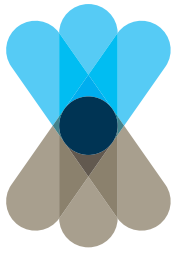


NCCARF

National
Climate Change Adaptation
Research Facility

PHASE 1: ESTABLISHMENT PHASE
MAY 2008-MAY 2010 REPORT





NCCARF

National
Climate Change Adaptation
Research Facility

Published by the National Climate Change Adaptation Research Facility

June 2010

Email nccarf@griffith.edu.au

Website www.nccarf.edu.au

The National Climate Change Adaptation Research Facility hosted by Griffith University is an initiative of, and funded by, the Australian Government, with additional funding from the Queensland Government, Griffith University, Macquarie University, Queensland University of Technology, James Cook University, The University of Newcastle, Murdoch University, University of Southern Queensland, and University of the Sunshine Coast.

The role of the National Climate Change Adaptation Research Facility is to lead the research community in a national interdisciplinary effort to generate the information needed by decision-makers in government and in vulnerable sectors and communities to manage the risks of climate change impacts.

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ISBN 978-1-921609-10-7

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NCCARF Publication 08/10

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MISSION

To lead the Australian research community in a national interdisciplinary effort to generate the information needed by decision-makers in government, and in vulnerable sectors and communities, to manage the risks of climate change impacts



Photo: Ron Cox



1. HISTORY OF NCCARF

NCCARF dates from the signing of the Funding Agreement between the (then) Department of Climate Change and Griffith University on 7 May 2008.

In April 2007, the Council of Australian Governments endorsed the National Climate Change Adaptation Framework. The Framework identified the need for a facility to coordinate Australia's climate researchers and to deliver information to support decision makers in adapting to climate change. In response, in May 2008, the Australian Government established the National Climate Change Adaptation Research Facility (NCCARF). NCCARF is hosted by Griffith University together with a partnership of seven other universities and the State of Queensland.

The partner universities are:

James Cook University
Macquarie University
Murdoch University
Newcastle University
Queensland University of Technology
University of Southern Queensland
University of the Sunshine Coast

NCCARF was formally established in May 2008 on signing of a Funding Agreement between Griffith University and then Australian Government Department of Climate Change.

NCCARF FUNDING

The Australian Government is investing \$117 million (from 2008 to 2012) in climate change adaptation policies, programs and research through the Department of Climate Change and Energy Efficiency. This investment supports implementation of key elements of the National Climate Change Adaptation Framework.

From this investment, \$20 million is being used to support NCCARF and its activities, as follows:

- \$10 million to support the core activities of NCCARF at Griffith University.
- \$10 million to support eight Adaptation Research Networks (see section 7).

In addition, and as part of the Australian Government's investment in climate change adaptation, the DCCEE has established the Climate Change Adaptation Research Grants Program. This Program provides seed funding of up to \$30 million to fund priority adaptation research needs.





2. NCCARF ESTABLISHMENT PHASE: AN OVERVIEW

Since its establishment in May 2008, NCCARF has embarked on an ambitious work program, with a focus on setting up frameworks for coordination and planning of climate change adaptation research in Australia, on developing links between researchers and research end-users, and on improving access to existing and emerging research in this field.



Photo: Nurbis

PRIORITY ACTIVITIES ARE AROUND:

- Developing National Climate Change Adaptation Research Plans in eight thematic areas, to identify critical gaps in the information available to decision makers, and to set research priorities.
- Through Implementation Plans, scoping the landscape of Australian research activity in the eight thematic areas, identifying both the purchasers and the providers.
- Working with the Department of Climate Change and Energy Efficiency to develop research projects in their Climate Change Adaptation Research Grants Program to address the priorities identified by the Research Plans.
- Establishing a program of synthesis and integrative research.
- Establishing eight Adaptation Research Networks around the thematic areas.
- Engaging with key stakeholders and developing mechanisms for improving access to, and communication of, climate change adaptation research.

KEY ACHIEVEMENTS INCLUDE:

- Finalising seven National Climate Change Adaptation Research Plans, together with their Implementation Plans;
- Managing research calls under the Climate Change Adaptation Research Grants Program
- Establishing eight Adaptation Research Networks, which now have over 3000 members nationally;
- Embarking on a program of synthesis and integrative research;
- Establishing the NCCARF website, seminar series, quarterly newsletter, and running symposia as mechanisms of knowledge communication; and,
- Engaging with key stakeholders, including local, State and Territory governments, via a series of roadshows and forums.

The 2010 International Climate Change Adaptation Conference, co-hosted by NCCARF and the CSIRO, and due to be held in June 2010, will be a significant achievement showcasing leading impacts and adaptation research from around the world.

The aim of this report is to provide an overview of NCCARF activities and achievements during its establishment phase. The report also looks to the future and briefly outlines opportunities, challenges and priorities for the future of climate change adaptation research in Australia, and the ongoing role of NCCARF in coordinating and supporting this endeavour.



3. THE NCCARF THEMATIC AREAS

WATER RESOURCES AND FRESHWATER

BIODIVERSITY – the impacts of climate change on surface and groundwater, inland aquatic and semi-aquatic ecosystems. The associated social and economic impacts of changing water regimes and adaptation strategies for managers and users.

MARINE BIODIVERSITY AND RESOURCES

– the biophysical impacts of climate change and variability on coastal, estuarine and marine ecosystems including fisheries, the social and economic impacts and adaptation strategies for industries and sectors that depend on the marine environment.

TERRESTRIAL BIODIVERSITY – the species and ecosystem level impacts of climate change, the adaptive capacity of ecosystem and ecological communities and the implications for biodiversity management strategies.

PRIMARY INDUSTRIES – the impacts of climate change on horticulture, viticulture, livestock, cropping, intensive and extensive farming practices and forestry. The social and economic impacts of climate change on these industries and sector and region specific adaptation strategies.

SETTLEMENTS AND INFRASTRUCTURE

– the impacts of climate change on coastal settlements, public and private infrastructure including building and facility design and construction; urban water security; flooding and stormwater overflow. The social economic and institutional implications of these impacts, and the implications for planning design and management.



Photo: Matthew Godfrey





AUSTRALIAN INDIGENOUS COMMUNITIES

– recognising that the impacts of climate change are already being felt by Indigenous Communities, and that there are particular challenges and opportunities that climate change presents to Australian Indigenous Communities.

HUMAN HEALTH – changes to the range and persistence of vector and food-borne diseases, the physical and mental health impacts of heat waves and other extreme events and the social, economic and management implications of these impacts for the Australian health care system.

EMERGENCY MANAGEMENT – the implications of changes in frequency and intensity of extreme weather events for disaster mitigation, preparedness, response and recovery and the strategies for building community and organisation resilience in the disaster and emergency management sectors.

SOCIAL, ECONOMIC AND INSTITUTIONAL DIMENSIONS OF CLIMATE CHANGE

– a cross-cutting analysis of issues such as methods for understanding whole-of-economy impacts. The implications of social and economic trends for vulnerability to climate change. Understanding and developing adaptation strategies for vulnerable communities and the institutional challenges of adapting to climate change.



Photo: Geoff Edgar

4. DIRECTOR'S REPORT



I arrived in Australia nearly two years ago to become the Director of NCCARF, and it's been a fascinating and absorbing two years if, at times, exhausting. When I applied for the position, I found the job description somewhat unrevealing. As is often the case with innovative, new institutions, the mission statement was well-defined but the means of achieving the objectives were a little obscure; and so no-one quite understood what my job would entail.

The last two years have been a steep learning curve for all NCCARF staff, for our networks, partners and, indeed, for all our stakeholders. So, this is a most appropriate time at which to report

on progress; because we all now have a much clearer idea of who we are, what we do, where we're heading and, most importantly, how we are going to get there. Along this learning curve, we've achieved a remarkable amount, and this Report is an opportunity to set out those achievements before we move forward to our next phase of activity.

I'd like to take this chance to thank all the many people I have met while Director of NCCARF, and especially the staff based here in Griffith University. I was made very welcome when I joined NCCARF, and have met with unfailing friendliness and interest as I have moved around Australia promoting NCCARF activities.

Australia's climate change policy rests on three main pillars: mitigation (reducing the amount of climate change), adaptation (dealing with the impacts and taking advantage of the opportunities presented by a changing climate) and international participation (contributing to a global solution).

NCCARF was set up by the Australian government to foster and co-ordinate the research activity around one of these pillars – adaptation. When NCCARF started out, it was very much embedded within the research community, and this was natural given its presence at Griffith University. But a key feature of the last two years has been the growing



recognition that NCCARF must move much closer to its end users – the people responsible for policy-making and decision-making in government, industries and communities. This is the only way to ensure that our research outputs are properly communicated to end users, that the outputs take account of the, sometimes competing, needs and aims of end users, and that they contribute positively to the challenge of adapting Australia to future climate change.

I have no doubt that the next, operational, phase of NCCARF will be characterised by a growing and productive dialogue between NCCARF and its stakeholders.

If I had to name the big challenges for Australia in adapting to climate change, what would I say? They lie in the management of our unique marine and terrestrial biodiversity under climate change, not only in the internationally-renowned locations of the Great Barrier Reef and the Kakadu wetlands, but also in those quintessentially Australian and much loved landscapes of the Mallee shrublands, the Karri forests, the Atherton Tablelands, the bush and the Outback.

They lie in maintaining and improving the diversity and quality of lifestyles which characterise this country – not only in the great coastal cities, but also in rural and remote regions. And they lie in managing climate change at the international scale – how changing trade flows and demand for goods will affect Australia.

I have no doubt that the next, operational, phase of NCCARF will be characterised by a growing and productive dialogue between NCCARF and its stakeholders.

Adapting to climate change should be seen as an economic opportunity rather than, as is often the case, simply another tax or extra cost. If NCCARF can make a contribution to meeting these challenges, then it will have fulfilled its vision.



5. NCCARF ACTIVITIES AROUND CLIMATE CHANGE ADAPTATION RESEARCH

5.1 THE CONTEXT

It is now widely accepted that human activities are contributing to climate change and that this change is producing significant physical effects.

Some of the effects from climate change are already happening; some are inevitable and will become more severe if we do not modify our behaviour.

Since 1950, Australian average temperatures have increased by 0.9°C, with more heatwaves, more rain in the north-west and less rain in the southern and eastern regions and an increase in the intensity of droughts [see <http://www.climatechangeinaustralia.gov.au/pastchange.php>]. Australia is already experiencing impacts from recent climate change with increasing stresses on water supply and agriculture, and is expected to face more severe extreme events with more intense and frequent heatwaves, droughts, floods and storm surges.

There are two main categories of human responses to climate change: mitigation and adaptation. Both types of response help to reduce the risks of climate change.

Mitigation involves actions that are intended to reduce the magnitude of our contribution to climate change. It includes strategies to reduce greenhouse gas sources and emissions and enhance greenhouse gas sinks.

Adaptation consists of actions undertaken to reduce the adverse consequences of climate change, as well as to harness any beneficial opportunities.

Adaptation actions aim to reduce the impacts of climate stresses on human and natural systems.

Both types of responses are essential and complementary. However, climate change is already happening and is bound to continue because of the amount of greenhouse gases already in the atmosphere. Even the toughest mitigation efforts and targets cannot avoid further impacts of climate change in the next few decades. Adaptation to these impacts which are already 'locked in' and cannot be avoided is therefore essential and of critical importance.

There are many different types or categories of adaptation. The most common distinctions concern:

- Timing: proactive adaptation if it is done in anticipation of an impact, reactive if it is done in response;
- Temporal and spatial scope: short term as opposed to long term, localised as opposed to widespread;
- Purposefulness: autonomous if it is done unconsciously, planned if it is the result of a policy decision;
- Agent: public or private; government, industry, business or individual.

These different characteristics demonstrate the range of actions that are classified as adaptations.

Adaptation will be undertaken by a variety of actors, including individuals, communities,





businesses, private actors, civil society and governments, and will consist of a wide range of behavioural, institutional, structural and technological adjustments.

Examples of adaptation measures include construction of sea walls; building of new water reservoirs; establishment of early warning systems; revision and/or modification of building codes; alteration of farming practices and crop use; improvement of risk management; and enhancement of water use efficiency.

Australians have a long history of responding to an extremely variable climate and to climatic extremes, such as floods, droughts and cyclones.

This history, as well as the high educational standards and standard of living in Australia, provides Australians with a strong capacity to adapt to many of the expected impacts of climate change.

However, climate change will pose new risks outside the range of historical experience. The continuing drought in many parts of Australia and the bushfires, floods and storm tides experienced in 2009 highlight Australia's existing vulnerability to extreme events. There is a need to enhance our society's resilience to current climate and to build our capacity to respond and adapt to the impacts of climate change, which will likely fall beyond the range that Australia has experienced so far.



Photo: WTMA

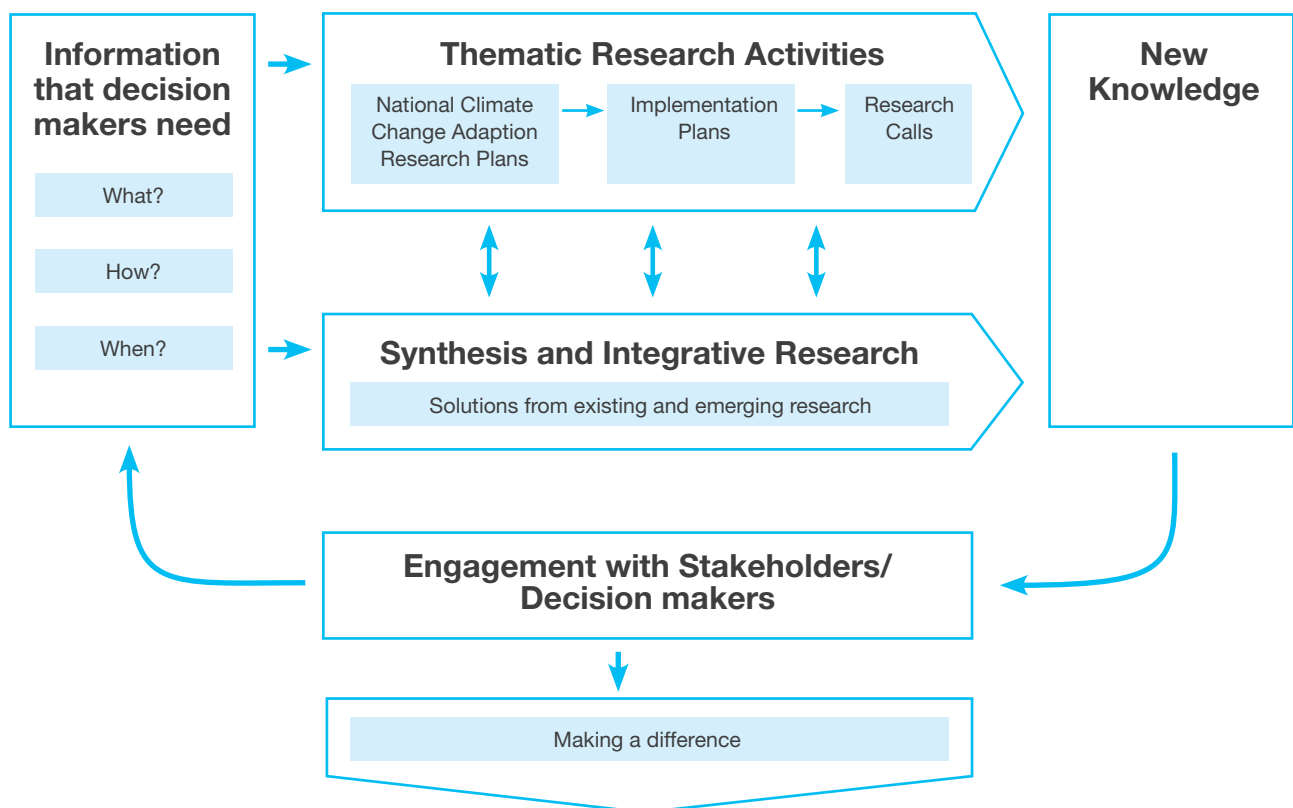
5.2 RESEARCH-RELATED ACTIVITIES AT NCCARF

Nccarf's research-related activities can be separated into:

- Activities around thematic research –** with priorities identified in National Adaptation Research Plans, and seed funding for the implementation of these Plans provided by the Australian Government's Adaptation Research Grants Program.
- Synthesis and integrative research –** with a focus on collating and synthesising existing climate change adaptation knowledge and on research projects generating new knowledge relevant to issues that cut across NCCARF's thematic research priorities.

The linkages between the thematic and synthesis and integrative research activities are shown in Figure x1.

FIGURE x1: LINKAGES BETWEEN RESEARCH-RELATED ACTIVITIES IN NCCARF



5.3 ACTIVITIES AROUND THEMATIC RESEARCH

Activities in this area are built around the nine thematic areas identified in Section 4. The pathway through these activities is shown in Figure x2.

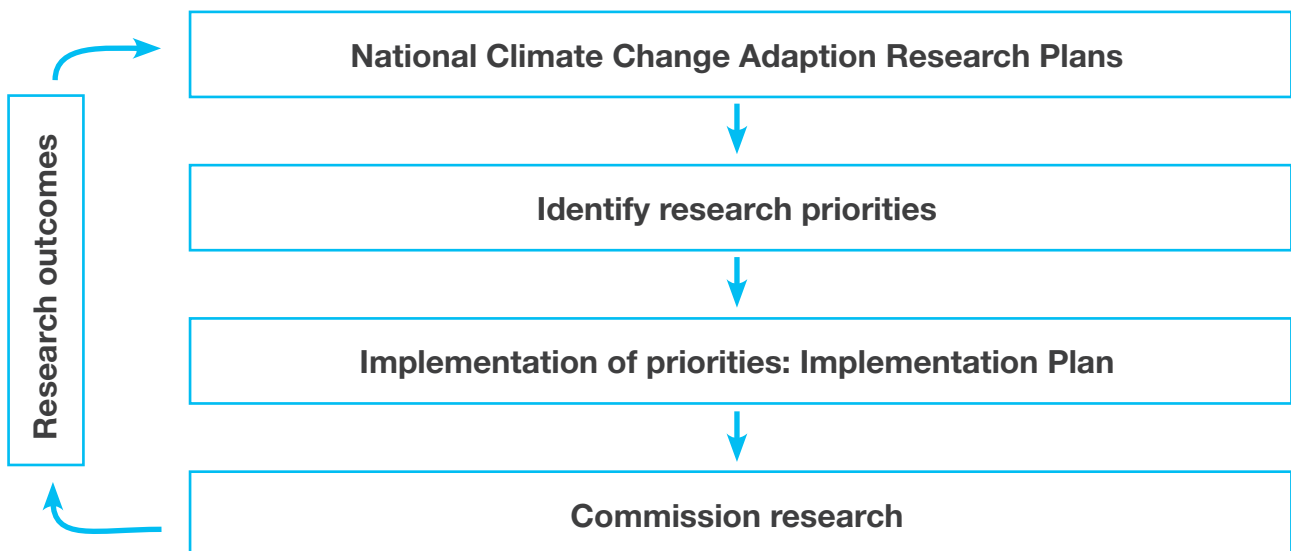
The first step in the pathway, for each theme, is to write a National Climate Change Adaptation Research Plans which identifies research priorities. This is accompanied by an Implementation Plan, again for each theme, which sets out the national capacity to address these research priorities, with respect to both purchaser and provider. These Plans are available from the NCCARF web page at www.nccarf.edu.au

As noted in Section 2, under the Climate Change Adaptation Research Program, there is \$30 million available for seed funding to address the research priorities identified by the Research Plans.

The next step is therefore to commission research projects, either through the Department of Climate Change and Energy Efficiency alone, or in partnership with other funding organisations.

The process is dynamic – the Research Plans will be revised during NCCARF Phase 2, to incorporate the latest research results, whether from DCCEE-funded projects or elsewhere.

FIGURE x2: THEMATIC RESEARCH ACTIVITY PATHWAY



Development of National Adaptation Research Plans

NCCARF has completed the following National Climate Change Adaptation Research Plans (NARPs), and associated implementation plans:

- Human Health (approved by the Minister in February 2009)
- Emergency Management (approved by the Minister in September 2009)
- Marine Biodiversity and Resources (approved by the Minister in November 2009)
- Settlements and Infrastructure (approved by the Minister in March 2010)
- Terrestrial Biodiversity (submitted for approval in January 2010)
- Social, Economic and Institutional Dimensions of Climate Change (submitted for approval in May 2010)
- Primary Industries (submitted for approval in May 2010).

Drafting of the NARP for Water Resources and Freshwater Biodiversity was paused following the COAG decision to develop a National Water Knowledge Research Strategy, in order to evaluate the links and overlap between the two activities. The scope of this NARP is now focussed entirely on freshwater biodiversity, and this document will inform the National Water Knowledge Research Strategy. This NARP is due for completion in late 2010.

Following feedback from the Australian Indigenous community, the need for a NARP with a focus on climate change adaptation and Indigenous communities has been identified. The writing of this Plan has commenced, and the writing team is being led by Professor Marcia Langton from the University of Melbourne. It is planned that this NARP will be finalised in late 2011.

The process for development of a NARP typically includes the following steps.

- Appointment of a writing team, made up of leading experts in the field.
- Development of an Issues Paper by the writing team, setting out existing knowledge, gaps, and issues.

- Development of a consultation strategy, identifying key stakeholders for the theme, including representatives from research, government, industry and community. Stakeholder consultation typically includes an initial stakeholder workshop, using the Issues Paper as a basis for discussion; and an open public review and consultation on the draft NARP.

- Following the initial round of consultation, a draft NARP is prepared for review.
- The four-week review period is advertised in the press, and is managed primarily via the NCCARF webpage. However, as part of the process, the identified key stakeholders are contacted directly by NCCARF and strongly encouraged to provide comment on the draft document.



