grew up in Waikerie continue to play for or stay involved with the local football club even when they have moved away from the town for work. At the same time the community has been bruised in recent times, first by drought and then by economic circumstances regarding its staple products. Waikerie itself relies on its land in economic terms and the river as a focus for its social activity (and the water that fuels its economy). The community – at all levels from the council to businesses and individuals – is implementing plans and schemes to deal with the new economics for its industries, through diversification and new activities. It has dealt with the drought as best it could, but the long term effects of that climatic event have still to be seen. For instance teachers from both schools who were interviewed in this study had seen the effects of the drought on students and their families, and they also believed that the impacts of the drought would strongly influence the students in their later lives. The directions of these influences may still be uncertain, but the conservation of water resources is one keenly felt influence already seen.

While agricultural production is most likely to remain the mainstay of the local economy and the new initiatives in that sphere are crop diversification and new farming methods, the major initiatives on the economic front are aimed at broadening the economic base through investment and development of new industries and services.

The tourism potential of the town and its region has not yet been fully realised, with the Murray River the chief drawcard.¹⁰ Riverfront Park (see Figure 3) has recently been redeveloped as a mixed activity tourist site, taking advantage of the river setting as well as providing passive and active recreational spaces and facilities, including a small native wildlife park. The Murray River itself is a major tourist attraction, and one that has still to be fully realised. The spectacular cliffs along the river immediately upstream

¹⁰ See Urban and Regional Planning Solutions (2007) for a more comprehensive discussion of the tourism potential of Waikerie.

of Waikerie provide one potential site for further tourism development – perhaps through boat trips that enable tourists to see the cliffs from the water.

The other area seen as important for economic and social development is the promotion of Waikerie as a place for retirement living, using the natural attractions of the town, its high standard infrastructure, facilities and services, and its accessibility to Adelaide. This is seen as one strong means to support and develop the local economy and community. The town's population profile suggests that this phenomenon is already present – the challenge for Waikerie is to attract retirees from further afield than the Riverland.

So where does climate change adaptation fit in this picture? The almost unanimous view of the stakeholders is that it does not feature as a separate issue in its own right. Climate as a determinant of environment is seen as important, with conservation and sustainability the key concerns for the Waikerie community. Adaptation to changing circumstances, largely economic but also social, demographic and environmental, is seen as a necessity for that community, and something that Waikerie and its people have done well over many years. But adaptation specifically to climate change was not identified as an issue of local importance. Some stakeholders saw it as part of the concern for environmental sustainability, others had some scepticism about the reality of climate change in their region. Yet there was a pervading view that conservation of natural resources and protection of the environment were key factors for the present and future of this attractive town.

5.5.5 Conclusions

Waikerie is a town that has grown and developed because of its relationship with the land and the river. Its staple industry is agricultural production of fruits, nuts and other produce. Climatic and economic conditions have hurt the town in the past decade, but it is a resilient place with a strong feeling of community identity and a history of initiative and adaptation. The town of today recognises the challenges that it faces and is actively seeking solutions to its problems through its own endeavours. Climate change would be but one of many influences on the future of the town and its hinterland. Adaptation to those factors is the key to its future circumstances, based on lessons learnt from recent experiences. Waikerie sees its problems but has an underlying sense of self belief in itself and the ability of its citizens to overcome those problems.

5.6 Moving to adaptation: insights from the case studies

The literature on the practice of climate change adaptation for inland Australia is in prospect, but has not yet emerged in any meaningful way. This body of work will follow on from the risk assessment plans and literature currently being released nationally, albeit mostly in relation to urban and coastal settlements. Reviewing this material can be overwhelming and there is a need for resources targeted to particular types of impacts, interventions and strategies. There is also a need for resources that address how to best manage the place-specific impacts of climate change.

Moreover, there is clearly a need to evolve plans and actions beyond the more framework/functional/operational/risk identification nature of these documents. Discussions with key stakeholders in our case study locations identified an appetite for broader partnership approaches to climate change adaptation; to incorporate climate change adaptation with other regional and community development actions for the sustainability of settlements. Stakeholders acknowledge, however, that this is a broad remit, and for many they simply want clearer pathways to the tools and information available to understand climate science, local and regional level impacts and how these can be managed or ameliorated.

This is the logical next step for inland communities, particularly given that many of these communities face a range of challenges in terms of population, economic growth and restructuring and access to adequate services and employment opportunities. Devolving responsibility to local government for such intense activities should not be allowed to occur without access to the adequate planning and financial resources to develop whole of community focussed local or regional action plans for the sustainability of country towns, including the impact of climate change.

Finally in terms of the current situation with regard to risk management and adaption planning in inland Australian, our research echoes that of Pillora (2011):

A high priority identified by councils is the need for specialist localised information on effects, impacts and responses. Progress is being made in some regions, but much more work is needed. Consistent messages from all key sources will also assist in enabling decisive action by local authorities (Pillora 2011: 16).

A clear step forward here is the development of a clearinghouse of sorts, or centralised database/portal where actors and institutions interested in, or driving climate change adaptation planning for their communities, towns or regions can easily access the many resources available. This portal should be a searchable facility, with resources listed according to their focus, particularly for non-coastal and non-metropolitan communities, local governments and other region-based institutions. Our inland towns and communities need such resources to ensure that they don't lag behind other areas of the country in climate adaptation, with impacts on their future roles and sustainability.

6. GARNERING EXPERT OPINION ON THE FUTURE OF AUSTRALIA'S COUNTRY TOWNS: A DELPHI ANALYSIS

6.1 Introduction

An important component of this research was garnering expert opinion on the future of Australia's country towns to 2050. This component of the research was undertaken via a Delphi Analysis with key stakeholders working in and for Australia's inland settlements, including representatives of government, officers of regional development agencies and other key local agencies, as well as academics with specific expertise in and concern for regional, rural and remote communities.

