Australian Government
Department of Climate Change
and Energy Efficiency

Risks from Climate Change to Indigenous Communities in the Tropical North of Australia

Risks from Climate Change to Indigenous Communities in the Tropical North of Australia

A scoping study for the Commonwealth Department of Climate Change and Energy Efficiency, the Western Australian Department of the Environment and Conservation and the Northern Territory Department of Natural Resources

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Executive Summary

This scoping study presents an assessment of the potential impacts of climate change on Indigenous settlements and communities across tropical northern Australia, including the Torres Strait Islands and the Pilbara region of Western Australia. The study region is home to about 87,000 Indigenous people, around a quarter of the total population of 355,000. The region includes 665 settlements varying from less than 50, to 3,500 people. Approximately 50 per cent of this Indigenous population lives within 20 kilometres of the coast or on offshore islands.

Indigenous people in northern Australia face many existing challenges. These include: remoteness, poor health, inadequate infrastructure, lack of educational and employment opportunities, and low incomes. Climate change will exacerbate many of these pre-existing challenges. However, new opportunities also exist for some of these communities from climate change. Many of these opportunities will stem from existing roles that community members play in managing natural and cultural resources in remote areas on behalf of the nation.

Climate change is expected to impact the study region in diverse ways. Although the magnitudes are uncertain, impacts that are certain to occur include:

- Increasing atmospheric carbon dioxide levels that will alter plant growth;
- Increasing temperatures that will affect human and natural systems;
- Rising sea levels that pose threats to low-lying settlements and estuarine ecosystems; and
- Ocean acidification that will endanger coral reefs and affect marine food chains.

Other impacts likely to occur but with less certainty include:

- Seasonal change in rainfall with likely increases in intensity in the rainy season for some regions which will affect access and water supplies; and
- Greater cyclone intensity that will increase inundation of coastal areas.

Further information on these impacts for the study region is provided in Chapter 2.

In summary, this study specifically considers the impacts of climate change for Indigenous communities living in the tropical north of the country on: biodiversity, health, infrastructure, education and livelihood opportunities. Key findings from this analysis include:

Climate projections for the region indicate a range of biophysical impacts with various levels of certainty. Uncertainty in climate projections will be an ever present constraint, however this concern cannot be allowed to delay action. There is sufficient certainty to enable immediate policy development, as well as to further research agendas and engage with the community directly about prioritising activities (discussed in Chapter 2).

Climate change will impact the natural environment of the north both directly and indirectly, with major flow-on implications for remote communities dependent on natural resources. These impacts are generally poorly understood although it is clear that the role of people in the landscape to manage these impacts will be crucial (discussed in Chapter 3).

Climate change is likely to exacerbate existing, and create new, health risks for Indigenous people. Proactive adaptation to these risks would lead to no-regrets improvements to health. These strategies should be identified and acted on as soon as possible (discussed in Chapter 4).

Both transport and communications infrastructure in many areas of the study region are extremely limited. Climate change will cause disruption to the infrastructure that does exist, particularly in coastal regions. Improving key access points, raising new and existing building standards for cyclone-proofing and enhancing the resilience of local energy provision and maintenance systems are critical investments (discussed in Chapter 5).

Education has an important to role to play in preparing northern communities for climate change. However, amendments to current curricula are required to enhance the capacity of communities to adapt and build resilience to climate change impacts. The role of Indigenous knowledge in strengthening cultural resilience must also be specifically recognised in any education program (discussed in Chapter 6).

Some economic opportunities may arise from the need to better manage, and in some cases restore, ecosystems for biodiversity conservation and for carbon dioxide mitigation and sequestration activities. Opportunities and livelihood options related to this issue need to be better understood (discussed in Chapter 7).

The study recommends that the next step in developing well-articulated adaptation strategies for Indigenous people in the study region will require collaboration and partnerships between Indigenous communities, government, research and non-governmental organisations. Such strategies will require an exploration of future scenarios of integrated changes for their specific contexts to determine what actions would most improve the resilience of these different communities. Specific recommendations are listed in Chapter 9.

Chapter 1

Introduction

Terms of Reference and Objectives

This scoping study has been commissioned by the Department of Climate Change and Energy Efficiency (DCCEE). Its purpose is to identify the impacts of climate change on Indigenous communities in Australia's tropical north and assess the vulnerability and adaptive capacity of these communities. Further, it is intended to assist in identifying knowledge gaps, areas for future research and on-ground priorities.

As directed by the terms of reference, the main subject areas investigated include:

- Projected climate changes;
- Impacts on Indigenous health due to climate change;
- Impacts on Indigenous people due to changes to the environment because of climate change;
- Impacts on infrastructure due to climate change and the effect on service delivery to Indigenous communities;
- Impacts on Indigenous education due to climate change;
- Impacts on Indigenous employment and enterprises due to climate change; and
- Opportunities for Indigenous communities due to climate change.

Following discussion with an expert group established to assist the project team, some of these subject categories were redefined, with the agreement of the DCCEE, to increase their relevance to the Indigenous policy context and to an Indigenous audience. As a result, the revised subject areas include:

- Climate projections;
- Health;
- Biodiversity (encompassing environment);
- Transport and communication infrastructure;
- Education; and
- Livelihoods (encompassing employment, enterprise and opportunities).

The objectives of this scoping study are outlined on the following page, with an indication as to where they have been fulfilled in the report.

Methods

> "There can be no 'one size fits all' approach to working with communities in relation to adaptation strategies - every community is unique and has varying strengths and weaknesses."
>
> - Regional stakeholder.

The terms of reference for this multidisciplinary scoping study indicated that it should entail an evaluation of relevant literature and key stakeholder interviews, and present data and analysis using mapping as appropriate. Designed as a scoping study to describe the state of knowledge, the team was not expected to undertake new research that would involve engaging directly with Indigenous communities beyond key stakeholder interviews. Moreover, the study team was not expected to undertake new climate change projections. It was acknowledged in the terms of reference, however, that extensive, focused consultation and community interaction should be undertaken in any future work commissioned by the DCCEE.

At the start of the project, an expert advisory group[1] was formed to advise on project design, methods and approach. In particular:

- How to overcome the limitations posed by scarcity of published information relevant to the climate projections;
- How to adequately address the significant diversity of Indigenous circumstances and experiences across such a large geographic area in a limited time period; and
- How best to collate and integrate existing information and integrate spatial, demographic and qualitative data and insights.

Scoping study objectives	Report response
Develop a comprehensive summary of the current knowledge of projected climate changes in the tropical north, including consideration of timescales, intensity and extent.	**This summary is presented in Chapter 2, with additional material in Appendix 3.**
Identify and summarise the direct and indirect impacts of climate change on Indigenous communities in the tropical north, including impacts on the main subject areas previously detailed.	**The direct and indirect impacts of climate change on the main subject areas are discussed in Chapters 3-7.**
Undertake an assessment of the factors that affect the vulnerability and resilience of Indigenous communities.	**The assessment of the factors that affect the vulnerability and resilience of Indigenous communities are discussed in Chapters 3-7. More detailed analysis was undertaken and is presented in the case studies in Chapter 8.**
Identify regions in which Indigenous communities are vulnerable to the effects of climate change based on the projected impact of climate change and geographical locations.	**The ability to identify the regions where Indigenous communities are most vulnerable to climate change is severely limited by the lack of available data. To avoid creating a false sense of certainty over which areas are more or less vulnerable, this report has used case studies in Chapter 8 to highlight the contextually specific nature of Indigenous vulnerability. The report recommends a regionalisation approach as a partial resolution to this issue in Chapter 9.**
Identify current gaps in knowledge within the main subject areas previously listed.	**The gaps in knowledge for the main subject areas are noted throughout Chapters 1-7.**
Present data and information about the main subject areas that can assist resource managers and Indigenous communities to begin addressing the impacts of climate change.	**Chapter 9 discusses the findings of Chapters 1-7 with reference to the case studies presented in Chapter 8.**
Identify opportunities that may exist for Indigenous people brought about by climate change under the subject areas previously listed.	**Opportunities relating to carbon abatement and the provision of environmental services are discussed in Chapter 7.**
Provide recommendations for future research and on-ground priorities under the main subject areas.	**Recommendations for future research and on-ground priorities for the main subject areas are provided in Chapter 9.**

The report relies on information from a variety of sources: published and unpublished scientific and policy literature; informal researcher networks; Indigenous land management agency networks; and interpretation of climate change scenarios for the study regions. It also draws on different types of information to capture diverse perspectives on a complex topic that has to date been given little attention by the research sector. For example, geographic information was derived from maps of Indigenous socio-economic characteristics and overlaid with maps of projected changes to climate variables such as increasing temperatures.

The expert advisory group reinforced the value of informal methods to complement the literature survey and quantitative data analysis. These methods included personal communication with experienced researchers and policy-makers in the field. As a result, valuable commentary on preliminary findings was included prior to the final drafting of the report.

For the literature review and data analysis section of this report, references were obtained through keyword searches of databases and websites of relevant organisations. The majority of these searches were carried out by early 2009, with limited updates to include information from key government policy documents (e.g. the Outstation/Homelands policy, Northern Territory Government), scientific conferences (e.g. Greenhouse2009) and national reports (e.g. 2008 Native Title Report), which were all publicly available by May 2009. Literature presented in this document is therefore current as of this date.

This assessment used data from the Australian Bureau of Statistics (ABS) and other publicly available datasets for topography, landform and socio-economic information. This data was then manipulated using Geographic Information System mapping tools. Where possible, maps are used throughout the report to illustrate aspects of the subject areas of interest. Unless otherwise stated, these maps contain data from the Community Housing and Infrastructure Needs Survey (CHINS) 2006 dataset.

The details of the climate projection methods are included in Chapter 2, with additional information on evaporation and sea level rise in Appendix 3.

Due to the context specific nature of climate impacts and the diversity of Indigenous circumstances, the significance of local factors affecting social and economic vulnerability were explored through a set of eight case studies (presented in Chapter 8). The case studies cover a range of communities from isolated, small communities; to larger communities with significant non-Indigenous populations. The case studies were chosen to broadly demonstrate how major differences in size, remoteness, socio-economic characteristics, location (coastal versus inland) and environmental drivers can influence the outcomes of climate change assessments.

The terms of reference indicate that this report was not aimed at engaging stakeholders at the community level; however, the expert group considered some Indigenous participation essential, and this was undertaken through the case studies. The case studies were written by experts who had a long track record working in the case study community (or locality) and were available on relatively short notice to prepare a commentary on how a set of climate change scenarios may affect the communities concerned. These case studies were prepared in consultation with community leaders, or in one case, written directly by a community leader. As a result, the case studies provide rich, qualitative and personalised descriptions of the current circumstances facing many Indigenous communities in a variety of environments from which a range of potential and speculative impacts are discussed.

For each of the case studies, stakeholder feedback was sought from a representative group of government, non-government organisation (NGO) and community leaders. This feedback has been included in report revisions and in some cases by anonymous direct quotation. All stakeholders' comments were highly valuable and the authors gratefully acknowledge this feedback.

Following analysis of literature, climate change projections and case studies, the recommendations for future work were identified and discussed amongst the project team, and are reported in Chapter 9.

Background and context to study

Study Area

As directed by the terms of reference, this study is limited to the 'tropical north', specifically, the Timor Sea and Gulf of Carpentaria drainage basins, and the north-east coastal drainage division north of the city of Cairns. The Pilbara region of Western Australia was included in the study area after discussion with DCCEE staff.

This area includes the major northern cities of Darwin and Cairns, larger regional centres of Broome, Kununurra, Katherine, Wadeye (Port Keats), Maningrida, Nhulunbuy, Borroloola and Cooktown, and the mining towns of Port Hedland, Karratha, Mt

Isa and Weipa. Figure 1 shows Indigenous population community locations and sizes. Population density is low across the region, at around 0.1 people per square kilometre (Whitehead et al 2003b) although the proportion of Indigenous people, particularly outside the urban centres, is high when compared to Australia as a whole. For example, 60 per cent of the total population in Cape York is Indigenous, while in the Kimberley the Indigenous population is 47 per cent and it is 66 per cent in Arnhem Land (Hill et al 2008). Within the regions that comprise the study area there are thousands of clan estates and more than 130 language groups (Woinarski et al 2007).

The regional economy is dominated by sectors dependent on natural resources and the provision of government services. The largest industry sectors in the tropical north are mining, tourism and cattle. The dominant land use is pastoral grazing under pastoral leasehold tenure. Another key feature of this region is the very large proportion of land held under Aboriginal title, although the figures vary considerably from jurisdiction to jurisdiction.

Study population - historic context and current situation

Indigenous people in north Australia face many challenges, and much public debate has concentrated on the acute and persistent social and economic disadvantage that the majority of these communities experience. Many of them are distant from major transport routes, have minimal communication infrastructure and lag behind considerably on most conventional indicators relating to health, education, income and employment (SCRGSP 2007). These concerns are relevant to this study because, for example, more extreme weather caused by climate change is likely to further impede access to information, goods and services and make participation in market-based economic activity more difficult. These features contrast with the relatively good access to services and economic opportunities that contribute to the well-being and resilience of non-Indigenous communities in other regions of Australia.