- When the review closes, the writing team prepare the final draft using the review comments as a basis.
- The final NARP is delivered to the Department of Climate Change and Energy Efficiency for Ministerial approval.

The NARPs follow broadly the same structure, providing an overview of the ‘state of the knowledge’, identifying current gaps in knowledge, and then prioritising research questions that aim to address these gaps.

Priority research questions

The seven completed NARPs provide a current and comprehensive set of priority research questions for thematic research¹, and a framework for climate change adaptation research investment in Australia. These priority research questions are listed in Table 1.



TABLE 1: PRIORITY RESEARCH QUESTIONS

Marine Biodiversity and Resources

AQUACULTURE

- Which farmed species in which locations are most likely to be impacted by climate change?
- What options are there for businesses to adapt to climate change effects either by minimising adverse impacts or taking advantage of opportunities? What are the barriers to implementing such changes and how might they be overcome?

COMMERCIAL AND RECREATIONAL FISHING

- Which fishery stocks, in which locations, are most likely to change as a result of climate change? What will those changes be (e.g., in distribution, productivity) and when are they likely to appear under alternative climate change scenarios?
- What options or opportunities are there for commercial fishers in identified impacted fisheries to adapt to climate change effects through changing target species, capture methods and management regime, industry diversification, relocation or divestment?

CONSERVATION MANAGEMENT

- Which ecosystems and species of conservation priority most require adaptation management and supporting research, based on their status, value, vulnerability to climate change and the feasibility of adaptive responses?
- How should conservation managers and planners adapt their practices to ameliorate climate change risks and enhance adaptation options? What intervention strategies will increase system resilience and improve the time within which biological systems can adjust to a future climate?

TOURISM AND RECREATIONAL USES

- What are the predicted regional impacts of climate change for marine tourism assets (e.g., what tourism sites will be most vulnerable to change and to what degree)?
- What is the adaptive capacity of the marine tourism industry and how can it be enhanced to cope with climate change impacts?

CROSS-CUTTING ISSUES

- What are the key interactions across sectors, cumulative impacts and cross-jurisdictional issues that will affect the development of adaptation strategies in each sector and how can these cross- and multi-sectoral issues best be addressed?

1. Noting that the NARPs for Freshwater Biodiversity and Indigenous Communities are yet to be completed.



Terrestrial Biodiversity²

NATIONAL/CONTINENTAL SCALE ISSUES

- How will climate change affect existing conservation goals and how should changed conservation goals be promoted and achieved?
- How can the existing Australian legal, policy and institutional architecture for land management and biodiversity conservation respond to changes in conservation goals caused by climate change?
- What conceptual models and long-term observation systems are needed to support the design, analysis and assessment of active adaptive management and policy experiments at regional and national scales under climate change?

REGIONAL ISSUES

- What designs of landscapes in regions having different land-uses confer maximum resilience for biodiversity in the face of climate change, including the uncertainty associated with future climate scenarios?
- How will climate change interact with other key stressors such as fire, invasive species, salinity, disease, changes to water availability, grazing and clearing, and what are the integrated implications for ecosystem structure and functioning?
- How can large-scale carbon mitigation initiatives, such as revegetation and forest-related mitigation, be designed to maximise biodiversity conservation benefits and to avoid adverse impacts on biodiversity?
- How can major socio-economic trends occurring in many regions of Australia contribute to effective climate change biodiversity adaptation responses?

MANAGING KEY SPECIES

- Which species should be the focus of investment in climate change adaptation?
- How will climate change affect current management actions for protecting priority species and what management changes will be required?
- How will climate change affect current or potential problem species and what management responses will be required?



Photo: Mike Trenary

2. The NARP research priorities for Terrestrial Biodiversity have not yet received Ministerial approval, and are provided here in draft format only.

Primary Industries³

UNDERSTANDING AND EXPANDING ADAPTIVE CAPACITY

- What is adaptive capacity in the primary industries sector and how can it be measured and increased at individual, industry, regional and national level?

LEVELS OF ADAPTATION

- What factors define the effectiveness of different levels of adaptation response: adjusting practices, changing production systems, and transforming enterprises, industries and regions?
- What information, knowledge, tools, programs and policies are necessary for primary producers and industries to identify the range of potential climate change adaptation responses and understand their benefits, costs, risks and opportunities?



Photo: NSW State Emergency Service

3. The NARP research priorities for Primary Industries have not yet received Ministerial approval, and are provided here in draft format only.



ADJUSTING PRIMARY PRODUCTION PRACTICES AND TECHNOLOGIES

- What types of improvements to production practices and technologies exist or could be developed to increase the adaptive capacity of Australia's primary industries, and what practical issues need to be addressed for implementation?
- What adaptations could yield benefits from changing atmospheric and climate conditions, such as increased atmospheric CO₂ and changes to temperatures and water availability?

CHANGING PRODUCTION SYSTEMS

- What characteristics of production system change in primary industries are likely to provide advantage under changed climate conditions?
- What information, knowledge, tools, programs and policies are needed to support effective changes in primary production systems?

TRANSFORMING PRIMARY PRODUCTION

- What characteristics of transformational change in primary industries are likely to provide advantage under changed climate conditions?
- What information, knowledge, tools, programs and policies are needed to support effective transformative adaptation in primary production systems?
- How can the well-being of individuals and communities unable to undertake transformational changes be maintained?

INTEGRATING, IMPLEMENTING AND REVIEWING ADAPTATION

- How can integrated climate change adaptation response plans be developed at the local, landscape and regional scales?
- How can climate change adaptation requirements, options, benefits and costs be integrated with other information critical to primary producers and industries and communicated to support successful adaptation being determined and implemented?
- How can adaptation by primary industries be monitored and measured, including assessing synergies, maladaptation and interactions with other sectors, to support ongoing improvements to adaptation approaches and initiatives.



Photo: Wally Irwin

Settlements and Infrastructure

URBAN AND REGIONAL PLANNING AND MANAGEMENT

- How can existing urban planning principles and practices accommodate climate change and the uncertainty of climate change impacts? How should these principles and practices differ based on the location and spatial scale of the settlement? What can we learn about the adaptive capacity of settlements from responses to stresses in the past?
- How can the governance of urban planning in Australia, including formal and informal rules, nationally consistent approaches and guidelines and locally driven standards and outcomes, and the institutions responsible for decision-making, be improved to facilitate planning processes and outcomes which incorporate adaptation to climate change?
- What are the particular planning needs of remote and Indigenous settlements under a changing climate?

BUILT ENVIRONMENT

- What are the design options and principles for adapting new buildings to climate change in different locations and how can these be implemented?
- What are the design options and principles for adapting existing buildings to climate change in different locations and how can these be implemented?
- What are the full life-cycle costs and benefits of adapting the built environment and how can they be reliably estimated? Who will bear these costs and who will benefit? What financial and other policy instruments can be used to address equity impacts of these costs?

VULNERABLE COASTAL COMMUNITIES

- How will demographic pressures and changes in different Australian coastal settlement types affect (1) potential impacts of extreme and gradual climate change, and (2) current policy and regulatory settings which govern the decision-making by government agencies, businesses and individuals? How will planning for coastal climate change impacts respond to local circumstances?
- How well do we understand the relationship between climate and coastal processes? How can methods currently used to determine the physical risk on a regional basis of extreme inundation and coastal erosion from climatic and oceanic processes, either singularly or in combination, be improved and new methods developed and applied?



INFRASTRUCTURE

- What is the vulnerability of infrastructure (individual and interlinked critical sectors) to existing and predicted climate change conditions at various spatial scales, considering average and extreme weather conditions? How can climate-induced service or structural failure thresholds for infrastructure and services be identified in light of the inherent uncertainty in climate projections?
- What impacts on key infrastructure may have downstream or cascading impacts during extreme climate events, and how might these impacts be avoided?
- What design standards for the Average Recurrence Interval (ARI) and/or Average Exceedance Probability (AEI), and planning periods for the various infrastructure components, should be adopted for particular locations and over what time frames?

CROSS-CUTTING

- What would a climate-adapted Australian settlement look like?
- What sectors of society are most vulnerable and least able to adapt to climate change in urban, regional and remote settlements? What is the nature of those vulnerabilities and the barriers to adaptation? How can physical, social, economic and institutional factors reduce their vulnerability and increase their adaptive capacity? At what spatial and temporal scales should adaptation responses for vulnerable communities be developed?
- To what extent can geologic/geomorphic/historical/traditional/local knowledge be best applied to assessing vulnerability of existing settlements under different climate change scenarios?



Photo: Newspix/Scott Fletcher

Human Health

HEAT

- Which categories of persons are most vulnerable to short-term extremes of heat?
 - Do levels of understanding of the nature of the risks, and personal/household-level ways to ameliorate them, vary between these population sub-groups?
 - Are changes needed to public health policy in order to manage heatwave impacts?
- Do early warning systems (EWSs) for heat waves and other extreme weather events reduce adverse health impacts?
 - Which types of EWS are most effective?

EXTREME WEATHER EVENTS

- Does public education about the risks of extreme events, and their avoidability, alter people's knowledge and behaviour?

VECTOR-BORNE DISEASES

- What are the future increased risks of arbovirus diseases arising from climate change? This question should focus on population movements and changes in Northern Australia, and monitoring of potential vectors.
 - Does climate-driven predictive modelling of any particular vector-borne infectious disease outbreak reduce the occurrence of such outbreaks?
 - How would existing public health systems cope with increased levels of vector-borne disease infections?
- Can meteorological forecasts of impending seasonal weather conditions provide useful advance warning of altered risks of vector-borne infectious disease outbreaks? Does such usefulness differ between human-only and zoonotic VBDs?
 - Are such forecasts enhanced by inclusion of information about changes in environmental indicators (e.g. surface water conditions, vegetation levels, etc.)?
 - Will the implementation of such Early Warning Systems result in reductions in outbreaks or infection rates?



FOOD, AIR AND WATER QUALITY

- Where will the likely climate change impacts on food safety and quality be observed, and what measures/practices can be implemented to reduce the risk of food-borne disease outbreaks?
- What is the role of water authorities responsible for treating water in the management of climate change impacts?

MENTAL HEALTH

- What interventions are required to minimise the potential adverse mental health effects of natural disasters (such as drought, windstorm and floods)? Initiatives to address this question should build on the established models and frameworks in disaster mental health planning.

COMMUNITY AND INDIGENOUS HEALTH

- How might climate change and changes in occurrence of extreme events affect aspects of indigenous culture and living conditions that affect health?
- Which types of intervention most effectively increase the level of community resilience?
 - What key characteristics of indigenous, rural and urban communities determine their level of resilience to the stress of long-term changes in climatic and environmental conditions?

HEALTH CARE SYSTEM AND INFRASTRUCTURE ISSUES

- What models of integrating the entire health sector's adaptive responses best support co-ordination of adaptive activities?
 - What models of linkage and knowledge exchange between climate change researchers and policy-makers best provide relevant decision support in planning health sector responses?
 - What role should the primary health care sector play as part of a broader public health adaptive response to climate change?
 - Is the healthcare system adequately structured and staffed to handle increased demands from (a) extreme weather events, and (b) outbreaks of infectious diseases?
 - What improvements are needed, feasible and effective?
 - What forms of in-career training of healthcare professionals best prepares them to identify and respond to climate-related health impacts?
-

Emergency Management

UNDERSTANDING RISK

- Where and how are changes in climate going to put us at greatest risk?
- What tools are needed to enable decision-making under future climate uncertainty?

COMMUNITY AND ORGANISATIONAL RESILIENCE

- What does community resilience mean in a changing climate?
- What behaviours promote community preparedness and preventive strategies in a changing climate?
- What are the most effective strategies to ensure that individuals, governments and the private sector adopt better practices in preparing for the increased risk to communities, business operations or critical infrastructure arising from climate change?

ADAPTIVE STRATEGIES

- How will climate change affect the emergency management sector's capacity to support preparedness, response and recovery?
- What is the role of the private sector in adaptation through emergency management?

REGIONAL IMPLICATIONS

- How will the climate change adaptive capacity of other countries, particularly those in the Pacific region, impact upon the Australian disaster management system and Australian fire and emergency service organisations?



Photo: Newspix/Alex Coppel



Social, economics and institutional dimensions of climate change⁴

UNDERSTANDING VULNERABILITIES AND ADAPTIVE CAPACITY

- The development and application of methods for assessing vulnerability and adaptive capacity that engage and harness the knowledge and skills of individuals, households, communities, businesses, industries and governments.
- Identification of the capacity of individuals, households, communities, businesses, industries and governments to adapt to climate change, and of options to enhance this capacity.
- Understanding the equity dimensions of current and future vulnerability and adaptation including:
 - a. the issues for specific population groups who have particular vulnerabilities and limited capacity to adapt by virtue of their socio-economic status, skills, livelihood, cultural or linguistic background, or other characteristics such as age; and,
 - b. understanding the interaction between existing stressors and climate change, and the implications of this interaction for vulnerability and adaptive capacity.

UNDERSTANDING AND OVERCOMING THE BARRIERS AND LIMITS TO ADAPTATION

- Understanding the cognitive and affective dimensions of adaptation, including:
 - a. the knowledge, perceptions and emotional responses of people and groups regarding climate risks;
 - b. the time horizons of people and groups who make decisions about adaptation; and,
 - c. the degree to which people and groups feel empowered to adapt.
- Understanding enablers and barriers to collective action, including:
 - a. how shared symbols, beliefs and practices enable or constrain adaptation;
 - b. how economic factors, including distribution of capital and investment, enable or constrain adaptation;
 - c. how social practices and opportunities enable or constrain adaptation;
 - d. how the distribution of power in decision making enables or constrains adaptation.
 - e. what differing types of decision makers consider to be the goals of adaptation (e.g. what defines 'successful' adaptation in their eyes); and,
 - f. what and how differing types of decision makers know about the vulnerability of others.

- Measures to value adaptation. Understanding how to assess and value adaptations to climate change, including the value of opportunity costs, avoided damages, residual impacts, and benefits gained. This may involve:
 - a. reviewing and determining the suite of assessment and valuation methodologies that are most appropriate for use by Australian adaptation policy and decision-makers;
 - b. identifying the limits to the use of these methodologies; and,
 - c. testing the identified methodologies against relevant current policy in Australia.

UNDERSTANDING GOVERNANCE, INSTITUTIONS AND DECISION-MAKING

- Analysis of existing responses from public and private institutions to climate change risks, and assessment of proposals to improve the effectiveness, efficiency and equity of future responses, including:
 - a. analysis of responses in the public, private and third (civil society) sectors; and,
 - b. analysis of the distribution of roles, responsibilities and capacities of different levels of government and cross-jurisdictional bodies.
- Understanding how laws and legal institutions, including regulatory instruments, support or impede adaptation planning and practice, and identifying reforms needed to reduce obstacles.
- Assessing the potential for, and limits to, market-based adaptation measures, including insurance markets.



Photo: Jan McDonald



Implementation of NARPs

The thematic climate change adaptation research priorities outlined in Table 1 provide a framework for progressing climate change adaptation research in Australia. NCCARF, together with the Adaptation Research Networks, has roles to play in:

- promoting these research priorities,
- coordinating research capacity to address them
- brokering the consortia best able to undertake research to address them, and
- leveraging funding to support this research.

The Australian Government, through its Adaptation Research Grants Program, has seed funding of \$30 million available for allocation towards research that addresses these priority research questions. The Department of Climate Change and Energy Efficiency (DCCEE) has made a number of open competitive calls for funding proposals under this program in the following areas:

1. DCCEE in partnership with the National Health and Medical Research Council have allocated up to \$6 million towards addressing the research priorities identified in the Human Health NARP. The identification of projects is being managed by the NHMRC, and there have been two rounds of the NHMRC special Health challenges of climate change funding call.
2. DCCEE in partnership with the Fisheries Research and Development Corporation have allocated up to \$6 million towards research that addresses priorities identified in the Marine Biodiversity and Resources theme. In early 2010, FRDC opened a call for funding proposals. The results of this funding round had not been finalised at the time of writing.
3. DCCEE and NCCARF have coordinated a call for funding proposals for research that addresses research priorities identified under the Emergency Management theme. Up to \$2 million was potentially available as part of this call and over 100 expressions of interest were received. The projects to be funded have been identified, but had not been announced at the time of writing.
4. DCCEE and NCCARF have also recently announced a call for funding proposals for research that addresses the priorities identified by the Settlements and Infrastructure NARP. Up to \$7 million is potentially available, and successful projects are expected to be announced later in 2010.

4. The NARP research priorities for Social, Economic and Institutional Dimensions have not yet received Ministerial approval, and are provided here in draft format only.

5.4 DELIVERY OF SYNTHESIS AND INTEGRATIVE RESEARCH

A core function of NCCARF is to conduct a program of research that synthesises and integrates existing and emerging national and international climate change adaptation knowledge.

This program is now underway, starting in June 2009, and will be conducted over four years, with the majority of projects being one year or less in duration.



Photo: Keith Pakenham



5.5 PHASE 1 SYNTHESIS AND INTEGRATIVE RESEARCH PROJECTS

In Phase 1, research is being undertaken in three areas:

- Forest Vulnerability Study – a Preliminary Assessment of the Vulnerability of Australian Forests and Plantations to the Impacts of Climate Change
- Historical Case Studies – a suite of case studies will be developed examining the management of recent climate extremes in Australia, and the lessons that can be learned from these events for adaptation to future climate change.
- Adaptive Capacity – an assessment of the nature and utility of adaptive capacity research.

Adaptive Capacity – an assessment of the nature and utility of adaptive capacity research.



Photo: Image Melburnian

A PRELIMINARY ASSESSMENT OF THE VULNERABILITY OF AUSTRALIAN FORESTS AND PLANTATIONS TO THE IMPACTS OF CLIMATE CHANGE



Australia's forests may be considered as a continuum with large-scale industrial plantations at one extreme and native forests at the other.

Photo: Peter Halasz



Background

This project will improve understanding of the implications of climate change for Australia's forest estate including native forests, plantations, farm forestry and environmental plantings. It will provide information to assist governments, natural resource managers and the business sector to adapt to the changing climatic environment in a manner consistent with principles of sustainable forest management.

Project aim

The aim of the project is to provide governments, natural resource manager and the business sector with:

- an improved understanding of current knowledge of the likely biophysical and socio-economic consequences of climate change for Australia's native and planted forest regions,
- an assessment of the vulnerability of Australian forests from the perspectives of both resource use and ecosystem services - identifying particularly vulnerable forests and communities in major forest areas,
- an understanding of what is already being done in Australia in relation to understanding and managing climate related risk in relation to forests, and
- guidance on key gaps in information available to assist climate change adaptation.

Project approach

Using the same definition of forests as used in the 2008 Australia's State of the Forests Report (SOFR), which includes Australia's diverse native forests and plantations, this project will provide a synthesis of current knowledge and understanding of the implications of climate change for Australia's forests. It will also identify key gaps in information available that need to be addressed to improve the capacity of forest and natural resource managers to manage climate risk.

Australia's forests may be considered as a continuum with large-scale industrial plantations at one extreme and native forests at the other. The classification to be used in this project is:

- Plantation/farm forests
- Productive native forests
- Conservation native forests
- Environmental plantings

Project structure

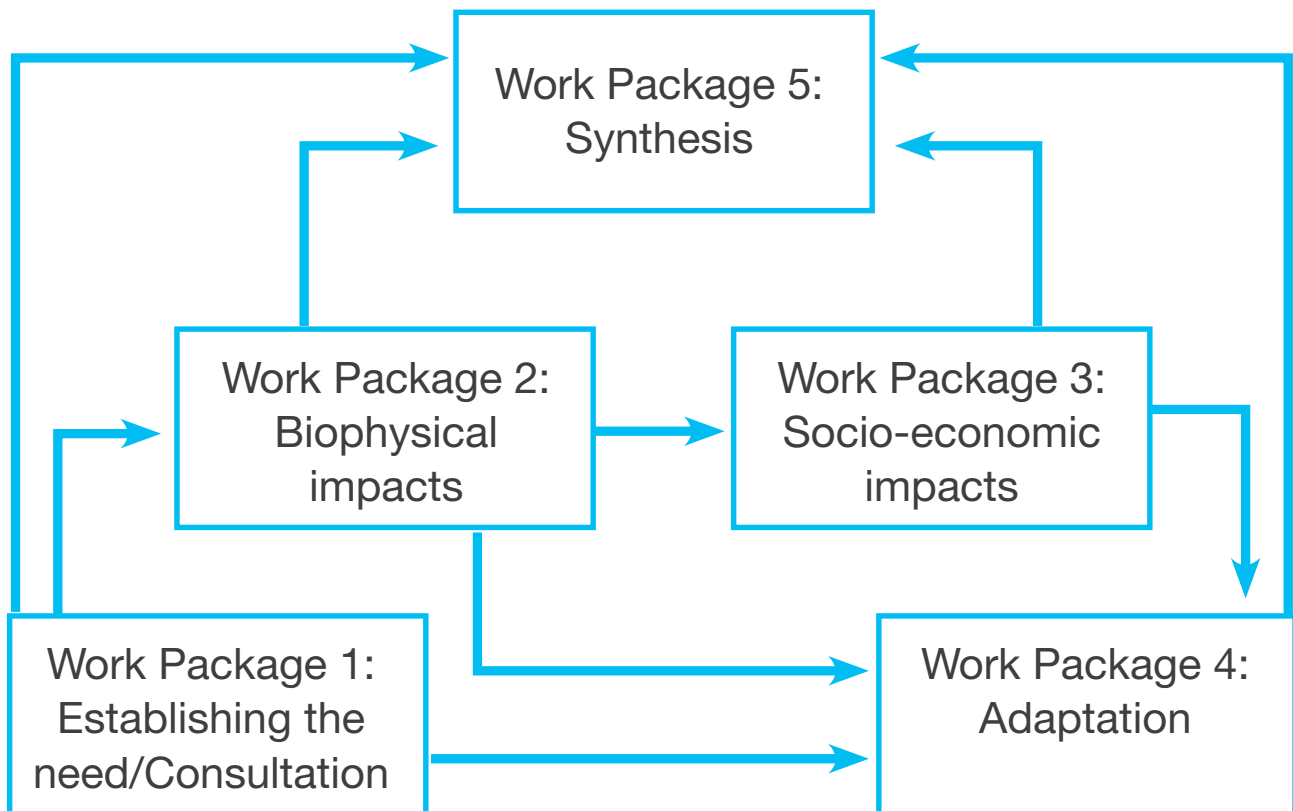
The Forest Vulnerability Assessment has been divided into five work packages:

WP1: Establishing the need and stakeholder consultation, carried out by the University of the Sunshine Coast.