Twenty-four respondents participated in this element of the broader project. The majority of these participants were from regional development agencies (11); nine were from academia, two were representatives of state or local government and two people did not give their affiliation. Most respondents in the Delphi analysis were from WA (35 per cent), followed by Victoria (22 per cent), SA and NSW (17 per cent each) and Qld (nine per cent). No one from the ACT, NT or Tasmania participated in the Delphi, despite concerted efforts to recruit opinions from these jurisdictions. Invitation to participate in the Delphi was provided to 83 participants, with 20-30 participants considered a workable number for the exercise.

6.2 The Delphi Analysis Technique

The Delphi Analysis Technique is a research method that has been around for more than 50 years, and has most commonly been associated with futures research and forecasting the impact(s) or effect(s) of a particular change or situation.

The Business Dictionary (online) offers the following description of the technique:

[Delphi Analysis is a] "collaborative estimating or forecasting technique that combines independent analysis with maximum use of feedback, for building consensus among experts who interact anonymously. The topic under discussion is circulated (in a series of rounds) among participating experts who comment on it and modify the opinion(s) reached up to that point ... and so on until some degree of mutual agreement is reached." (see <http://www.businessdictionary.com/definition/delphi-method.html>)

The technique allows for feedback of research findings until some level of consensus around expert opinion on an issue is reached. Delphi Analysis aims to overcome some of the challenges with other group-based opinion methods, such as the dominance of one voice in a focus group. It is not a method without controversy, but is becoming more widely used and accepted in forecasting research with time.

For further information on the technique and its application is in the seminal work in this field edited by Harold Linstone and Murray Turoff (1975) entitled *The Delphi Method: Techniques and Applications* (Addison-Wesley). Additional articles of interest on the technique can be found in *Technological Forecasting and Social Change* vol. 78 (2011) and the *International Journal of Forecasting* vol 15 (1999).

The Delphi Analysis for this project was undertaken via SurveyMonkey during October and November 2012.

6.3 Findings from the Delphi Analysis

6.3.1 Settlement type impacts

Do you think climate change will have an overall negative impact, positive impact or no impact on the following types of settlements in Regional Australia to 2050? Very remote communities (more than four hours drive from the nearest large town); Remote communities (more than two hours drive from the nearest large town); Small towns (200-1,999 population); Large towns (2,000-9,999 population); Regional cities (more than 10,000 population); Metropolitan areas (more than 100,000 population).

What level of impact (negative or positive) do you think climate change will have on the following settlement types in Australia to 2050?

Responses to this question indicated a general feeling of a negative climate change impact across all settlement types, and particularly for small towns (200-1,999 people), as well as remote and very remote communities. No respondents indicated a positive impact for remote and very remote communities. Fewer respondents indicated a negative impact for the larger settlement types and a small number of respondents felt that the larger settlement types could see a positive impact from climate change.

Responses to this question showed an evident level of uncertainty about the impacts of climate change on Australia's inland settlements, for all settlement types with the exception of Metropolitan areas.

The most frequent level of impact indicated for all settlement types was a moderate impact, with massive impact expressed by many respondents for the smaller settlement types and particularly for remote settlements. Two thirds of respondents indicated moderate impacts for regional cities.

Between one quarter and one third of respondents were undecided on level of impact across settlement types, and especially for remote settlements.

6.3.2 Region based impacts

Which regions in Australia do you think will be most affected by climate change to 2050? Remote Australia; Northern Australia (Tropical); South Eastern Australia; South Western Australia; Alpine Australia; Coastal Australia.

Which region in Australia do you think will be the MOST affected by climate change to 2050? (ONE answer only)

What impact do you think climate change will have on the following regions in Australia? (Please indicate for each region type)

Consideration of the regional impacts of climate change was clearly a challenging area of inquiry. It was clear from the responses to this line of questioning that no one region stood out among the selections as expected to be the most impacted. Many commentators noted that this is because of the many and varied impacts of climate variability and their uneven impact across the country.

When asked to indicate the ONE region type most likely to be impacted by climate change there was a slight preference overall for greater impact for Coastal Australia, followed by South Eastern Australia. In saying this, however, it is important to note that responses to this question were fairly evenly spread among all region types.

The questioning about the level of impact for regions generally reinforced these findings, with a slight preference expressed for greater level of impacts on South Western Australia and Coastal Australia, with over 80% and 90% of respondents respectively indicating a massive or moderate impact for these regions of the country. South Eastern Australia and Alpine Australia, were also considered to be regions where massive and moderate impacts were expected, with 72.7% and 77.3% of

respondents indicating such levels of impact. Remote Australia and Northern Australia were the regions selected for the less marked impacts of climate change (negligible impact and fewer indications of massive impact).

6.3.3 Industry sector based impacts

Which industry sectors in regional Australia do you think will be MOST affected by climate change to 2050? (Please indicate, multiple answers accepted)

In what ways will these industry sectors in regional Australia be affected by climate change to 2050?

The Agriculture and Wine sectors were singled out as the industry sectors respondents felt would be most impacted by climate change, with the Manufacturing, Services and Mining sectors considered to be those sectors least affected.

Agriculture was singled out as the industry sector to be/being MOST affected by climate change, with over three quarters of respondents indicating this.

In terms of actual impacts on each of the specified sectors, respondent comments emphasised:

- changed and new geographies of production due to changed extreme weather events, reduced and increased rainfall events (depending on region discussed), as well as changes in soil conditions and increased or new types of pests and diseases;
- clear threats and opportunities for industry sectors, for example, potential for new technologies to overcome and lessen impacts of extreme weather events on transportation and infrastructure systems; development of new broadacre crops to meet seasonal variation in rainfall etc; loss of natural amenity leading to changes in tourist flows in particular areas, or shorter peak tourist season, i.e. in the Alpine Regions due to reduced snow cover and coastal areas;
- uncertainty about adaptation and mitigation actions and approaches and meeting the costs of such actions, balanced with potential for technological and other innovations to meet these needs.

Views from stage one of the Delphi Analysis for each industry sector is provided below:

Agriculture

Key themes: reliability and variability in rainfall impacting soils and production; spatial and temporal differences in climate.