While the environmental condition of the study region at the landscape scale is generally good (Woinarski et al 2007), increasing environmental stress from a range of threats (e.g. changed fire regimes, exotic plants and animals, increased urban development and farming) highlights the need to address the sustainability of current land use, economic development pathways and socio-

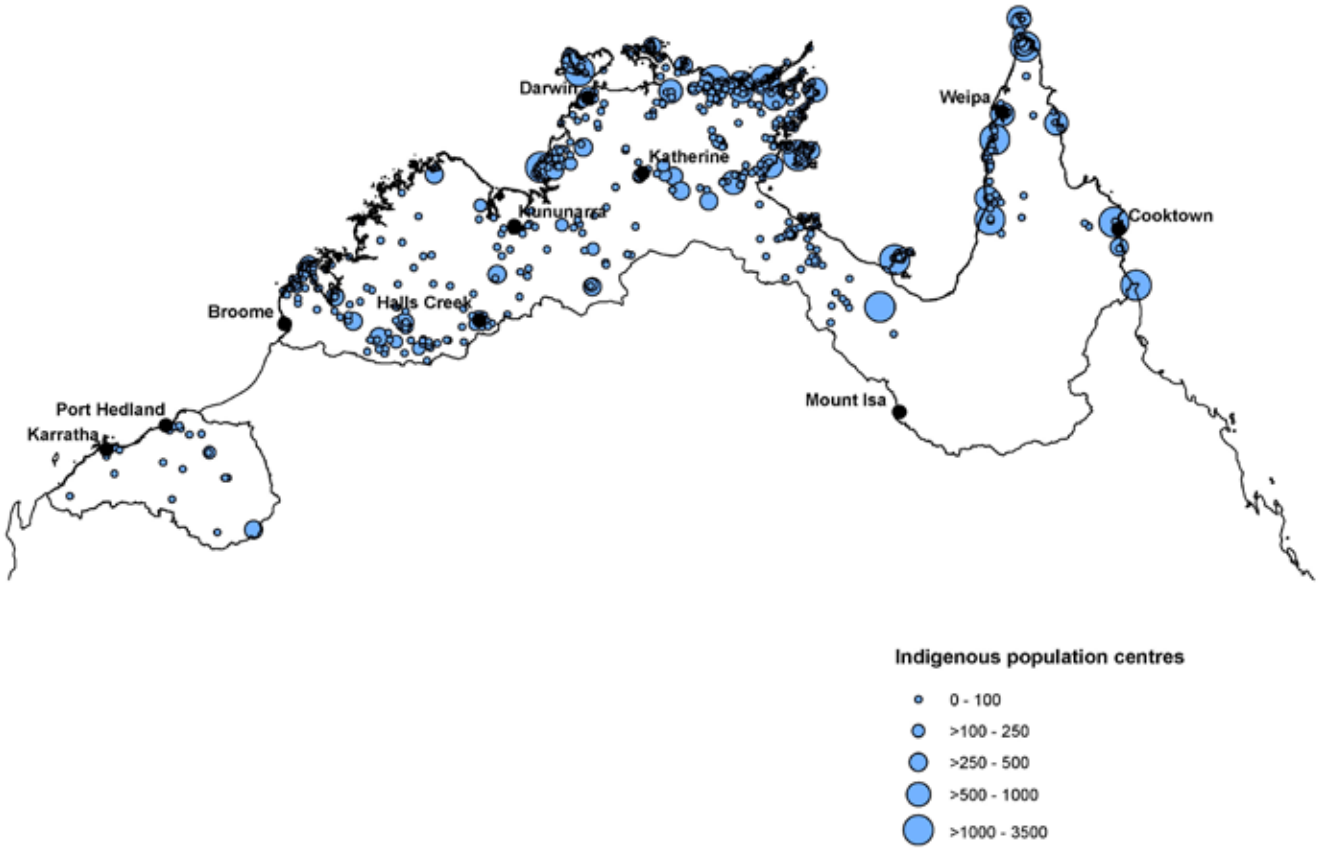


Figure 1: Indigenous community location and size included in study region

economic disparity. All of these factors will be affected by climate change.

In many areas of the study region, Indigenous people are actively involved in sustainability initiatives and can offer innovative contributions to environmental management and restoration and natural resource based enterprise development. These initiatives are attracting policy attention for the positive effect they may have on broader social well-being, as well as their contribution to local livelihoods (Hill et al 2008). For example, 74 per cent of communities report that involvement in Indigenous Protected Areas (IPA) makes a positive contribution to reducing substance abuse and to restoring family and community structures (Gilligan 2006). Altman and Jackson (2008) argue that restitution of environmentally beneficial relationships with the land may contribute to reducing the vast differences in social outcomes between Indigenous and non-Indigenous Australians. Such trends are explored in Chapter 7.

The current socio-economic status of most Indigenous settlements in this study region is very low. Life expectancy for Indigenous Australians is well below the national average, and the Indigenous communities located in this study region broadly reflect these patterns. Key factors that have led to this disproportionate burden of disease include: inactivity, malnutrition, social disorders and a long-standing history of socio-economic disadvantage (Burgess et al 2009).

Demographics of the study region

In 2006, the total population of the tropical north was about 355,300, of whom about 24.6 per cent were Indigenous.[2] The age structure of the Indigenous and non-Indigenous population is markedly different, as shown in Figure 2, with the Indigenous population having a much younger age profile. At one extreme, the first four age groups each have above or close to 10 per cent of the total Indigenous population. Given the lifecycle patterns of education, employment, childbirth and retirement, this age structure has implications for the level and types of services demanded by Indigenous and non-Indigenous Australians in the region. For example, although the Indigenous population makes up 24.6 per cent of the region, it includes 36.2 per cent of those of compulsory school age (5 to 14 years).

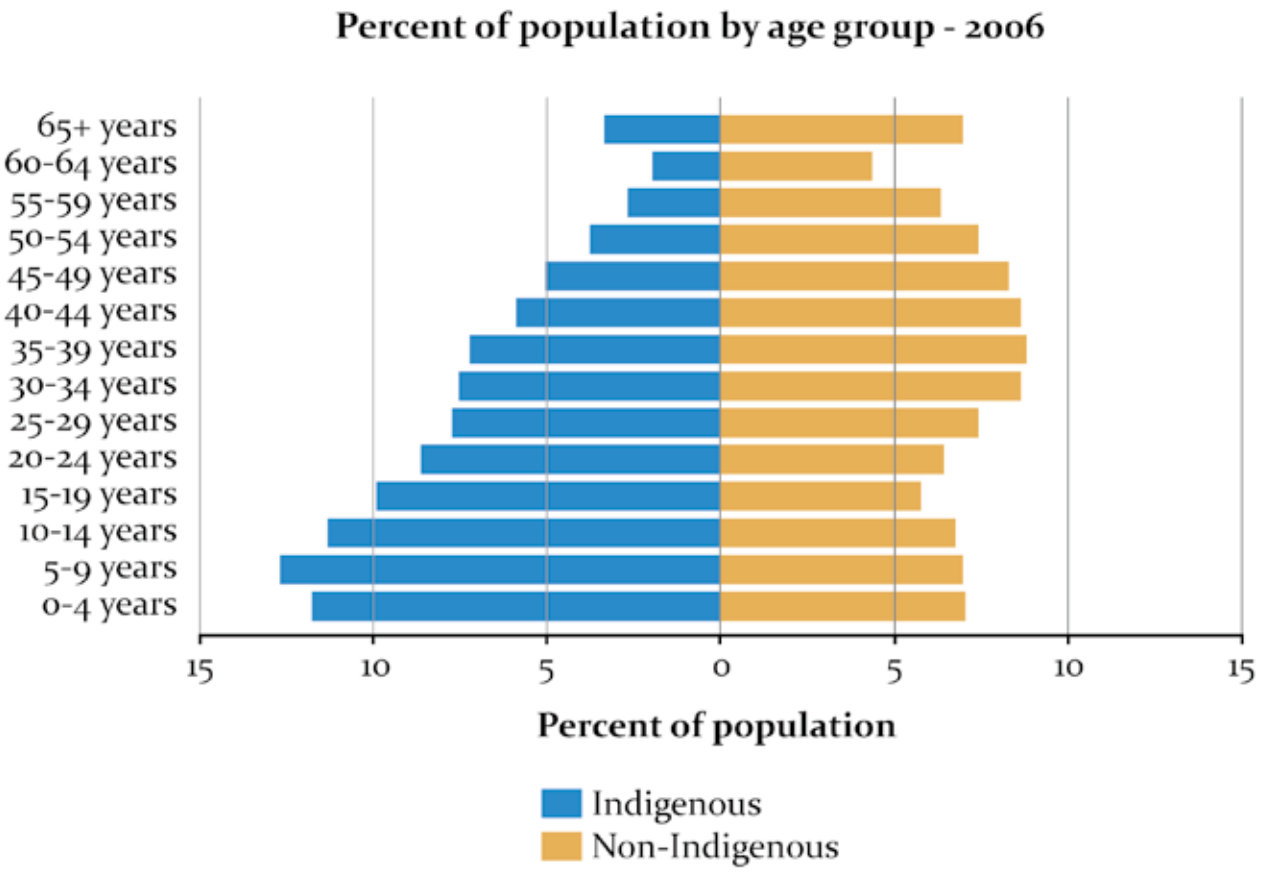


Figure 2: Age distribution of Indigenous and non-Indigenous Australians in the tropical north

Major past and current policy affecting the region

Indigenous communities' sense of cultural security relates very strongly to land rights. Following the High Court's *Mabo* judgement in 1992 and the passage of the *Native Title Act 1993* (Cth), more land has been claimed by Indigenous Australians. It is now estimated that close to 20 per cent of Australia is Indigenous owned, and a large proportion of that growing land base is found in the tropical rivers region. In the Northern Territory, for instance, approximately 85 per cent of the coastline and 44 per cent of the total land mass is held under Indigenous title.

Indigenous people have experienced many externally imposed policy changes over the past few decades, from being recognised as citizens in the 1967 referendum, through to support for the 'outstation movement' from the 1970s, the establishment of the Aboriginal and Torres Strait Islander Commission (ATSIC) with its regional governance model of self-determination in 1990, to its dissolution 14 years later. Recent policy initiatives include the reversal of the decentralisation of outstations since the late 1990s in favour of larger centralised settlements, and the assertion of stronger Commonwealth powers culminating in the Northern Territory Emergency Response (NTER), or the Intervention, in 2007. Further changes to Northern Territory outstation/homeland policy are underway (see for e.g. Socom and DodsonLane 2009) and many people in this region remain confused about who will be responsible for future service delivery and governance.

The 'Closing the Gap' policy implemented by the Australian Government has earmarked considerable financial investment ($1.3 billion over five years) for infrastructure, health and education as detailed in the recent 2009 Budget. Programs developed through the COAG Indigenous Reform agenda include $8 billion to be spent over 10 years, as part of the commitment to 'close the gap.' Areas of investment include: remote housing, health outcomes, early childhood development, remote services delivery and Indigenous economic participation.

History has shown that the relocation of Aboriginal people from traditional homelands to the larger regional centres has had a negative impact on spiritual and social health, as well as reduced opportunities to participate in important cultural activities (Burgess et al 2009). Any further centralisation of Indigenous settlements will likely continue that pattern of social dislocation and the full costs and benefits of this course of action should be taken into account in any climate change related policy developments.

Communities in the study region also face uncertainties from other global change drivers. The continued pressure on natural resource extraction, the uncertain potential to engage in international carbon-trading activities, access to water allocations, and ongoing fall out from the global financial crisis are all major issues in the development and future security of the region.

Future scenarios for Indigenous populations in the region

This report is focused primarily on climate change impacts on Indigenous people in northern Australia. However, this section provides a brief consideration of wider future scenarios, that confront and implicate the entire population of the region, since the prospects for Indigenous people under climate change are deeply bound up with these. In a broad sense, two pathways vie for attention. In one pathway, the north is considered to be a land of opportunity for development, increasing population and agricultural intensification with access to good water supplies. In the other pathway, the north is considered a remote, fragile and challenging environment in which human occupation will only grow slowly. In either case, it is likely that there will be rapid population growth around the existing major centres such as Cairns and Darwin, and continued slow development in more remote regions.

Indirect impacts of climate change are likely to affect both scenarios and include: lost agricultural production in southern Australia, proximity to Asia leading to displaced people putting further pressure on the north, through to increased transport costs with consequent increases in the price of goods and services.

The alternative futures deserve further analysis in relation to climate change. For example, the net migration of non-Indigenous and Indigenous people into this region has major implications for planners and communities organising investment in infrastructure and delivery. Appendix 5 shows how different assumptions about these processes lead to substantially different population profiles over the coming decades. Under historical migration rates, the total population (currently 355,000) would be around 430,000 in 2031, with around 27 per cent of them being Indigenous. If development was rapid and in-migration enhanced (Appendix 5 scenario 1), the 2031 population would be 651,000, but only 23 per cent Indigenous; and if conditions were unattractive and net in-migration of non-Indigenous people

stopped (Appendix 5 scenario 2), then the 2031 population would only reach 400,000, but 29 per cent would be Indigenous. The populations would diverge further between these scenarios over time.

In the scenarios with a declining Indigenous proportion of the population and all other factors being equal, Indigenous people, particularly those living remotely, are likely to be further marginalised. In these circumstances, the issues around livelihood opportunities discussed in Chapter 7 become increasingly important. In scenarios with an increasing Indigenous proportion but more limited general growth, the service demands of the Indigenous population will be growing, but the gross regional product will not, leading to potential problems for Indigenous communities if adequate attention is not paid to service delivery models and regional governance.

In short, these alternative future scenarios although they are not intended as predictions, provide a context against which the climate changes described in the reminder of this report would play out. The development of these scenarios is outside the scope of this report, but future studies could usefully aim to combine the consideration of climate and more general future population trajectories to identify key points for intervention.

International context of this study

Overseas projects can provide useful insights into ways of undertaking vulnerability assessments and developing adaptation strategies. The following section briefly details the international response of Indigenous people to climate change, and the potential for Australia's Indigenous people, government policy-makers and scientists to learn from this work.

Indigenous people across the world have long observed the effects of natural and human-enhanced climate change on their land (Nickels et al 2005). However, these observations have largely been ignored by the mainstream science community that has almost exclusively focused on observations derived from instrumental records, and many of these from regions with dense populations (Tebtebba 2008).

In recent years this situation has improved to some degree. An increasing number of western scientific partnership projects documenting Indigenous observations of environmental change have been initiated in several regions of the world.

Documenting the impacts of human-enhanced climate change (from here on, referred to as 'climate change') and developing adaptation measures to reduce harm caused by climate change, are most established in the Arctic. This is most likely related to the fact that local people have observed the impacts of climate change, such as melting ice, in this region over several decades. The most advanced climate impact assessment programs include the Arctic Climate Impact Assessment (ACIA 2005), which is notable in its direct inclusion of Indigenous participants, and its accessibility in a number of relevant local languages. The contribution of the Inuit Circumpolar Council in the preparation of the ACIA with researchers at the University of Alaska, Fairbanks shows a high degree of collaboration between Indigenous leaders and research scientists.

Internationally, a number of video and multimedia projects have been specifically set up to record Indigenous knowledge of environmental change by community members themselves. These activities are more in keeping with Indigenous oral history as a way of passing down local knowledge through generations – see for example, the Snowchange project.[3]

International collaboration between Indigenous nations

A coordinated global response linking regional assessments of climate change and observational work amongst Indigenous people has been slowly developing. Recently, a number of international institutions have begun 'knowledge sharing' programs and clearinghouses to facilitate exchange, and provide a point of reference for adaptation-building strategies. In 2008, UNESCO, in partnership with the Secretariat of the Convention on Biological Diversity, the Secretariat of the United Nations Permanent Forum on Indigenous Issues and the Office of the High Commissioner for Human Rights created the online forum *On the Frontlines of Climate Change* acknowledging that 'many small island, rural and Indigenous communities are already facing the first impacts of climate change.' The online resource is intended to provide a website for sharing observations and aiding adaptation of Indigenous people. There are other websites, for example the Northern Climate ExChange[4] or StraightUpNorth,[5] which contain similar information at regional or national levels.

In April 2008, Northern Australian Indigenous Land and Sea Management Alliance (NAILSMA) in conjunction with the United Nations University and the Secretariat of United Nations Permanent Forum on Indigenous Issues convened an International Expert Group Meeting on Indigenous Peoples and

Climate Change in Darwin. The Expert Group Meeting discussed issues surrounding climate change impacts and opportunities for Indigenous people.[6] This meeting noted that 'the lack of full and effective participation of Indigenous peoples in the development of any policies, programs and projects that impact directly on their communities tends to lead to the failure of such projects as well as a loss of biodiversity' (UN 2008).