WP2: Scene setting and biophysical impacts, carried out by Macquarie University and Murdoch University.

WP3: Socio-economic impacts, led by the University of Southern Queensland.





WP4: Adaptation, led by James Cook University

WP5: Synthesis, led by Griffith University.

The relationship of the five work packages in the FVA project is shown above.

Project outcomes

The principal project outcome should be an enhanced awareness of, and engagement with, climate change issues by managers of Australia's native and plantation forests used for timber production, forests for carbon sequestration and forests for natural resource management outcomes.

This first national Forest Vulnerability Assessment provides a snapshot of what is known about future climate change impacts on forests and forest dependent communities and their vulnerability to these impacts. Some preliminary findings include:

- Forest species will be affected by climate change, with likely flow-on effects to ecosystem structure, composition and function, fire regimes, introduced and invasive species and disease.
- Elevated CO₂ may increase forest productivity. However, in Australia, large positive responses to rising CO₂ can only be expected where soils are fertile and water is limited. It is yet unclear whether forest water use will decrease at higher concentrations of atmospheric CO₂, or whether leaf area will increase to compensate, resulting in higher productivity but no change in water use. More experimental evidence is required.
- Higher temperatures may have positive or negative effects on growth depending on the plant's optimum growth temperature and capacity to acclimate. Growth effects are likely to be small for 1 – 2 °C warming, beyond this however effects could be marked.
- Fewer frosts could increase productivity but insufficient acclimation to low temperatures may expose plants to greater damage when frosts do occur.
- Lifecycle events (e.g. flowering, insect emergence, migration) are expected to shift in time or increase or decrease in intensity with likely and serious implications for mutualistic relationships (e.g. pollinator-plant or mycorrhiza-tree) and biodiversity.



- Plants and animals are likely to alter their distributions in response to changing climate conditions. However, our capacity to predict distribution changes is limited by differences in species-specific tolerances and acclimation behaviour and the unknown contribution of non-climate factors in determining distributions
- The response of pests, pathogens and weeds will vary. Some are expected to spread and become more severe while others will retract.

Biophysical impacts of climate change will have flow-on impacts on society. Both literature review and stakeholder surveys suggest that:

- Forest managers must manage for multiple-outcomes. Their perception of climate change issues extends to social, economic and governance concerns. However responses to climate change vary greatly.
- Future socio-economic impacts of climate change may include changes in land use (including abandonment), changes in intrinsic values of forests (production, habitat), changes in carbon storage (and value) and changes in ecosystem function values (e.g. salinity control). Impacts will differ according to forest type.

The authors also explored regional differences in the vulnerability of forest types to climate change, using the agroclimatic framework of Hobbs and McIntyre (1995). For example, the tropical savanna biome is likely to experience warmer temperatures, more rain in the wet season and less in the dry season. Natural vulnerabilities in this biome include exposure to extreme weather events, risk of pest/disease/weeds, changing fire regimes and increasing severity of the dry season. Closed forests in mesic savanna may expand, while xeric savannas are likely to experience tree death in times of drought.

This kind of regional vulnerability assessment has been applied to all ten biomes. The adaptive capacity of Australia's forests is strengthened by: a well developed economy; extensive scientific and technical capabilities; disaster mitigation strategies and plans; and biosecurity procedures.

In addition there is a history of management and existing policies in place specific to forests. Factors that may diminish adaptive capacity include: limited, slow or non-acceptance of adaptive measures at a local level; organisational, political, economic and social obstacles; the demographic of the forest industry; exposure to failed schemes (e.g. Managed Investment Scheme); market uncertainty; land use competition; loss of expertise; lack of local knowledge; economic costs; and policy uncertainty. The areas with the greatest vulnerability will be: those with the highest exposure to extreme events; forests/species at the edge of their tolerance; established plantations; and/or land that is already stressed.

Legal arrangements and policy in Australia are directed at conservation and ecologically sustainable development of forest resources and are for the most part fragmented, sectoral and largely without reference to climate change, its causes and its impacts. New models of environmental law may be required to manage forest resources under climate change.

The Forest Vulnerability Assessment also identified significant knowledge gaps and makes recommendations for future research. It is expected that the Final Reports from this assessment will be released in mid 2010.

THE NATURE AND UTILITY OF ADAPTIVE CAPACITY RESEARCH

While there has been a recent increase in studies and publications on adaptive capacity, there has been no assessment of the nature of adaptive capacity research, or on its utility for decision-making. This project assesses the interpretation and approach to adaptive capacity research among a range of disciplines, and the utility of the concept, in order to make recommendations to improve synergies between climate change adaptation researchers and decision makers.

The project, led by Professor Tim Smith, Director of the Sustainability Research Centre at the University of the Sunshine Coast, actively engages stakeholders through an online survey and key informant interviews.

Project objectives

- To assess the interpretation and approach to adaptive capacity research among a range of disciplines.
- To critique case studies in which an attempt is made to assess adaptive capacity of a community, region or sector.
- To assess the utility of the concept of adaptive capacity for decision-making on adaptation policy and planning.
- To develop recommendations to improve synergies between climate change adaptation researchers and decision makers.

Project approach

The project was undertaken in three parts:

- Literature review
- Online survey
- Key informant interviews

Project outcomes

Adaptive capacity has become widely acknowledged as a fundamental component of vulnerability to climate change. The aims of this project are to:

- (i) assess the interpretation of, and approach to, adaptive capacity research among a range of disciplines; (ii) critique case studies in which an attempt is made to assess adaptive capacity of a community, region or sector; (iii) assess the utility of the concept for decision-making; and (iv) to make recommendations to improve synergies between climate change adaptation researchers and decision makers.

Survey results show that there is little difference in the conceptualisation of adaptive capacity among researchers from a range of disciplines. Anthropocentric conceptions dominated comments within most disciplines, while a systems view is also evident, but dominates in the biological sciences.

The two disciplinary fields found to be most positive about a socio-ecological future with respect to adapting to climate change are studies in creative arts and writing, and physical sciences. The two most negative disciplinary fields are law and legal studies and philosophy and religious studies. All disciplinary fields shared the dominant belief that power/agency to create the future lies both internally and externally.

Both the literature review and survey results support the proposition that the next frontier that may challenge the assumptions underlying adaptive capacity research may be a greater appreciation of holism born out of resilient systems thinking. A shift across all disciplines from the dominant anthropocentric view of adaptive capacity to a holistic systems view based on resilience science is likely and may change the understanding of adaptive capacity. The literature review, survey and key informant interviews all suggest that the approaches and methods used for adaptive capacity research tend to show paradigm shifts from mono-disciplinarity to trans-disciplinarity; linear one-way research by scientists for practitioners to participatory research; and actor-orientated to systems-orientated conceptualisations of adaptive capacity.

The findings of the key informant interviews support the literature review regarding the proposition that multi-disciplinary research methods and diverse ways of knowing are needed to understand adaptive capacity. The key informants' comments about knowledge gaps put the greatest emphasis on the need to focus on context-specific research; as well as, the socio-cognitive factors of adaptive capacity.

These two identified areas of further research, when combined, aim to unpack the diverse value systems, worldviews and behaviours operating within a context-specific system.

The literature, case studies and survey results indicate that adaptive capacity research has enhanced the knowledge base of decision makers for effectively devising policy, planning and implementing adaptation strategies. While over half of the decision makers (55%) surveyed considered that responding/adapting to climate change impacts is now core business within their policy/decision-making, 72% of decision makers agree with the statement that more effective ways are needed of building their organisation's capacity to adapt and become more resilient to climate change impacts. This suggests ongoing demand for mainstreaming adaptive capabilities within organisational systems. Furthermore, 65% of decision makers rated the concept of adaptive capacity as useful in directing their programs. In contrast, 16% of researchers rated the application of adaptive capacity programs undertaken by communities, organisations and governments as ineffective (inclusive of partly ineffective and strongly ineffective), 17% took a neutral position, and only 39% believed adaptive capacity programs are partly effective. However, from the

literature review it was apparent that not enough is known about monitoring and evaluation of adaptive capacity programs.

Context and uncertainty are recurring themes for decision makers around the utility of adaptive capacity. The survey results indicate that adaptive capacity research is occurring largely across scales and systems at the State/Provincial level when considering socio-ecological systems.

The least effort is occurring at the local scale when studying biophysical systems: the sphere where the literature review found the greatest need (more environmental information is needed for local governments to be effective adaptors and policy makers). Key informants also raised the need for further research to understand the effectiveness of interventions at the appropriate scale, barriers to adaptive capacity, and how governance drives success or failure of adaptations and adaptive capacity interventions in an uncertain world.

Knowledge gaps in adaptive capacity research from the literature review and key informant interviews indicates considerable convergence, although additional and perhaps more marginal issues are identified from both sources.

The report concludes with recommendations for improving synergies between climate change adaptation researchers and decision makers. This can be achieved by providing:

- socio-ecological systems research meta-criteria for the development of adaptive capacity; and
- guiding principles for decision makers to navigate the complexities of adaptive capacity.



Photo: Annabelle Jones

HISTORICAL CASE STUDIES OF EXTREME EVENTS

A suite of case studies are being developed examining present-day management of climate variability and the lessons that can be learned for adaptation to future climate change.

Although the parallels are not exact, understanding community, institutional and governance responses to climate extremes, and their interactions, is informative of the conditions that determine the success or failure of climate change adaptation strategies.

These projects are examining case studies of six historical extremes:

- Cyclone Tracy, Darwin, Christmas 1974, undertaken by Macquarie University
- East Coast Lows and the Newcastle Central Coast 'Pasha Bulker' storm, undertaken by Newcastle University
- The 2009 heat wave in southern Australia, led by Queensland University of Technology
- Drought and the future of small inland towns (2 projects)
 - Kalgoorlie and Broken Hill, undertaken by Murdoch University
 - Mildura and Donald, undertaken by Newcastle University
- Storm tide inundation and coastal erosion, undertaken by Griffith University
- The 2008 floods in Queensland, led by the University of Southern Queensland, together with James Cook University

The outcome will be a set of freestanding case studies that together provide in-depth explorations of our knowledge of present-day adaptation, vulnerabilities and resilience to climate variability and change.

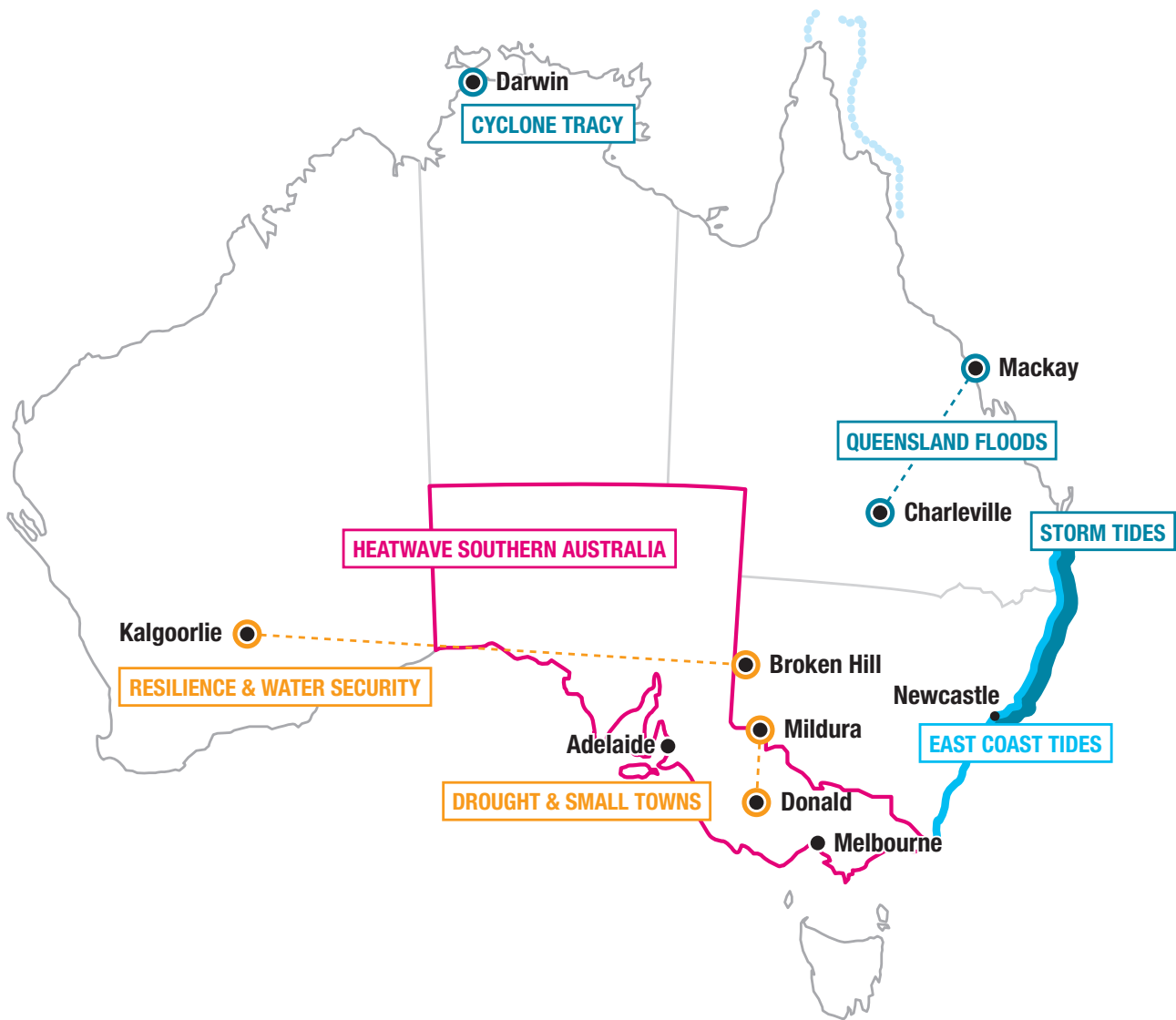
Project reports will be published on the NCCARF website, and targeted information resources using this research will be developed for key research end users. A book is planned around the title 'Natural Disasters and Adaptation to Climate Change' to which these projects will contribute chapters.



Photo: EMA/Geoscience Australia



MAP SHOWING LOCATION OF HISTORICAL CASE STUDIES



CASE STUDY 1: ADAPTATION LESSONS FROM CYCLONE TRACY

Chief Investigator: John McAneney, Director of Risk Frontiers at Macquarie University.

The study reviews the impact of Tropical Cyclone Tracy on the city and people of Darwin, the Australian engineering and institutional responses it invoked and the relevance of these lessons in the face of climate change.

At Christmas, 1974, Tropical Cyclone Tracy laid waste the city of Darwin, an iconic episode in the history of Australian natural disasters. It provides one of the clearest and most successful examples worldwide of adaptation to a catastrophe.

Three decades on, this study reviewed the historical context of the event; examines why Darwin was so vulnerable; the government and societal responses to the event; and, the relevance of these responses today. It sourced and reviewed archival newspaper and official reports, and conducted interviews with key people involved in post-event reconnaissance and implicated in the introduction of new wind regulations; those responsible for administering these regulations today; and, those engaged in research and emergency management aimed at improving public safety in at-risk communities.

A scenario analysis of a repeat of Cyclone Tracy under today's conditions was performed to evaluate the financial impact of improvements in construction standards. In so doing, the project updated a report undertaken for the Australian Building Codes Board and re-examined assumptions made in that report in relation to Cyclone Tracy.

The report briefly considers how the response might differ today, given the much greater private sector ownership of buildings than was the case for Darwin in 1974. An investigation of the role the insurance sector plays in future-proofing communities against subsequent disasters was performed through interaction with key personnel at the Territory Insurance Office in Darwin.

Project objectives

1. Determine the cause of structural failures in Darwin buildings during Cyclone Tracy. Show how these shortcomings in engineering knowledge have been overcome.
2. Study the role of institutional bodies in overcoming engineering shortcomings and how these bodies implemented positive change. Determine whether current government bodies could act in a similar manner.
3. Quantify the potential damage to Darwin's building stock if Cyclone Tracy were to impact the city today. Compare this to the 1974 scenario and comment on how/why this has changed.
4. In examining the published material, evaluate the level of public awareness of cyclonic impacts in Darwin prior to Tracy and how this has changed over the last 35 years.
5. Evaluate the role of insurance in improving the resilience of the community in any future damaging cyclonic event.
6. Use lessons learnt from previous objectives to comment on how these could be applied in a changing climate predicted to produce more severe atmospheric hazards.



Photo: EMA/Geoscience Australia

Summary of project findings

Cyclone Tracy was an engineering failure. Much of the ensuing human toll could have been significantly reduced with engineering solutions. After the cyclone passed, approximately 60% of Darwin's houses were destroyed beyond repair, with only about 6% considered immediately habitable. This left approximately 40,000 people homeless and necessitated an evacuation of 80% of the city's residents. Larger structures performed considerably better, with the number destroyed dropping to around 20%. These factors highlight two significant changes that had to be made to the way housing was constructed:

- The structural integrity of housing had to be considered more seriously than was current practice. It was no longer acceptable to suggest that the low cost of housing justified an unscientific approach to its design, based on the fact that it could be easily and cheaply replaced in the event of failure. The human toll of this occurrence was shown to be too great.
- As highlighted by the significantly improved performance of larger structures, when use of engineering based codes of practice was enforced, significant improvement in structural resilience could be achieved.

To address these two issues, the engineering community resolved to determine the cause of failures that occurred during Tracy, to improve current codes of practice to account for the new understanding of cyclone winds, and to completely overhaul the methods for constructing housing and develop improved, engineering based, techniques to build stronger homes and ensure occupant safety. The changes, particularly to housing construction, were at the time radical, but the national horror at the damage to Darwin meant the social and political will was right for such changes to be made, irrespective of any resistance by industry. Outside of a post-disaster time frame the extent and rapid implementation of such significant changes would not have been possible. In the immediate aftermath of Tracy, engineers analysed most of the failed structures, determined general failure mechanisms, and developed interim, but conservative, design recommendations so reconstruction could begin.

The improved building standards were applied to large structures and housing alike and, at least for the reconstruction phase, a certified engineer was required to approve all building designs. This was a huge step for a housing construction industry that had typically relied largely on a builder's experience to determine the most appropriate method of construction.

With time, new research allowed refinement of the recommended design and construction methods, and these eventually made their way into national building standards and to other cyclone prone regions of the country (though some were using them well before they were found in the standards). Because of the new rational approach to housing design, it was found that many of the post-Tracy recommendations were equally applicable to non-cyclone regions, and through the newly developed wind loading standard for housing, were applied in these regions also. In principal, every home now built in Australia encompasses the lessons learnt from Cyclone Tracy.

To investigate the impact of improvements made to the wind resistant design method, two studies that aimed at predicting present day losses if Tracy were to recur, were reviewed. In all, it is suggested that in the event of recurrence, the proportional damage to the building stock of Darwin would be reduced by up to 85% (damage ratio), and importantly to a level that would no longer necessitate an evacuation. This greatly reduces the monetary and sociological impact of the recurrence of a similar event.

Despite positive changes made, there are still issues with building methods that may unnecessarily increase the risk of failure under extreme wind conditions. Irrespective, changes made to the wind loading standard in light of Cyclone Tracy have led to the development of a world leading wind resistant design practice in this country.

CASE STUDY 2: EAST COAST LOWS AND THE NEWCASTLE-CENTRAL COAST 'PASHA BULKER' STORM

Chief Investigator: Professor Garry Willgoose, University of Newcastle

The Pasha Bulker storm was a result of an East Coast Low (ECL); these systems are the cause of most major flood events in autumn and winter on Australia's coastal strip from the Sunshine Coast south to the Victorian border.

The June 2007 Pasha Bulker storm was one of the most significant meteorological events in Australia's history. It was the 4th largest general insurance loss (inflation adjusted) since systematic insurance records were started in 1968. The storm consisted of three distinct impacts:

- (1) flash flooding in the urban area of Newcastle and as far south as the NSW Central Coast impacted 800,000 people on the night of 8 June (about 1 in 100 year return period)
- (2) more general flooding on the Hunter River 3 days later impacted about 100,000 people (about 1 in 40 return period), and
- (3) high winds and wave heights on the night of 8 June were the worst in the Newcastle-Sydney region since the Sygna storm in 1974, also an east coast low.

While the media focus was on the bulk carrier Pasha Bulker grounded on a Newcastle beach, and the Hunter floods, it was the 8 June flash flooding that caused the bulk of the insurance losses, and 5 fatalities.

Significant economic losses and social disruption occurred as a knock-on effect of the loss of critical infrastructure that left 300,000 people without mains electricity for 4 days, some for up to a month and halted the coal export chain for two weeks.

The worst flooding impact was in the Newcastle CBD. This area is now undergoing active urban revitalisation with Federal and State Government financial support, and provides a possible case study of adoption of adaptation measures as part of urban redevelopment.