- ‘with less rain and more severe weather events crop yields and quality will decline, stock will be impacted as a result of less feed and pest/weed risks could intensify’.
- ‘consequent greater difficulty in planning’.
- ‘highly variable outcomes depending on location / commodity / incidence of extreme weather conditions / length of growing season / reliance on irrigation / incidence of flood and fire / impact of climate change on other exporting nations of agricultural commodities – could go either way’.

Wine

Key themes: water availability; diseases and pests.

Commentary around the wine industry elicited similar responses to for Agriculture generally, with a much stronger emphasis on the impact of diseases and pests.

- ‘new wine grape varieties needed to deal with changed temperatures, less water’.

- 'climate will eventually be either too warm to grow grapes or will require larger amounts of water'
- 'some regions will face harvest seasons where diseases and pests will be difficult to control; other seasons in which quality is affected by heat and moisture stress'.

Tourism

Impacts identified for this sector strongly emphasised impacts on particular tourist experiences (coastal, alpine).

- 'probable negative environmental impacts on desirability of certain locations'.
- 'less amenity water'.
- 'coastal asset such as reefs could be damaged and impact international tourism'.
- 'more seasonal tourism'.
- 'clearly alpine areas affected by reduced ski season; I wonder about the timing of peak seasons in other areas too'.

Mining

Key themes: harsher climate conditions for mining operations; physical, cost and productivity impacts of extreme weather events on production in certain locations.

- 'cost of energy and transport could be significant'.
- 'some sites likely to be hit by more frequent extreme weather events (e.g. the Pilbara)'.
- 'coal mines likely to be affected as measures are taken to reduce carbon emissions'.
- 'closures in production and rail infrastructure and shipping affected by increase in extreme weather events – particularly flooding in QLD and cyclones in WA'.

Manufacturing

Key themes: cost of inputs for sector.

- 'cost of energy, increased regulation, transport costs, may be opportunities in becoming green and marketing this to the world'.
- 'increased costs of production; viability dependent on ability to diversify into, inter alia, alternative energy technology'.

There was widespread concern mentioned over localised energy generation capacity:

'lack of localised energy generation capacity from traditional sources, loss of energy generation capacity due to increased natural disasters'.

Infrastructure

Key themes: extreme weather events placing pressure on key infrastructures; increased cost associated with building and maintenance of key infrastructure.

- 'need for updated infrastructure across a range of fields: irrigation/reticulation; urban transport; interstate rail (freight and passenger)'.
- 'increased costs associated with building and maintaining critical infrastructure, increased loss of critical infrastructure'.

- 'highly variable outcomes depending on location / structure of economic base / incidence of extreme weather conditions / incidence of flood and fire / technological progress in alternative energy + machinery and equipment'.

A small number of respondents also mentioned opportunities, particularly around more efficient design of infrastructure.

Transport

Key themes: carbon and fossil fuel dependency.

Concerns regarding the transport sector mirrored those for infrastructure generally, with the addition of concerns about fossil fuel dependency:

- 'increased costs, especially for fossil fuel dependent modes. Need for shift to non greenhouse fuels. Greater use of rail and intermodal, short-haul modes'.

One respondent commented: 'Reliance on private vehicles and road freight is a significant competitive weakness of the economy'.

Services

Key themes: demand for services.

Responses related to the services sector were limited and the small number of comments were demand-focussed. 'Medical and social provision likely to be strained by greater severity of conditions'.

Other commentators noted:

'could be opportunities for new services'.

'potential for new jobs and economy responding to climate change'.

Other

Defence was mentioned by one respondent as an industry sector where impacts may need to be considered. 'Defence will become more strategic to protect our agriculture and food production'.

6.3.4 Broad social/economic/built environment sector impact

In your opinion will climate change have a bigger impact on ... (Please indicate ONE answer only)

Why do you think this?

The overwhelming majority of respondents indicated that the biggest sector impact associated with climate change would be on the economy, rather than on society/communities and the built environment. The majority of respondents noted this impact in relation to primary industries and production impacts due to more variable rainfall and extreme weather events. The logical concern here relates to the flow-on effects for productivity, wealth and jobs, 'loss of production creates loss of wealth and then trickles down through the communities'. One respondent from WA added further context here:

- In the Wheatbelt of WA agriculture is the predominant economic base for the region and the main employer of people. We are already witnessing significant hardship as a result of the progressively warmer and dryer climatic conditions that have been experienced over the past 10 years. According to a report from the Department of Agriculture and Food WA (2011), since season 2008 WA broadacre farm businesses, as a whole, have experienced poor years with sizeable negative farm business profit being recorded in 2009-10 and 2010-11. Cash incomes have been substantially reduced, indebtedness has increased, equities have eroded and low or negative rates of return to capital have been

generated. This has significantly impacted on the farming community and local businesses that service the agricultural industry

In indicating the biggest impact on the economy over society/communities and the built environment most respondents noted the direct and indirect impacts on regional communities and the built environment from overriding economic impacts and restructuring occurring, and that many commented will need to continue to occur in the short and longer term.

Two commentators summed up this general commentary:

- 'I think all three are likely to be affected, and that in reality these are difficult to separate. My sense is that there are major changes occurring in agriculture, and that we are likely to see major redistribution in production. Ultimately, this will require substantial reinvestment and economic adaption. In terms of society/communities, in many areas these have a long history of adapting to economic shocks, restructuring and climate variability. Thus, many of the changes may well be viewed as 'more of the same' but with a different cause'.
- 'It seems that the likely spatial variability of climate change is going to impact on many different parts of the settlement system, in terms of influencing land use change, the nature of local economic bases and the towns and cities where people live. Of course, the three categories above are highly and complexly interrelated so it's difficult to single one out'.

Concern was clearly expressed for already struggling communities, regions and industries:

- [climate change is] 'Likely to have greatest impacts in already marginal areas, thereby placing great strains on existing economy ... with knock-on effects on local society'.
- 'disadvantaged communities and people will become more disadvantaged by climate change'.