One year later, in April 2009, the first international summit on climate impacts and Indigenous people was held in Anchorage, Alaska. Background documentation on the summit's website[7] includes a guide to climate change and Indigenous people, and UN documentation on the Declaration on Indigenous Rights. This meeting noted the alarm felt by Indigenous people from unsustainable development that has:

> *Profound and disproportionate adverse impacts on our cultures, human and environmental health, human rights, well-being, traditional livelihoods, food systems and food sovereignty, local infrastructure, economic viability, and our very survival as Indigenous Peoples.*

A major recommendation of this meeting was for the fifteenth meeting of the Conference of the Parties to the United Nations Framework Convention on Climate Change in December 2009, to commit to binding emissions reduction targets for developed countries (Annex 1) of at least 45 per cent below 1990 levels by 2020 and at least 95 per cent by 2050 (Indigenous Summit 2009).

Documented climate impacts on Indigenous Australians

Although the potential for climate change to impact differentially on Indigenous lands has been noted for some years (e.g. Stafford Smith and Milligan 1994), the most authoritative peer-reviewed scientific document to discuss the impacts of climate change on Indigenous communities living in remote areas of northern Australia is the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (2007b). In Working Group II, Chapter 11, there is a section dedicated to this specific issue (Hennessy et al 2007). In addition to this section, many of the broader impacts documented for Australia in the rest of this chapter would directly and indirectly affect Indigenous Australians living in urban and semi-rural areas of the country.

The 2008 Native Title Report's chapter on Indigenous people and climate change identifies several risks and opportunities (AHRC 2008). Dispossession and loss of access to traditional lands, waters and natural resources as well as a loss of ancestral, spiritual, totemic and language connections to lands and associated areas are a major concern. The report also notes that migration from island and coastal communities, and those dependent on inland river systems will affect a much larger population. As a result, stresses are likely to be felt in the migrant communities, as well as those in extended families in more urban areas who are likely to need to accommodate more people.

Other issues of concern noted in the AHRC report include: the potential to compromise cultural maintenance due to an inability to manage changing environmental conditions, an increase in vector-borne and water-borne diseases, disruption to food security, and the risk of being excluded from the establishment and operation of carbon markets, biodiversity credit generation and other market mechanism based solutions to environmental problems.

A major concern highlighted in the Native Title Report (AHRC 2008) is the lack of understanding in the Indigenous community of climate change and how it may affect the environment, access and rights to lands and waters, infrastructure and buildings. This report notes that there is no mechanism or communication strategy to redress this problem. The Aboriginal and Torres Strait Island Social Justice Commissioner recommends that this oversight be promptly rectified with a culturally aware information campaign.

Concepts in vulnerability and adaptation

This report uses the concept of vulnerability adopted by the DCCEE after the Allen Consulting Group's *Climate Change Risk and Vulnerability Report* (Allen 2005). This definition considers vulnerability to be a function of exposure, sensitivity and adaptive capacity, as illustrated in Figure 3.[8] Here the concepts of vulnerability and adaptive capacity are explored in an Indigenous context.

Indigenous vulnerability

Existing social and economic disadvantage exacerbates many remote Indigenous communities' vulnerability to climate change. This is covered in the *Overcoming Indigenous Disadvantage Report* (SCRGSP 2007) and includes a range of social disadvantage and vulnerability factors. As yet there is no literature on community-level perceptions of vulnerability or resilience to climate change in Australian Indigenous communities. Despite this, it can be confidently asserted that different groups

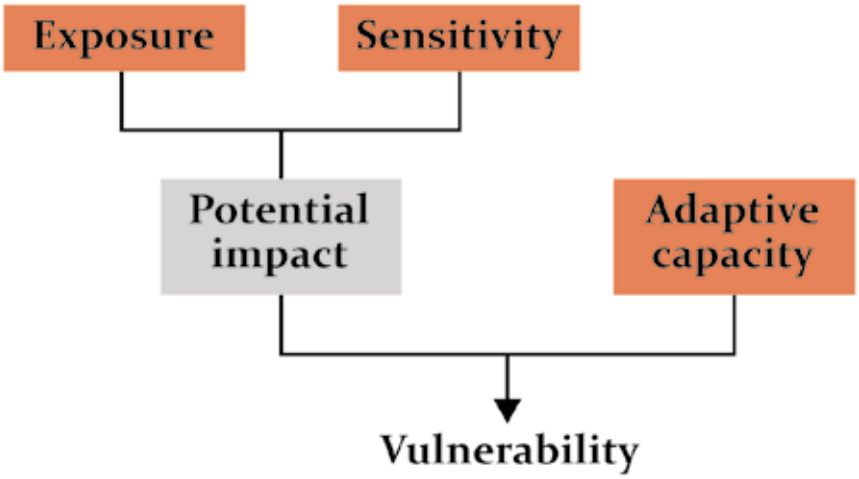


Figure 3: Model of vulnerability and its components (Allen Consulting Group 2005)

of Indigenous people in northern Australia, for example those living in cities or remote settlements, will have very different levels of exposure, sensitivity and adaptive capacity. The most vulnerable are those suffering from multiple sources of disadvantage (e.g. low incomes, low education levels, poor health). Other less vulnerable sections of Indigenous society will be best supported by mainstream adaptation activities, for example some Indigenous residents of major cities such as Darwin. This study assumes that the most vulnerable are generally those with low incomes, poor access to education and health services and living in remote areas. Remote settlements exposed to coastal weather patterns and inland temperature increases are particularly vulnerable.

The vulnerabilities to climate change impacts for disadvantaged Indigenous communities may be unexpected when viewed through mainstream lenses. The case studies document how some communities are quite resilient to disruption that incapacitates nearby non-Indigenous settlements (e.g. see Chapter 8, Maningrida), whilst health risks that would be trivial in mainstream Australian communities may have a seemingly disproportionate impact in remote Indigenous communities. In elucidating these differences, it is important to avoid depictions of Indigenous people as passive victims, and instead to emphasise the engagement of the community in understanding and developing adaptation and mitigation strategies (Ellemor 2005; Green 2006b; Green 2008). International literature on this topic further emphasises the need to avoid viewing communities 'as timeless and static' recognising that many Indigenous societies have continuously confronted and engaged with changing environments for generations (UNESCO 2007). Indigenous ontology emphasises the connections between culture, the health of the community and their land and sea country (Rose 1996; Monaghan 2004; Dockery 2009). Differing paradigms of non-Indigenous western scientists and Indigenous communities can create or challenge collaborations involving Indigenous and non-Indigenous management approaches (Howitt 2001), and this will also no doubt apply to climate adaptation activities. Acknowledging these cultural differences points to the need for thorough community engagement and research partnerships to better understand Indigenous vulnerability, a process only partially initiated by this preliminary study.

Adaptive capacity

Adaptive capacity in relation to climate change impacts is defined by the IPCC as 'the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences' (IPCC 2007b, p. 869). In the present context, it is essentially the degree to which Indigenous communities can adapt in the face of climate change. Of course, this hides many complexities (see Preston and Stafford Smith 2009) particularly relevant to this study, including the following:

1) In impact and vulnerability studies, adaptive capacity is generally regarded as the degree to which communities can adapt endogenously. Vulnerability in this view is essentially defined as the residual impact after this endogenous adaptive capacity has responded to the potential impacts and exposure of the community. Further adaptation that responds to this residual vulnerability by calling on major

changes beyond those endogenous resources of the community, is then referred to as 'planned', anticipatory or proactive adaptation (Easterling et al 2004). However, if the main interest is in adaptation responses, rather than in mapping the potential magnitude of the impending disaster, then the distinction between endogenous and planned adaptation becomes difficult and unhelpful.

2) Adaptive capacity tends to be discussed as if it occurs only at the focal scale of interest. The options open for responses at the community scale are greatly affected by the adaptive capacity of households and individuals (e.g. do they have spare financial capital, is there strong leadership, what level of education and understanding is present?) and by the context set by policy and programs at larger scales (e.g. what infrastructure does the region possess, is there a state awareness program, what options are opened up by the formation of a national carbon trading scheme?). Conversely, the options available to households are clearly affected by community responses, as are the response options at regional scales. Thus, again, if the core interest is in how communities may respond to climate change, rather than mapping their current vulnerability, it becomes vital to cast the analysis across all these scales at once (Adger 2006).

3) Specified adaptive capacity – the ability to adapt to a particular change such as sea level rise – is only a narrowly useful concept compared to general adaptive capacity, the ability to respond nimbly to a variety of impositions, conferred by effective capacity at a series of nested scales. Much of the future planning in an uncertain climate is about preparing for a range of poorly specified futures, in which the uncertainty may be mostly irreducible, at least for decisions with longer-term implications. In this context risk management and robust decision-making approaches (Dessai et al 2008) embedded in flexible governance processes are more important than the ability to make precise assessments of what might turn out to be the wrong issues.

The conceptualisation of impacts, vulnerability, endogenous adaptive capacity is widely embedded in the approach of the IPCC and consequent national policy instruments, e.g. Climate Adaptation Framework (COAG 2007), which are predicated on first determining impacts, then vulnerability, before identifying adaptation strategies or actions.

As the world moves beyond recognising potential vulnerability to actively supporting adaptation, a more sophisticated view of adaptive capacity is required; this includes a re-conceptualisation towards supporting general adaptive capacity to a variety of uncertain futures which may not require much precision in defining impacts or vulnerability in order to be able to act. Such an approach recognises that endogenous and planned adaptation fall on a continuum, not in neatly separated boxes, and that adaptive capacity is a multi-scalar, nested concept in which the capacity of the Indigenous community itself both affects and is affected by the capacity of individual households within the community and the wider regional, state and national level policy context outside the community. It also emphasises enhancing general adaptive capacity, rather than adaptive capacity to specific threats, with the attendant risk of becoming more vulnerable to some other threat or at some other scale. These concepts are particularly important to a discussion of how governance issues are relevant to the vulnerability and adaptation responses of Indigenous and other remote communities.

Governance issues and their influence on adaptive capacity

Governance is broadly defined as the formal and informal processes and structures by which a group, community or society makes decisions, distributes and exercises authority and power, determines strategic goals, organises corporate and individual behaviour, develops institutional rules, and assigns responsibility for those matters (Hunt and Smith 2006). In a practical sense, the more public of these decisions at the local to regional scale are related to the delivery of a variety of services, including:

- Social services like health, education and childcare;
- Technical services such as infrastructure, power and water;
- Environmental services such as maintaining ecosystem services and biodiversity; and
- Cultural services such as supporting culture, language and, for Indigenous people, traditional practices.

All of these services are, directly or indirectly, affected by global environmental change. Thus issues of governance underlie any collective decision-making in response to climate change. Indeed, the importance of governance to adaptation is well recognised, not least because, as noted by Adger (2006, p. 276) 'Vulnerable people and places are often excluded from decision-making and from access to power and resources.'

In recent years there has been a resurgence of interest in the importance of effective governance in and for Indigenous communities, and remote settlements

more generally, as these are generally often far from centres of power and decision-making (Stafford Smith 2008). The 'RemoteFocus' initiative of Desert Knowledge Australia suggests that government is failing to govern adequately in remote Australia, with implications for resource industries, environmental management and Indigenous issues alike (Dillon and Westbury 2007; DKA 2008). At the same time, a number of strands of work are coming together to offer insights as to how this situation could be improved:

- A major project explicitly exploring Indigenous governance, with case studies in northern Australia, has identified a series of key principles and guidelines that would promote better governance in Indigenous communities (Hunt and Smith 2007, Hunt et al 2008); this work is supported by similar analyses and conclusions in native American communities in North America.
- Research in central Australia has helped to clarify the significance of particular governance design principles for desert settlements (Moran and Elvin 2009), building on concepts from the sustainable rural livelihoods development literature; they highlight the concepts of subsidiarity, connectivity and accountability.
- Marshall (2008) has shown how the governance of natural resource management in rural Australia could be improved, and Measham et al (2009) have explored how the interface between government and community could be improved for better natural resource management outcomes.
- The latter lines of work draw on an extensive body of both observational and experimental work on governance design in common property systems (Ostrom 1999) which now commands a very large array of international case studies.

In short, good design principles and practices for governance in remote and Indigenous regions can be detailed, even though the predominantly state-based legislative framework and local capacity to implement them may not yet be in place (a brief synthesis of these is summarised in Appendix 6).

As noted by a regional stakeholder, "the Borroloola study makes some excellent points about how 'communities' are externally conceptualised but internally there are many functional groups and interest groups who would speak for different elements of community concerns, management [structures] and interests." Stafford Smith (2008) and Stafford Smith and Cribb (2009) argue that the particular nature of remote regions means that the state and national legislative framework needs to allow some flexibility in implementing remote area governance in ways that may be different to those applied in more densely settled regions. It is also important that long-term consistency be applied to governance arrangements, which have not occurred in recent years with the abolition of ATSIC, and the sudden changing of control arrangements with the Intervention (Smith 2007).

The foregoing general principles apply as much to the governance and delivery of natural resource management services as for any other service (Marshall 2008). These are particularly important for all inhabitants in remote areas since they underpin many of the primary livelihood options available. However, they deserve additional attention for Indigenous people, because livelihoods associated with caring for country provide a particularly good cultural fit among the livelihood options that are open to Indigenous people living in remote communities.

This recognition has partially fuelled the development of the IPA and related Indigenous Rangers programs (see Chapters 3 and 7). This constitutes a significant opportunity for remote Indigenous people to carry out and be paid a salary for activities that are genuinely, if belatedly, valued by the broader Australian society whilst simultaneously satisfying local cultural imperatives and enhancing positive self-image and social cohesion in remote communities. While a growing literature is showing the multiple benefits that such programs can deliver (e.g. Burgess 2005, Campbell et al 2007), a continued effort is required to clarify the public, community and private portions of these benefits so as to justify the public investment component.

Planning in an uncertain climate is often about preparing for a range of poorly specified futures. In this context, risk management and robust decision-making approaches embedded in flexible governance processes are far more effective than rigid, command-and-control decision-making (see Nelson et al 2008 for a review of the benefits of adaptive governance, and its distinct differences from decentralisation or devolution; and Dessai et al 2008 for decision-making modes in the face of pervasive uncertainty in climate change adaptation).

Detailed consideration of how changed governance processes for north Australia could improve its resilience to climate change was outside the scope of this study. However, based on these initial observations, utmost importance should be placed on better engagement with, and empowerment

of, local communities in determining their own future, whilst structuring this within multiple tiers of government. The roles of different players in providing this support and action depend on the magnitude of the effort required. For example, major health risks are better tackled centrally with community support and understanding, whereas planning for local impacts is better carried out locally with central support. The following chapters will illustrate potential actions at all these scales, and some indication of how such thinking could play out in integrated community outcomes is provided by the case studies in Chapter 8.

Endnotes:

[1] This group included: Jon Altman, Geoff Buchanan, Donna Green, Sue Jackson, Kirrily Jordan, Joe Morrison, Benjamin Preston, John Taylor, Will Steffen & Peter Whitehead.