Project objectives

The study provides a whole-of-government, business and community perspective on the:

- climatological context and impacts of the Pasha Bulker storm;
- adaptation measures being put in place as a result of the knowledge gained from the experience from within and immediately after the storm, for example in emergency services and provision of social support;
- adaptation measures being put in place following subsequent reflection on ways of better preparing for such storms e.g., urban planning guidelines, electricity infrastructure, etc.

The impact study focussed on some key stand-alone impacts, and impacts that resulted from interactions between the infrastructure of key government and private enterprise providers.

The study of the adaptation response focussed on three aspects:

- (1) The success of the Maitland Hunter River Flood Protection system in minimising losses as a result of the Hunter River flooding.
- (2) The apparent failure of protection measures for urban flash flooding, and the institutional and political impediments to addressing the problem.
- (3) Lessons learned that are applicable to other urban areas impacted by ECL and the lessons assimilated into future plans for redevelopment of inner-city Newcastle.

The project pulls together existing government and stakeholder analyses of the impacts of the storm as well as an extensive set of pre-existing analyses of the event from hard and soft infrastructure holders and service providers.



Some outcomes from the project

Policy based recommendations that have been highlighted in this report include:

- The experiences gained during the June 2007 event highlight the need to have a list of pre-established facilities that would be suitable to act as a Disaster Recovery Centres (DRCs) in such an event.
- State and local governments must continue to invest in ensuring that an adequately skilled environmental health workforce is available and equipped to respond to disasters and emergency events such as the Pasha Bulker storm.
- Greater community awareness of insurance cover inclusions is needed along with a framework to cover aspects of storm damage not included under general home/business insurance (e.g., landslip, fallen trees)
- A consistent policy for coastal developments (agreement at Federal, State and local level of governments) is needed to deal with existing coastal infrastructure/housing and planning guidelines around new infrastructure/housing.
- Increased community awareness of emergency procedures and processes is needed, along with information and education opportunities which strengthen the community's sense of safety and confidence in preparedness for future disaster events.
- Ongoing communication and education of communities susceptible to flooding (both flash flooding and river flooding) is required to ensure people respond appropriately to flood warnings in the future.
- Further work needs to be carried out to evaluate the benefits of flash flood warning systems in fast response catchments in order to build a strong case for the installation of such systems.
- It is recommended that all States and Territories would benefit from formal arrangements with the ABC [radio and television services] for provision of emergency health information during a disaster.
- It would be beneficial for Natural Disaster Recovery Relief Arrangements (NDRRA) funding guidelines to be more flexibility in situations where cleanup and emergency works are unable to be carried out immediately.



Photo: Webster Chen

CASE STUDY 3: 2009 STORM TIDES IN SOUTH-EAST QUEENSLAND AND NORTHERN NEW SOUTH WALES

Chief Investigator: Professor Roger Tomlinson, Director Griffith Centre for Coastal Management, Griffith University.

This study focuses on the May 2009 storm that affected South East Queensland and Northern NSW. It examines socio-economic vulnerability and adaptation responses to extreme coastal storm events that result in severe erosion and coastal inundation.

Project objectives

1. Identify current socio-economic and physical vulnerabilities of coastal communities and coastal ecosystems to climate and weather-related hazards.
2. Determine the factors contributing to socio-economic vulnerability to coastal storm hazards and identify areas, communities and social groups particularly vulnerable.
3. Review past technical, policy, planning and regulatory responses to extreme coastal erosion and storm tide events and identify attributes of capability to cope with and recover from past events.
4. Assess the effectiveness of past responses and their suitability for likely future events under climate change.
5. Identify alternative or additional strategies that can improve community preparedness.

The study explores vulnerabilities, disaster responses and changes in planning, management and policy which are enacted or proposed, and which may result in long-term adaptation improvements. This analysis is supported by an examination of previous storms which have impacted on coastal settlements. In particular the study examines the locations where specific planning and management action has already been implemented in response to past impact, including:

- Collaroy/Narrabeen, where a range of measures has been used including property buy-back schemes
- Byron Bay, which has adopted a policy of 'planned retreat', involving planning set-backs and associated constraints on new development
- Gold Coast, where the principal strategy has involved the construction of coastal protection infrastructure.

Project Outcomes

The majority of Australia's population and major cities are located on the coast. Since the 1950s, many coastal settlements have changed from 'family' beach holiday villages to permanent settlements and in some cases growing urban areas. The Gold Coast is now the sixth largest urban area in Australia and Noosa has highly priced CBD real estate. Many of the people who have moved to these rapidly growing coastal areas have not experienced the physical or economic impacts of major coastal storms and are unaware of the risks from sea-level rise and intense tropical cyclones.

Sea level around Australia has risen some 130mm since 1820, with 70mm of that rise since 1950. Rising sea-levels will result in greater impacts from storm tides, which are a major natural hazard for coastal communities. Severe storms and cyclones account for a third of the total damage cost from natural hazards to the Australian community; estimated at \$40 billion between 1967 and 1999 (calculated in 1999 dollars)

This study mirrors the findings of other recent studies showing that infrastructure and development immediately adjacent to beaches is vulnerable to erosion and damage. Climate change predictions suggest that regardless of greenhouse gas reduction programs sea level will continue to rise for centuries. As a result, the coast will continue to move inland.

In recent decades, significant storm surges have not occurred and vulnerable areas have been populated.



Many low lying recently developed coastal areas are vulnerable to inundation from significant storm surges. The absence of severe storms has lured beachfront residents into a false sense of security and lessons learnt in the 1960s and 1970s will have to be learnt again. In many cases, relocation will be the only option and it is unlikely that it will happen in a planned orderly fashion as envisaged in the Byron Planned Retreat policy. Relocation will not happen until people are forced to move by events.

While each of the site studies is facing the same problems of ongoing erosion from rising sea-levels, three decades of very low storminess has only lightly stressed the coast. Future storms, as those that have occurred in the past, will cause unprecedented damage. In general, emergency management is well placed to prevent loss of life and experience of past major storms shows that there is little that can be done during the event. In all three site studies there are examples of material being dumped over the dunes to lessen erosion damage.

Adaptive management responses are predominantly reactive i.e. during events. There are considerable problems building adaptive capacity into coastal planning schemes due to a lack of cooperation and

consistency across government. Policy makers and stakeholders need to be aware of the issues and provided with tools to help them assess risk and make decisions.

Communities have been loath to accept seawalls or groynes across the beach. Proposed groynes at all three of the site studies were rejected by the community and not built. Seawalls to control erosion have also been rejected by the community, with the exception of the Gold Coast where the wall is buried under the dunes at the back of the beach.

Storms in recent years have not been severe enough to seriously stress beach systems. The return of severe storm energy will change the engineering and economics of nourishment.

We need to bridge the gap between adaptive theory and the practicalities in terms of planning and development on an eroding coast. This will be resolved by storms causing unacceptable damage and forcing governments and communities to face up to the issue.



Photo: Michael Mitchell

CASE STUDY 4: THE 2008 FLOODS IN QUEENSLAND: A CASE STUDY OF VULNERABILITY, RESILIENCE, AND ADAPTIVE CAPACITY

Chief Investigator: Associate Professor Armando Apan, University of Southern Queensland

Co-Investigator: Associate Professor David King, James Cook University

This study aims to enhance understanding of the vulnerability, resilience and adaptive capacity of people and communities to flooding, and to assess the extent to which flood mitigation measures have been implemented by institutions. It focuses on two flood events: the Mackay floods and Charleville floods in 2008. The study comprises an intensive literature review together with questionnaire surveys, focus groups, and extensive interviews to gather relevant data for interpretation and synthesis.

The outcomes of this study will provide information, knowledge and insights on how various stakeholders can better respond and adapt to flood events.

Project objectives

1. To understand how societies that are regularly flooded operate and the characteristics of their resilience or non-resilience.
2. To understand the characteristics of communities that are 'on the edge', where flooding might push them into non-viability.
3. To understand the extent to which flood mitigation measures (including State Planning Policy 1/03) have been applied to reduce the vulnerability to flood events.
4. To identify the characteristics of vulnerability, resilience and adaptive capacity to flooding of households, businesses and institutions.

Both case studies were selected to be representative of different levels of impact and types of settlement. Mackay is a medium sized city in which the issues, experiences and responses are expected to be representative of major urban areas. It lies on a highly vulnerable flood plain and

experiences sustained population and economic growth. Mackay's flood vulnerability derives from its proximity to the Pioneer River, as well as flash flooding which may also accompany cyclone events. These two characteristics are common to a number of other coastal cities in Australia, including large cities such as Brisbane.

Charleville is representative of the inland and outback regions, with a small population and economy, vast hinterland service area, basic infrastructure and slow population and economic growth. It lies on an extremely vulnerable extensive flood plain with no significant elevated areas for relocation. Like many inland regions, Charleville experiences frequent flooding, thereby representing a community 'on the edge' in terms of its susceptibility to repeated floods, and often experiences long periods of flooding leading to isolation and disruption of services.

Project outcomes

The study concludes that those established in areas that are vulnerable to regular flooding, who had greater connections within the community, displayed more resilience in the event of a disaster flood event. Thus, the Charleville community was found to be staunchly resilient, with high levels of sense of belongingness and commitment on the part of residents, businesses and institutions to remain in the community irrespective of future flood events. In comparison, low participation rates in the community, low formal volunteerism rates in Mackay and the belief that they have a limited personal responsibility to prepare for floods and mixed views on the question of belongingness, indicates weaker levels of resilience in Mackay.



In Mackay, the length of time a business had been established was linked to flood impacts indicating a complacency to flood events at some point as evidenced by the expansion approved for the development of industrial estates and retail outlets in lower lying areas of Mackay. The Mackay community could be considered a less resilient community as compared to Charleville in terms of social capacity but Charleville was considered to be a less resilient community in terms of economic capacity.

This study found the elderly was a social group vulnerable to disaster flood events. It also highlighted the psychological impacts of the flood on the community. The research of the Mackay 2008 flood indicated that lack of prior exposure to disaster events was a critical factor contributing to mental health and reducing the resilience of communities in the post-disaster phase. Consequently, it is recommended that mental health be included as a component in the consequences phase in addition to the 'macro-economic' impacts that may in turn increase the vulnerability of a population.

The research conducted did not show any direct correlation between implementing mitigation measures and avoidance of flood impacts

in Mackay. However, due to the purposive methodology used in the research design where those households and businesses that received flood damage were selected, this may subsequently indicate that those who were not impacted by the floods had implemented a greater number of mitigation measures which provided greater resilience to the flood event. Planning and development was found to play a critical role in the resilience of communities to disaster events such as flooding.

This research indicates a significant increase by households and businesses affected by the disaster flood event to implement flood mitigation actions. Data from the research found both residents and businesses may consider moving to other parts of Mackay but the majority indicated that they would not move to another town which highlighted the preference to live in the urban coastal city despite its vulnerability to natural disaster events such as flooding. However, there may be some scope to recognise that households affected by natural disasters move to another suburb or town as a means to increasing their adaptive capacity. Businesses in Charleville had no alternative location to move to and few of their residents contemplated relocation.



Photo: Wally Irwin

CASE STUDY 5: DROUGHT AND THE FUTURE OF SMALL INLAND TOWNS

Principal investigator: Dr Anthony Kiem, University of Newcastle

Australia's vulnerability to climate variability and change has been highlighted by the recent drought situation. For example a persistent rainfall deficiency over the past seven to ten years has resulted in low inflows into the Murray-Darling systems with some active storages currently at less than 20% of capacity.

This project examines the impact of drought on two case study sites, Mildura and Donald, in Victoria. The towns have differing water sources, rainfall and climate patterns, economic bases, population sizes and water resource management practices, but both have been strongly impacted by the current drought.

For each case study this project:

- places water supply and drought into context;
- identifies where drought related problems lie, what the potential solutions are, what adaptation strategies are in place or have been trialed, what decision-making processes were, or are, in place to arrive at drought management solutions;
- collates information on the experiences of people living with water shortages; and,
- discusses the likely future under different water resource scenarios, including options for adaptation to drought in the future.

Project outcomes

Drought and long-term drying of these traditional agricultural regions represents just one challenge of many. Drought itself is experienced in different ways from Mildura to Donald. For Donald, drought conditions are not uncommon in an agricultural area that relies almost solely on rainfall. However, some of the most devastating and influential effects of drought have been felt through the irrigation districts

of Mildura: declining water supply and security; a new system of water trading and allocations; and navigating and managing a water market of tradeable and saleable water unbundled from the land. In Mildura, there is a deep attachment to the Murray River. Drawing on people's close relationship with the river and water can present opportunities in nurturing new understandings of water. Such a change in thinking around water, its value, and availability will be essential under the continued predicted drying of this region into the future.

It is not just drought confronting these regions. Exacerbating the issues of water security and supply is the complex of farming industry and rural demographic changes currently occurring across both regions:

- changes presented by declining and fluctuating commodity prices;
- shifts in the farming sector more broadly (e.g., rise of the large amalgamated farm and multinational agri-business and flow-on effects); and
- rural demographic shifts characterised by declining and ageing populations, decreases in young people and an influx of retirees, immigrant and low socio-economic groups seeking access to low cost housing and employment.

Economically, many farms are experiencing dwindling financial returns and reserves after many years of drought and low commodity prices. Many farming families are subsequently seeking to diversify their income base through secondary or 'off-farm' employment. Off-farm income can ensure economic survival but it limits more strategic financial and farm planning and is putting increasing strain on family relationships. In Mildura, economic survival is also supported by a burgeoning "welfare industry", created and sustained by reactive government support programs.



Although Donald may demonstrate a better picture of economic health, the situation still does not support investment, adaptation, or long-term planning for the future. At best, there are significant opportunities for proactive action in these dryland regions to avoid the looming ‘welfare disaster’ presented by Mildura.

There are extensive social impacts created by the drought and other conditions confronting these regions:

- Farmers are increasingly suffering from depression and emotional exhaustion with an increased incidence of suicide, separation and relationship breakdown, grief and feelings of loss and shame, and withdrawal from the community and social activities.
- Initial contact with these farmers is often through the Rural Financial Counselling Service, accountants, and financial advisors who are performing support roles well outside their professional capabilities in many instances. Trained and supported mental health professionals are needed immediately.
- Children are increasingly deprived of essentials and educational opportunities, and are experiencing the pressures placed on their parents.
- The educational and training opportunities for farmers are also impeded, with increasing pressures of time, money and exhaustion limiting farmers’ participation in training programs.
- Withdrawal of farmers and farming families into their own problems can often result in decreasing participation in community events.

Ideas of strength and resilience central to the identities of these rural communities are being tested to their limits. Uncertainty is leading to stagnation and is impeding change, adaptation and activity. There is scepticism in relation to anthropogenic climate change and research continually targeting these communities.

For farmers and those working in support services, there were four commonly identified practices and programs that they observed as successful and fundamental to the provision of effective long-term support in the region: 1) Collaboration between rural service providers and practitioners; 2) Community-led projects and programs; 3) Proactive, consistent and long-term approaches to service provision; and 4) Practice-oriented research and development schemes.

Extensive adaptation and mitigation measures are being used, experimented with and talked about on farms. Even in remote conservative rural areas renowned for scepticism and disbelief in anthropogenic climate change, people undertake adaptive on-farm practices, and think about different climatic futures. For Mildura, its size and industry scope will provide some buffering from the rapid changes and impacts on farming in the region. For many of the smaller towns throughout the dryland region, their future remains uncertain as people, services, schools and businesses are depleted – a pattern which is likely to be enhanced under a drying climate.

Ongoing drought and drying, and less available water, are widely acknowledged as a realistic climatic future for such regions. For the irrigated areas of Mildura, they are facing “uncharted territory” as they learn to live without water. Whilst in the dryland regions around Donald, drought has in many ways merely accelerated already occurring changes to both the farming industry and rural demographic make-up of these small rural towns. The economic and social impacts of these shifts require multiple service and support strategies, agency coordination and lots of learning. People will need to be well-supported through the processes of change, in ways that are respectful and revitalising for people who are fatigued from the chronic drying of their environment and the increasing pressures on their farming enterprise.

CASE STUDY 6: RESILIENCE AND WATER SECURITY IN TWO OUTBACK CITIES

Principal investigators: Professor Glenn Albrecht and Dr Helen Allison, Murdoch University

This project explores the adaptive capacity of two relatively large inland regional centres, Kalgoorlie in WA and Broken Hill in NSW, facing different challenges relating to climate change and water supply.

The study will:

- Outline the challenge of water security and sustainability for the inland cities of Kalgoorlie and Broken Hill.
- Identify the historical and current processes that interact to create this challenge, and that also provide the basis for a systematic understanding of water resource use.

- Provide a range of water security future scenarios that will assist in planning for, and adapting to, climate change and other pressures.
- Consider the infrastructure, cultural and organisational change needed to meet the water security and sustainability challenge for each city.

This project should complete in late 2010.



Photo: Brian Voon



CASE STUDY 7: IMPACTS AND ADAPTATION RESPONSE OF INFRASTRUCTURE AND COMMUNITIES TO HEATWAVES THE SOUTHERN AUSTRALIAN EXPERIENCE OF 2009

Principal Investigator: Jim Reeves, Queensland University of Technology

This study will detail the impact, vulnerability, and adaptation responses to the heatwave of 2009 at state and local government levels in southern Australia with an emphasis on Victoria and South Australia. The heatwave that affected southern Australia in the summer of 2009 brought unprecedented temperatures for prolonged periods of time. Whilst the extended duration and intensity of these high temperatures were predicted in short term weather forecasts, state and local governments were ill prepared. The multi-state heatwave induced increased power failures and load shedding with subsequent downstream impacts on transport infrastructure in the greater Melbourne area.

This study focuses on the already stressed utilities in this region and related infrastructure, and the community impacts and responses, including in the areas of emergency management and human health. Interviews and surveys will determine what adaptation mechanisms were in place prior to the event, how successful they were and what changes have since been made to improve future responses. The project includes: a detailed assessment of the climate event in the context of available records and indicators; an impact, vulnerability and adaptation assessment, including an analysis of the adaptive capacity of the region and post-event adaptation responses/measures; and, direct stakeholder engagement through interviews and workshops.

This project is expected to complete in late 2010.



Photo: Brian Voon

5.6 PHASE 2 SYNTHESIS AND INTEGRATIVE RESEARCH PROJECTS

NCCARF is currently commissioning a set of Phase 2 projects around the following topics:

Coastal ecosystem response to climate change

The goal of this project is to provide a synthesis of current knowledge and experience, drawing on Australian and international sources, to assess the implications of climate change for Australia's coastal ecosystems. The project will focus on a range of priority ecosystems and species across Australia's coastal zone, identified on the basis of their importance and vulnerability. Priority ecosystems and species are:

- fringing reef coral ecosystems;
- ecosystems dominated by macroalgae;
- mangrove ecosystems;
- saltmarsh ecosystems;
- seagrass beds;
- intact sandy beach systems including those that provide turtle and seabird nesting sites and haul-out sites for seals and sea lions
- coastal wetlands
- intact estuaries
- migratory bird species using coastal wetlands and shoreline habitats

The project will consider how these priority ecosystems and species will respond to the impacts of climate change, within the parameters set by the underlying geomorphological characteristics and processes, and the potential for and types of adaptive response..

Literature review: impacts of climate change

Understanding the likely impacts of climate change is an important foundation for adaptation. Such an understanding helps identify adaptation priorities, provides insights into the responses that may be effective, and underpins perceptions of the need to act. Information about impacts is limited and dispersed.

This project will search the literature to generate a consolidated and regularly updated set of 'facts' about the impacts of climate change in Australia. This will be valuable for policy-makers and will assist in preparing the Australia and New Zealand Chapter of the IPCC Fifth Assessment Report.

Learning from regional climate analogues

The project will take a spatial approach to the identification of analogues for future climate environments. It will be concerned with policy, process and planned adaptation, rather than behavioural response and autonomous adaptation. The hypotheses are, first, that there are regions of Australia, defined by their location, that currently experience climatic conditions which are indicative of future climates elsewhere and, second, that these conditions will affect institutional policy and practice.



To take a simple example, the climates of urban centres such as Darwin or Broome will affect the way that institutions are set up and managed. Understanding the influence of climate on institutions in such locations can inform our understanding of how institutions in urban centres where climates are currently more moderate, for example large southern cities, will have to adapt to future climate change. The analogues do not necessarily lie in the northern areas of Australia. They may, for example, lie in the drier, hotter regions of the centre.

By comparing government policy and institutional practice in present-day urban centres with their future analogues, it should be possible to identify differences which exist in response to differences in climate. By identifying these differences, it should be possible to define how decision-making, policy and management practices should change in order to adapt, where 'adapt' in this context means creating/maintaining high quality of life under a changed climate. That quality of life should include consideration of ecosystem services, as well as human welfare-related considerations such as appropriate building and urban design and appropriate expertise in primary and hospital health care.

Limits to adaptation

Much of the research on adaptation avoids the question of what adaptation cannot achieve. It is therefore implied by omission that adaptation can avoid all climate impacts. Yet this is clearly not going to be the case for many systems, sectors and places at even modest rates of warming, let alone at the more rapid rates of warming that now seem almost inevitable (Meinshausen et al. 2009).