Society/Communities

It is noteworthy that for the small number of people who indicated the greatest climate change impact will be on society/ communities, physical and mental health impacts were emphasised.

6.3.5 Key determinants of adaptability

What do you see as the key determinants of the ability to adapt for Australia's country towns in the face of climate change?

What respondents see as the key determinants of adaptability for country towns in the face of climate change elicited a strong consensus view around four key points:

- solid information on the science of climate change and the implications of this for individuals, communities, settlements and regions;
- leadership and community engagement on climate change action;
- community resilience, flexibility, adaptability and innovation – particularly around climate change related economic restructuring and diversification;
- strong regional policy outlining threats and opportunities, as well as agreed courses of action to address impacts, including through infrastructure, population growth and settlement sustainability.

Commentary in this regard included:

- ‘communication and public education strategies that inform and advise, more media coverage on national; Political consensus around climate change; Coordinated approach to climate change at all three levels of government inclusive of nationally accepted programs that are fully funded and go beyond election cycles; National approach to disaster planning, management and recovery; A greater understanding of the rural and regional communities by urban communities with an increase in shared responsibility’.
- ‘preparedness, acceptance, flexibility and innovation will be the key determinant of the ability to adapt to climate change.
 - Acceptance: People first need to accept that climate change is a real and significant threat.
 - Preparedness: Acting now rather than waiting for conditions to worsen
 - Flexibility: Willingness to change traditional practices to ensure sustainability in a changed environment.
 - Innovation: Adoption of new technology and practices, particularly in the agricultural sector’.
- ‘only one seem crucial – local adaptive capacity based on leadership / entrepreneurship / knowledge / local invention and innovation / ability to adapt other people’s ideas to local circumstance / ability to re-evaluate resources / community and business networking / and a raft of psychologies and attitudes connected with the ability to see yesterday as ancient history and tomorrow as a pool of opportunity. Much of this appears to lie with local communities themselves rather than superior tiers of government’.
- ‘greater political consensus and clear communications are the most important first step towards climate change adaptation and mitigation success’.

6.3.6 Wealth

Do you think Australia’s country towns will be richer or poorer by 2050? (Please indicate ONE answer only)

In your opinion what role will climate change and adaptation play in this outcome?

The line of questioning around the wealth of Australia’s country towns into the future showed mixed views. Just under 50% of respondents (47.7%) indicated towns will be poorer in 2050, while 21.1% indicated richer, 10.5% the same and 21.1% unsure.

As raised in other questioning for this study, the issue of the unevenness of impacts was a common theme here. Many respondents linked this to the adaptive capacity and responsiveness of communities and key local leaders, as well as innovation in technologies to overcome production issues, consumption trends and broad environmental concerns. Importantly, allied with this, respondents noted that the sustainability of country towns and regions more broadly is not simply about adapting to climate change related impacts but a broad range of factors – environment-influenced and otherwise. These include market demands, including export market demands, the impact of commodities markets and mining activity, energy, water and food security, employment and services provision, and lifestyle factors.

- ‘depends upon how proactive people are. Innovative communities will be winners, also depends how exposed they are to climate affected agriculture or unlimited water and power ...’
- ‘I say poorer as I envisage some selective decline in mid-small sized communities with fewer economic opportunities. On adaptation ... Not sure. It

may be that we can shift agricultural production to different crops, those that are less sensitive to the higher temperatures and rainfall amount and variability’.

- ‘If you’d asked me in the late 1960s or early 1970s what things might look like in 2012 based on the information I had then, I would probably have been miles off the mark. A pessimistic response would be to say they will be poorer, however I suspect the net change may not be that much over all, but that the geography will be vastly different (surprising call from a geographer?). I’d suggest that some areas may improve their situation, either through good planning or good luck, and others will go backwards. I think climate change is just going to be part of a very complex picture, and trying to isolate it from everything else is very difficult’.
- ‘It’s a little difficult to say. In some years, natural hazards associated with long-term climate change (e.g. droughts, floods) will deleteriously affect rural economies while in other years it will deliver excellent conditions. Those business operators and, collectively, those rural communities that best appreciate the potential impacts of climate change on their particular region will obviously be better prepared to ride out the good and bad weather/seasonal outcomes and be better situated to maximise the gains and minimise the losses associated with each scenario’.

6.3.7 Number of country towns

In your opinion will there be more or fewer country towns in Australia by 2050? (Please choose only one answer)

In your opinion what role will climate change and adaptation play in this outcome?

In terms of the impact of climate change on the number of country towns in Australia to 2050, respondents generally felt there would be a negative impact, with some 73.7% of respondents indicating fewer country towns to 2050. Importantly, climate change was noted as only one factor amongst many in determining this predicted outcome. One respondent succinctly summarised this position:

- ‘Climate change will contribute perhaps a small amount, but largely these processes are much more structural and determined by underlying trends in industry and population’.

Towns where water availability is expected to continue to be a challenge and towns dependent on traditional broadacre farming were singled out here as those likely to suffer most, whether in terms of completely disappearing off the map or declining to the point of threatening their longer-term sustainability.

- ‘The lack of or reduction in water will be the single most important factor that many regional towns will face over the coming decades that will determine whether they survive or die’.

Smaller towns were considered much more likely to suffer, with population, growth and wealth gains for regional centres, coastal towns and metropolitan areas. This said, a number of commentators noted that process of country town growth and decline has been ongoing for decades, linked to the economic opportunities and prospects of towns and their ability to adapt to the social, political, economic and environmental challenges they face.

- ‘Currently, the trend is towards smaller numbers of towns in the drier inland zones but ongoing growth in the number of urban centres in the more accessible peri-metropolitan and coastal zones, together with the peri-urban areas around robust regional centres. Climate change is likely to exacerbate population and economic decline in the inland. If there is rapid sea level rise, and associated coastal hazards (e.g. storm surges) there may well be some

abandonment of some towns in the littoral zone. In aggregate, though, we may just see no net loss of town numbers but an ongoing spatial shift in their distribution by 2050’.