[2] These figures were 23.6 per cent Indigenous for men and 25.6 per cent Indigenous for women.

[3] www.snowchange.org

[4] www.uga.edu/iws/IK/databases.html

[5] www.straightupnorth.ca/Sikuliriji/SUN_Home.html

[6] www.nailsma.org.au/forum/international_forum_climate_change/international-experts-forum-on-climate-change.html

[7] www.indigenoussummit.com

[8] See appendix for glossary of key terms.

Summary

Little attention has been given to the topic of Indigenous vulnerability to climate change in northern Australia by the research sector despite clear evidence that this demographic is likely to be disproportionately impacted.

Work carried out in Indigenous communities overseas can provide useful guidance into ways of performing vulnerability assessments, and developing culturally appropriate adaptation strategies.

Future work in this area in Australia must set aside adequate resources to design comprehensive community engagement strategies for adaptation planning, and employ ethnographic methods informed by Indigenous philosophies, and social and cultural values.

The acute and persistent social and economic disadvantage evident in many Indigenous communities will exacerbate their vulnerability to climate change.

The Indigenous population in the tropical north has a young age profile. This leads to significant implications for the level and types of services they will need now and in the future.

The study area has a very large proportion of land held under Aboriginal titles, with thousands of clan estates and more than 130 language groups. The regional economy is dominated by sectors dependent on natural resources and the provision of government services.

Dispossession and loss of access to traditional lands, waters and natural resources as well as a loss of ancestral, spiritual, totemic and language connections to lands and associated areas are well documented. This issue is likely to add to the level of Indigenous vulnerability to the impacts of climate change.

Restitution of environmentally beneficial relationships with the land may contribute to reducing the vast differences in social and economic outcomes between Indigenous and non-Indigenous Australians, and help to build resilience to climate change.

Relocation of Indigenous people from traditional homelands to the larger regional centres has had a negative impact on their spiritual and social health has reduced opportunities to participate in important cultural activities.

Communities in the study region face other global change drivers. The continued pressure on natural resource extraction, the uncertain potential to engage in international carbon trading, access to water allocations, and ongoing fall out from the global financial crisis are all issues requiring consideration in the future development and security of the region.

Adaptation strategies need to be reconceptualised to support general adaptive capacity to a variety of uncertain futures. Action may not require further precision in defining impacts of vulnerability. Further development of broad scenarios for the north, incorporating climate change, development and demography as well as other drivers, would help communities to imagine the alternatives open to them, and service providers in planning for them.

Many Indigenous people want to understand the impacts of climate change from a non-Indigenous perspective, and how climate change might impact their access and rights to lands and waters, infrastructure and buildings and the threats and opportunities from policy responses. A comprehensive communication strategy about climate impacts for Indigenous people is critical to the success of Australia's adaptation response.

Although not a major focus on this report's terms of reference, recent work points to the importance of obtaining appropriate integration among local, regional, state/territory and national governance structures, particularly to develop general adaptive capacity to deal with uncertain futures in ways that are sensitive to local conditions.

Chapter 2

Climate Change Projections

The climate change projections discussed here are based on the most up to date and widely peer reviewed projections produced for the IPCC's Fourth Assessment Report (2007a). These projections are created by running global climate models (GCM) with changes in atmospheric composition, essentially increases in the concentration of greenhouse gases.

Given the strong human influence on the emission of greenhouse gases, the rate of emissions depends heavily on the future development path of nations around the world. To cope with these uncertainties, the IPCC introduced a series of emission scenarios designed to encompass the range of possible future emissions under various development paths (IPCC 2000). Since this time, observed emissions have exceeded those of the highest emission scenario (Raupach et al 2007), hence the high emission scenario is focused on in this report. These recently measured emissions have led to observed changes in variables such as sea level and sea surface temperature being close to the highest IPCC projections (Rahmstorf et al 2007).

There are a number of limitations in GCMs that generate uncertainty in their projections for the future. These include important feedbacks not included in this generation of GCMs. For example, the effect of aerosols on rainfall in north-western Western Australia, and rising levels of carbon dioxide in the atmosphere which can change the growth rate of plants. Models that will explicitly include these feedbacks are under development.

There are also some regional phenomena that add uncertainty to the projections including the atmospheric effects of the aerosols, smoke and pollution produced in Asia, and the modeling of the tropical warm-pool sea-surface temperatures and the associated El Niño – La Niña cycles. GCMs have, however, made steady progress in the simulation of these phenomena and are expected to continue to improve (Guilyardi et al 2009).

Future efforts to reduce greenhouse gases, such as methane, could also have implications for agriculture in the study region since cattle are a major contributor to methane emissions.

Rising carbon dioxide levels in the ocean are known to be lowering pH levels which is causing acidification. Ocean acidification is detrimental to many calcifying organisms, including corals. The extent to which species respond to ocean acidification and induce changes into the marine ecosystem remains unclear.

The following sections discuss the projected average changes in specified biophysical factors: temperature, precipitation, evaporation, sea surface temperature, sea level rise and extreme weather.

Temperature

Analysis of the temperature change simulated by the IPCC can be found in Pearce et al (2007) and Suppiah et al (2007). Both discuss the entire Australian continent including information relevant for tropical north Australia. These papers show the greatest warming over the north-west and lesser warming over the far north and north-east regions of the tropical study area.

In general, the research suggests that by 2030, temperatures are expected to increase by between 0.5°C and 1.5°C, while by 2070 temperatures are expected to have increased between 1.5°C and 3°C, see Figure 4.

Precipitation

Most precipitation in tropical north Australia is associated with the Australian summer monsoon. Many studies have been undertaken to understand the mechanisms that affect the length and intensity of the annual monsoon (Godfred-Spenning and Reason 2002; Miller et al 2005; Kim et al 2006; Kullgren and Kim 2006; Davidson et al 2007; Lau et al 2007). This is significant because much of the study region relies heavily on tourism for employment and economic development. Access is limited to the dry season for these areas, and any increase in rainfall will likely shorten the already restricted tourist season.

The monsoon is impacted by multiple processes some of which have regional-scale influences, such as the temperature contrast between the land and nearby sea, while others are at a much larger scale, including the influence of the El Niño-Southern Oscillation (ENSO) cycle, Indian Ocean Sea Surface Temperature, the Madden-Julian Oscillation and cyclogenesis in the extra-tropics.

Some of these factors are poorly simulated by the GCMs at least in part because of the large size of the GCM grid cell (approximately 300km) compared to the scale of the process itself. There is no consistent indication of discernible changes in these climatic processes in the current GCM simulations, so their future impact on the monsoon remains unclear.

Analysis of the precipitation change simulated by the IPCC GCMs can also be found in Pearce et al (2007) and Suppiah et al (2007). These authors indicate little change in mean precipitation for the tropical north and small decreases for the Pilbara region reaching approximately 15 per cent by 2070. They also project increases in precipitation intensity rather than mean rainfall levels in the north with the intensity level projected to be the greatest in the Gulf of Carpentaria region.

The changes in rainfall in the wet and dry season are shown in Figure 5. This figure indicates broadly that the wet season rainfall is projected to increase for the northern tropics in all areas (other than the Pilbara) for both 2030 and 2070. In the dry season, rainfall is projected to decrease in most of the northern region, however, it is useful to remember that for many of these regions rainfall in the dry season is already low.

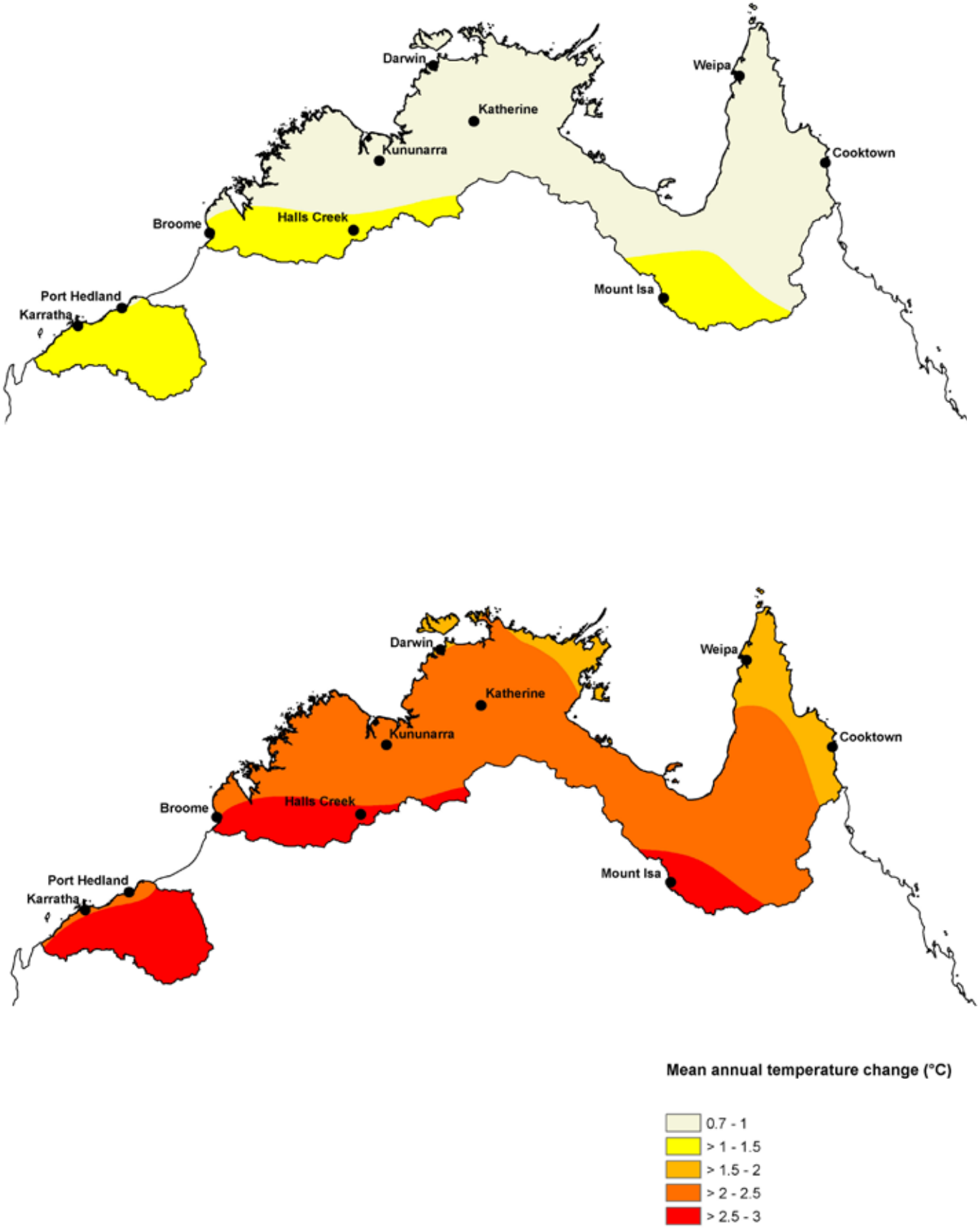


Figure 4: Mean annual temperature change (2030 top figure, 2070 bottom figure)

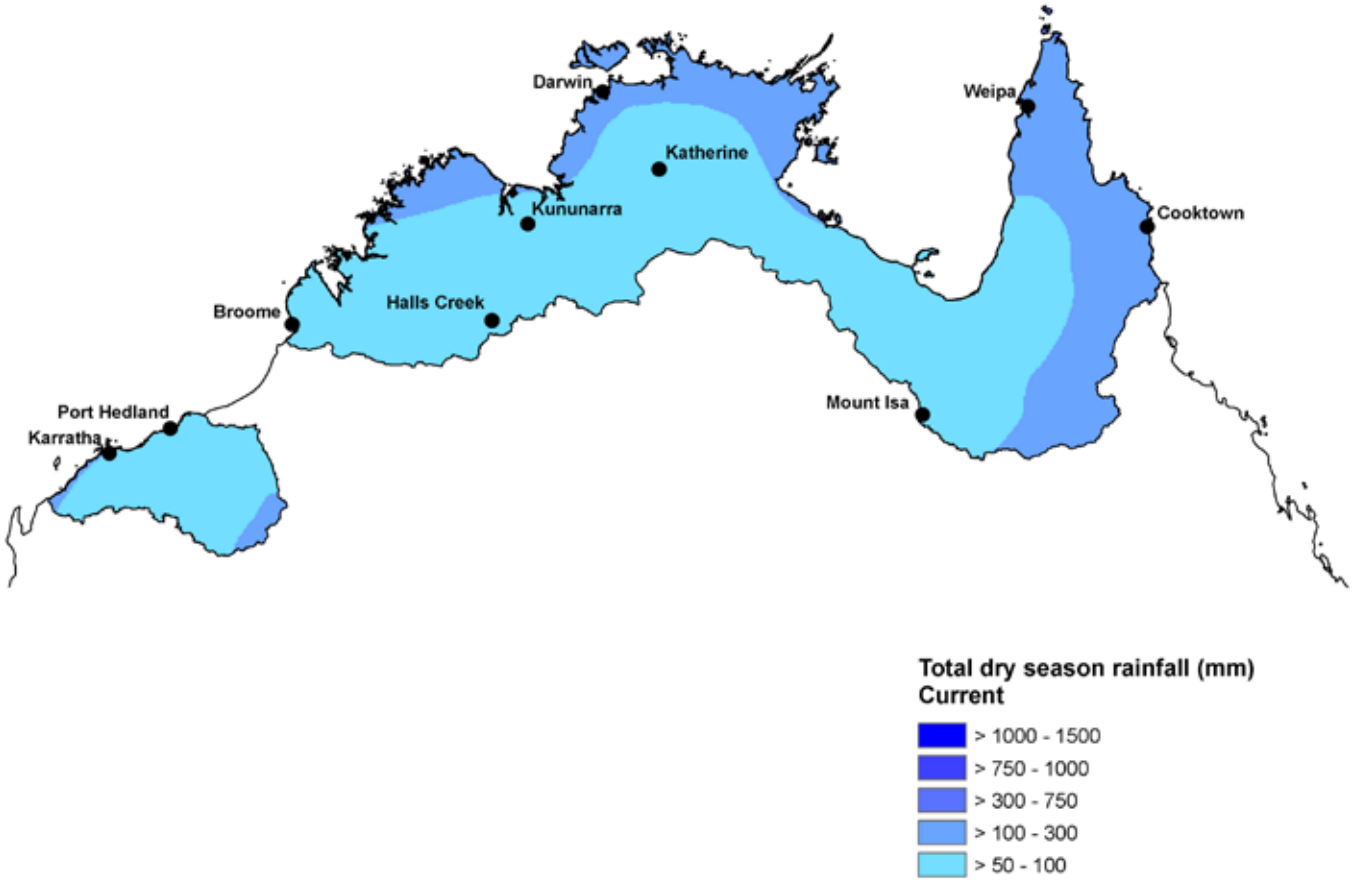


Figure 5: Total dry season rainfall (current year)

