RANGELANDS
NRM CLUSTER

CLIMATE CHANGE IN AUSTRALIA

IMPACTS & ADAPTATION
INFORMATION
FOR AUSTRALIA'S NRM REGIONS

Australian rangelands and climate change – guidance to support adaptation

Addressing climate adaptive capacity, resilience and vulnerability of people in remote and marginalised regions

Citation

Measham TG (2014) *Australian rangelands and climate change – guidance to support adaptation: Addressing climate adaptive capacity, resilience and vulnerability of people in remote and marginalised regions*. Ninti One Limited and CSIRO, Alice Springs.

Copyright

Disclaimer

ISBN: 978-1-74158-245-1

Front cover image credit: Ninti One

An Australian Government Initiative

CSIRO

Territory Natural Resource Management

NINTI ONE RANGE LANDS CLUSTER

Government of South Australia
Alinytjara Wilurara Natural Resources Management Board

Government of South Australia
South Australian Arid Lands Natural Resources Management Board

desert channels QUEENSLAND

RANGELAND alliance

South West NRM Ltd
Achieving sustainable landscapes for rural communities

UNIVERSITY OF CANBERRA

INSTITUTE FOR APPLIED ECOLOGY

Rangelands NRM Western Australia

NSW GOVERNMENT Local Land Services Western

Contents

List of Tables

List of Figures

Acknowledgements

Thanks to all the NRM planners who took part in the workshops underpinning this report. Thanks to Yiheyis Maru for conceptual input and for making available the graphics of the linked vulnerability-resilience framework for remote systems. Thanks also to Gary Bastin for input regarding Rangelands experience with climate extremes.

This project was funded by the Australian Government and was part of a collaboration between the Rangelands NRM Alliance, CSIRO, University of Canberra and Ninti One. Thanks to the following NRM regions for their review and input: Rangelands WA, Territory NRM, Alinytjara Wilurara NRM, SA Arid Lands NRM, Desert Channels Qld, South West NRM Qld and Western Local Lands Services. Thanks also to the members of the project's Scientific Advisory Panel for their advice and guidance: Steve Morton, Craig James, Stephen van Leeuwin, Ian Watterson, Colleen O'Malley, Daryl Green and Digby Race.

Executive summary

This report brings together information and methods that will be of practical use in addressing adaptive capacity, resilience and vulnerability of people in the rangelands.

To date, most adaptation responses to climate impacts have tended to develop in urban areas where relatively dense populations are concerned about specific and localised threats, such as coastal inundation. In practical terms, a main focus of climate adaptation has been concerned with prioritising assets and estimating impacts on those assets. Priority is given to defending those assets against impacts such as related tidal surge and storm events.

Although this report draws on those approaches, they have limited value in rangelands due to the dispersed nature of climate impacts, the already highly variable climate in rangelands regions and the distinct character of rangelands populations. The people of the rangelands are not only more sparsely distributed compared to people in higher rainfall areas, they have different social networks. Moreover, they are accustomed to bouncing back from adversity, are highly resourceful and rely more on their local knowledge.

For this reason, rangelands researchers have developed a unique framework tailored to remote areas, and this framework is summarised in this report. Importantly, it brings together two different sides to adaptation, vulnerability reduction and enhancing resilience, in a single coordinated framework. Rangelands populations tend to think long term – and this is exactly the approach put forward in the remote area framework – using some types of management strategies to 'buy time' while other types of strategies are coming into effect.

This framework is illustrated with case studies drawing on past research, including research about human responses to heatwaves, to show how different strategies for reducing vulnerability and building resilience can be combined over time (Maru et al. 2014). The framework is also considered in relation to buffel grass management, drawing on one of the other cluster research projects (Davis 2014).

The report was developed in collaboration with rangelands NRM planners, biophysical scientists and social scientists to provide an appropriate level of detail in an accessible format.

Key points

- Rangelands have distinct ecologies and social systems such that conventional approaches to climate adaptation may not always work in these remote areas.
- This report draws on those approaches but presents a rangeland-specific approach to information and guidance to support climate change adaptation.
- The approach balances resilience and vulnerability reduction and draws on the existing capacity of rangelands residents.

Tom Measham
CSIRO Ecosystem Sciences

1. Introduction

Most mainstream adaptation has focused on standard vulnerability reduction in areas with relatively high populations, often in urban areas. This approach was not designed for the rangelands.