Another commentator added:

- ‘There is too much complexity to be definitive. New towns will no doubt emerge in some areas associated with mining, tourism and other new industries. I am sure others will decline and gradually disappear. My sense is that there is a great deal of inertia in the settlement system though. Climate change will play a role, but it will be difficult to disentangle it from industrial change, social preferences etc. etc’.

In noting the likely negative impact of climate change (and other factors) on the number of country towns in Australia to 2050, respondents emphasised the importance of adaptive capacity and government- and community-driven actions to address climate change and other economic and social drivers of regional development and growth. As one respondent noted:

- ‘All three levels of government in Australia will need to support policies that enable economic growth across regions’.

Those participants who did not indicate fewer towns generally noted that some towns would inevitably decline in size, particularly smaller inland towns and again those settlements heavily reliant on agriculture. One commentator noted that this was because ‘Many communities have passed their use-by date’.

Finally on this issue, one respondent noted the potential for new towns too, linked strongly to the mining sector. How such settlements fit within the settlement system overall however will depend on This same respondents also qualified their thoughts here adding ‘If the mining industry declines either through the effects of climate change or a reduction in natural resources there may be fewer towns especially if the towns have not diversified’.

6.4 Conclusion: the future of Australia’s country towns

Commentary on the future of Australia’s country towns provoked a range of responses: some relevant to a particular location or industry and others more broadly applicable; some negative and some positive.

In general, respondents commented that Australia’s country towns are not a homogenous group and therefore predicting the impacts of climate change and other factors on the settlement system over time is difficult. As one respondent noted, this is ‘because the impact of climate change will range from the adverse to the beneficial and differ widely from one place to another’.

Many respondents saw climate change as just another factor influencing the prosperity and growth (or otherwise) of towns, with many noting that ‘For the larger places the outlook is bright; for the smaller places much less so’. Population decline was predicted for smaller and more remote settlements, and for a range of structural, social and economic reasons – including the impact of economic restructuring due to the direct and indirect impacts of climate change among other processes. Adaptation, leadership and innovation were seen as key to sustainability for settlements.

Two comments from respondents summarise the views of many here:

- ‘It is very difficult to generalise about the future of Australia’s country towns as though they are an homogenous entity. I feel very confident that the major inland regional centres (i.e. neither the remote nor the coastal ones) will further cement their administrative, economic and socio-cultural positions within their

respective urban hierarchies, and will draw increasing numbers out of the capitals. Spread effects will nourish smaller centres within commuting range of these regional cities and maintain population densities within the region, further bolstering the demographic and economic health of the broader region. It is hard to feel very optimistic about the fortunes of the towns in the remoter, drier inland areas. The ongoing farming cost/price squeeze and associated drive for ever-greater scale economies across a range of industries (i.e. not just farming) will continue to undermine local and regional labour markets and population bases. Long-term drying/warming will affect the viability of agriculture here also, exacerbating the trends just discussed. In the coastal zone, there are also concerns. In the short- to medium-term, housing and land affordability issues and political pressures to cap development are, for the time being, holding back economic development (for better or for worse) and further demographic expansion. Some communities are currently experiencing natural decrease in this context, with ongoing retiree in-migration keeping numbers up. Structural ageing (i.e. together with the net migration loss of young people) is further harming the long-term prospects of such communities. Even some of the now quite substantial regional centres in this zone may experience some decline once the baby boomers have passed through ... unless they can attract a greater share of international migration flows (which they just might). Increased susceptibility to storm conditions via climate change may well see some of these places abandoned but it would have to take a series of fairly catastrophic events for that to happen – which of course just might occur’.

- ‘I think the impact of climate change (and how places adapt) is incredibly dependent on local context – the physical setting, the economic base, the social structure will also play a role here. I am just not sure how easy it is to isolate the impacts of climate change from other things, such as trade policy, exchange rates, commodity prices, the business cycle, social preferences/norms etc. I think climate change is just one additional element of complexity here. None of this is to say that understanding its impacts and how places adapt is unimportant – quite the opposite. However, I wonder if we really need to see all of this wrapped together as more of a package that needs to be tackled in an integrated way’.

And for many respondents this ‘package’ requires strong individual, community and government support. It needs to be underpinned by comprehensive regional policy, supported by evidence-based scientific understanding and knowledge of climate change and its impacts on regional Australia, as well as being interwoven with understanding of the structural and other pressures on regional communities and Australia’s settlement system. Local leadership is clearly the key to unlocking our understanding of the sustainability of Australia’s country towns in a climate change impacted world, and in understanding their place in the fabric of the nation.

7. CONCLUSIONS AND POLICY IMPLICATIONS

This report has considered the potential impact of climate change on Australia's country towns and the challenges to their adaptation for this new future. It has reviewed the nature of climate change and its anticipated manifestation in Australia; adaptation, maladaptation and mitigation. It has also considered the potential impact of sudden extreme shifts in climate patterns and the likely influence of extreme events on the nature and distribution of human settlement in Australia to the year 2050. Critically, the research has focussed on the issue of vulnerability and how vulnerability intersects with adaptation to shape the future.

One of the distinctive features of this piece of work is its focus on Australia's country towns as part of the national settlement system. While there has been a great deal of research completed on the likely impact of climate change on Australia and its economy, there has been no work to date on the risks confronting Australia's country towns as a group. Research has been completed on individual towns, and places in particular regions, but until this point in time we have not considered how country towns in total will be affected by climate change. This is an important step in the evolution of planning for climate change in Australia.