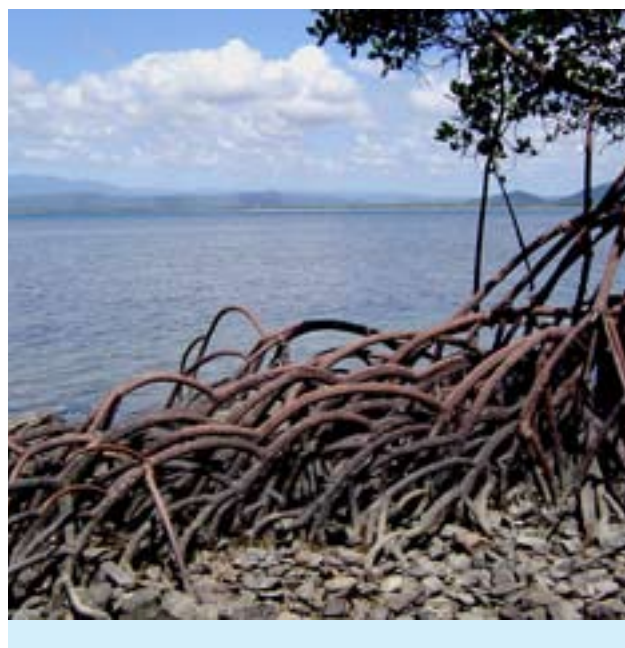


Photo: Jan-Olaf Meynecke

Understanding the limits to adaptation is an emerging frontier of climate change research. It is important for decision making about adaptation for three reasons. First, it helps to determine which responses to climate change are both practicable and legitimate, and the time scales over which adaptation may be considered to be effective. Second, it helps to understand how people may respond to the damage to, or the loss of, things that are important to them, for which there may, in some cases, be substitutes or ameliorating policy measures. Third, it can help prioritise adaptation strategies, refine their intentions, and identify communities that will be served by them.

It is planned to commission around 4-5 sub-projects under this heading, each concerned with a different region of Australia located in, for example, Alpine regions, wetlands, small islands and coral reefs. The principal task of projects will be to systematically work through the possibilities for and limits to adaptation.



6. ADAPTATION RESEARCH NETWORKS

BACKGROUND

Eight Adaptation Research Networks were established in January 2009 to assist in the delivery of information that policy and decision-makers need to determine climate change adaptation strategies and actions. The Australian Government has provided \$10 million in funding via NCCARF to operate these Networks, with additional contributions from Network host and partner institutions.

The purpose of the Networks is to build a collaborative, inclusive environment supporting creative, inter-disciplinary research that aims to: bridge gaps between fundamental and applied science, and advance priority sectoral research; and to facilitate interactions between researchers to advance climate adaptation knowledge. The host institutions will work closely with NCCARF to contribute to the synthesis of research related to a sector or region, and to ensure that all relevant expertise is harnessed to identify targeted research needs and facilitate the sharing of information.

These Networks have four key roles:

1. To promote and facilitate open exchange of information and sharing of resources.
2. Contribute to the work of NCCARF in synthesising existing and emerging research.
3. Contributing to the development and implementation of National Adaptation Research Plans.
4. Nurturing the careers of young investigators

and research students by promoting a sense of community, collaboration and strong, effective mentoring.

The Networks also have a key role to plan in engaging and communicating with key stakeholders, to better understand their information needs, to work with them in addressing these needs by improving access to information resources, and by facilitating information exchange between researchers and research end users.

Funding for the Networks is for a period of four years until December 2012.





ADAPTATION RESEARCH NETWORKS

- Adaptation Research Network for Emergency Management hosted by RMIT University and convened by Professor John Handmer
- Adaptation Research Network for Human Health hosted by the Australian National University and convened by Professor Tony Capon.
- Adaptation Research Network for Marine Biodiversity and Resources hosted by the University of Tasmania and hosted by Associate Professor Neil Holbrook
- Adaptation Research Network for Primary Industries hosted by the University of Melbourne and convened by Professor Snow Barlow.
- Adaptation Research Network for Social, Economic and Institutional Dimensions hosted by the University of Melbourne and convened by Associate Professor Jon Barnett
- Adaptation Research Network for Settlements and Infrastructure hosted by University of New South Wales and convened by Associate Professor Ron Cox
- Adaptation Research Network for Terrestrial Biodiversity hosted by James Cook University, and co-convened by Professor Stephen Williams (JCU), and Professor Lesley Hughes (Macquarie University)
- Adaptation Research Network for Water Resources and Freshwater Biodiversity convened by Professor Stuart Bunn.



Photo: Marie Waschka

Networks: approach and activities

Although the Networks have a common purpose, and seek to fulfil a set of agreed roles, they differ substantially in their focus, approach, funding, structure, and, management and governance arrangements. Networks have had the flexibility to develop their own set of activities and individual work programs, which has encouraged innovation and has allowed Networks to tailor activities that are best suited to their particular sector.

Now that the Networks have been in operation for more than year, and are moving beyond their establishment phase, a number of Network 'success stories', lessons learnt, challenges and priorities are apparent, which will provide a useful basis for continuing to build the capacity and usefulness of these Networks into the future.

Network activities during the first year 'establishment phase' typically included:

- Recruitment of Network staff (such as Network coordinators and support staff)
- Establishment of Network membership lists, and promotion of Network membership
- Establishment of Network websites
- Developing mechanisms for Network communication and information exchange (Network newsletters, e-lists, etc.)
- Setting up Network management and governance arrangements
- Work planning.

Network	Year 1	Year 2	Year 3	Year 4	Total
TERRESTRIAL BIODIVERSITY	363,636	363,636	363,636	363,636	\$1,454,544
WATER RESOURCES AND FRESHWATER BIODIVERSITY	363,636	363,636	363,636	363,636	\$1,454,544
MARINE BIODIVERSITY AND RESOURCES	363,636	363,636	363,636	363,636	\$1,454,544
SETTLEMENTS AND INFRASTRUCTURE	406,364	406,364	406,364	406,364	\$1,625,456
EMERGENCY MANAGEMENT	186,364	186,364	186,364	186,364	\$745,456
SOCIAL, ECONOMIC & INSTITUTIONAL DIMENSIONS	341,818	341,818	341,818	341,818	\$1,367,272
PRIMARY INDUSTRIES	330,000	310,000	310,000	156,000	\$1,106,000
HUMAN HEALTH	218,182	218,182	218,182	218,182	\$872,727

NOTE: All figures provided are exclusive of GST



Network activities have also included: research capacity building initiatives (including scholarship programs, early career researcher workshops, mentoring programs, and the development of an ‘Adaptation College’); some research synthesis activities (synthesis workshops and synthesis papers for example); and, some initiatives (delivered on-line) that have improved access to relevant resources, and to other researchers and research end-users.

Network funding

The following table summarises the NCCARF funding received by Networks over their four year term.

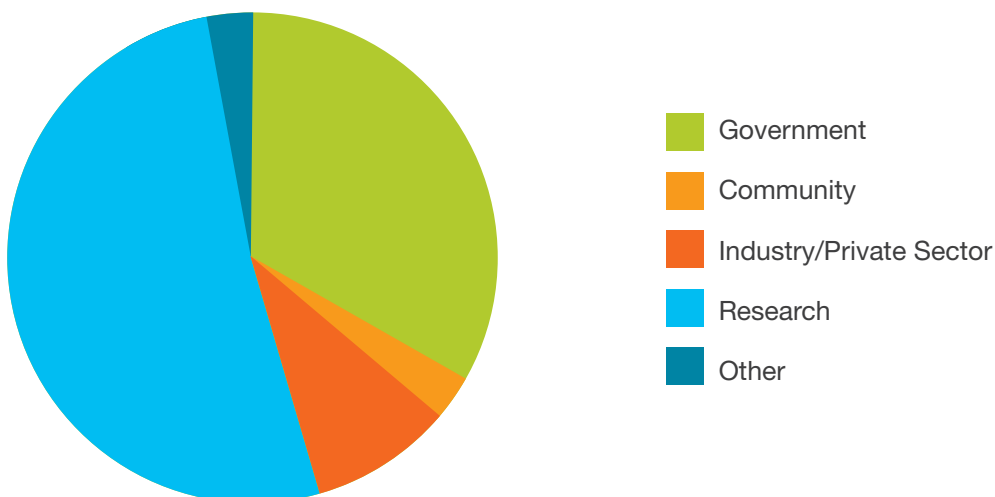
Network support

In addition to managing Network work planning and progress reporting, NCCARF also supports the activities of the Networks in a number of

ways, including by participating on a number of Network management committees, by providing communications support including the provision of communication templates, and by supporting the development and maintenance of Network websites, and by organising and hosting Network Convenors and Coordinators Meetings a year, which aim to encourage communication between Networks, and to support Network activities. NCCARF has also established a Network ‘intranet’ for Network Convenors and Coordinators.

There are approximately than 2800 members across Adaptation Research Networks. The distribution of Network membership across the research, government, industry and community sectors is illustrated in Diagram 1.

DIAGRAM 1: DISTRIBUTION OF NETWORK MEMBERSHIP ACROSS DIFFERENT SECTORS



Emergency Management Network



EMERGENCY MANAGEMENT NETWORK SNAPSHOT

Hosted by: RMIT University

Convened by: Professor John Handmer

Funding: \$745.456 over 4 years

Membership: over 270

Website: <http://www.nccarf.edu.au/emergency-management/>

Photo: Jan-Olaf Meynecke

The Network started from an original core group consisting of RMIT University, the Australasian Fire and Emergency Services Authority Council (AFAC), the Victorian State Emergency Services, University of Western Australia, Fire and Emergency Services Authority of Western Australia (FESA), the Australian National University, Macquarie University, Monash University, James Cook University, and Geoscience Australia. Altogether there are now some 80 organisations represented in this Network.

To establish a foundation for information exchange, the Network developed a regular newsletter, a membership email list and a Network website.

The Victorian bushfire disaster of 7th February 2009 and the subsequent and ongoing Royal Commission involved many of the key participants of the Network in the early months of 2009. Following this disaster, the Network co-hosted a workshop titled *Bushfire research after February 7: what we can expect and what's needed?* The workshop was for researchers, fire and emergency organizations involved in all aspects of fire risk management and recovery.

In partnership with the RMIT Centre for Risk and Community Safety, the Network is preparing an annotated literature review on climate change adaptation and emergency management.

This will contribute to a major review of the area being undertaken for the Network. The resulting bibliography will also contribute to the identification of gaps in knowledge and research activity.

The literature under review is multidisciplinary and includes climate change, geography, areas of social science, and disaster risk reduction. More specifically the review will include risk modelling, insurance/re-insurance, vulnerability, community engagement, decision making under uncertainty, resilience through adaptation, extreme events, warnings, emergency recovery, emergency organisations, coordination, engineering, economics, law, policy and policy development. It is designed to capture researcher, practitioner, and community perspectives.

The Network has played a key role in the development of the National Climate Change Adaptation Research Plan, with Professor John Handmer represented on the writing team for this NARP. The Network also assisted NCCARF in coordination of the funding call under the Australian Government's Adaptation Research Grants Program for this theme, including by promoting the research call and providing assistance in the preparation of funding proposals.



Human Health Network



NewsPix/Jake Nowakowski

HUMAN HEALTH NETWORK SNAPSHOT

Hosted by: Australian National University

Convened by: Professor Tony Capon

Funding: \$872,727 over 4 years

Membership: over 180

Website: <http://www.nccarf.edu.au/humanhealth/>

This Network has run a series of research planning workshops focussing on: vector-borne disease, mental health, and urban settlements, and supported a national workshop on thermal health impacts, vulnerability and adaptation.

The Network has developed a series of 'State of the Science and Policy' papers for publication, and has coordinated a collection of peer-reviewed papers on climate change and health for publication in the NSW Public Health Bulletin. Four of the five papers published in this bulletin were among the '20 Most Read Papers' in this bulletin in 2009.

The Network has established a mentoring program for early career researchers, with an initial focus on science writing. Network members also receive a regular newsletter, alert emails for relevant information items, and can access the Network website for the latest information about Network activities.

The Network is sponsoring the 2010 Australian Academy of Science Fenner Conference on the Environment on the theme of the co-benefits for health from action on climate change.

Dr Paul Beggs, Macquarie University, who co-leads the Air Quality node within the Network, was awarded the 2009 Eureka Prize for outstanding research on climate change and health.

The Network played a key role in promoting the NHMRC special call for funding related to research priorities identified in the Human Health NARP, including by convening information workshops.

Marine Biodiversity and Resources Network



MARINE BIODIVERSITY NETWORK SNAPSHOT

Hosted by: University of Tasmania

Convened by: Associate Professor Neil Holbrook

Funding \$1,454,544 over 4 years

Membership: over 450

Website: <http://www.nccarf.edu.au/marine>

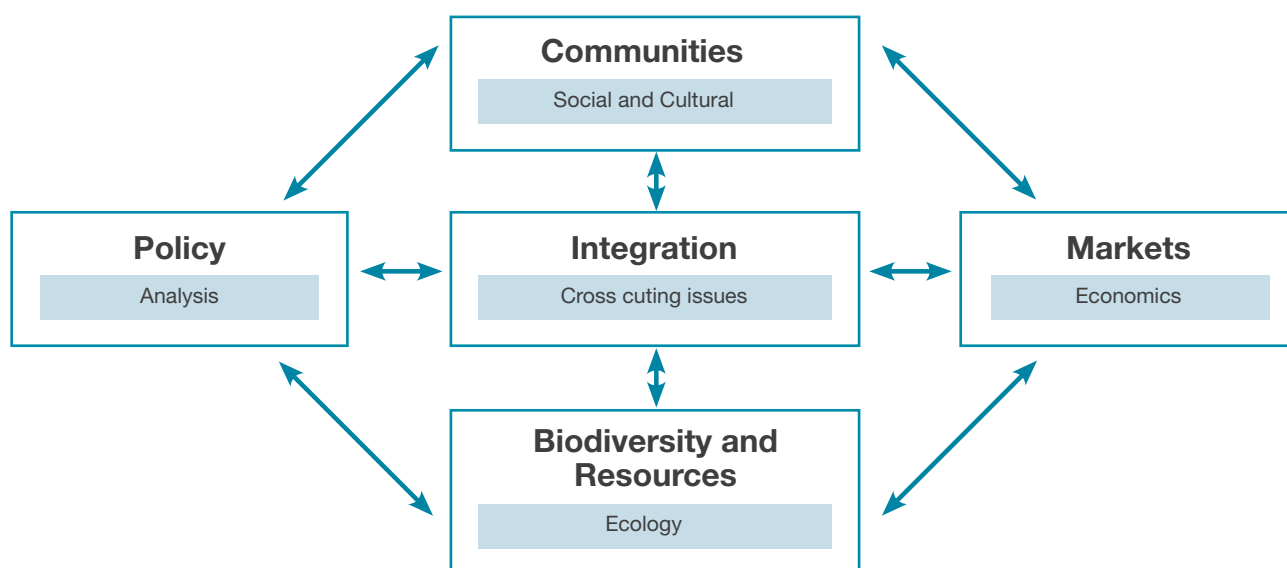
Photo: James Dunn

The framework for this Network comprises of a consortium of 14 partner institutions across Australia which are integral in the organisation and management of the Network and its activities.

The Marine Network comprises a holistic framework of five connecting marine themes (integration, biodiversity and resources, communities, markets, and policy, see Figure 1) that cross-cuts climate change risk, marine biodiversity and resources,

socio-economics and policy, and includes ecosystems and species from the tropics to Australian Antarctic waters. These themes are arranged so that each has a theme leader and co-leader who organise and drive the theme and activities, with valuable input from partner organisers. Each theme is also supported by a funded part-time Research Associate/Fellow who is integral in aiding the delivery of Network activities.

FIGURE 1: INTEGRATIVE MODEL OF THE MARINE ADAPTATION NETWORK



An important goal of the Marine Adaptation Network during its establishment year has been to set up mechanisms for promoting and facilitating information exchange between Network members. This includes the design and development of a comprehensive, functional and attractive website (including a password-protected discussion facility), publication of four informative network newsletters – the quarterly Marine Adaptation Bulletin – and three information sheets: (1) Species responses to climate change, (2) Ecosystem responses to climate change in the ocean, and (3) Climate Change impacts on Tasmania’s marine life.

Network activities and achievements to date include the development of research protocols for social participatory research projects relevant to marine biodiversity and resources, which are now available on the Network website, and the planning and initial drafting of a series of integrated synthesis papers across the five network themes on marine social-ecological resilience. These are Phase I: the current condition of the marine social-ecological system; Phase II: future change to the marine social-ecological system; and Phase III: enhancing resilience in the marine social-ecological system. The network Policy theme is examining and mapping science-policy connections in response to climate change across three marine sectors, and has recently undertaken a series of interviews

An interdisciplinary network that will build adaptive capacity and adaptive response strategies for the effective management of marine biodiversity and natural marine resources under climate change.

with researchers, stakeholders and policy makers regarding the edible oyster industry. Principles and guidelines for assessing and reducing vulnerability to climate change have been developed and drafted through a full-day network-partner workshop held at the University of Tasmania in October 2009.

As part of the Network mission to build adaptive and research capacity, and to educate the future generation of marine climate change adaptation researchers, the Marine Adaptation Network designed, developed and held the First National Marine Climate Change Adaptation Summer School in Hobart in December 2009. This intensive one-day Summer School focused on educating Honours, postgraduate students and Early Career Researchers on approaches to building resilience in the marine social-ecological system. The School included an afternoon workshop designed to build practical skills in vulnerability assessment with a view to developing adaptation strategies to climate change. The one day event was attended by 29 participants from around Australia, with every state represented.



Students and speakers at the First National Marine Climate Change Adaptation Summer School, 4 December 2009. Credit Christine Materia

Primary Industries Network



Photo: Frank Stadler

PRIMARY INDUSTRIES NETWORK SNAPSHOT

Hosted by: University of Melbourne

Convened by: Professor Snow Barlow

Funding: \$1,106,000 over 4 years

Membership: over 160

Website: <http://www.nccarf.edu.au/adaptation-research-network-primary-industries>

The Primary Industries Network has had a later start than all other Networks, following the closure of the original Network hosts, Land and Water Australia. Re-established in October 2009, with the University of Melbourne as host institutions, the focus of this Network now is to harness and make available a large body of relevant information that has been generated in under the theme of climate change impacts and adaptation in Primary Industries. There is significant interest in this Network, and its membership has grown rapidly since October.

The Network is supported by a research leadership group made up of Australia's leading researchers in this field, including Snow Barlow (University of Melbourne, , and Convenor of the Network), Mark Howden (CSIRO Climate Adaptation Flagship), Peter Grace (Queensland University of Technology), Richard Eckard (University of Melbourne and Victorian Department of Primary Industries), Ross Kingwell (University of Western Australia) and Peter Hayman (SARDI and the University of Adelaide).



Drought affected vines in mildura

Photo: Louise Askew

PIARN has six thematic research nodes each led by an expert in the field:

- **Farming Systems** – Professor Deirdre Lemerle (Charles Sturt University and the NSW Department of Primary Industries) and Dr Peter Hayman (SARDI and the University of Adelaide)
- **Soil management** – Professor Peter Grace (Queensland University of Technology)
- **Water management** – Professor Steve Tyerman (University of Adelaide) and Professor Wayne Meyer (University of Adelaide)
- **Plant Adaptation to Climate Change** – Professor David Ellsworth (University of Western Sydney), Dr Mark Hovenden (University of Tasmania)
- **Animal Health, Production and Biosecurity** – Dr Gary Muscatello (University of Sydney)
- **Regional Social and Economic Adaptation and Assessment** – Dr Paul Dargusch (University of Queensland).

The Network is currently in negotiations with Murdoch University to establish a seventh node with a focus on forests.



Social, economic and institutional dimensions network



Photo: Marie Waschka

SOCIAL, ECONOMIC AND INSTITUTIONAL DIMENSIONS NETWORK

Hosted by: University of Melbourne

Convened by: Associate Professor Jon Barnett

Funding: \$1,367,272 over 4 years

Membership: over 350

Website: <http://www.nccarf.edu.au/social-economic-and-institutional-dimensions/>

The Social, economic and institutional dimensions Network is involved in three core activities:

- (1) Building and facilitating the interaction of a large, inclusive and diverse community through Network membership, Network website, mailing list, and annual workshops.
- (2) Development of the Vulnerability and Adaptation to Climate Change in Indigenous Communities programme (led by Professor Marcia Langton).
- (3) Building a community of dynamic future leaders from government, research, community and Indigenous groups in adaptation research and policy through the annual Adaptation College.

The Adaptation College is an innovative initiative of this Network. The college is a group of 20 early career people from Australian civil society, government and research groups who demonstrate the potential to be future leaders in their fields. College participants have been selected as part of a competitive process.



Photo: Marie Waschka

College participants take part in an annual 2-3 day Adaptation College event held together with a broader Network workshop, focussing on priority themes. Network workshop themes are:

- Vulnerability and adaptation in Indigenous Australia
- Adaptive environmental management and policy
- Legal and policy frameworks for facilitating adaptation
- Economic impacts of adaptation and adaptation policies.

This Network has been very closely involved in the development of the National Climate Change Adaptation Research Plan for Social, economic and institutional dimensions, with the Network Convenor, Jon Barnett leading the writing team for this Plan.

The Network has also established an active e-list allowing Network members to share information and resources, a Network website and newsletter.

Settlements and Infrastructure Network



Photo: Dean Kennedy

SETTLEMENTS AND INFRASTRUCTURE NETWORK

Hosted by: University of New South Wales

Convened by: Associate Professor Ron Cox

Funding: \$1,625,456 over 4 years

Membership: over 250

Website: <http://www.nccarf.edu.au/settlements-infrastructure/>

Arguably the largest Network in terms of scope, this Network receives the highest amount of NCCARF Network funding. The Network is structured around the following thematic nodes: (1) coastal settlements (2) urban management, transport and inclusion (3) built environment innovation and institutional reform and (4) infrastructure.

This Network has been very active in organising and presenting at workshops, seminars and conferences, and seeking to connect stakeholders with researchers, and facilitating the development of common research interests and leveraging of research funding.

The Convenor, Ron Cox used Engineers Australia Eminent Speaker tour of 10 Capital and regional cities to promote the Network to more than 700 attending professionals.

A Network resource database for members continues to be developed. It currently includes more than 120 items (papers, reports, books, etc.) which have been reviewed and made available via this database.

The Network website provides regular updates on Network activities, events, and provides an information resource for users.