The purpose of this report is to bring together information and methods that will be of practical use in addressing adaptive capacity, resilience and vulnerability of people in remote and marginalised regions. Before focusing on the specific case of remote regions, it is important to consider the general experience of climate adaptation, which has mostly focused on reducing vulnerability to specific hazards in densely populated areas.

1.1 Background to adaptation and vulnerability

Adaptation to climate impacts has mostly evolved in urban (Bulkely 2013; Gill et al. 2007), and coastal areas (Adger 1999). The concept of vulnerability has evolved as the fundamental issue for climate change (Adger 2006), and the predominant response has been to reduce vulnerability. In practical terms, a main focus of climate adaptation has been concerned with prioritising assets and estimating impacts on those assets. Priority is given to defending those assets against impacts such as sea level rise and related tidal surge and storm events. At the local scale, this has seen a prevalence of climate adaptation expressed as infrastructure to reduce vulnerability. This can include careful positioning of wind turbines to protect urban beaches (Jacobson et al. 2014) and raising roads to reduce vulnerability (HCCREMS 2010).

Capacity building is also an important way of adapting to climate change (Adger et al. 2005), focusing on communicating climate information and building awareness of impacts.

While there has been progress towards climate adaptation (Webb et al. 2013), it is important to note that the way that most climate adaptation has been developed is not well suited to rangelands areas. Conventional approaches to adaptation will work in some contexts. For example, the construction of levee banks in Charleville has contributed to flood protection. However, studies have shown that rather than rely on engineering solutions, residents are already accustomed to dealing with flood and prefer to rely on their own methods of personal resilience, such as shifting valuable items to higher ground (Keogh et al. 2011) and drawing on their social networks for support. Building levee banks and raising roads in all areas vulnerable to inundation is simply not viable. The case of Charleville is therefore a useful analogy for much of the rangelands: conventional vulnerability reduction represents a relatively small part of climate adaptation in rangelands compared with denser, coastal settlements.

1.2 Steps in vulnerability assessment and reduction

There are a range of approaches to climate adaptation, but they tend to have significant overlap in terms of the actual steps involved. The following steps have been simplified and adapted from Li and Dovers (2011), which is one approach that has been implemented successfully in different parts of Australia, including rural areas.

1.2.1 Recognise climate change and climate variability as whole-of-system problems

To establish the context for vulnerability assessment, it is important to understand climate impacts and climate variability as ‘whole of system’ challenges and responses. On this basis, bring together existing knowledge to inform the vulnerability assessment process (Li and Dovers 2011).

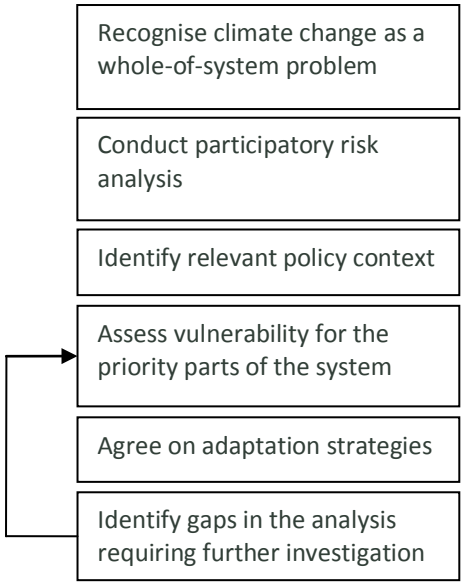

Figure 1.1 Generic integrated vulnerability assessment framework

Source: adapted from Li and Dovers (2011)

1.2.2 Conduct participatory risk analysis

The next step is to identify what is at risk and establish priorities to focus on within the overall system. Conducting this as an inclusive process involving non-government actors has multiple benefits. These include seeing risk from different perspectives and negotiating over what's at stake (Renn and Schweizer 2009).

1.2.3 Identify relevant policy context

It is important to identify current and historical policies and initiatives that may be relevant to the vulnerability assessment process.