7.1 Australia's country towns and climate change

The review of the literature undertaken as part of this project has shown that Australia's country towns will be subject to a range of new pressures as a consequence of climate change. Some of the critical transitions include:

- there will be increased pressure on health services, as some diseases and some risk factors spread to a larger proportion of the Australian land mass. Services that may already be stretched in country towns will then face greater difficulties in meeting need;
- infrastructure in some country towns will be found to be inadequate because of extreme events, or long-run pressures such as increased demand or more rapid deterioration. Examples of likely infrastructure deficits include:
 - road and bridge infrastructure in the face of greater levels of flooding;
 - electricity supply as a consequence of more frequent and extreme heat waves; and
 - emergency services (including/predominately volunteer-run services) required to respond to a growing number and range of events.
- reduced rainfall and reduced river flows affecting communities dependent upon irrigation;
- potential impacts on mental health as communities are confronted by both more challenging climatic conditions and an increased incidence of emergencies; and,
- labour market change as economic activity is affected by climate change.

The established literature in this field has highlighted a number of key lessons for policy makers looking to plan for the future of country towns. First and foremost, the literature recognises that the **community itself is the greatest asset and source of potential success in climate change adaptation.**

7.2 Economic activity in country towns

In writing this report we have considered the nature of economic activity in country towns and how it may change in the decades leading to 2050. Much of that analysis considered the potential impact of climate change on agricultural industries in Australia, because (a) agricultural production is clearly linked to climatic conditions and (b) agriculture has been the centrepiece of the economies of many country towns for 200 years or more.

The literature highlighted a number of key issues:

- Australia is a large nation with a number of major climatic zones, the impact of climate change will vary significantly by region which in turn will result in divergent outcomes with respect to climate change;
- the dairying industry is vulnerable to production loss associated with higher temperatures;
- some parts of horticulture production require a minimum number of cold nights (apples, cherries for example) and these conditions may be at risk in a climate change affected world;
- higher temperatures and potentially increased frosts in spring are a threat to cereals production;
- reduced rainfall in the southern part of Australia represents a challenge to one of the major cropping zones in Australia;
- some of Australia's major trade competitors for agricultural commodities will benefit from a warmer global economy, which will strengthen their position in world markets;
- water for irrigation will be reduced, which in turn will challenge the profitability for the sector as a whole;
- at least some parts of the wine industry will remain viable for wine grape production;
- some agricultural production will benefit from modest increases in temperature;
- more frequent extreme events will add a new dimension of risk to farming and farming enterprises;
- adaptation strategies including the use of new technologies and the application of existing management techniques may well mitigate the worst impacts of climate change and could even boost productivity.

Critically then, the impacts of climate change on Australian agriculture is a complex issue and the benefits of planning comprehensively for adaptation appear unambiguous. It is also clear that some country towns across Australia will lose their agricultural base and will either replace that economic activity or decline.

There are a number of other industries that are significant for country towns and these include mining industries, utilities, tourism and retail services. Of these, mining and tourism represent the most important 'export' industries – in a regional sense – and hold the greatest potential for boosting the growth of individual towns. On the other hand, support industries such as retail, medical and financial services are also vital to the wellbeing of country towns and it is important that they be considered in planning for a climate adapted settlement pattern. Strategies that maximise their welfare will have flow on benefits to the community as a whole.

7.3 The vulnerability of country towns to 2050

As part of this research we constructed an Index of Vulnerability for Australia's country towns that incorporated elements of exposure, sensitivity and adaptation. This model was applied to data for every urban centre and locality (UCL) across Australia that was more than 50km from the coast. These data were then mapped for all of Australia and at the State and Territory level.

Indicator based assessments are a widely used tool in climate change analyses, although they have been critiqued for their apparent blindness to complex relationships, their inability to capture the circumstances of individual cases or observations and their failure to shed light on the underlying processes that generate change or risk (Armitage and Plummer 2010 Erikson and Kelly 2007; Smit and Wandel 2006). They can, however, perform an invaluable role as part of a larger program of research.

This component of the research found that:

- remote inland settlements are most at risk in a climate-change affected Australia;
- many of the settlements found to be at risk according to the vulnerability index are towns that are already adversely affected by economic change, demographic shifts and the restructuring of services. Climate change will act as another impost on these communities and economies;
- many of the most at-risk communities are Indigenous communities in remote locations;
- many parts of the established cropping lands in the south east of Australia appear to face a relatively muted risk, while settlements in Western Australia's agricultural lands appear to face a greater threat than those in Tasmania or Victoria;
- the level of vulnerability appears high throughout NSW also, and this may partly be a function of the distance of many of these centres from Sydney or one of the other capitals; and,
- the least vulnerable inland centres tend to be located close to the capitals (for example, Crafers-Bridgewater and Summertown in South Australia) or larger settlements with diverse economies, such as Bendigo.

Critically, our research has demonstrated that the construction of such an index is possible and that the outcomes contain, at least a measure of, face validity. Importantly, the index can be used to inform both government decision making and the actions of communities planning for climate change.

7.4 Insights from the case studies

The five case studies undertaken as part of this project produced a range of insights, some of which were anticipated and some of which were not.

At a broad level, the case studies force us to reconsider the nature of adaptation and our understanding of the concept of vulnerability. The Alice Springs case study made it clear that, firstly there is the inevitable uncertainty about the impact of climate change – will it become wetter or drier – and, secondly, that the nature of human occupation in the region works to pre-adapt Central Australia. The non-Indigenous population is likely to respond through an increased 'cycling' into and out of Central Australia, while the Indigenous population will move within the region in response to both adverse events –

floods, fires *et cetera* – and new opportunities. As the case study makes clear, Indigenous Australians have occupied Central Australia under much more hostile climatic conditions than those forecast to 2050 and potentially their capacity to adapt is considerable. We need to recognise that the Vulnerability Index used in this report presupposes an economic and social system based on contemporary values and patterns of living. For Indigenous Australians who largely live outside such social and economic structures such indices have little, if any, value.