The Network has established an Industry Advisory Group to improve engagement with industry leaders, and to work to make the Network a valuable resource for industry.

Two workshops for early career researchers from across Australia have been organised by the

Network as an opportunity for these researchers to share their research outcomes, and to discuss research projects and opportunities for collaboration with their peers. Workshop presentations are available on the Network website. These workshops for early career researchers are scheduled to continue on a quarterly basis. The Network is also supporting research capacity building through a scholarships program.

The first in a series of targeted position or discussion papers has been finalised focussing on 'Adaptation research for Water Security'. Further papers to be developed by the Network will focus on topics such as 'Planning policy for sea level rise'; 'Feasibility analysis of long term infrastructure subject to climate change'; and, 'Sustainable alternative energy options' are underway.

An initial household nationwide benchmarking survey to assess knowledge and attitudes to climate change adaptation in relation to settlements and infrastructure was undertaken in late 2009. Approximately 3000 persons across six capital cities took part in this survey.

The Network has played a key role in both the development of the National Climate Change Adaptation Research Plan for Settlements and Infrastructure, and in coordinating the first call for funding proposals addressing research priorities identified in this Plan made under the Australian Government's Adaptation Research Grants Program.



Terrestrial Biodiversity Network



Photo: WTMA

TERRESTRIAL BIODIVERSITY NETWORK

Hosted by: James Cook University

Convened by: Professor Stephen Williams and Professor Lesley Hughes (Macquarie University)

Funding: \$1,454,544 over 4 years

Membership: over 270

Website: <http://www.nccarf.edu.au/terrestrialbiodiversity/>

The primary goal of this network is to develop explicit and practical strategies to maximize the resilience and adaptive capacity of terrestrial ecosystems to climate change. The philosophy of the network is to have a truly national focus, and thus to distribute both activities and funding opportunities across all states and territories, and amongst as broad a range of researchers, institutions, and stakeholder organisations as possible.

In the past year, this Network has:

- Created a powerful network of over 700 researchers and stakeholders from more than 120 institutions.
- Established a Steering Committee that includes some of the most eminent climate change biologists in Australia.
- Forged important links with state and federal government environment units and major NGOs.

The Network now has over 700 members from universities, research institutions and stakeholders, particularly from state and local governments, National Parks officers, Natural Resource Management, catchment agencies and non-governmental organisations. A Network website has been developed provides network members with resources and information that will maximise capacity to achieve outcomes in the field of climate change adaptation. The website provides downloadable resources such as GIS layers and relevant publications.

The Terrestrial Research e-Bulletin has been established to communicate relevant advances in research, and Network activities, together with a series of information sheets on topics such as Species Responses to climate change.

Research and travel support is offered by the Network to post-graduate students to encourage early career researchers in the field of climate change adaptation. Nine collaborative PhD travel grants and seven honours and masters research projects were offered over two funding rounds in 2009.

The tenth International Ecology Conference (Intecol) in Brisbane (August 2009) brought scientists together both nationally and internationally. The Network used this opportunity to host a symposium and present a poster, to highlight adaptation research within the Network. Seventeen invited speakers from the Network presented talks on Australian climate change adaptation research to an international audience.

The Network has hosted the first in a series of biannual 'research synthesis' workshops. These workshops bring together lead researchers in a particular field to discuss and develop research papers around a particular topic. The first workshop focussed on Dynamic conservation planning in a changing climate. The outputs from this workshop included manuscripts for three papers in high impact peer reviews journals.

Water Resources and Freshwater Biodiversity Network



WATER RESOURCES AND FRESHWATER BIODIVERSITY NETWORK

Hosted by: Griffith University

Convened by: Professor Stuart Bunn

Funding: \$1,454,544 over 4 years

Membership: over 220

Website: <http://www.nccarf.edu.au/water/>

Photo: Frank Stadler

The Water Resources and Freshwater Biodiversity Network brings together Australia's top water scientists with interests and skills in water resources and freshwater biodiversity, and the implications of climate change.

The primary goals of this Network are to:

- Facilitate the development of collaborative and cross-disciplinary research at the national scale.
- Build research capacity through support and mentoring of early career scientists.
- Synthesise relevant knowledge to give Australian water and biodiversity managers the best chance of coping with a difficult climate future.

This Network has played a key role in the ongoing development of the National Climate Change Adaptation Research Plan for Freshwater

Biodiversity, with the Convenor of this Network, Stuart Bunn, also chairing the writing team for the Plan.

Activities in this Network are largely based around five 'adaptation' themes:

- (1) Governance
- (2) Climate scenarios
- (3) Water Resources
- (4) Freshwater Biodiversity
- (5) Capacity building.

A key role of the Network will be to synthesise existing and emerging research under these five themes and to facilitate the establishment of research teams to work on priority research questions identified in the NARP.



Photo: Kasia Wallis

Regional Network 'nodes' have been established in each State and Territory to coordinate activities and support industry and jurisdictional engagement. A Newsletter and website have also been established to promote the exchange of information and resources within the Network. The Network has also been involved in a number of key events such as the International Riversymposium, and the Australian Society for Limnology Congress.







7. KNOWLEDGE COMMUNICATION AND ADOPTION

NCCARF has undertaken a number of activities, and established mechanisms to support engagement with stakeholders, communication of climate Change adaptation knowledge, and to facilitate the uptake of knowledge by research end users.

NCCARF has established its corporate identity, raised its profile, and promoted involvement in NCCARF activities by climate change adaptation researchers, government, industry and the community. Over 3000 people have registered to receive regular information updates from NCCARF, and over 2800 people are now members of the Adaptation Research Networks.

Stakeholder engagement

In addition to the stakeholder engagement activities undertaken by the Adaptation Research Networks, NCCARF has also sought to engage with all Australian States and Territories by undertaking a 'roadshow' across Australia to promote NCCARF, and to discuss opportunities for States and Territories to become involved in NCCARF activities, and to have provide advice on critical gaps in climate change adaptation information available to them.

NCCARF has convened the Forum for NCCARF Interaction with States and Territories which provides an avenue for representatives from all State and Territory governments to share information about climate change adaptation activities underway, and to inform adaptation research planning.

NCCARF will be establishing a similar forum for

Local Government following a workshop with representatives from Local Government from across Australia to discuss climate change adaptation challenges and information needs for Local Government. NCCARF is also developing an on-line information resource to support climate change adaptation at a local level specifically designed for Local Government.

Advancing information exchange

The NCCARF website and NCCARF quarterly newsletter are the main avenues through which NCCARF shares information about its activities, events, funding opportunities and research outputs. Increasingly, this website will be developed as the 'first-stop shop' for climate change adaptation information in Australia, including through the development of a climate change adaptation information portal which is currently underway.

This resource will allow users to easily search for, access and download information resources.

NCCARF has also organised a number of workshops and symposia to support climate change adaptation information exchange. In particular, two NCCARF symposia have been run, one in Brisbane and one in Perth, bringing climate change adaptation researchers from across Australia together with representatives



from government, industry and the community, to present climate change adaptation research, and to discuss opportunities for research collaborations. A collection of abstracts from both symposia are available on the NCCARF website.

Publishing knowledge

A critical part of knowledge communication is to make existing information more accessible to end users. NCCARF, in partnership with CSIRO, developed the Marine Climate Change Impacts and Adaptation Report Card for Australia 2009. This Report Card summarises knowledge on climate change impacts, identifies knowledge gaps and addresses key adaptation options. More than 70

authors from 35 universities and organisations were involved in the production of this card, including many members from NCCARFs Adaptation Research Networks. The report card collates and summarises information across a number of priority themes, and presents this information in a series of papers, and in summary format in a brochure available in hard copy, and on the web. The report card is supported by an interactive website <http://www.oceanclimatechange.org.au>. To date, some 2,500 hard copies of the Report Card have been distributed, and the website has attracted over 200,000 visitors since October 2009. The success of this project will inform future NCCARF knowledge communication activities.

2010 INTERNATIONAL CLIMATE CHANGE ADAPTATION CONFERENCE.

In June 2010, NCCARF and the CSIRO will host the 2010 International Climate Change Adaptation Conference which will showcase leading impacts and adaptation research from around the world. This conference will be one of the first informational forums to focus solely on climate impacts and adaptation. It will bring together scientists and decision makers from developed and developing countries to share research approaches, methods and results. Approximately 900 people are expected to attend, with approximately 800 presentations from around 55 countries. This event will also highlight Australia's research capacity in the field of climate change adaptation. The conference website will form a critical information resource both during and after the conference, and will enable even more people to 'participate' in the conference online. A number of side meetings are being held in association with this event, and outputs from the Conference will include a synthesis report and a book.



NCCARF has established the NCCARF Seminar Series as a means of making climate change adaptation research available to a broad audience. Open to the public, the seminar series provides a forum for researchers, educators, policy makers, non-government organisations, students and members of the general public to access and engage with the latest research developments from across a range of climate change adaptation themes. The seminars consist of one-hour lectures from leading Australian and international climate change adaptation researchers, following by an informal ‘meet the speaker’ networking opportunity. To date, seminars have been held in Brisbane, Townsville, Sydney and Canberra, and seminar presentations are made available for download from the NCCARF website.



NCCARF has initiated a publications series, including publishing of National Climate Change Adaptation Research Plans available in full and summary formats

NCCARF SEMINARS SERIES:

The 2009 bushfires and heat wave in SE Australia: Are they related to climate change?

Professor David Karoly, Professor of Meteorology, University of Melbourne

Public health: Adapting to the impacts of climate change

Dr Kristie Ebi, Executive Director of the Technical Support Unit for IPCC Working Group II, IPCC.

Flood, famine and dangerous climates: what can the past tell us about adapting to climate change?

Professor Jean Palutikof, Director, National Climate Change Adaptation Research Facility.

Pathways to Adaptation

Dr Andrew Ash, Director, CSIRO Climate Adaptation Flagship.

The Economics of Climate Change

Dr Samuel Fankhauser, Research Fellow, Grantham Research Institute on Climate Change and the Environment, London School of Economics.

Vulnerability to climate change: Concepts, assessment approaches and applications

Dr Hans-Martin Füssel, Research Fellow, Potsdam Institute for Climate Impact Research, Germany

Climate threat & urban response: An Australian perspective

Professor Brendan Gleeson, Director, Urban Research Program, Griffith University.



Climate change: Loving an even more sunburnt country?

Dr Mark Howden, Theme Leader for Adaptive Primary Industries, Enterprises and Communities, CSIRO Climate Adaptation Flagship.

Networks for Adaptation: Designing a Protected Area System for the 21st Century and the adaption network to make it work (ELAN)¹

Dr Jeff Price, Managing Director, Climate Change Adaptation, World Wildlife Fund (US).

CIAS and Climascope: Making decisions in an uncertain world – linking climate and impact models for decision-making and adaptation planning

Dr Rachel Warren, Research Leader, Tyndall Centre for Climate Change Research, UK.

Climate change and the future of coral reefs

Professor Terry Hughes, Federation Fellow and Director, ARC Centre of Excellence for Coral Reef Studies, James Cook University.

The Legal Dimensions of Climate Change Adaptation

Professor Jan McDonald, Director, Climate Change Response Program, Griffith University.

Managing the Unavoidable – Natural Catastrophes

Dr Sandra Schuster, Risk Analyst, Munich RE Insurance.

Enhancing Adaptive Capacity in Coastal Communities

Professor Tim Smith, Director, Sustainability Research Centre, University of the Sunshine Coast.

Climate Change, natural disasters and property losses

Professor John McAneney, Director Risk Frontiers, Macquarie University.

First NCCARF Kids Seminar

Speakers: Delwyn Langdon, Climate Change Project Ambassador and Manager Griffith University EcoCentre Environmental Education Centre; Ella Horton, Australian Youth Climate Change Coalition Gold Coast event organiser.

Un-Natural Disasters: the Fractured Science and Politics of Climate Change

Professor Barry Smit, Canada Research Chair in Global Environmental Change, University of Guelph, Canada.

Climate Services for Adaptation Planning

Dr Chris Gordon, Deputy Director Climate Science, The Met Office Hadley Centre, UK

The international ACRE initiative for climate services, applications and users

Dr Rob Allan, Project Manager, Atmospheric Circulation Reconstructions over the Earth (ACRE), The Met Office Hadley Centre, UK

Climate Change and Australia's biodiversity – can it adapt?

Professor Lesley Hughes, Head of the Department of Biological Sciences at Macquarie University, Sydney.

What controls year-to-year and decade-to-decade variability in Queensland rainfall?

Dr Nick Klingaman, UK National Centre for Atmospheric Science, Walker Institute, University of Reading.



8. THE NEXT STEPS FOR NCCARF

The production of this Report marks the completion of the first phase of NCCARF. We have established a solid basis for our operations, marked by:

- completion of seven Research Plans,
- commissioning of research to address the priorities identified by the Research Plans
- establishment of eight Adaptation Research Networks
- completion of Phase 1 of the NCCARF Synthesis and Integrative Research Program, and commencement of Phase 2
- development of activities to interact with our stakeholders and end users.

Where does NCCARF go from here? A key feature of the last two years has been the growing recognition that NCCARF must move much closer to its end users – the people responsible for policy-making and decision-making in government, industries and communities. This is the only way to ensure that our research outputs are properly communicated to end users, and contribute positively to the challenge of adapting Australia to future climate change. This view was confirmed in our Operational Review. Thus, the second, or Operational, Phase

of NCCARF, will be marked by strong growth in our activities around knowledge communication and adoption.

Clearly, knowledge communication and adoption require a firm foundation in the creation of that knowledge. Therefore, the activities around our thematic, synthesis and integrative research will continue. In framing our research agenda, in funding and managing our research programs, we very much welcome opportunities to collaborate with institutions around Australia which share our goal of ensuring that our country is well adapted to future climate change.

The concept of NCCARF is a challenging one, and we know of no other institution with quite the same mandate and mission. The creation and establishment of NCCARF has been a journey of intellectual challenge and innovation for its staff and stakeholders, and this journey will continue in Phase 2.





APPENDIX 1: NCCARF FUNDING

The Australian Government is investing \$117 million (from 2008 to 2012) in climate change adaptation policies, programs and research through the Department of Climate Change and Energy Efficiency (DCCEE). This investment supports the implementation of key elements of the National Climate Change Adaptation Framework.

From this investment, \$20 million is being used to support NCCARF and its activities, as follows:

- \$10 million to support the core activities of NCCARF at Griffith University.
- \$10 million to support eight Adaptation Research Networks.

In addition, and as part of the Australian Government's investment in climate change adaptation, the DCCEE has established the Climate Change Adaptation Research Grants Program. This program provides seed funding of up to \$30 million to fund priority adaptation research needs. These priority research needs are identified in National Climate Change Adaptation Research Plans developed by NCCARF, in consultation with lead researchers and stakeholders (see section XX). NCCARF has further responsibility to map out the potential for leveraging funding and, where appropriate, to work with the DCCEE to mobilise leveraging opportunities, and to manage some research calls to disburse this seed funding.

NCCARF partner institutions have also made significant cash and in-kind contributions towards the operation of NCCARF. Cash and in-kind contributions from the partners are in the order of \$6.2 million and \$15 million, respectively.

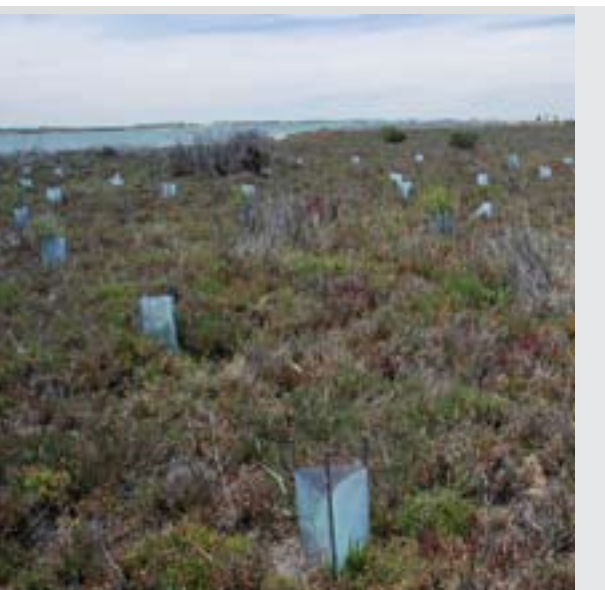


Photo: Bill Doyle





APPENDIX 2: NCCARF GOVERNANCE AND ORGANISATION

A2.1 NCCARF GOVERNANCE

NCCARF is a part of, and reports to, Griffith University, which in turn reports to the Department of Climate Change and Energy Efficiency. NCCARF is led by Professor Jean Palutikof.

An Executive Group made up of NCCARF's Director, Griffith University's Deputy Vice-Chancellor (Research) and a senior representative from the Australian Government Department of Climate Change and Energy Efficiency directs and supports the operation of NCCARF.

A Management Committee made up of representatives from NCCARF's partner institutions provides an avenue for partner input into NCCARF activities. NCCARF partners have played a key role in the establishment of NCCARF, contributing significant cash and in-kind resources towards the development of National Adaptation Research Plans, Adaptation Research Networks, and in undertaking synthesis and integrative research. Profiles of NCCARF partner institutions are provided in Appendix 3.

NCCARF is responsible for coordinating eight Adaptation Research Networks. NCCARF approves the annual Network workplans, and the Networks report to NCCARF. Further information about these Networks is provided in section 6.7.

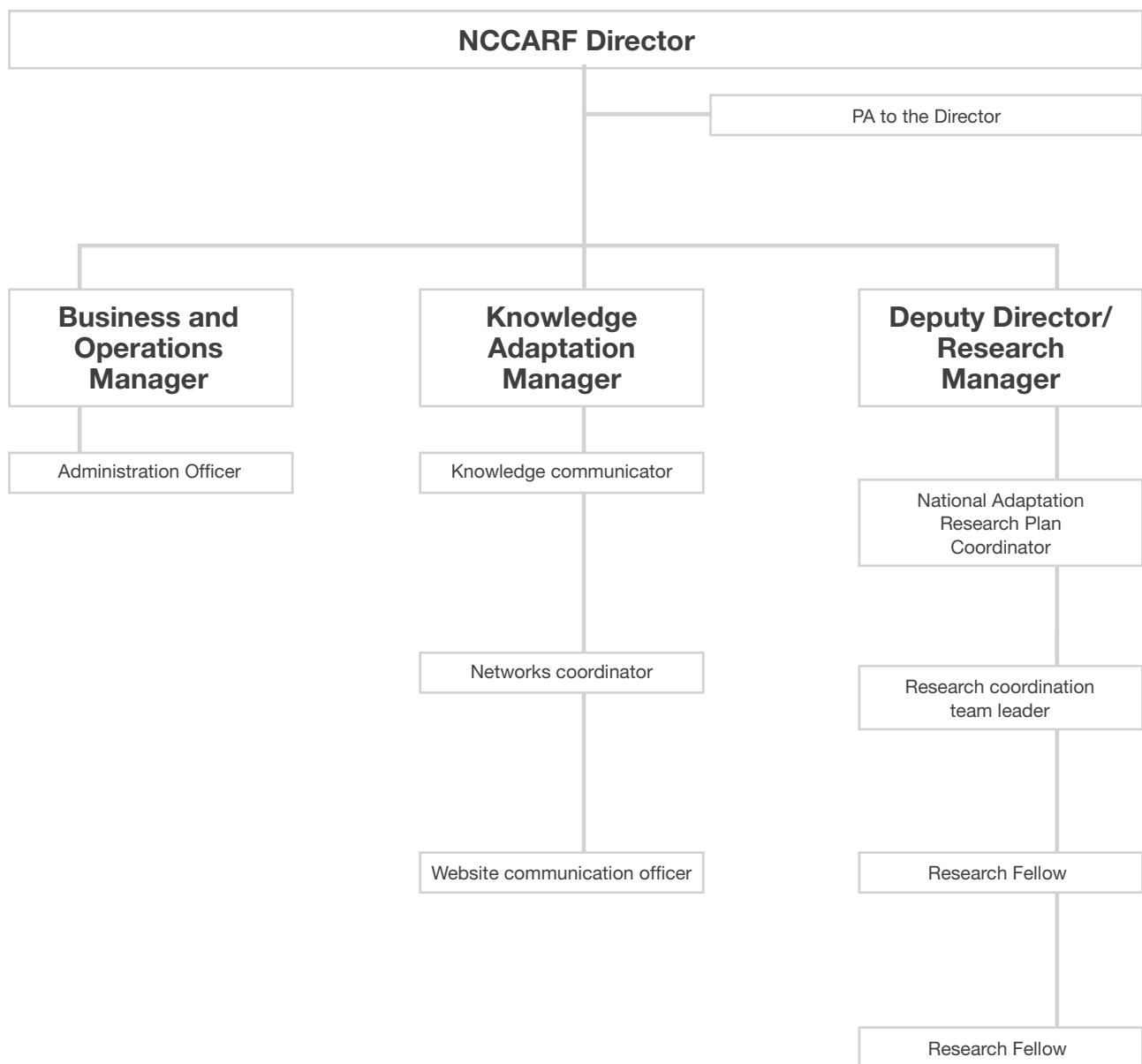
A2.2 NCCARF ORGANISATION

NCCARF has kept its administrative costs to a minimum during its establishment phase, with a small core team of 12 staff based at Griffith University's Gold Coast Campus. Figure A2.1 illustrates the organisational structure of NCCARF during the establishment phase, which is based around three key areas:

1. Business and Operations
2. Knowledge Adoption
3. Research.

APPENDIX 2: NCCARF GOVERNANCE AND ORGANISATION

FIGURE A2.1: ORGANISATIONAL STRUCTURE OF NCCARF





APPENDIX 3: NCCARF PARTNER PROFILES

ABOUT GRIFFITH UNIVERSITY

Griffith University is a national leader in climate adaptation research and hosts the National Climate Change Adaptation Research Facility. Its five campuses span three cities in Australia's fastest growing corridor from Brisbane to the Gold Coast – one of the regions most vulnerable to the impacts of climate change.