1.2.4 Assess vulnerability for priority parts of the system

Assess the vulnerability for the priority issues drawing on available data to establish exposure, sensitivity and adaptive capacity. Indicators of *Exposure* encompass such factors as days above a certain temperature, days without rainfall and population density. Indicators of *Sensitivity* refer to how sensitive the system is to hazards; examples of these indicators are the type of dwellings people live in, and the percentage of the population with certain health characteristics. The combination of exposure and sensitivity define the potential impacts or the gross vulnerability of the system. It may be helpful to express exposure and sensitivity in spatial formats. *Adaptive capacity* refers to the ability to change and therefore reduce gross vulnerability. Indicators of adaptive capacity may include issues such as mobility, financial resources and education (Measham and Preston 2012).

Assessing vulnerability can draw on quantitative and/or qualitative descriptions of sensitivity. This phase involves exploring potential adaptation strategies and actions to reduce overall vulnerability and ways to draw on adaptive capacity (Li and Dovers 2011).

1.2.5 Agree on adaptation strategies

Following the best available information about exposure and sensitivity, and after considering options to reduce gross vulnerability, this phase is focused on defining and agreeing on adaptation strategies (see Table 1 for an example looking at buffel grass). It is recommended that this phase is conducted with stakeholders as a dialogue, to ensure that diverse views are represented and actions are realistic (Renn and Schweizer 2009). It helps to address multiple spatial and temporal scales together. Given the importance of stakeholder engagement at this phase, it is important to recognise principles of successful engagement in rangelands regions. These include working strategically to understand the rules and priorities of different parties. It involves making use of social networks and involving local champions. Finally, it means acknowledging the unique timeframes and distances of dryland regions, and setting times that are realistic within these (Measham et al. 2011).

Table 1.1 Example of buffel grass in vulnerability assessment

Exposure/ sensitivity	Possible adaptation strategies
Future southerly expansion of buffel grass into high conservation value pastures	**Establish quarantine barriers for conservation reserves before buffel grass reaches those areas** **Raise awareness of likely new distribution**
Expansion of buffel grass in areas where it is currently sparsely distributed	**Adjust burning practices to favour species diversity before buffel grass takes hold** **Increase existing control efforts e.g. spraying to slow expansion**

1.2.6 Identify gaps in the analysis requiring further investigation

The vulnerability assessment process may bring to light knowledge gaps that require further investigation. This may require researching primary or secondary data to fill these knowledge gaps.

After addressing knowledge gaps it is time to communicate the vulnerability assessment and adaptation strategies to all stakeholders with a view to implementation. Depending on how complete and detailed the vulnerability assessment outcomes are, it may be necessary to take an iterative approach and go through some of the above steps again as required (Li and Dovers 2011).

1.3 How do you actually do it?

The steps above set out the agenda for conducting a vulnerability assessment, but how does it work in practice? Many NRM planners and managers who are already familiar with resource planning will likely have many of the skills for developing climate adaptation strategies, because there is some overlap with other types of planning processes. These involve choosing an appropriate working group to manage the overall process, including representation from partner organisations (Beer et al. 2014). Another important aspect is having access to resources and information about appropriate climate impacts, through cluster partners who can help translate climate information into relevant regional impacts.

Some stakeholders may be sceptical about climate change occurring. In these situations it may help to focus on strengthening responses to existing climate variability and thinking about 'no regrets' actions, that is, those that are valuable even if the climate does not change.

A recent National Climate Change Adaptation Research Facility (NCCARF) review identified the following principles of 'good adaptation' (Webb and Beh 2013):

- Sustained and effective leadership
- Effective stakeholder engagement
- Maintaining a balance of social, economic, environmental and institutional objectives
- Learning from experience of other adaptation initiatives
- Following adaptive management approaches, including evaluation and social learning
- Explicit framing of adaptation issues agreed up front
- Addressing multiple spatial and temporal scales together
- Taking a systems approach to climate risks
- Evaluating adaptation options most relevant to support decision-making
- Articulating a clear statement of adaptation vision
- Carefully choosing appropriate methods for relevant issues.

The higher costs of conducting stakeholder engagement in remote regions compared with more densely settled areas cannot be ignored. Furthermore, seasonal variability and a changing policy environment complicate the practice of climate adaptation and vulnerability assessment for rangeland regions. For these reasons, a flexible approach is recommended, working closely with stakeholders in a way that is

compatible with their many NRM commitments (Measham et al. 2011).