The case studies also highlighted the fact that adaptation for Australia's country towns is challenged by current governance structures. A number of the settlements examined – Waikerie, Moura, Horsham and Junee – have been challenged by climate associated events that are likely to become more common in a climate change affected future. This includes floods, but also droughts and bushfires. Many of the towns do not appear to be addressing adaptation in a systematic fashion. While some changes have been introduced that make an incremental contribution to climate change readiness, there is little sense of coherence. This challenge can be greater in towns which are just one of a number of settlements within the territory of a local government. In short, there is a mismatch between the need for actions at the scale of the town, and the scale of locally vested government, which tends to cover a much larger area. **Many Australian country towns lack effective progress associations or other group that have sufficient capacity to take up the challenge of reshaping their locality for the future.** While the community is potentially the greatest resource in preparing for a climate change affected future, too few country towns have the social infrastructure in place to mobilise that capacity. This challenge is exacerbated by scepticism toward climate change in many rural communities, and a consequent reluctance to both discuss and act upon it at the community level.

While in an ideal world community level action is needed in responding to climate change, local governments have an important role to play, in part because effective responses must also include a regional component. The case studies have highlighted three important points:

- first, smaller councils struggle to find the resources needed to plan for, and implement actions towards, climate change;
- second, national and state government legislative frameworks and funding programs have a considerable impact on the actions of local governments. Adjusting those frameworks and programs will be effective in mobilising local governments; and,
- third, local governments are able and willing to take a long term view of their future, but often must place greater priority on immediate needs. Linking climate change adaptation to future economic performance, and the survival of individual country towns, will attract the attention of decision makers in local government.

In many of the case studies the agriculture sector has already adjusted to a highly variable set of climatic conditions. Many felt that this flexibility and commitment to innovation would maintain the sector's productivity and profitability into the future. However, while individual farmers may survive, there can be no denying that there has been a contraction in agricultural employment in dryland farming regions. Economic diversification strategies are therefore needed to identify new economic opportunities, and this may be as simple as the development of strategies to sustain service industries.

7.5 What the experts said: outcomes of the Delphi Analysis

The Delphi analysis resulted in a vision of the future of Australia's country towns that conformed with current academic and policy maker understandings of change in Australia's settlement system. Some of the key messages to emerge from this analysis included:

- A strongly held view that impacts of climate change on Australia's settlement system will be uneven;
- That climate change may result in a reduction in the number of country towns in Australia, but in large measure this would simply be the speeding up of a process already in train;
- That innovation, leadership and adaptation would be pivotal to the sustainability of individual towns and groups of settlements; and,
- That there was a need to provide better information on the impacts of climate change – and not least to the residents of affected regions. Many interviewees in the case studies expressed a similar desire for better information.

Many of the insights to come from the Delphi analysis do not emerge as a surprise as they reflect themes already embedded in the published literature or encountered in fieldwork. What is important, however, is the sense that the success of country towns in the future will be highly dependent on their willingness to change and to plan for their future. As noted above, this calls for leadership at the local level and a willingness to 'think outside the square'. Path dependency is a very real risk in an environment of change, and the capacity to seek out new opportunities and respond to them will be critical.

7.6 Policy implications

As a number of authors have noted, climate change and climate change adaptation is a classic multidimensional problem. There is no single answer and no simple solution. If nothing else, the problem is made more complex by its geographic scale as the challenges vary from one location to the next and the solutions differ on a place by place basis. Climate change adaptation for Australia's country towns will take place in an environment where many country towns are already challenged by declining terms of trade for commodity production, the apparently inexorable growth in average farm size, increased mechanisation, the use of external inputs in farm production and long term demographic decline.

The Index of Vulnerability serves as a useful heuristic device: at one level it can be used as a prompt for action in the most at-risk locations, alternatively it could be used to differentiate government and community responses. There was a great deal of feedback in response to the release of the preliminary report from this project (Beer *et al* 2012). While some respondents rejected climate change, there was also a consistent and oft repeated message that our analysis overlooked the particular circumstances of that town, city or region and in particular under-estimated the sense of community mindedness or social capital to be found in those places. Their view was that while they acknowledged there are hardships to be overcome in the future, the community has proven resilient in the past, finding innovative solutions to challenges as they arise. Such perspectives need to be acknowledged as both powerful and reflective of a fundamental truth. However, we would argue that a reliance on social capital and the ability to adapt-on-the-run may not be sufficient in the long term. Economic change and shifting demographic processes have already resulted in the demise of a number of country towns across Australia, which indicates that **there are**

hard limits to what social capital can achieve. A more thoughtful, planned response is therefore needed.

As the earlier sections of this report have shown, there is already a substantial body of work on climate change adaptation that could be applied to country towns across Australia. A number of key policy documents have already been prepared by the Australian Government on how communities can adapt to climate change. In addition, the work of the European Commission and other international bodies is potentially highly relevant also. Unfortunately, **there appears to be relatively little awareness of climate change strategies and documents across regional Australia**, and while some state government produced frameworks have a high profile, they do not always address adaptability at the scale of towns or communities. The promotion of existing strategies and information sources is one of the key actions available to the Australian Government. This could take place through the further development of websites, the dissemination of pamphlets, speaking tours, and participation in relevant conferences – such as those of local government associations across Australia. It was notable that few interviewees in our case studies were aware of the available information resources, and there is a clear need to overcome this deficiency. A second and related action would be to expand and extend programs such as the Local Adaptations Pathways Program which sought to develop models of adaptation in communities across Australia. While this approach represents an important first step, communities and settlements need resources to make plans and take actions that reflect their own circumstances. Federal Government assistance in such actions is both necessary, because of limited local resources, and appropriate given the impact of national and global influences on climate change.

One of the key policy implications of this research is an acknowledgement that there is a local, regional and national scale to the question of climate change and Australia's country towns. This issue was identified and discussed in the policy workshops, with participants noting that policy needs to step in where science is unable to provide certainty, in order to better enable communities to respond. The question of scale is critical as it recognises that all three tiers of government have an important role to play in the process of climate change adaptation of Australia's country towns. Importantly, regional scale actions can be achieved in diverse ways, with local communities combining to act as a region, and/or central governments targeted their actions at the regional scale. Climate change adaptation for Australia's country towns will not be optimised unless it takes place within the context of a national policy framework that only the Australian government can provide. At the same time, many of the most effective actions will come about as one country town learns from the experiences of their neighbours. Such regional collaboration is critical for success in building a new future.