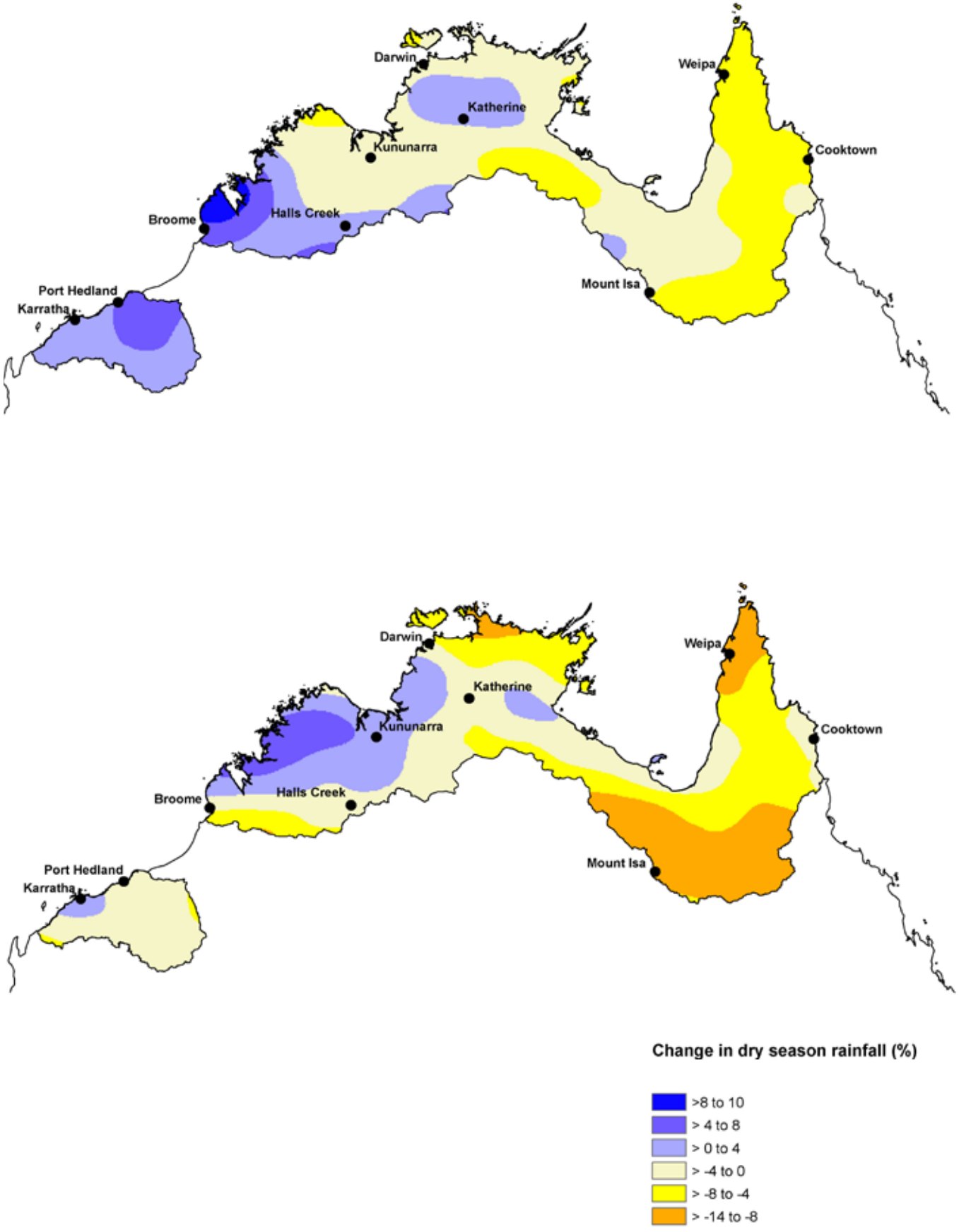


Figure 5: (continuing) Change in dry season rainfall (2030 top figure, 2070 bottom figure)

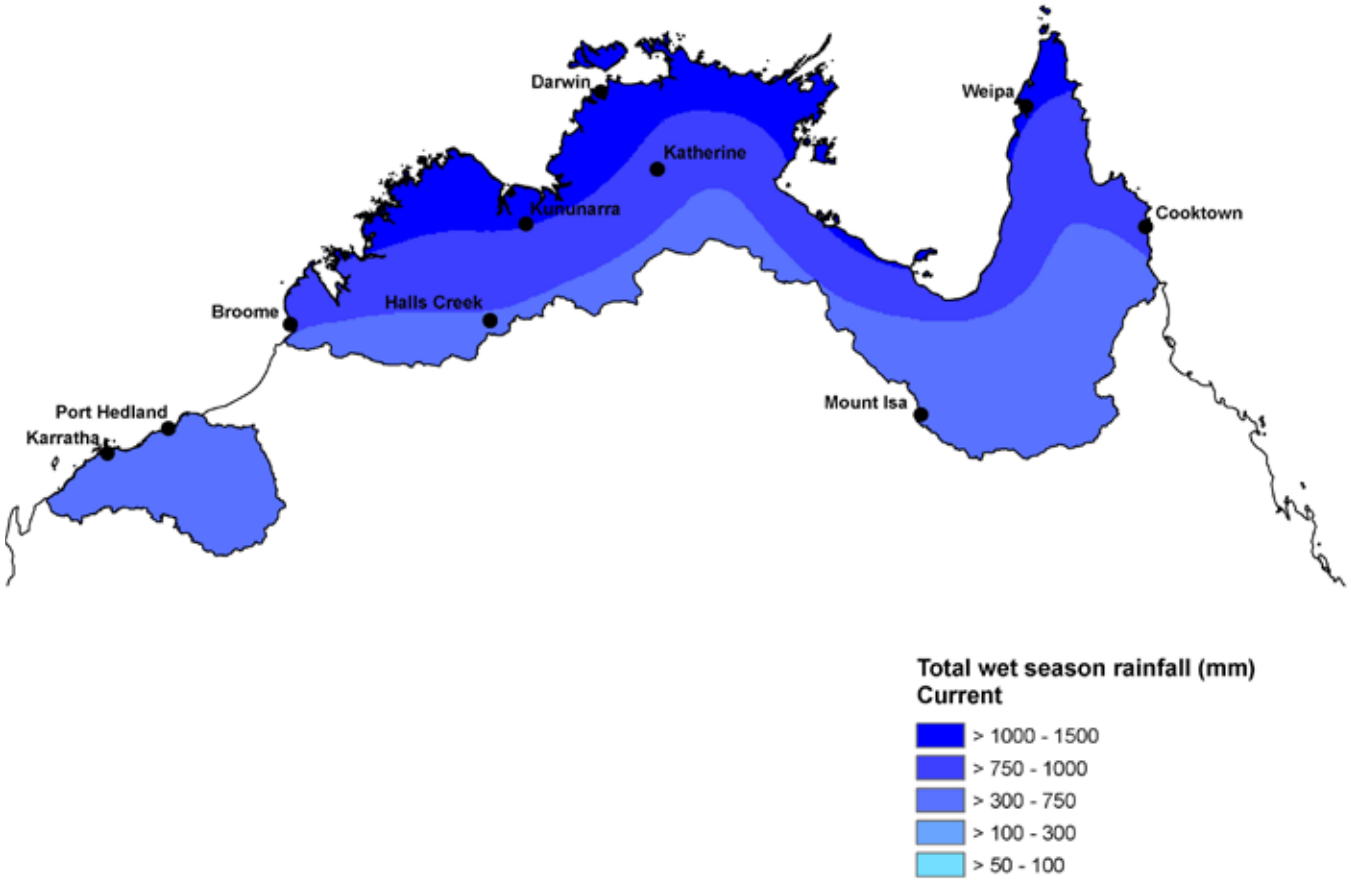


Figure 5: (continuing) Total wet season rainfall (current year)

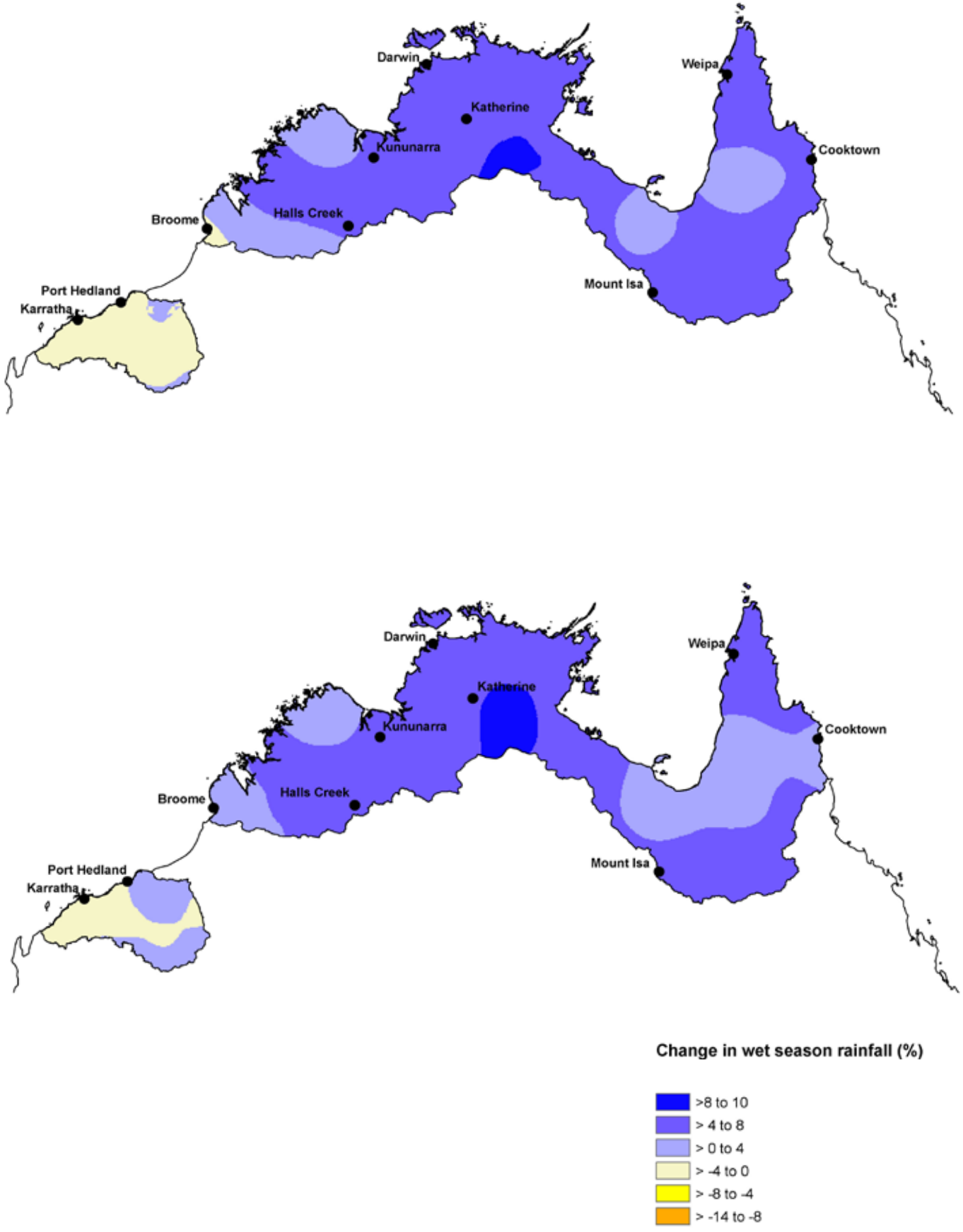


Figure 5: (continuing) Change in wet season rainfall (2030 top figure, 2070 bottom figure)

Evaporation

Possible changes in evaporation in the tropical north are not discussed widely in the scientific literature. The IPCC (2007a), for example, projects that by the end of the 21st century, the tropical north is likely to experience a minor increase in evaporation. Not all GCMs agree on this change, however, and significant uncertainty is associated with this projection. This is directly related to the uncertainty associated with precipitation and the Australian monsoon. Pearce et al (2007) presents changes in potential evaporation (not actual evaporation) of approximately three per cent for tropical northern Australia by 2030 and as much as ten per cent (with a mean of approximately six per cent) by 2070. Given the level of uncertainty, a figure is not included here (see Appendix 3 for a figure that includes uncertainty considerations).

Sea surface temperature

Few studies have looked specifically at the change in sea surface temperature of oceans surrounding Australia. Pearce et al (2007) show projections of sea surface temperatures near tropical north Australia increasing by approximately 0.7°C by 2030 and by approximately 1.7°C by 2070. Given the level of uncertainty, a figure is not included here (see Appendix 3 for a figure that includes uncertainty considerations).

Sea level rise

Pearce et al (2007) investigated the sea level rise in oceans surrounding Australia and expected sea level rise near tropical northern Australia to be similar to the global average – at least a rise of 79cm by 2100. They also noted that ENSO affects sea levels, which has the potential to affect north Queensland.

Sea level rise will have the most significant impact in the short to medium term when it is combined with extreme events such as king tides and storm surges. Church et al (2008) and ACE-CRC (2008) recently published a report on sea level rise and the added impact of tides and storm surges. They note that recent sea level rise has been near the upper bound of the range reported in IPCC (2007a). They also note that emissions have increased faster than the highest emission scenario included in the IPCC (2007a), increasing the likelihood of sea level rise being at or above the highest projections for 2100.