1.3.1 Further information on practical implications

In addition to the material in this report, practical guidelines to support adaptation have been prepared by a range of organisations. For example, generic guidelines for local scale adaptation have been prepared by the International Council for Local Environmental Initiatives (ICLEI), which has actively supported adaptation in North America and Oceania. As with many adaptation resources, they tend to focus on urban areas, but not exclusively (Snover et al. 2007; ICELI Oceania 2008; ICLEI Canada 2010).

While it is not focused on remote areas, a practical guide aimed at rural towns prepared by NCCARF may also be useful. The guide uses a slightly different procedure to Li and Dovers (2011), presenting adaptation planning in five steps: 'Review, plan, decide, implement and promote' (Beer et al. 2014). The guide includes an appendix summarising potential impacts relevant to rural regions, including issues such as increased costs of maintaining infrastructure, migration of rural residents and health impacts from natural hazards, as well as issues that will be more familiar to NRM organisations, such as changes to species distribution and fire regimes.

2. Approach

While it is useful to understand general approaches to climate adaptation and vulnerability assessment, it is crucial to recognise that rangelands regions are different in terms of both their physical environment and their human population. It is widely recognised that people in rangelands have become accustomed to higher levels of climate variability compared to other parts of the country (Stafford Smith 2008) and are therefore innovative and prepared for climatic challenges (Stafford Smith and Cribb 2009).

2.1 Social characteristics

Rangelands residents live across 70% of the land area of Australia, yet make up less than 3% of the national population. Moreover, rangeland residents have different characteristics from those of more densely settled areas. In particular, they are more spread out, with different types of social networks. Notably, in rangelands regions social networks have an increased number of 'weak ties' – 'a friend of a friend' connection – that can span great distances. Sometimes these links are called 'wiry' ties, as they can endure long timeframes and be drawn on efficiently to access resources. These types of links are an important characteristic of the resilience of rangeland populations and are very important for managing risk across time and space (McAllister et al. 2011).

Rangeland populations are highly mobile. Arid and semi-arid regions of Australia have a high degree of intra-regional mobility, such that there is a relatively high degree of people moving around within the rangelands, particularly among Aboriginal populations (Brown et al. 2008). In addition to internal mobility, there is a high migratory population as well, of people who visit the region for a period. These include 'Fly in, fly out' (FIFO) labour forces, which visit the rangelands regularly. Although the FIFO model was originally developed for remote mining projects, FIFO labour forces are prevalent across many sectors (Carson and Carson 2014).

2.2 Stronger resilience

Given the sparsely distributed exposure to risk in rangelands, and the small, widely distributed population, approaches to vulnerability in the rangelands will need to be different from that in more densely settled areas close to particular impacts such as coastal flooding. While there will always be some role for containing impacts through physical infrastructure, the combined physical environment and social characteristics of the rangelands dictate that there will always be some areas that cannot be elevated or barricaded in some way. Therefore, rangeland-specific vulnerability frameworks need to draw more on the existing resilience of rangeland populations and find ways to maintain and extend that resilience. Furthermore, it will be necessary to be very strategic about combining resilience and vulnerability reduction to work together as best as possible. For this reason, vulnerability researchers have developed a vulnerability framework that is specifically designed for remote areas (Figure 2.1).

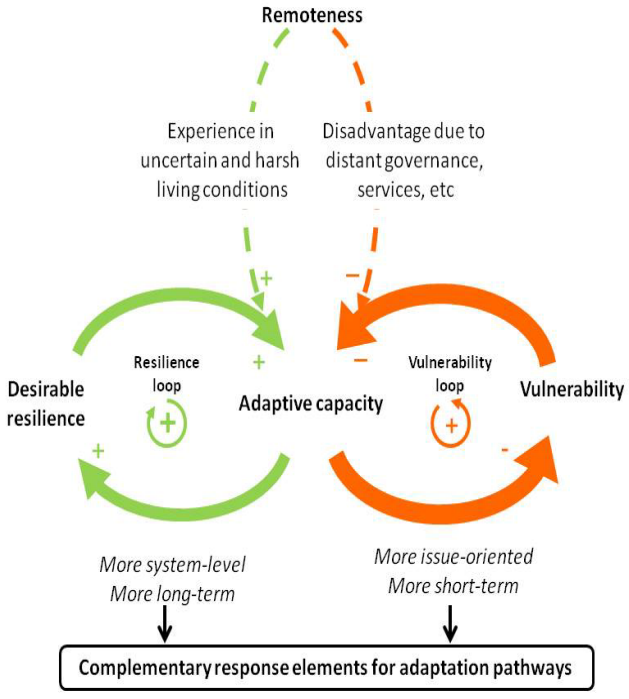

Figure 2.1 Remote regions vulnerability framework

Source: Maru et al. (2014)

3. Application of framework

To apply the remote regions vulnerability framework it is important to keep in mind the two dimensions (vulnerability reduction/resilience) and to align the different types of responses across time, so that near-term actions can 'buy time' to deal with longer-term actions. An example of the framework from Maru et al. (2014) is presented below in relation to heatwaves.