At the national level, policies will be better informed and better directed if governments are aware of 'climate change hotspots' for country towns. This does not necessarily imply an identification of those places where climate change will be greatest, but instead it reflects those places most likely to be affected. The Vulnerability Index discussed in this report is a first step to the identification of such hotspots, but needs to be complemented with on-the-ground research in a number of locations where climate change adaptation planning is trialled, and the results assessed. The identification of hot spots will allow for the development of a more nuanced approach to the challenge of climate change adaptation for Australia's country towns.

The research also brings into question the values and preferences of the residents of country towns. In the first instance, more information is needed to understand what the residents of country towns aspire to and how they see those values as being influenced by climate change. Secondly, there is a need to better understand how preferences and behaviour can be shaped in order to better prepare for the climate of the future.

Policy also needs to recognise that the adaptation strategy for Indigenous communities are likely to be different to those for non-Indigenous communities. Work therefore needs to be undertaken to develop culturally-appropriate strategies for this type of settlement. In part NCCARF has already completed this task through its work on adaptation and Indigenous Australians. However, it needs to be refined further to consider the specific issues facing settlements, including questions of the adequacy of water supply, the impact of extreme weather events, and the sustainability of employment. Our aspirations to 'Close the Gap' on Indigenous health and provide better educational and employment outcomes for young Indigenous people will not be met if large sections of that population are accommodated in settlements that have failed because of the erosion of their economic base, the inadequacies of their infrastructure and the inability to provide decent living conditions in these places.

It may be that for country towns across Australia a graduated response to climate change is needed, with some settlements unlikely to make a successful transition unless quite substantial levels of support are provided. In other instances, climate change adaptation will merely be a matter of the uptake of new technologies and methods of farming, the amendment of mine production schedules and investment in new or upgraded infrastructure. We should be mindful also that for the nation as a whole there are risks: many of those communities identified through this analysis as being most at risk – and especially the remote Indigenous communities – are already among the most disadvantaged communities in the nation.

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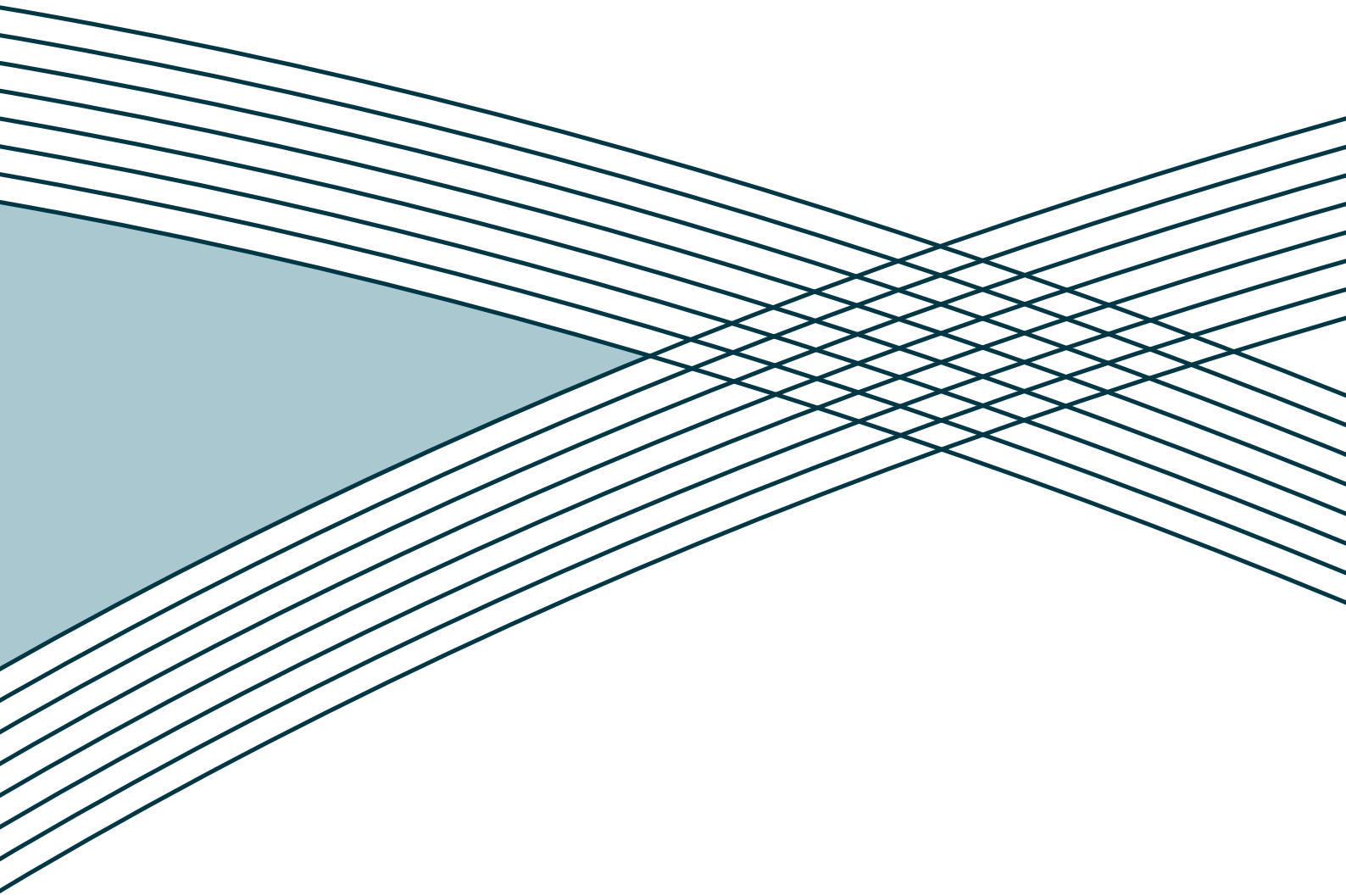
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