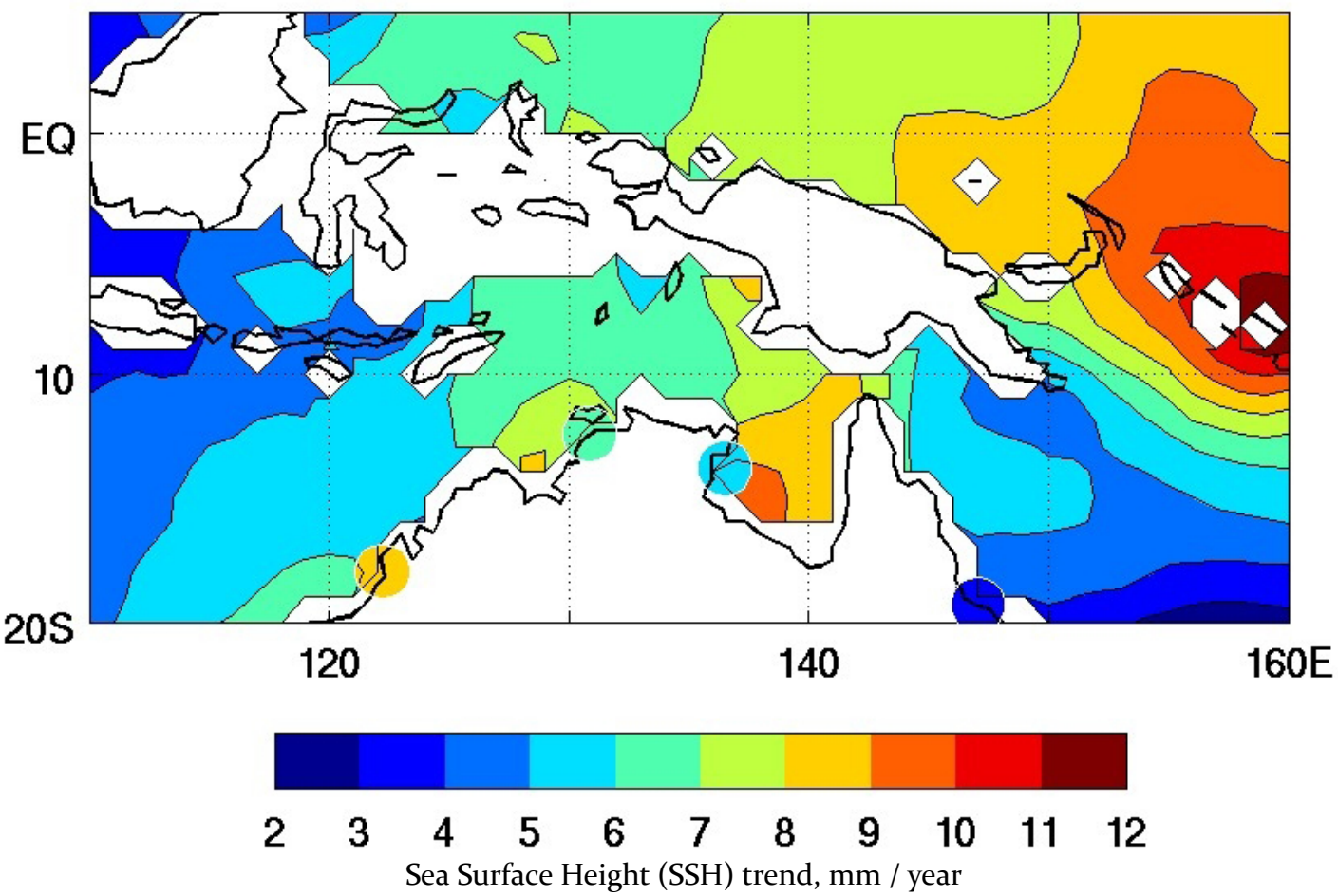


Figure 6: Sea level trends in the region estimated from satellite altimeter data from January 1993 to December 2007 (Green et al 2009b)

They also predict that extreme sea level rises coupled with king tides and storm surges will increase coastal flooding markedly during this century.

Sea level trends in the region estimated from satellite altimeter data from January 1993 to December 2007 are presented in Figure 6. Sea level trends from tide gauge data from the National Tidal Centre are indicated by the coloured dots.[1]

> "Flooding is an annual event [in Katherine] that will get progressively worse as rainfall increases with greater risk of catastrophic floods in the catchment area that feeds into the Katherine River. This is likely to result in inundation of many communities with resulting evacuation and property damage."
>
> - Regional stakeholder.

It is expected that rising sea levels, in combination with storm surges caused by more extreme weather, will have impacts on low elevation coastal settlements in northern Australia. Many Indigenous settlements in the study area are located in coastal low-lying areas, see for example the case studies of Borroloola (see Figure 7) and Saibai in the Torres Strait.

It is imperative that modelling of worst-case scenarios for these communities is carried out to enable coastal adaptation planning. This would also enable more accurate assessment of effects and response measures.

A national coastal vulnerability study is currently underway that will:

- Provide an initial assessment of the future implications of climate change for nationally significant areas of Australia's coastal regions;
- Identify key barriers or impediments that hinder effective responses to the impacts of climate change in the coastal zone; and
- Identify critical knowledge gaps that constrain adaptation and identify national priorities for adaptation to reduce climate change risk in the coastal zone (Mummery 2009).

Further information about climate impacts on Australia's coasts is also available at ozcoasts.[2]

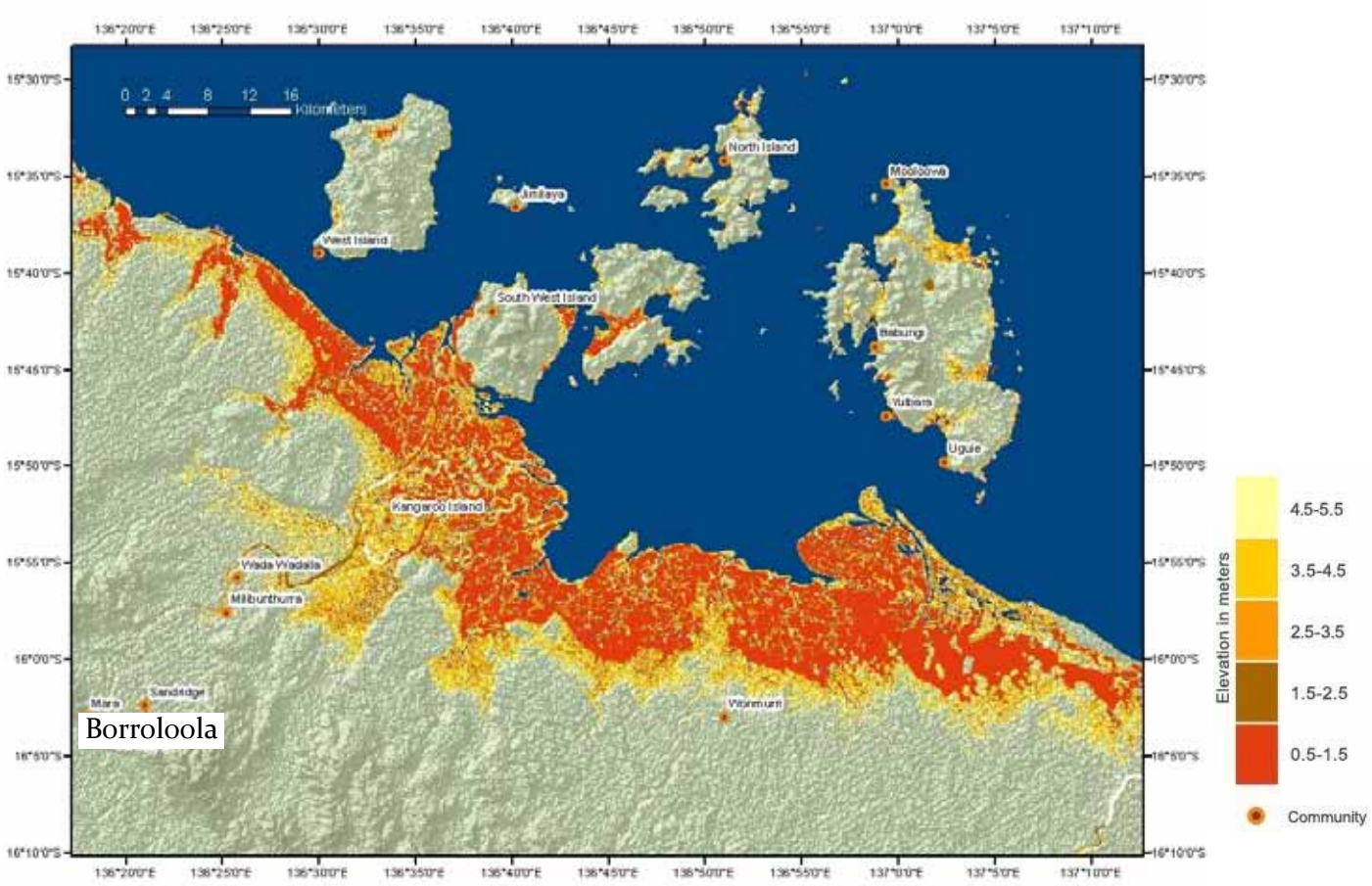


Figure 7: Low-lying region in the Gulf of Carpentaria

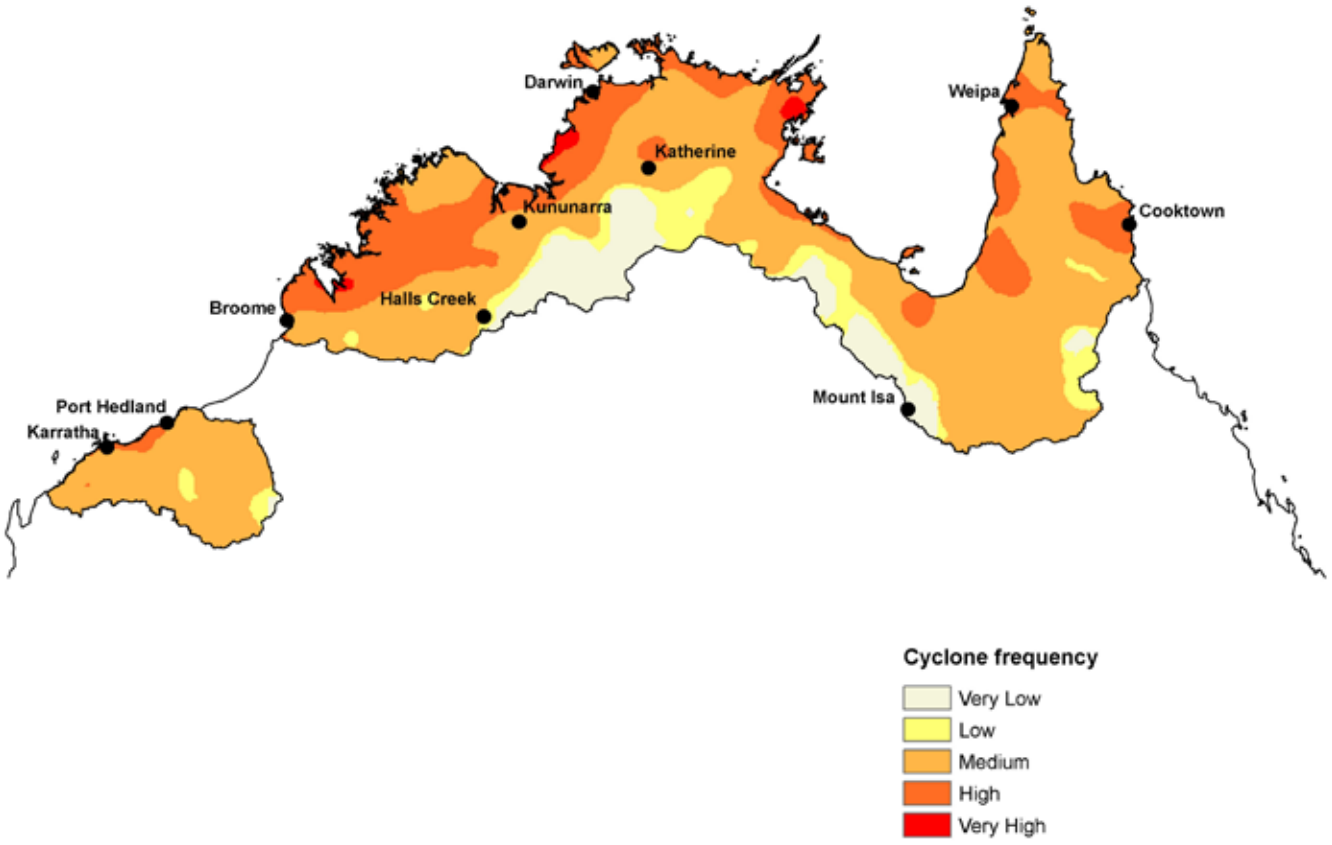


Figure 8: Current cyclone frequency

Extreme weather

Nicholls (2008) provides a current summary of Australian climate and weather extremes. In addition, there are a number of papers in peer reviewed scientific journals that discuss specific extreme weather projections. These are briefly reviewed below.

Changes that affect tropical cyclones globally have been investigated by several groups (Lambert and Fyfe 2006; Pezza et al 2007; Emanuel et al 2008; Wu et al 2008). Focusing on the Australian region, Pearce et al (2007) found that similar to the global findings, there is likely to be an increase in the proportion of tropical cyclones in the more intense categories, but a possible decrease in the total number of cyclones, see Figure 8. The reliability of the earlier Australian data sets has been queried by Harper et al (2008) with the suggestion that a review of intensities for cyclones be carried out to establish whether observed changes are reliable.

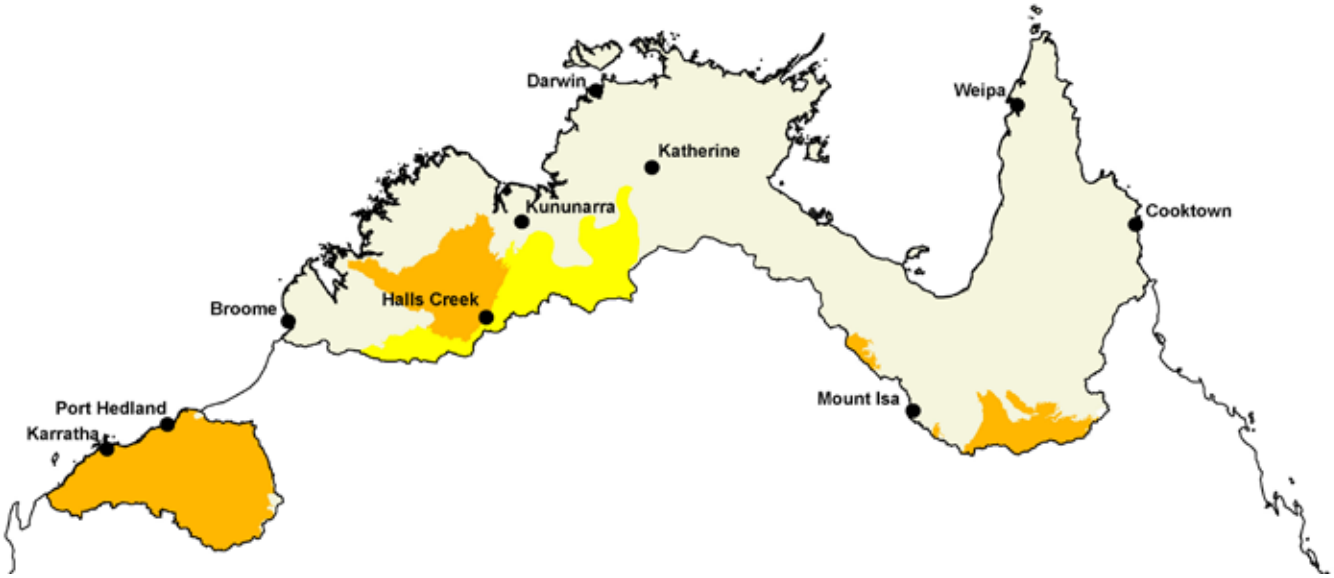
Changes in extreme rainfall unrelated to cyclones remains uncertain, though Tebaldi et al (2006) report an increase in average precipitation intensity of up to 2mm/day in the tropical North Australia by 2070.

Pearce et al (2007) discuss changes in extreme hot days and nights, finding increases throughout the tropical north. They find, for example, increases in the number of days per year above 35°C for Darwin from 11 to 44 by 2030 under a mid-level emission scenario. The current days over 40°C and the increase in these days for 2030 and 2070 are shown in Figure 9.