In Figure 3.1, which was tested through case study research, the frequency of heatwaves is presented as increasing from currently one or two per year though to five or six per year.

Considering that rangeland residents already have a high level of resilience and are accustomed to climate variability, doing nothing will suffice for a little while, but eventually residents will be overwhelmed as frequency increases. One option to reduce vulnerability would be to install air-conditioning, which might help for a little while longer. Improving the quality of the housing stock will help further. However, eventually the 'vulnerability reduction' side of the model will become exhausted. Considering the resilience side of the framework, investments in better health will be important, given that heatwaves express themselves through health impacts. However, improving health takes time to achieve, so relying only on resilience options will not work in the short term. Only by combining vulnerability-reduction and resilience-enhancing options can a complete response be developed.

The framework can be used in conjunction with any of the findings developed during the Rangelands NRM Cluster research process. In Figure 3.2, this framework is used to structure the lessons from the report on buffel grass, showing how different strategies from vulnerability reduction and resilience can be brought together.

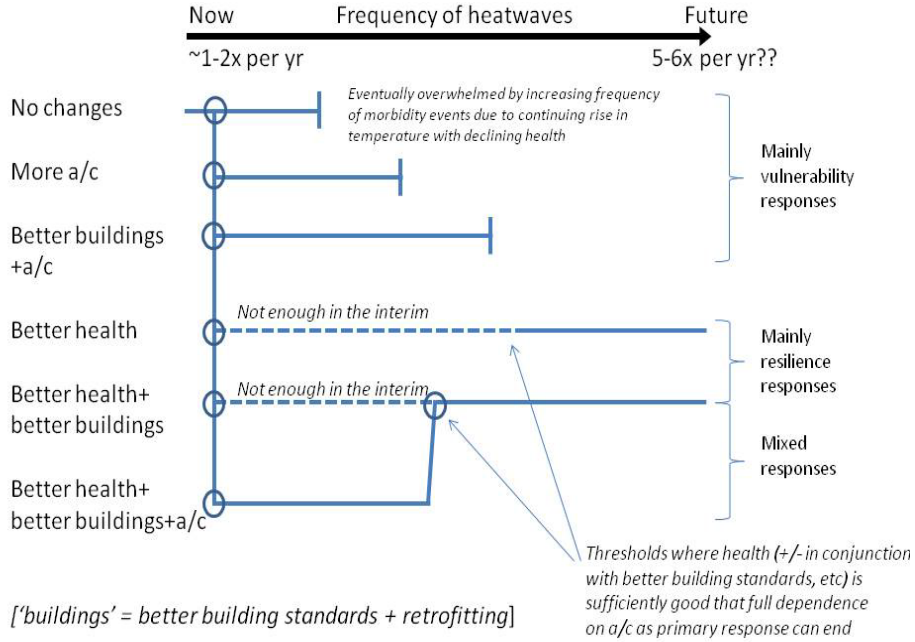

Figure 3.1 Application of the remote regions vulnerability framework to heatwaves

Source: Maru et al. (2014)