Griffith is a pioneer in environmental research and education. It has the largest group of environmental professionals of any university in Australia working, in collaboration with industry and the community, to tackle one of the big issues of the twenty-first century.

Climate change adaptation research at Griffith University

The Griffith Climate Change Response Program spearheads the University's strategic research into climate change adaptation. Established in 2006, the GCCRP undertakes research into the physical, socio-economic, institutional and legal dimensions of adapting Australia's towns and cities – and their populations – to the unavoidable impacts of climate change.

The GCCRP comprises researchers from across the University, including the Centre for Coastal Management, the Urban Research Program, Environmental Futures Centre, and the Centre for Infrastructure Engineering Management. The

common goal of all this work is effective action. The immediate tasks are to understand and decide adaptation priorities and to develop a wide range of adaptation tools. These practical instruments will include land use planning tools for new and existing urban developments; effective coastal protection structures; robust (mathematical) modelling of beach erosion, storm surge and flooding impacts; and adaptive shoreline management planning. Research is also underway into the governance of adaptation across Australian society and the psycho-social dimensions of societal and individual behavioural change.

Research Project Profile

The Intergovernmental Panel on Climate Change has identified ongoing coastal development and population growth in vulnerable regions such as South East Queensland as exacerbating the impacts of future climate change. The *South East Queensland Climate Adaptation Research Initiative (SEQ-CARI)* is a three year multi-institution research initiative to develop practical and cost-effective



adaptation strategies for the region across a number of industry sectors. The project is funded through a Queensland Smart State Innovation Fund research grant, CSIRO Collaboration Fund Cluster Project, and the Commonwealth Department of Climate Change. Griffith leads the human settlements component of the project, encompassing urban planning and management, coastal management, human health and emergency management. The Griffith team, led by Professor Jan McDonald, is investigating what aspects of the design, form, functioning and governance of human settlements in SEQ are most vulnerable to climate change impact. Working with stakeholders in government, business and the community, the project will determine how vulnerabilities can best be overcome and identify and test adaptation options.

Climate change will bring sea level rise and more intense cyclones and storm events. The concentration of human settlement along the Australian coast exposes people and property to the heightened risks of flooding, storm surge and beach erosion. The Smart State Future Coastlines project, led by the Griffith Centre for Coastal Management's Professor Rodger Tomlinson, is creating new models for coastline response under climate change and extreme events. In partnership with Queensland's Environmental Protection Agency, Department of Community Safety and the Bureau of Meteorology, the Project will identify and test a range of emergency response strategies for dealing with the risks of weather events on coastal settlements.

The vulnerability of properties on the Gold Coast is also a focus for PhD student Oz Shahin. Shahin is developing a model for assessing vulnerability



and evaluating adaptation options for Gold Coast waterfront properties, using a combination of system dynamics (SD) simulation, geographic information system (GIS) modelling, multi-stakeholder consultation, and multi-criteria decision analysis (MCDA).

The use of urban planning strategies and tools to design climate-adapted urban form and assist in retrofit of existing cities and towns is a major focus for researchers in the Urban Research Program. Dr Jason Byrne is exploring the extent to which urban greenspace could help adapt built environments to the impacts of climate change, by reducing stormwater runoff, and offsetting urban heat island effects.

The impacts of climate change on human health are also a major research focus of the Urban Research Program. Associate Professor Scott Baum's preliminary study of the health impacts of climate change on the Gold Coast City region showed that heatwaves and flooding were likely to be the biggest health risks. Baum modelled the multiple vectors of the risk of impact, the degree of social sensitivity and the level of community resilience to assess both the general physical risk of a particular event and estimate the vulnerability of different groups in different places.

QUEENSLAND GOVERNMENT

The Queensland Government is a key NCCARF funding partner working in close cooperation with NCCARF through its Office of Climate Change and Department of Community Safety.

Part of the Department of Environment and Resource Management, the Office of Climate Change was established in October 2007 to integrate and strengthen Queensland's ability to lead an effective climate change response.

The office combines specific climate change policy functions and the scientific expertise of the Queensland Climate Change Centre of Excellence (QCCCE).

Key functions of the office include:

- Coordinating and implementing Queensland's revised climate change strategy, *ClimateQ: Toward a Greener Queensland*. The \$196 million strategy takes the latest national and international science into consideration, and outlines the next phase of Queensland's response to climate change.
- Implementing measures to achieve Queensland's Q2 target of reducing Queensland households' carbon footprint by one-third.
- Analysing Queensland's greenhouse gas emissions projections and developing policy recommendations for achieving further cuts to Queensland's emissions profile.
- Providing policy support to the Premier's Council on Climate Change.
- Administering the \$431 million Queensland Climate Change Fund and developing new climate change initiatives from the \$30 million per year the fund provides.
- Coordinating and reviewing Climate Change

Impact Statements (CCIS) in Cabinet and budget proposals to ensure that consideration has been given to the impact of decisions on Queensland's greenhouse gas emissions profile.

- Fostering international relationships to ensure that Queensland remains engaged in international climate change negotiations

QCCCE, the specialist whole-of-government unit based within the Office of Climate Change, provides specific climate science and research to inform Queensland's response to climate change. It provides information and science on climate change impacts, including the application of international research and science to the Queensland context.

QCCCE undertakes research that is innovative and addresses climate change issues of relevance to Queensland. The Centre works collaboratively with Australian and international research agencies, industry and all levels of government.

The Centre researches the climate system to determine how and why the climate is changing, and to identify the drivers of change. It uses global and regional climate models to produce projections of climate change for Queensland and provides climate risk management tools, including seasonal forecasts.

Queensland's scientific capacity is bolstered by collaborative relationships with world-class international climate science institutions such as the Met Office Hadley Centre and the Walker Institute in the UK. These have brought high-level expertise to improve Queensland's climate modelling and

understanding of extreme events, and to ensure that the State’s policies and programs are informed by the best available climate science and advice.

One of QCCCE’s priorities is to analyse the results of climate change modelling and examine the effects of climate change on Queensland’s communities and industry sectors, including water planning and services, agriculture, human settlements, emergency preparedness, human health, and tourism

QCCCE maintains extensive climate databases which are used to deliver temporal and spatial climate data. The SILO enhanced climate database

includes data from 1890 to the present. The AussieGRASS Environmental Calculator is a national water balance and pasture growth model to analyse and advise on the historical, current and future impacts of climate variability, climate trends and extremes on natural resources.

The climate change risk management matrix tool has been developed to help communities and sectors work through their climate change issues and identify management and adaptation options (see Box on following page).

The climate change risk management matrix

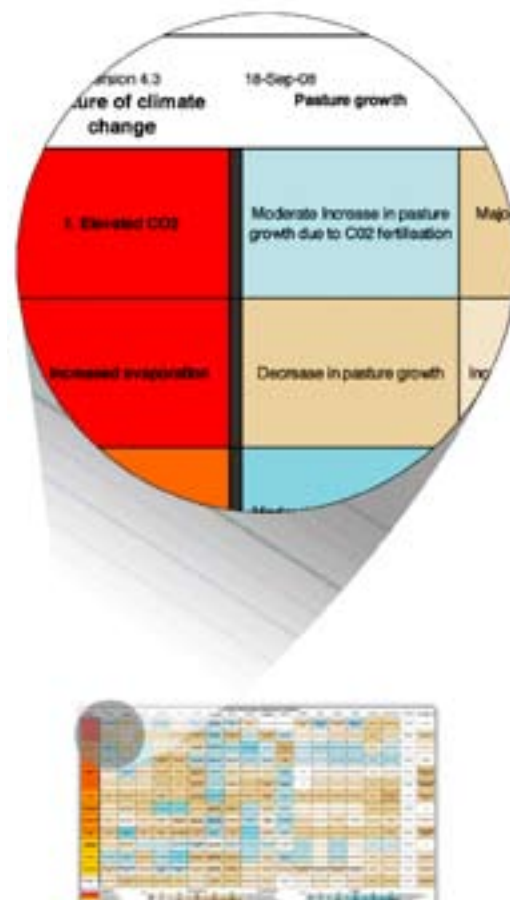
The Queensland Climate Change Centre of Excellence has developed a risk assessment methodology (risk matrix) for engaging with industry and agencies to explore potential climate change impacts at a regional, industry or sector level, to identify vulnerable assets to build the capacity of regions, industries and sectors to adapt to climate change and to plan appropriate adaptation strategies.

Developed initially for the grazing industry, the tool provides a risk management approach to climate change adaptation and is useful for any industry or sector. The risk management approach involves:

- identifying potential climate change impacts
- understanding the likelihood and potential consequences of those impacts
- developing appropriate management responses to climate change.

The climate change risk management matrix approach is a useful first-step to facilitating a better understanding of climate change impacts and fostering a risk management approach to dealing with climate change within Queensland industry at State and regional levels.

FIGURE A3.1: AN EXAMPLE OF THE MATRIX



DEPARTMENT OF COMMUNITY SAFETY

The Department of Community Safety (DCS) is responsible for providing community safety and crime prevention through the humane containment, supervision and rehabilitation of offenders, and ensuring that Queensland communities are supported by, and benefit from, an effective disaster and emergency management system and essential response services.

The DCS vision is to support healthy, safe and secure communities through public safety, emergency management, and secure and appropriate correctional services.

A key priority of DCS is to manage preparedness and responses, including impacts of climate change, and working to adapt to those impacts.

Working closely with OCC, DCS is implementing a number of State-wide initiatives to enhance community preparedness, resilience and adaptation to the impacts of climate change through initiatives funded through the Queensland Climate Change Fund. These include:

- Disaster preparedness in vulnerable communities: a \$7.7 million program that includes community education, information for businesses and evacuation planning.
- Bushfire community training package: a \$4.6 million program for the development and support of a network of 3,000 volunteer community education officers throughout Queensland.
- Disaster management warehouses and caches: a \$3.4 million initiative to provide additional equipment to the State Emergency Service for responding to large-scale emergencies and disasters.
- Supporting our heroes in the Rural Fire Service and State Emergency Service: a \$13 million

initiative to strengthen the response capability and preparedness of volunteers by boosting numbers and providing additional equipment and resources.

- Keeping our mob ClimateSafe: a \$2 million initiative to help remote Indigenous communities prepare for the impacts of extreme weather events.

DCS is also implementing the Natural Disaster Resilience Program (NDRP). This 4-year, \$44 million disaster mitigation and community resilience competitive grants program seeks to reduce community vulnerability to natural disasters and the impacts of climate change.



Photo: DCS/ Michael Marston



JAMES COOK UNIVERSITY

James Cook University (JCU) is Australia's leading tropical research university. Strategically placed near the World Heritage Areas of the Wet Tropics Bioregion and the Great Barrier Reef, JCU is guided by its Statement of Strategic Intent, which focuses on creating a brighter future for life in the tropics worldwide through training graduates and making discoveries that make a difference.

JCU is a multi-campus university with sites in Townsville, Cairns, Brisbane and Singapore. There are also smaller campuses in Mackay, Mount Isa and Thursday Island.

Climate change adaptation research at James Cook University

Climate change adaptation research is a priority at JCU. Its researchers were amongst the first to identify the potentially catastrophic effect of climate change on tropical systems, and there are researchers working on climate change

adaptation issues across all faculties. In particular, JCU researchers are investigating climate change impacts and adaptation potential in biological systems, effects on tropical tourism, and social and health implications.

In addition there are also three key research centres at JCU whose activities are largely focused on climate change research: The Centre for Tropical Biodiversity and Climate Change (<http://www.jcu.edu.au/ctbcc/>), The ARC Centre of Excellence for Coral Reef Studies (<http://www.coralcoe.org.au/>) and the Cyclone Testing Station (<http://www.jcu.edu.au/cts/>).



Photo: Joanne Isaacs

Research profile

Worldwide, there is evidence that many species are adapting to climate change by shifting their ranges. For example, butterflies have moved up mountains and many birds have shifted northwards as they track their preferred climate and habitat. But imagine a frog species restricted to the top of a single mountain, or a possum surviving in small isolated pockets of rainforest. These species cannot move – the frogs will disappear off the top of the mountain and the possums will come to the end of the rainforest. But all may not be lost for these species. Researchers at the Centre of Tropical Biodiversity and Climate Change (CTBCC) are investigating whether natural and man-made refuges could help some species adapt to climate change by protecting them from extreme temperatures.

Dr Luke Shoo, a postdoctoral researcher at the CTBCC, is investigating how canopy cover and other landscape features could provide shelter for rainforest species in Australia's Wet Tropics. His research demonstrates that foliage cover is critical in reducing exposure to high temperatures and also that maximum temperatures under logs can be more than 2°C cooler than the ambient rainforest temperature. Shoo says "We could restore forest in key areas to increase cool refuges and lessen exposure to extreme temperatures for some species by artificially engineering the availability of microhabitats like logs and rock piles".

Dr Jo Isaac conducted similar studies on tree hollows and nest boxes in open eucalypt woodland. She found that the largest trees had hollows which were up to 6°C cooler than those of smaller trees during the hottest part of the day and says "For



Photo: Joanne Isaacs

arboreal marsupials that use tree hollows, larger, older trees may be a critical resource in the future". Isaac and co-workers also found that nest boxes were generally warmer than natural hollows, but that placement was important. Exposed nest boxes reached temperatures which could be lethal to some marsupials, but those which were shaded by canopy were a similar temperature to natural hollows.

The findings of these studies can be directly translated into conservation actions by managers and policy makers. For smaller terrestrial species, such as snakes, frogs and lizards, this could include introducing refuges such as large logs or constructing artificial shelters. For species which utilise tree hollows, such as possums and birds, the protection of older hollow-bearing trees will be crucial, but well-placed nest-boxes could also provide shelter from heat where hollows are scarce.



MACQUARIE UNIVERSITY

Macquarie University is a dynamic institution that engages in strong relationships with partner institutions, government agencies, industry leaders and community groups. Its strong value system supports a commitment to excellence and Macquarie is fast becoming one of Australia's top research universities.

With recent developments such as a new research hospital and state-of-the-art library, Macquarie is creating an academic environment that provides both students and staff with the resources to build on their knowledge, capabilities and research aims. Macquarie's long-term goal is to provide increased opportunities for international leadership and service within the global community.

Climate change research at Macquarie University

Australia's response to climate change requires innovation in the assessment of climate impacts, their translation to risk evaluation, and the development of effective adaptation and mitigation solutions. At present, there is a fundamental disconnect between scientific knowledge of climate change and the implementation of this knowledge into sustainable environmental strategies. Macquarie's overarching aim is to connect science to policy by identifying end-user needs and redesigning climate impacts research and associated climate risk and adaptation assessment.

Macquarie recognises the importance of a multidisciplinary approach to climate change issues. In 2010 the university established Climate Futures @ Macquarie, a research centre aimed at enhancing research capacity and strengthening expertise and leadership in this area. Climate Futures comprises more than 30 research staff and spans a wide range of climate-related expertise including climatology,

hazards and disaster risk reduction, climate change adaptation, environmental law and policy, environmental economics, ecology, ecophysiology, atmospheric chemistry, energy policy, conservation biology, engineering, behavioural and political science, Indigenous education, and social research. Research staff participate in a broad range of advisory groups at the international, national, State and local government levels.

Climate Futures has three specific goals:

1. To undertake collaborative, trans-disciplinary research on climate risk and adaptation across all major sectors.
2. To facilitate the connection of this research with policy makers and other stakeholders to reduce the impacts of climate change on the environment and society.
3. To build the capacity of Australian industry, government and society to deal with the challenges of climate change by undertaking focused, integrated and targeted educational activities.

Some of the specific research projects that it aims to complete over the next 5 years include:

- Assessment of current and future climate change variability and impacts on conservation planning, vulnerability of coastal systems and communities, human health, biosecurity, water resources, biodiversity, and agriculture.

- Assessment of socio-ecological vulnerability, resilience and adaptive capacity across all major sectors, including human health, human settlements, and ecosystems.
- Cost–benefit analysis of alternative climate change adaptation strategies.
- Development of innovative approaches for adaptive governance
- The role of traditional knowledge and practices in resilience building.
- assessing the potential distribution of a range of alien plant species in Australia under projected climate change;
- examining native and alien vine distribution along a latitudinal gradient in an endangered ecological community (littoral rainforest) to assess the impact of predicted climate change on vine distribution;
- using laboratory experiments to assess alien plant response to increased CO2 under conditions of competition and fire.

With strong links to other research centres, such as the Centre for Social Inclusion, ARIES, and Risk Frontiers, Macquarie will continue to expand its existing internationally recognised capabilities in exposing and resolving the complex physical, ecological and socio-economic vulnerabilities and impacts arising from climate variability and change.

Invasive plant species and climate change in Australia: predicting the threat and projecting the future

Invasions by alien species and climate change are major, and growing, issues facing biodiversity conservation, but the nature of the interaction between these two threats has rarely been investigated. A collaborative research project is being undertaken at Macquarie University in collaboration with NSW DECCW, funded by an ARC Linkage grant. The research team is led by Professor Lesley Hughes, Associate Professor Michelle Leishman and Dr Paul Downey. They are investigating the impact of climate change on a broad range of alien plant species by

The work identifies those alien plant species most responsive to climate change, defines hotspots of plant invasions (for example, conservation reserves at greatest risk of new invasions), and provides a framework for invasive plant risk assessment for land managers throughout Australia. This research will contribute significantly to the prioritisation of management activities.

More information can be found at <http://www.environment.nsw.gov.au/weeds/climatechange>.



Murdoch
UNIVERSITY

MURDOCH UNIVERSITY

Murdoch University comprises three campuses across Perth and south-west Western Australia as well as international sites in Dubai and Singapore, with a total enrolment of more than 18,000 students.

A member of Innovative Research Universities Australia, Murdoch is committed to innovation and high-quality higher education that can be applied on a global level. It produces national leaders in environmental and urban planning and energy, and offers an important Western Australian regional perspective to the challenges of climate adaptation research.

In 2008 Murdoch University opened eight new Research Institutes that will work with industry to identify and tackle the greatest challenges facing Australia and the world in the 21st century, including climate change adaptation and mitigation.

These include:

- **Institute for Resource Technology:** with areas of focus including minerals, hydrocarbons, biomass (including waste), wind, wave and solar energy, and water resource research.
- **Institute for Sustainable Ecosystems:** working within the areas of ecosystem management, plant ecology, land management, fish research, wildlife, climatology and freshwater ecology. The Institute's challenge is to find results that could have a far-reaching influence on tomorrow's world.

- **Institute for Crop and Plant Sciences:** working to improve crop varieties, operating on a global level in areas such as plant biology, pathology and biosecurity, as well as bioinformatics and fungal diseases, with a focus on delivering real-world improvements.

Murdoch University has also been awarded the administration of the new National Centre of Excellence in Desalination, part of the \$1 billion National Urban Water and Desalination Plan. The Centre will bring together Australia's leading desalination and water science research organisations.

A new State research hub was launched at Murdoch this year to fast-track the creation of clean alternative fuels for Western Australia's growing transport needs. The WA government provided \$2.3 million to fund the University's new Centre for Research into Energy for Sustainable Transport (CREST) as a WA State Centre of Excellence. CREST brings together the State's leading researchers in alternative transport fuels and technologies and draws upon expertise in the university, industry and public sectors. The new collaborative hub will fast-track the creation, testing and commercialisation of clean alternative fuels.

Clean algae biofuel project a world leader

A joint \$3.3 million project, led by Murdoch and involving the University of Adelaide, now leads world algae biofuel research after more than 12 months of consistent results at both universities. Although previously thought impossible, large quantities of algae for biofuel are being grown by the team in open ponds, consistently and without contamination. Led by Murdoch's Professor Michael Borowitzka, the project has received \$1.89 million funding from the Australian Government as part of the Asia-Pacific Partnership on Clean Development and Climate.

This is the only biofuel project in Australia working simultaneously on all steps in the process of microalgal biofuels production from microalgae culture, harvesting of the algae and extraction of oil suitable for biofuel production. Due to the project's success, construction of a multi-million-dollar pilot plant to test the whole process on a larger scale will begin in Karratha in January 2010 and is expected to be operational by July 2010.



Professor Michael Borowitzka



NEWCASTLE UNIVERSITY

The University of Newcastle is a national and international leader in teaching and research. Ranked in Australia's 'top ten' for research, the University's strengths are in the areas of health, energy and the environment, and science and engineering.

Across these fields, the University has 12 priority research centres, leads two Australian Research Council Centres of Excellence, and hosts large national and international research partnerships.

Staff, students, and industry partners are drawn to Newcastle because of its reputation for innovation and excellence.

Climate change research at the University of Newcastle

Water availability in Australia strongly influences national well-being and environmental health. In 2007 the University of Newcastle established the Centre for Climate Impact Management (C2IM) to address the key issues of natural climate variability and climate change, and their impacts on water availability. This includes understanding the magnitude of predicted climate change relative to natural variation, the environmental impact of climate change and variability, and optimal management of our water resources.

C2IM is a strategic initiative involving more than 20 researchers in two research groups: the Environmental Engineering Research Group in the Faculty of Engineering and Built Environment, and the Environmental and Climate Change Research Group in the Faculty of Science and IT. The Centre assesses the potential effect of climate change on water availability. Its research will lead to a new generation of tools to manage the security of Australia's urban and rural water supply systems.