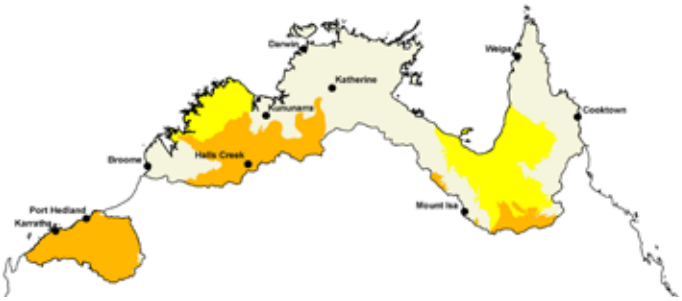
Pearce et al (2007) also discuss changes in extreme wind speed due to climate change. They find that these changes remain very uncertain: few GCMs report the wind extremes, and the lack of horizontal resolution precludes the possibility of capturing local effects that impact wind gusts and extremes. Due to these uncertainties, the change in extreme winds has not been mapped.

In summary, some impacts are fairly certain. For example, rising carbon dioxide emissions lead to regionally differentiated rising temperatures, rising sea levels and, eventually, to ocean acidification. These will happen at least for the next century, and will at least pass the levels equivalent to a degree temperature rise globally, although the timing is uncertain (somewhere between 2040 and 2060).

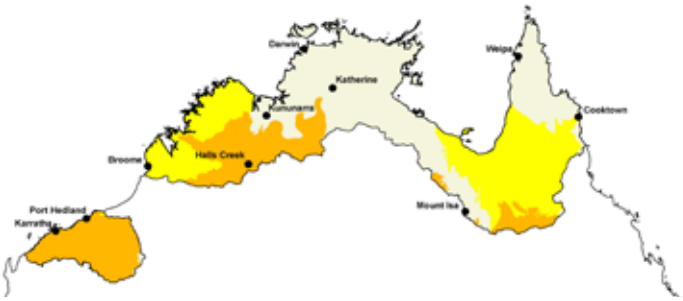
Other impacts are far more uncertain. Rainfall, although likely to generally increase in the wet season is one such impact, as is changing intensity of cyclones, other extreme event frequency change,



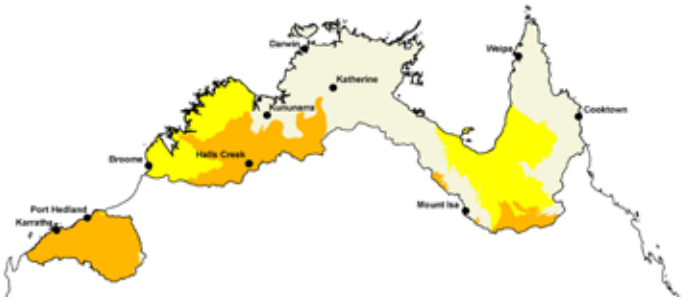
IBRA region - Current number of days over 40°C



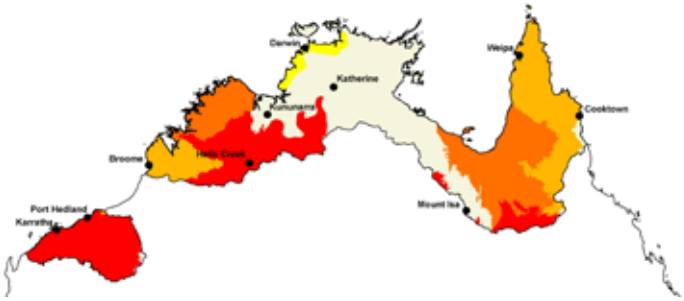
IBRA region - Minimum number of days over 40°C 2030



IBRA region - Maximum number of days over 40°C 2030



IBRA region - Minimum number of days over 40°C 2070



IBRA region - Maximum number of days over 40°C 2070

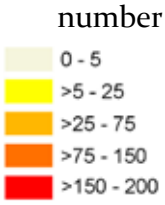


Figure 9: IBRA regions days over 40°C, min and max days over 40°C (2030 and 2070)

and potentially an interaction between heat and humidity.

Beyond 2050, a key concern is whether the world reduces its greenhouse gas emissions, leading to a different suite of projections than are currently being considered. Although climate science will improve in the short run, adaptation strategies will need to manage the numerous and interdependent risks associated with minimal emission reductions that global negotiations are currently considering.

Endnotes:

[1] The sea level data have been corrected for vertical land motion associated with glacial isostatic adjustment but not for changes in atmospheric pressure.

[2] www.ozcoasts.org.au

Summary

Temperature projections for northern Australia show the greatest warming over the north-west of the country, and lesser warming over the far north and north-east regions. Hot spells and number of days over 35°C are projected to increase for much of this region.

Most precipitation in tropical north Australia is associated with the summer monsoon. Wet season rainfall is projected to increase in areas across the study area (other than the Pilbara), whilst in the dry season rainfall is projected to decrease in most of the study area.

Possible changes in evaporation in the tropical north are not discussed widely in the scientific literature. This is directly related to the uncertainty associated with precipitation and the Australian monsoon.

Projections of sea surface temperatures near tropical north Australia indicate an increase of approximately 0.7°C by 2030 and by approximately 1.7°C by 2070.

Sea level rise in the tropical north of Australia is expected to be similar to the global average of at least 79cm by 2100. Sea level rise will have the most significant impact in the short to medium term when it is combined with extreme events such as king tides and storm surges.

Some studies indicate an increase in the proportion of tropical cyclones in the more intense categories, but a possible decrease in the total number.

Chapter 3

Climate Change Impacts on Ecosystems and Associated Communities

Ecosystem change will affect Indigenous communities in ways that are significantly different to non-Indigenous Australians. This is because Indigenous people's cultural and religious beliefs strongly connect individual and community health to that of their land and sea country. Therefore, any unexpected changes in 'natural' systems, or change in abundance or composition of flora and fauna are likely to impact the well-being of the communities associated with them.

Despite the growing recognition of the 'healthy country - healthy people' link amongst scholars working on Indigenous issues (Garnett et al 2009), the indirect impact on human systems caused by ecosystem change is not one that has been systematically explored in the literature to date. Therefore, this chapter details what has been documented about climate impacts on northern ecosystems to allow a better exploration of the likely indirect impacts on Indigenous communities' land and sea country, and consequently attempts to make some rudimentary assessment of the nature and scale of likely impacts on Indigenous communities associated with them.

Bioregions contained in the study region

Northern Australia is an area of high diversity containing 19 bioregions comprising largely tropical and subtropical grasslands, savannas and shrub-lands (DEWHA 2008a). The Pilbara region contains desert and xeric shrub-lands, and the Cooktown-Cairns area contains tropical and subtropical moist broadleaf forests (see Figure 10). Marine areas

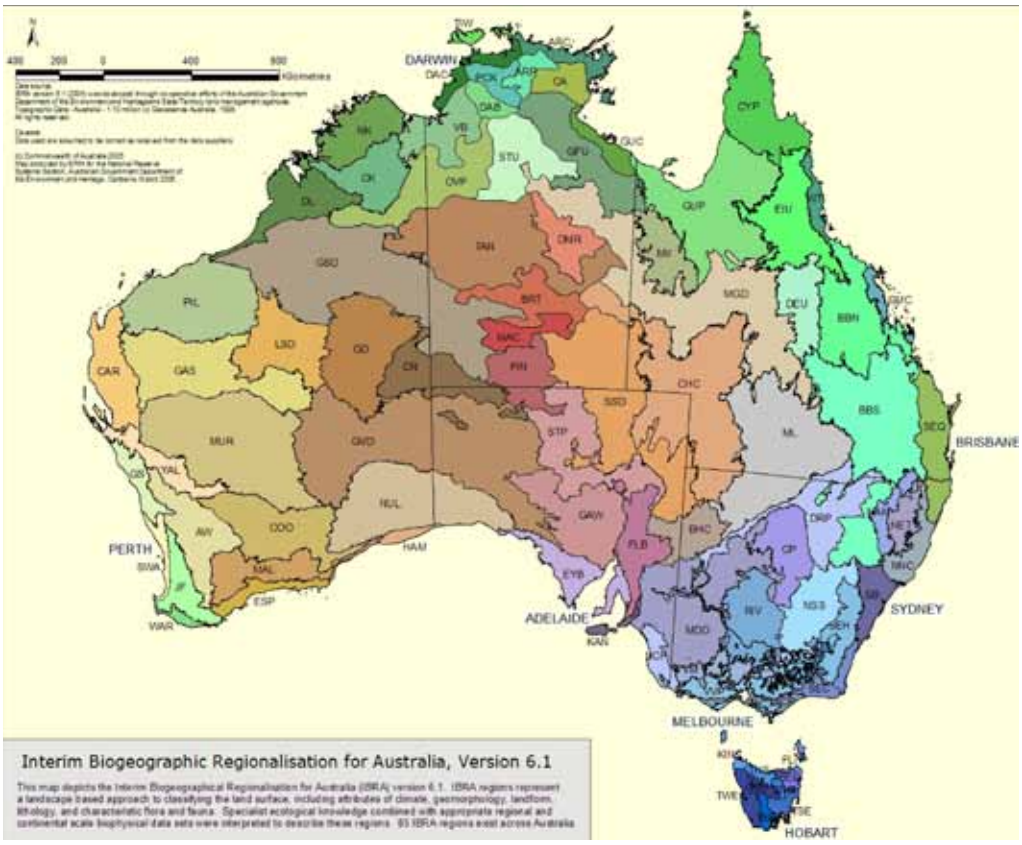


Figure 10: Bioregion map of Australia

are divided into the North, East and West Marine Regions, and are currently in the process of being divided into bioregions (DEWHA 2008b).

The terrestrial area contains the largest remaining relatively intact tropical savanna in the world and a largely free-flowing network of tropical rivers, which are considered globally significant in terms of freshwater conservation (Woinarski et al 2007). Other notable ecosystems in the region include mangrove systems, monsoon forests, fringing coral reefs, wetland systems, rainforests, heathlands and mound springs (Mummery and Hardy 1995).

Ward and Harrison (2009) identified 67 sites in the Northern Territory that are significant for the conservation of biodiversity at the national and international level. Australia's northern savannas and river systems are relatively intact compared to other ecosystems in southern areas (Woinarski et al 2007). Marine fisheries in tropical northern Australia have been rated among those least impacted globally by human influences, such as climate change (Halpern et al 2008).

Climate impacts on natural systems

The environmental changes to bioregions in the tropical north resulting from climate change include:

- Shifts in species distribution and range (Brommer 2004; Hickling et al 2005);
- Changes to breeding patterns of migratory birds that rely on fairly specific annual climatic patterns (Both and te Marvelde 2007);
- Changes to interactions between species such as predator-prey relationships (Durant et al 2005);
- Changes to plant and animal susceptibility to disease (Sinclair and Byrom 2006); and
- Potential changes to community dynamics and ecosystem function (Sinclair and Byrom 2006).

Plants and animals will respond to climate change in one of three ways: stay put when they are able to tolerate or adapt to conditions; move to more suitable habitats where possible; or die out (ACB 2008).

The literature generally deals with biophysical impacts of climate change, rather than focussing on ecosystems, with two notable exceptions. Pittock (2003) and Hyder Consulting (2007) consider impacts in key ecosystems across Australia, and northern Australia respectively.

Dunlop and Brown (2008) and Steffen et al (2009) also provide a more general national overview of these issues, whilst Woinarski et al (2007) provide a comprehensive report on the state of ecosystems of northern Australia, though the implications of climate change are not addressed in detail. A workshop report on 'biodiversity conservation research in a changing climate' provides a summary of key research and management priorities (Hilbert et al 2007). The sections below focus on the literature detailing climate impacts on the ecosystems found in northern Australia.

Savannas

Savanna ecosystems are made up of tropical eucalypt forests and woodlands (Myers et al 2004) and are the result of a monsoonal climate and relatively nutrient-poor soils (Woinarski et al 2007). They constitute the most significant ecosystem of northern Australia and cover 1.5 million square kilometres.

Indigenous Protected Areas

The Indigenous Protected Areas (IPA) Program grew from recognition on behalf of the Australian Government that:

Indigenous people's interests in national park management were not being met; there was increasing interest in and initiatives by Aboriginal and Torres Strait Islander landholders to revive traditional land management practices; and Indigenous people are interested in working with government conservation agencies to address contemporary environmental issues (Kreimer and Arnold 2000).

In 2009, there were 28 IPAs that covered a combined area of 20.3 million hectares of land.[1]

IPAs will have to cope with projected changes and threats to biodiversity within reserves, as well as possible changes to the size of IPAs that may come about as a result of policies to build resilience to climate change in natural systems.

The recent review of the IPA program found that this form of conservation management was very successful. If one means of adapting to climate change is to increase the conservation estate and to provide more habitats for mobile and vulnerable species, then there is potentially a significant role for Indigenous land owners (Altman and Jackson 2008).

Grasses and wooded vegetation respond strongly to fire, making fire a key tool available to managers to influence the savanna landscape (DEWHA 2007). Given Aboriginal experience in the use of fire,

and the present interest in re-establishing mosaic burning regimes by Traditional Owners to enable corporations and other organisations to participate in carbon abatement strategies, this is clearly one significant livelihood opportunity for many communities.

Species richness in savanna ecosystems is shown to decline with lower frequency of fires (Edwards et al 2003; Woinarski et al 2007), while species abundance responds varyingly depending on preference of individual species (Woinarski et al 2007), leading to the conservation challenge of achieving balance in fire regimes to optimise habitats.

Increased rainfall in some areas and increased atmospheric carbon dioxide content as a result of climate change can be expected to augment wet-season growth and consequently increase the fuel load, which in turn can be expected to increase the risk of high-intensity fires (Hennessy et al 2004). Controlled burns in the early dry season are one of the few tools available to limit destructive fires (Pittock 2003). It is not clear what these changes in fire regimes might mean for Indigenous communities, especially whether traditional burning practices are flexible enough to cope with the increased variability. This issue would benefit from further research and investigation to establish the nature and scale of these opportunities.

Tropical cyclones and other extreme wind events have a substantial impact on the trees of the Australian savanna (Wilson and Bowman 1987; Williams and Douglas 1995; Cook et al 2008). Cook et al (2008) write that the impact of tropical storms on decadal carbon fluxes may be underestimated with consequences for carbon sequestration rates.

The impact of potential increases in frequency and intensity of storms on savannas as the result of climate change in northern Australia also remains unexplored.

Freshwater ecosystems

Nearly two-thirds of Australia's fresh water is carried by rivers and streams in northern Australia (Woinarski et al 2007). Rivers in this region have very high seasonal variability, with only the aquifer-driven rivers flowing through the dry season. Extensive wetlands form throughout the region and are internationally recognised through Ramsar and World Heritage listing – notably Kakadu National Park in the Northern Territory and the Southern Gulf Aggregation in Queensland.

Due to its significant iconic status, a number of climate change studies have focused on Kakadu National Park (DEWHA 2007), the Mary River (Mulrennan and Woodroffe 1998; Bach and Hosking 2002) and the Alligator Rivers region.