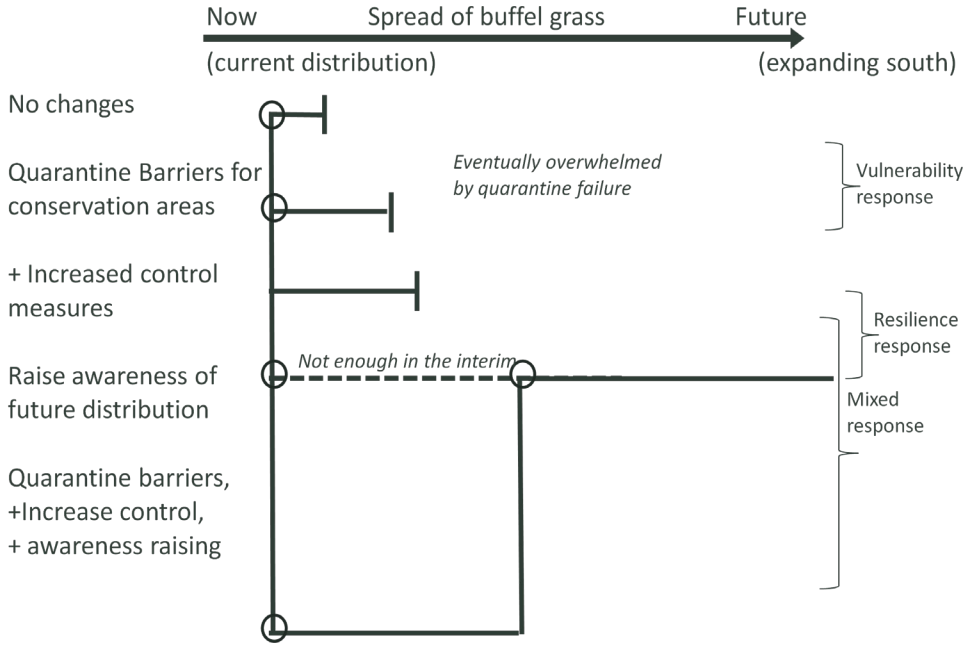

Figure 3.2 Example of using the framework to structure the recommendations of the buffel grass report prepared as part of the Rangelands NRM Cluster research process

4. Conclusions

Rangelands communities are already accustomed to dealing with climate variability and extreme events, but these are likely to increase in the future. The purpose of this document has been to provide information and guidance to support climate change adaptation with a particular focus on addressing climate adaptive capacity, resilience and vulnerability of people in remote and marginalised regions.

There are a range of well-developed vulnerability assessment and reduction frameworks, which all have some value. These frameworks draw on general principles but will not always work in rangeland regions due to the distinct biophysical and social characteristics of these areas.

For this reason, a remote area–specific framework has been developed that brings together the vulnerability reduction and resilience sides of adaptation. Moreover, it emphasises addressing adaptation by thinking of different types of actions that 'buy time' while other actions are developed and implemented.

Abbreviations

IN THIS REPORT	
TERM	**DEFINITION**
FIFO	fly in, fly out
ICLEI	International Council for Local Environmental Initiatives
NCCARF	National Climate Change Adaptation Research Facility
NRM	natural resource management

IN ALL REPORTS IN THE SERIES	
TERM	**DEFINITION**
ABS	Australian Bureau of Statistics
ACRIS	Australian Collaborative Rangelands Information System
AFCMP	Australian Feral Camel Management Project
BoM	Bureau of Meteorology
BS	bare soil
CMA	Catchment Management Authority
DKCRC	Desert Knowledge Cooperative Research Centre
DSI	Dust Storm Index
EI	Ecoclimatic Index
EMU	Ecosystem Management Understanding™
ENSO	El Niño Southern Oscillation
GAB	Great Artesian Basin
GCM	General Circulation Model
GDM	Generalised Dissimilarity Modelling
GHG	greenhouse gas
GW	Groundwater
GWW	Great Western Woodlands
IBRA	Interim Biogeographic Regionalisation for Australia
IPCC	Intergovernmental Panel on Climate Change
LEB	Lake Eyre Basin
LGM	last glacial maximum
MOF	manual observation frequency
mya	million years ago

IN ALL REPORTS IN THE SERIES	
TERM	**DEFINITION**
NAFI	North Australian Fire Information
NPV	non-photosynthetic vegetation: senescent pasture and litter
OH&S	occupational health and safety
PV	photosynthetic vegetation: green
RCP	Representative Concentration Pathways
SAAL	South Australia Arid Lands
SDM	species distribution modelling
SW	Surface water
TGP	total grazing pressure
TM	Thematic Mapper
Western CMA	Western Catchment Management Authority
Western LLS	Western Local Land Service

Glossary

IN THIS REPORT

TERM	DEFINITION
Adaptive capacity	The ability to change and therefore reduce gross vulnerability; includes issues such as mobility, financial resources and education
Gross vulnerability of a system	The combination of exposure and sensitivity of system
Indicators of exposure	Factors such as days above a certain temperature, days without rainfall, population density
Indicators of sensitivity	How sensitive a system is to hazards; indicators include the types of dwellings people live in and the percentage of the population with certain health characteristics