The Centre's research program focuses on:

1. A data-driven program to assess the historical record of recent climate extremes – for example drought and unusually hot weather – and their driving processes. Researchers are analysing instrumental and palaeo-records of climate to develop a long-term model of climate variability. This data will address the issue of whether the recent drought is unusual and whether it is indicative of a changing climate.
2. A program to better understand how environmental processes operate. While this program has elements of traditional hydrology and climatology, researchers are also working in the exciting new areas of non-linear dynamical systems and remote sensing.
3. The development of management tools to reflect the novel technical challenges of managing climate change impacts. This is particularly important for hazardous waste containment in mines, the rehabilitation of mining landscapes and understanding soil carbon dynamics.

These areas of focus will provide a greater scientific understanding of climate variability and environmental response, and the potential impact of climate change. They are the scientific foundation upon which decisions and policy can be made to manage climate change impact.

C2IM collaborates with the eWater Cooperative Research Centre and the Tom Farrell Institute for the Environment.

QUEENSLAND UNIVERSITY OF TECHNOLOGY

One of Australia’s largest universities, QUT is ‘a university for the real world’, and is recognised for maintaining strong connections with industry and delivering applied research related to ‘real-world challenges’.

QUT’s new Science and Technology Precinct, opening in 2012, will mark a critical stage in the evolution of QUT’s cross-faculty response to dealing with global issues such as climate change. It will also mark a further step in meeting QUT’s core strategic commitment to building on its strengths in science, technology, energy and mathematics.

Institute for Sustainable Resources

One of four institutes at QUT, The Institute for Sustainable Resources (ISR) is the university’s portal to sustainability and climate change research. ISR conceptualises, plans and manages the delivery of sustainability-related research projects by harnessing research expertise and capability.

ISR Director, Peter Grace, was Australia’s first Professor of Global Change and his position is dedicated to engagement in internationally recognised climate change research.

ISR’s research portfolio is based on the following domains:

- Greenhouse gas management
- Long-term ecological research
- Water and geosystems
- Energy systems
- Sustainable communities and infrastructure
- Food security.

Within these domains, integrated research is informing technological, social and policy solutions to the sustainable use of natural

resources and adaptive responses to the impacts of climate change.

By bridging traditional boundaries and bringing together teams from across QUT’s disciplines and faculties including Science and Technology, Built Environment and Engineering, Business and Law, ISR ensures that the strengths and capabilities of the university can be channelled into dynamic, trans-disciplinary research teams. The Institute collaborates and builds relationships and networks locally, nationally and internationally.

In addition to its core research, the Institute is developing tools such as the Greenhouse Gas Calculator for agriculture, managing living laboratories such as the Samford Ecological Research Facility, attracting external funding into sustainability research, shaping policy, and supporting a range of postgraduate and postdoctoral research.



Photo: QUT

Climate mitigation and adaptation through improved farm practices

Agriculture contributes to greenhouse gas (GHG) emissions, including the release of nitrous oxide (N₂O), one of the most potent GHGs. ISR-led research is investigating management practices which reduce soil-based GHG emissions, particularly N₂O, and improve soil carbon management.

Professor Peter Grace is coordinating a national research program supported by the Federal government and national industry bodies. This study involves measurement and analysis of emissions from a range of sites and farming systems across Australia, including grains, cotton, cane and dairy. Automated GHG monitoring chambers, developed by ISR in conjunction with the Institute for Meteorology and Climate Research in Germany, are being deployed as part of the experiment.

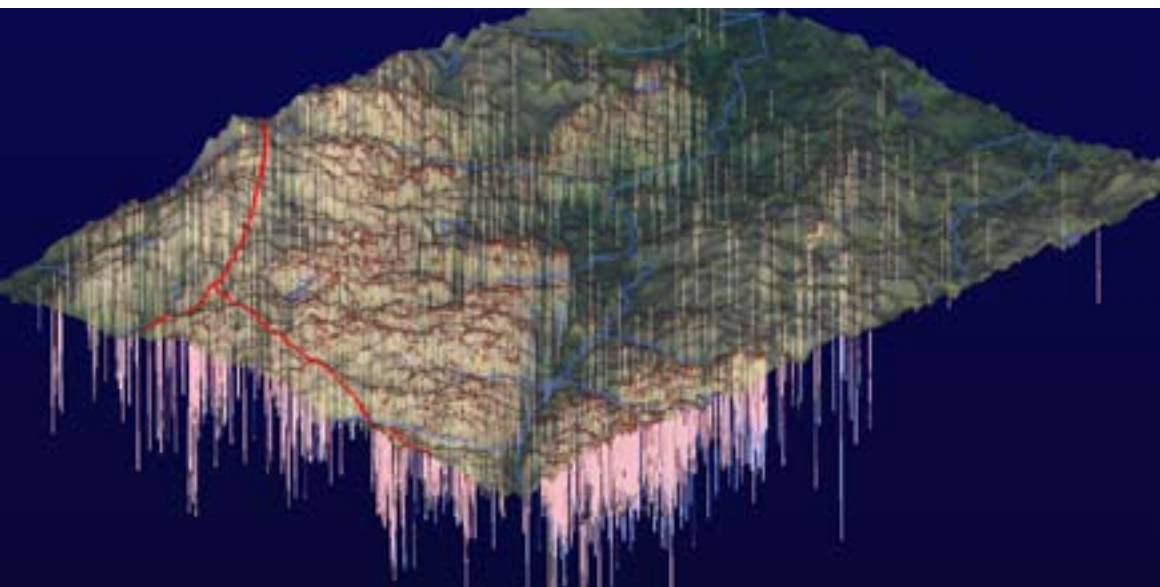
The results of this study will inform farming practices that reduce GHG emissions. By changing current regimes of nitrogenous fertiliser application, tillage, irrigation and crop selection, farms have the potential to become more sustainable, efficient and profitable. Such farms would be better placed to

adapt to the effects of climate change.

Data from this research will also be used by the National Carbon Accounting System and the Department of Climate Change to estimate GHG emissions from managed land systems.

The **Groundwater Visualisation Unit (GVU)** led by Associate Professor Malcolm Cox brings together expertise from the Schools of Natural Resource Sciences and Mathematical Sciences, and the High Performance Computing Unit. Many significant groundwater systems are stressed and overexploited. The signs and impacts of stress are not as visible or as well understood as they are with surface water systems. GVU is developing three-dimensional visualisation models of groundwater systems by integrating data from a variety of sources. GVU is also determining the information, technical and policy interventions that might be required for communities to adapt to changing groundwater regimes.

The models effectively present complex, dynamic processes and are useful management and communication tools accessible to water resource managers, groundwater users and policy makers.



Visualisation model for demonstrating the intensity of groundwater extraction showing topography, bore locations and depth

The **Centre for Subtropical Design (CSD)**, headed by architect Rosemary Kennedy, conducts research into a range of building typologies and urban planning approaches which better harmonise the relationship between the built, natural and social environments in a subtropical setting. With the need to adapt to climate change combined with rapid population growth in south-east Queensland, the Centre focuses on planning and design that delivers more sustainable outcomes and improved liveability in both the public and private realm.

To achieve this, the Centre works with external industry partners to improve the integration of elements such as natural ventilation, shading, building orientation, vegetation, and open space elements into building design and community planning. CSD promotes design principles that respond to the opportunities presented in a subtropical environment through research papers, publications, conferences and workshops.

Social research into climate adaptation at ISR is being led by Professor Laurie Buys. Research includes a NCCARF-funded project examining the socio-economic impacts of climate change on forestry regions and the communities dependent on them. It draws on the contributions of a team skilled in community and regional development, social sustainability, resource management and economics. This study will provide insights for forest managers into both the impacts of climate change and community adaptation responses in terms of forest management, future investment, lifestyle and employment issues.

A residential typology designed for liveability and higher-density living in the subtropics



UNIVERSITY OF SOUTHERN QUEENSLAND

The University of Southern Queensland is a dynamic young university with three campuses across regional Queensland in Toowoomba, Fraser Coast and Springfield.

USQ is committed to excellence in fundamental research as well as developing innovative technologies for the future. It maintains relevance in research by linking with industry and business through local and international research networks and is committed to providing excellence in research training for its students.

USQ has a particular emphasis on research in sustainable futures.

It is home to the Australian Centre for Sustainable Catchments, a research centre with national expertise in climatology and agriculture and a focus on underpinning the profitability and sustainability of water and catchment management in Australia.

The Centre has established a 20-year research program aimed towards helping Queensland develop a thriving regional economy based on world-leading practices in regional water and catchment management, including the most efficient and sustainable stewardship of our natural resources.





This multidisciplinary Centre comprises four key research groups:

- **Climate Science, Environmental Measurement and Modelling**
Dedicated to developing integrated environmental models to provide stronger predictive capacity for regional land and water planning and management.
- **Sustainable Landscapes**
Investigating broader issues concerning the sustainable management of natural resources and connections with communities within catchments.
- **Sustainable Water Use**
Focusing on issues concerning water quality in rivers and reservoirs; on urban stormwater runoff; on wastewater treatment and reuse; and on groundwater hydrodynamics and quality.
- **Spatial Analysis and Modelling**
Exploring new spatial modelling tools to support the development of sustainable land and water management.

The Centre is led by world-renowned climatologist Professor Roger Stone, who has a long career in climatology and meteorology both at an operational level and in research and development in climate modelling. He has spent more than two decades liaising closely with industry, especially rural industry, and government in Australia and internationally, on practical issues associated with adaptation and the development of effective management systems that can be applied to better manage the potential impacts of climate variability and climate change.

UNIVERSITY OF THE SUNSHINE COAST

The University of the Sunshine Coast campus is located at Sippy Downs, on Queensland's Sunshine Coast, with additional learning and research facilities in Noosa Junction and on Fraser Island.

The campus has won a host of awards for its architecture and is a designated wildlife reserve, home to Eastern grey kangaroos.

The 2009 Good Universities Guide awarded the University five stars for teaching quality, staff qualifications, graduates' generic skills and graduate satisfaction.

One of Australia's youngest universities, USC has researchers involved in climate change adaptation projects across Australia and internationally, across tiers of government, including the COAG National Climate Change Adaptation Framework Taskforce, National Seachange Taskforce, and Sustainable Economic Growth for Regional Australia.

USC's fully articulated program in Climate Change Adaptation has attracted the interest of students from as far as Tanzania and Guyana. This year, USC graduated the first students in the world with advanced degrees (Masters) in Climate Change Adaptation. Some of these graduates are employed by local and Federal government agencies, and have already used their degree to advise on climate change issues.

Climate change research at USC

Research in climate change adaptation within the University is undertaken by two primary groups within the School of Science and Education: Climate Change, Coasts and Catchments and The Sustainability Research Centre

These cross-disciplinary groups focus on climate change adaptation, in particular assessing coastal vulnerability, integrated coastal zone management and catchment management, sustainable communities and environments, and the institutions that relate to them. The two groups are committed to research that supports the transformation of society towards sustainability. Examples of USC's research foci include coastal management, climate change adaptation, water management, natural and cultural heritage, innovation, adaptive growth, and community well-being.

USC staff's areas of expertise include:

- A lead author in all four of the Intergovernmental Panel on Climate Change (IPCC) Assessment Reports in 1990, 1995, 2001 and 2007
- A senior consultant with the International Union for Conservation of Nature (IUCN)
- A representative of Land–Ocean Interactions in the Coastal Zone (LOICZ) Intergovernmental Oceanographic Commission of UNESCO (IOC Assembly, Executive Council, IOC Coastal–GOOS Panel)
- A convener of the Port of Brisbane Community Consultative Committee
- A member of the Steering Committee for the Sustainable Economic Growth for Regional Australia (SEGRA)
- A director of the Consortium for Integrated Resources Management (CIRM)
- A member of the Management Group for NCCARF.

Some recent examples of USC's research projects include:

- Assessing the impact of climate variability and change on a community project while enhancing adaptive capacity: Case study Shinyanga agriculture project, Tanzania.
- Erosion or shoreline retreat: A vulnerability assessment of Rainbow Beach in Queensland and implications for future management.
- Potential sea-level rise and coastal retreat along the western coast of Fraser Island.
- Ecosystem-based assessment of the Sigatoka River system, Viti Levu, Fiji and development of a management plan for sustainable use of the resources.



Caption: Environmental Change Management postgraduate program student shown sampling water quality parameters at the Maroochy River estuary credit: USC



APPENDIX 4: NCCARF STAFF PROFILES

Directorate

Professor Jean Palutikof is Director of the National Climate Change Adaptation Research Facility at Griffith University. She took up the role in October 2008, having previously managed the production of the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report for Working Group II (Impacts, Adaptation and Vulnerability), while based at the UK Met Office.

Prior to joining the Met Office, she was Professor in the School of Environmental Sciences, and Director of the Climatic Research Unit, at the University of East Anglia, UK, where she worked from 1979 to 2004, and a Lecturer at the Department of Geography, University of Nairobi, Kenya, from 1974 to 1979.

Her research interests focus on climate change impacts, and the application of climatic data to economic and planning issues. She specialises in the study of changes in extreme events and their impacts, especially windstorms. She was a lead author for Working Group II of the IPCC Second and Third Assessment Reports, and is contributing to the development of the Fifth Assessment. She is a member of the Science Committee of the IGBP. She has authored more than 200 papers, articles and reports on the topic of climate change and climate variability. Her proudest moment to date was attending the ceremony in 2007 at which the IPCC was awarded the Nobel Peace Prize.

Maree Lauder joined the Facility in November 2008. Prior to joining NCCARF she was at James Cook University (JCU) in the role of Executive Assistant to the Executive Dean of the Faculty of

Science, Engineering and IT, and later as School Manager for the School of Maths, Physics and IT. Maree obtained her Masters degree in Professional Accounting and Business Administration while working at JCU.

Research Team

Richard McKellar has 28 years of experience in climate change research, policy, planning and communication, strategic planning for regions, industries, infrastructure and urban areas, conflict management, communication and organisational management and change. Mr McKellar has worked in a variety of roles in government, and has conducted and managed consultancies. He has specific skills and demonstrated capacity in guiding cross-disciplinary initiatives which link policy priorities, directed research, management engagement and evaluation and process improvement.

Richard has provided consultancy services to NCCARF, specifically coordinating the development of the Settlements and Infrastructure, Freshwater Biodiversity, Primary Industries, and Terrestrial Biodiversity National Climate Change Adaptation Research Plans.

Frank Stadler joined NCCARF in August 2008. Before this he provided freelance education and consultancy services to educational and natural history organisations. His services included school in- and excursions, National Science Week programs, curatorial and exhibition design services and consultancy services to the Botanic Garden of Adelaide.



Frank holds a Bachelor of Science with Honours from Macquarie University, and in 2000 was awarded the Macquarie University Bill Cantwell Prize for outstanding achievements in Honours research. He investigated plant–herbivore relationships under elevated atmospheric carbon dioxide concentrations and the symbiotic relationship between a sessile hydroid and its intertidal marine snail host.

Frank also brings extensive curatorial and project management experience to this position. In 1999–2002 he curated the Biological Sciences Museum at Macquarie University and in 2006–2007 the public program at the Tweed River Art Gallery. As Team Leader of Research Coordination at NCCARF, Frank contributes to the development of National Climate Change Adaptation Research Plans, and to coordinating research funding calls relevant to these Plans, as well as administering synthesis and integrative research projects.

Dr Ida Fellegara joined the Facility in June 2009. Prior to this, she was the Education Officer with CRC Sugar Industry Innovation through Biotechnology for 9 months. During her time at CRC SIIB, she organised education activities for the CRC SIIB postdoctoral students, the general public and the sugar industry community. Ida has extensively tutored and lectured university students, as well as primary and secondary school students and the general public, in marine and coral reef ecology and other environmental subjects. Ida also worked at the Queensland Museum on the Seabed Biodiversity projects.

Ida obtained a PhD from the Centre for Marine Studies at The University of Queensland. Her PhD focused on the ecophysiology of corals living in

a marginal environment (Moreton Bay, south-east Queensland). As an NCCARF Research Fellow, Ida has been involved in outlining implementation plans for the National Climate Change Adaptation Research Plans, and in assisting in the administration of synthesis and integrative research.

Dr Daniel Stock joined the Facility in October 2009. Prior to joining the Facility he was the National Lantana Best Practice Management Officer and worked for the Queensland Department of Primary Industries and Fisheries. In this position, he oversaw the production of the Lantana Best Practice Management Manual and Decision Support Tool, a software system that advises landholders on the best integrated solutions when tackling lantana, involving efficacy control rates, costs and benefits.

Daniel obtained a PhD from Griffith University, Australia, focusing on the competition between the environmental weed Lantana and subtropical rainforest in south-east Queensland to determine the forest's resilience to lantana invasion. He has published a book: *The Dynamics of Lantana Invasion of Subtropical Rainforest: Can Subtropical Rainforest Defend Itself from the Environment Weed?* His research interests focus on environmental weeds, rainforest ecology, rainforest invasion resilience and primary production extension. As an NCCARF Research Fellow, Daniel has contributed to the development of National Climate Change Adaptation Research Plans, and in administering synthesis and integrative research projects.

Knowledge Adoption Team

Marie Waschka has been a member of NCCARF's management team since its inception, and has been involved in the establishment of the NCCARF office, the development of a number of National Climate Change Adaptation Research Plans, and the establishment of Adaptation Research Networks. Marie is currently the Knowledge Adoption Manager, responsible for the coordination of the Adaptation Research Networks and for NCCARF's knowledge communication activities. Marie holds a Bachelor of Science in Australian Environmental Studies, and has extensive experience in project and research management, policy development, and in knowledge communication.

Formerly Griffith University's Research Development Manager, Marie has also held the positions of Knowledge Communication Manager, and Manager of Water Policy Development and Liaison at the former Murray–Darling Basin Commission. While at the MDBC, Marie was responsible for the management of the MDB Groundwater Status Report 1990–2000 project, which was shortlisted for the Eureka Prize for Water Research in 2005, and has been involved in a number of large knowledge communication projects, including the National Dryland Salinity Program's enhanced communications year. Marie has also held various environmental management roles within Commonwealth and local government, and in the private and community sectors.

Jeannette Langan joined the Facility as Knowledge Communicator in February 2009. She began her career as a news journalist with APN and later News Ltd media groups before moving into local government stakeholder communications and engagement. Jeannette specialises in science communication and, prior to joining NCCARF, served as Science and Technology Group Communications Officer for Griffith University.

Jeannette is currently responsible for running NCCARF's seminar series, managing production of its quarterly newsletter, NCCARF publications, assisting in the maintenance of NCCARF's website, and assisting in the organisation of NCCARF events.

Ann Penny has recently joined NCCARF from James Cook University in Townsville, where she worked as the Communications and Liaison Officer with the Fishing and Fisheries Research Centre. In this role, Ann provided all the media and science communication needs for the Centre as well as having a central role on the social science team.

Ann has recently worked on projects as diverse as: the resilience of reef line fishers to extreme events; socio-economic indicators for sectors of the Queensland Inshore fishery; and risk assessments of tropical fisheries. Ann holds a Bachelor of Science with Honours from James Cook University, where she investigated the impact of fishing on mud crabs. Having worked in the tourism industry, taught at university, and spent time on fishing boats, Ann has experience in communicating and working with a diverse range of people.

Ann has a strong project management background and experience working with university and government-based researchers to achieve project outcomes. She is particularly interested in communicating the outputs of research in a way that results in real change in policy and legislation.

In the role of Networks Coordinator, Ann will play a key role in administration and support for Adaptation Research Networks, as well as in NCCARF's knowledge communication activities.

Kasia Wallis joined NCCARF in September 2009 as the Website and Database Communications Officer. Kasia studied Multimedia at Griffith University, where she started a successful multimedia company. She moved onto working at Logan City Council, ABC and WWF Australia, where she acquired the skills to lead online teams, provide innovative solutions, and to develop web and social media strategies, CMS development and online communications. Kasia has an extensive background in environmental issues from the 3 years spent at WWF Australia and NCCARF.

Kasia is currently responsible for the development and maintenance of NCCARF's website.

Business and Operations Team

Jennifer Watson joined NCCARF in May 2008 as the Business and Operations Manager.

Jenny has been involved in financial management and administration for many years. Prior to joining NCCARF, she was the Financial Controller for Early Learning Services, a publically listed company, and for 5 years before that was the Chief Financial Officer for a joint venture partnership between the Queensland government and IMG. Jenny is a qualified Certified Practicing Accountant and undertook a Bachelor of Business Degree at Griffith University, majoring in Accounting and Business Law.

Jenny is responsible for the management of NCCARF's financial management, reporting, and business operations, including administration and human resources.

Kerry Fitzgerald joined the Facility in February 2008 as the Personal Assistant to the Interim Director before taking on the role of NCCARF Administration Officer. She has a wealth of experience in administration.

Kerry began her working career in Tasmania in an accountant's office, followed by 7 years with the Hydro-Electric Commission of Tasmania. Work was interrupted to nurture a family, and in 1983 she moved to Malaysia where she did 5 years of volunteer work. Kerry has been employed for the past 20 years in education administration in Canberra, and more recently at NCCARF at Griffith University.

Kerry supports all aspects of NCCARF's business and operations.

Former NCCARF staff

Professor Jan McDonald was the NCCARF Interim Director between May 2008 and October 2008, and was then the Deputy Director/Research Manager until mid-2009. Jan led Griffith University's bid to host NCCARF, and played a critical role in the establishment of the NCCARF office, and in the development of all the National Climate Change Adaptation Research Plans.

Dr David Ugalde was the acting Research Manager at NCCARF from the end of 2009 until April 2010. David led the Research Team during this period, and in particular was responsible for the development of Implementation Plans for the National Climate Change Adaptation Research Plans.

Dr Florence Crick was a Research Coordinator at NCCARF from early 2009 until early 2010. During this time, Florence assisted in the development of National Climate Change Adaptation Research Plans, and in the coordination of synthesis and integrative research projects.

Dr Claudia Ollenburg was a member of the NCCARF Research Team in the role of Research Coordinator for a short period in late 2008, and assisted in the development of National Climate Change Adaptation Research Plans.





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