IN ALL REPORTS IN THE SERIES

TERM	DEFINITION
Bioregion	A large, geographically distinct area of land that has groups of ecosystems forming recognisable patterns within the landscape
C_3 and C_4 plants	The different methods plants use to convert carbon dioxide from air into organic compounds through the process of photosynthesis. All plants use C_3 processes; some plants, such as buffel grass and many other warm climate grasses, also use C_4 processes. C_4 plants have an advantage in a warmer climate due to their higher CO_2 assimilation rates at higher temperatures and higher photosynthetic optima than their C_3 counterparts
Contentious species	A species that presents special challenges for determining the adaptation response to climate change, because it is both a threat and a beneficial species (Friedel et al. 2011, Grice et al. 2012)

IN ALL REPORTS IN THE SERIES

TERM	DEFINITION
Dust Storm Index (DSI)	The Dust Storm Index is based on visibility records made by Bureau of Meteorology (BoM) observers. The DSI provides a measure of the frequency and intensity of wind erosion activity at continental scale. It is a composite measure of the contributions of local dust events, moderate dust storms and severe dust storms using weightings for each event type, based upon dust concentrations inferred from reduced visibility during each of these event types.
DustWatch	DustWatch is a community program that monitors and reports on the extent and severity of wind erosion across Australia and raises awareness of the effects of wind erosion on the landscape and the impacts of dust on the community.
Ecological refugia	Refugia defined according to the water requirements of the species they protect. The conservation significance of ecological refugia, and the priority assigned to their conservation, depends on the level of knowledge available for the species they support.
Evolutionary refugia	Those waterbodies that contain *short-range endemics* or *vicariant relics*. Evolutionary refugia are most likely to persist into the future and should be accorded the highest priority in NRM adaptation planning.
Generalised Dissimilarity Modelling (GDM)	A method of modelling based on compositional turnover of a group of species at a location; it considers whole biological groups rather than individual species
Heatwave	Continuous period beyond a week when a particular threshold temperature is exceeded
Hyporheic water flows	Below-surface flows
'No regrets' strategies	These strategies yield benefits even if there is not a change in climate

IN ALL REPORTS IN THE SERIES	
TERM	**DEFINITION**
Novel ecosystem	Species occurring in combinations and relative abundances that have not occurred previously within a given biome (Hobbs et al. 2006)
Rainfall event	One or more closely spaced rainfalls that are large enough to produce a significant vegetation response
Refugia	Habitats that biota retreat to, persist in and potentially expand from under changing environmental conditions
Return period	The number of days from the end of one rainfall event to the start of the next
Reversible strategies	Flexible strategies that can be changed if predictions about climate change are incorrect
Safety margin strategies	Strategies that reduce vulnerability at little or no cost
Short-range endemics	Species that occur only within a very small geographical area
Soft strategies	Strategies that involve the use of institutional, educational or financial tools to reduce species vulnerability to climatic change
Species Distribution Modelling (SDM)	A species-specific approach whereby observational records are used to model the current potential distribution of a species
Species invasiveness	A species that causes environmental or socioeconomic impacts, is non-native to an ecosystem or rapidly colonises and spreads (see Ricciardi and Cohen 2007). In the Invasive animals report it refers to non-native species (that is, those introduced to Australia post-1788) that have caused significant environmental or agricultural changes to the ecosystem or that are believed to present such a risk.
Strategies that reduce time horizons	Strategies that reduce the lifetime of particular investments

IN ALL REPORTS IN THE SERIES	
TERM	**DEFINITION**
Vicariant relicts	Species with ancestral characteristics that have become geographically isolated over time

References

Adger WN (1999) Social vulnerability to climate change and extremes in coastal Vietnam. *World Development* 27(2), 249–269.

Adger WN, Arnella NW and Tompkins EL (2005) Successful adaptation to climate change across scales. *Global Environmental Change* 15(2), 77–86.

Adger WN (2006) Vulnerability. *Global Environmental Change* 16(3), 268–281.

Beer A, Tually S, Kroehn MM, Martin J, Gerritsen R, Taylor M, Graymore M, Law J and Horne S (2014) *A Tool Kit for assisting Australia's country towns and communities with understanding and addressing longer-term climate change impacts*, NCCARF, Gold Coast.

Bulkeley H (2013) *Cities and climate change*, Routledge, London.

Brown D, Taylor J and Bell M (2008) The demography of desert Australia. *The Rangeland Journal* 30(1), 29–43.

Carson DB and Carson DA (2014) Local economies of mobility in sparsely populated areas: Cases from Australia's spine. *Journal of Rural Studies* DOI: 10.1016/j.jrurstud.2013.10.011.

Davis J (2014) *Australian rangelands and climate change – aquatic refugia*. Ninti One Limited and CSIRO, Alice Springs.

Gill SE, Handley JF, Ennos AR and Pauleit S (2007) Adapting cities for climate change: the role of the green infrastructure. *Built Environment* 33(1), 115–133.

HCCREMS (2010) *Climate change risk assessment and adaptation plan: coastal councils*, Hunter Councils, NSW.

ICLEI Canada (2010) *Changing climate, changing communities. Guide and workbook for Canadian municipalities*. ICLEI Canada, Toronto.

ICLEI Oceania (2008) *Local government climate change adaptation toolkit*. Cities for climate protection Australia adaptation initiative. ICLEI Oceania, Melbourne.

Jacobson MZ, Archer CL and Kempton W (2014) Taming hurricanes with arrays of offshore wind turbines. *Nature Climate Change* 4(3), 195–200.

Keogh D Apan A, Mushtaq S, King D and Thomas M (2011) Resilience, vulnerability and adaptive capacity of an inland rural town prone to flooding: a climate change adaptation case study of Charleville, Queensland, Australia. *Natural Hazards* 59(2), 699–723.

Li G and Dovers S (2011) Integrated assessment of climate change impacts on urban settlements: Lessons from five Australian cases. In *Climate Change Adaptation in Developed Nations*. Eds. JD Ford and L Berrang-Ford. pp. 289–302. Springer, Netherlands.

Maru YT, Stafford Smith M, Sparrow A, Pinho PF and Dube OP (2014) A linked vulnerability and resilience framework for adaptation pathways in remote disadvantaged communities. *Global Environmental Change*. [online] http://dx.doi.org/10.1016/j.gloenvcha.2013.12.007

McAllister RRJ, Holcombe S, Davies J, Cleary J, Boyle A, Tremblay P, Stafford Smith DM, Rockstroh D, LaFlamme M, Young M and Rola-Rubzen MF (2011) Desert networks: A conceptual model for the impact of scarce, variable and patchy resources. *Journal of Arid Environments* 75(2), 164–173.

Measham TG, Brake L, Robinson CJ, Larson S, Richards C and Smith TF (2011) NRM engagement between remote dryland communities and government agencies: Success factors from Australia. *Journal of Arid Environments* 75(10), 968–973.

Measham TG and Preston BL (2012) Vulnerability analysis, risk and deliberation: the Sydney climate change adaptation initiative. In *Risk and Social Theory in Environmental Management*. Eds. T Measham and S Lockie. pp 147–157. CSIRO Publishing, Collingwood.

Renn O and Schweizer P-J (2009) Inclusive risk governance: concepts and application to environmental policy making. *Environmental Policy and Governance* 19(3), 174–185.

Snover AK, Whitely Binder L, Lopez J, Willmott E, Kay J, Howell D and Simmonds J (2007) *Preparing for climate change: a guidebook for local, regional, and state governments*. ICLEI-Local Governments for Sustainability, Oakland.

Stafford Smith DM (2008) The 'desert syndrome' – causally-linked factors that characterise outback Australia. *The Rangeland Journal* 30(1), 3–14.

Stafford Smith DM and Cribb J (2009) *Dry Times: Blueprint for a Red Land*, CSIRO Publishing, Melbourne.

Webb R and Beh J (2013) *Leading adaptation practices and support strategies for Australia: An international and Australian review of products and tools*. National Climate Change Adaptation Research Facility, Gold Coast.

Webb RJ, McKellar R and Kay R (2013) Climate change adaptation in Australia: experience, challenges and capability development. *Australasian Journal of Environmental Management* 20(4), 320–337.

Contact Details

Tom Measham
Research Scientist
+61 2 6242 1789
tom.measham@csiro.au
http://www.csiro.au/Organisation-Structure/Divisions/Ecosystem-Sciences/TomMeasham.aspx