These studies indicate that saltwater intrusion into the low-lying floodplains presents the major coastal management problem (Hennessey et al 2007), with Garnaut (2008) reporting that as much as 90 per cent of the Kakadu wetlands may be adversely affected by a sea level rise of 18-59cm.[2] Salt intrusion of this magnitude would not only directly impact local land owners, but would likely indirectly impact income and employment through a reduction in local Indigenous tourism operations (Muir pers. comm. 2007).

As wetlands switch from being predominantly freshwater systems to salt-dominated, they effectively collapse until a new suite of plants and animals that are salt-tolerant colonise the area over time and create new ecosystems (Henriksen 2006). In the coastal floodplain areas of the Mary River, saltwater intrusion has resulted in a substantial loss of habitat and has impacted significantly on wetland resource use for pastoralism, fishing and hunting (AGO 2004).

Pittock et al (2003) report that changes in temperature and runoff due to climate change will also likely slow the rate of decomposition of detritus in wetlands with resultant impacts on a range of species. Protection and revegetation of riparian areas is one of the obvious opportunities to improve landscape condition with significant net benefits to be realised from preventing salinisation, for example, of the Mary River wetlands (Campbell 2008). There are likely to be similar, although undocumented, benefits in other wetland regions.

Consequently, it is likely that there are opportunities for Indigenous people to engage with and manage landscape conservation and restoration projects through further expansion of ranger or other country-based land management programs.

Saltwater ecosystems

Mangroves

Mangroves cover 1.5 million hectares of northern Australia and are very important sources of food for Indigenous people (Monaghan 2004). They are also vital nurseries for fish (Woinarski et al 2007), and are important in coastal protection against storms (Voice et al 2006).

Sea level rise is considered the greatest threat to mangroves worldwide (McLeod and Salm 2006).

It is uncertain whether mangroves will be able to migrate at a sufficient pace to keep up with sea level rise (IPCC 2007b; Lovelock and Ellison 2007). Given the number of Indigenous communities living in coastal areas, it is very likely that traditional cultural activities reliant on mangrove systems will be affected, although no studies currently exist about the extent or direction of ecosystem change.

Cyclones and tropical storms are important influences on northern Australian coastal ecosystems. Increases in rainfall from more frequent or more intense storms are likely to impact water flow throughout mangrove systems. The water running through the ecosystems flushes out lagoons, wetlands and eventually mangrove systems. However, as waves move sediments, and therefore nutrients into marsh areas, problems may occur as more intense cyclones are likely to cause high mangrove mortality (Heron et al 2002; McLeod and Salm 2006).

Coastal and marine ecosystems

Ocean acidification, increased sea surface temperatures, irradiance, frequency of intense tropical storms and altered rainfall and river flood plumes that result from climate change are expected to have implications for coral reefs (Johnson and Marshall 2007; Fabricius et al 2007). Coral bleaching has begun to increase in frequency and severity due to rising sea temperatures and increasing acidification (Done et al 2003). According to sea surface temperature projections, coral bleaching may become an annual event during the course of this century (Jones 2004).

More generally, increasing acidification of the ocean will impact on the ability of animals and plants to produce calcium carbonate skeletons (Fabricius et al 2007). Increases in temperature or turbidity due to increased rainfall or flooding may also negatively affect reef development by reducing oxygen content and promoting algal growth (Pittock 2003). According to the Great Barrier Reef Marine Park Authority, rising sea levels could also lead to large redistributions of benthic habitats and the animals that depend on them (Johnson and Marshall 2007).

Other changes could occur as tropical storms and cyclones limit coral heat stress by lowering the sea surface temperatures through evaporative cooling, local upwelling and increased cloud cover (McField and Kramer 2007). However, the potential impacts of increased cyclonic activity resulting from climate change in northern Australia on coastal and marine ecosystems in general are likely to be profoundly negative due to the structural destruction that follows strong cyclones (Fabricius et al 2007).

Seagrass beds are also likely to be affected by climate change (Waycott et al 2007; Hobday et al 2008) although the possible extent of damage is uncertain at this point.

The effects of climate change on tropical fish are still unknown, though it is speculated that there will be significant impacts such as population decline, range expansions and contractions, shifting life history traits and a decline in reproduction (Munday et al 2007). Many species have a wide range of temperature tolerance that would facilitate adaptation to higher temperatures. A complication arises however with the highly sensitive larval stages of development instead of 'reproduction' which implies limited adaptive capacity overall.

Overall, the marine environments of northern Australia are some of the world's most intact (Halpern et al 2008). This is significant since their intactness may serve to increase their resilience to the impacts of climate change if they are not further impacted by other factors such as overfishing. The north Australian fisheries, apart from the Torres Strait area, are rated as being in a relatively better condition than most Australian waters. Hughes et al (2003) found that overfishing acts as a catalyst to increase algal dominance on reefs and concluded that limiting overfishing is one tool to reduce impacts on coral reefs.

Tropical rainforests

Rainforests are scattered in relatively small pockets over less than one per cent of the land area in northern Australia, but they contain a high proportion of the region's biodiversity (Woinarski et al 2007). Most of these forests are found in Queensland, and many of these ecosystems face increased risks of fire encroachment, seasonal drying, as well as structural impacts from storms (Dunlop and Brown 2008).

The wet tropical rainforest of north Queensland is highly vulnerable to climate change due to its relatively small area, fragmentary nature, and its compression of climate zones over a sharp altitudinal gradient (Williams 2009). Climate change is impacting this region through increasing temperature, increasing the severity of the dry season and increasing fire frequency. In addition, the decreasing leaf nutritional quality and digestibility for vertebrates and invertebrates with increasing atmospheric carbon dioxide concentration will directly impact the region's wildlife (Kanowksi 2001).

Great Barrier Reef

The Great Barrier Reef is internationally renowned for its biodiversity. Its network of reefs - about 2900 in total - is home to thousands of species of marine life. Extensive areas of seagrass meadows, mangroves, saltmarsh and sand and mud areas also provide a diverse range of habitats for many species between the reef and coast and off-shore islands (Fabricius et al 2007).

A no-mitigation case is likely to see, by mid-century, the effective destruction of the Great Barrier Reef and other reef systems such as Ningaloo in Western Australia. Even if strong mitigation activities are carried out, it is likely to be too late for large sections of the reef (Johnson and Marshall 2007).

Ocean acidification is potentially the most serious of all predicted outcomes of anthropogenic carbon dioxide increase for the Great Barrier Reef, with some scholars suggesting that that acidification has the potential to trigger a mass extinction event (Veron 2008).

Even the partial loss of these reefs over the next decade would have profound ramifications for marine biodiversity, with consequent impacts on the health and well-being of the region's Indigenous custodians.

There would also be significant impacts on Indigenous livelihoods due to loss of tourism and associated service industries reliant on the reefs (Garnaut 2008).[3]

Impacts are also likely to be felt at the extreme northern tip of the reef for places such as Mer Island, in the Torres Strait, where traditional fishing for subsistence as well as for income would likely be substantially affected. There is no reliable quantification of this impact in the literature available to date.

Even modest climate changes of only one degree temperature increase and small reductions in rainfall are predicted to lead to greatly reduced and more fragmented areas of cloud forests and other highland rainforest types, with consequent impacts on the species that are limited to these habitats (Hilbert et al 2001; Williams and Hilbert 2006). With temperature increases of over two degrees, which are probable later this century, most endemic rainforest vertebrate species will suffer dramatic declines in distribution (Williams et al 2003).

Desert and xeric shrublands

As previously noted, the Pilbara region is comprised of a very different ecosystem to the others included in this review, although this type of ecosystem is the most extensive on the continent. Climate change projections indicate more rainfall extremes for this region in the wet season, which may make the area more suitable for new species, but the uncertainty around this projection is still high (Dunlop and Brown 2008).[4] These authors also highlight fire as an increasing risk for this ecosystem.

Invasive species

According to Low (2008), a major impact of climate change in Australia may be an increase in invasive species as they move to replace native species when habitats are significantly altered (Zaveleta and Royval 2002; Cox 2004). Given the success of Indigenous ranger programs working on country in recent years, this risk may also present an opportunity to develop further employment for Indigenous people to manage and monitor invasive species on country.

Invasive species constitute one of the three main current threats to biodiversity in Australia, the other two being climate change and habitat loss (Australian Biosecurity Group 2005). Dunlop and Brown (2008) write that the lack of knowledge concerning the impacts of climate change on biodiversity makes it difficult for planners to prepare conservation actions. They explain that while it is more convenient to analyse change in individual species, interactions are more complex and important to understand. They warn against creating conservation efforts based on narrow predictions of change, and go on to suggest an alteration in the core of Australia's conservation objective from "preventing ecological change, to managing change to minimise the loss" (p. 14).

In addition to the impacts of buffaloes and pigs on low-lying wetlands, such as the Kakadu National Park region (as discussed in the Yellow Water case study), cane toads are exacerbating impacts on biodiversity (especially reptiles) as they migrate across the north towards Western Australia (Lindenmayer 2009).

One of the challenges to climate adaptation research is to estimate the impacts of climate change on invasive species – that is, to determine who will be the 'winners' and 'losers' as climate change continues (Low 2009). It is possible that Indigenous people may have different perspectives on what constitutes a winner or loser to the assessments made by non-Indigenous ecologists. Indigenous knowledge could help to guide and prioritise the efforts to control and, hopefully, eliminate the most threatening of

these invasive species.

Biodiversity

Climate change is a new and different stressor on biodiversity for two reasons: it changes the basic physical and chemical processes underpinning all life, and the current rate of climate change is probably unprecedented since the last great extinction event.

However, climate change is not operating on a 'clean slate' in terms of the status or resilience of Australia's biodiversity, which has already been modified considerably since pre-European times and suffers from a number of existing stressors (Lindenmayer 2007). As previously discussed, the most important of these for northern Australia's biota includes invasive species, altered disturbance regimes, modification of landscapes, and direct hunting and fishing pressures. Many of these existing stressors are still present, and interact with climate change.

Two overarching issues confront any attempts to deal with the threat of climate change to biodiversity in northern Australia.

First, given the complex ways in which ecosystems are responding to a changing climate, and the likelihood that indirect, interacting effects will dominate these responses, there are severe constraints for proactive approaches to increasing the adaptive capacity of natural ecosystems. In short, we often do not have the knowledge base required to support specific interventions aimed at protecting species or ecosystems in the face of a rapidly changing climate (Steffen et al 2009).

A far more robust approach is to make space for ecosystems to self-adapt to climate change in ways that we cannot predict (Mansergh and Cheal 2007). This approach, which is based on enhancing the resilience and transformative capacity of ecosystems, uses management actions such as controlling current stressors on ecosystems (e.g. invasive species) and building appropriate connectivity across landscapes.

Addressing these issues will be important in any efforts to enlist Indigenous people to help with managing biodiversity in the face of climate change.

Complex interactions and multiple stressors

Understanding and predicting how climate change will affect northern Australian ecosystems is very difficult given the complex ways in which climate change and ecosystems interact. For example, the direct impacts of climate change on individual species are rarely the most important ones; rather, the impacts of climate change on species' interactions or on ecosystem processes are more important (Steffen et al 2009). Ecosystems behave as complex systems with non-linearities, time lags, thresholds, feedbacks, rapid transformations and surprises, all of which make modelling the impacts of climate change on ecosystems extremely challenging.

No matter what approach is taken to enhance the adaptive capacity of natural ecosystems, there are intrinsic limits to how much and how fast ecosystems can adapt to a changing climate. The current rate of climate change, which is tracking at the upper limit of the IPCC suite of projections (Rahmstorf et al 2007), is much too fast for many ecosystems to adapt, even with the limited assistance that societies can provide (IPCC 2007b). If the present rates of change are maintained through the century, the world – and northern Australia – is likely to see escalating numbers of extinctions (and certainly local extinctions) as the century progresses. The only way to avoid this likely massive wave of extinctions over the coming decades is to rapidly and vigorously reduce emissions of greenhouse gases and thus significantly slow the rate of climate change (Steffen et al 2009).

Ecotonal shifts

An expansion of monsoonal forest in the north at the expense of grassy savannas has been observed over the last half-century, with some evidence to suggest that climate change may be playing a role in driving the shift (Bowman et al 2001). Rainfall has increased over the region during the same period, which would favour monsoonal forest species over savanna trees and grasses. The direct effects of carbon dioxide enrichment on plant competition and forage quality are not well known for this region, but given the potential for increasing plant growth to the fuel load, this should be considered further.

Furthermore, increasing atmospheric carbon dioxide concentration would favour plants with the C_3 photosynthetic pathway (monsoon forest species) over plants with the C_4 pathway (savanna grasses). However, there are also other factors at work. The ecotone between monsoonal forest and savannas is also sensitive to grazing pressure, fire intensity and fire frequency, both of which have also changed significantly over the past 50 years. Alternative explanations of monsoonal forest expansion can thus be supported (Werner, pers. comm. 2008). This is another example of the complexity of attributing observed change in biodiversity to climate change, and to the very likely interaction between climate change and other factors to drive the observed change.

The effect of increasing temperature on reptile reproduction is one example of the direct effects of climate change at the species level. As temperatures continue to rise, species such as crocodiles and turtles will experience a larger fraction of female hatchlings (Steffen et al 2009). For some species, use of cooler micro-habitats may be able to avoid this impact, as least for some time.

Indirect effects

The indirect effects of climate change on biodiversity are significant. These indirect effects can, for instance, impact on key species such as predators, mutualists and structuring species (Steffen et al 2009). They can impact disturbance regimes, such as the frequency and extent of fires (Williams and Bradstock 2008), and mitigation activities on landscapes and in the sea, for example planting rapid-growing tree species (Barlow et al 2007) and the fertilisation of marine biota with added iron (Watson 2004).

In dealing with the threat of climate change to biodiversity in Australia's north, the role of people in managing the landscape is crucial. In recent decades, the emphasis in managing landscapes has been on extracting 'provisioning services' from them – food, water resources, timber and minerals. The processes needed to extract these services – land clearing, dam construction, mining, logging – have had negative impacts on biodiversity, most clearly in southern Australia. While many of the northern Australia landscapes have been much less modified than those in the south, should an accelerated development of the north occur, landscape management will need to be more sensitive towards maintaining well-functioning, connected ecosystems if biodiversity is to be conserved. Climate change complicates this challenge.

Given the daunting uncertainties surrounding the impacts of climate change on biodiversity, the most viable, near-term approach that policy-makers and managers can take to increase the adaptive capacity of our natural ecosystems is to increase their resilience towards a range of interacting stressors (Steffen et al 2009). This will require a number of actions. First, existing stressors on ecosystems will need to be reduced or eliminated. Perhaps the two most important of these for northern Australia are invasive species and inappropriate disturbance regimes, especially fire. Second, adaptive management approaches should be instituted more widely, as discussed in Steffen et al (2009). In these approaches, research becomes an integral, ongoing part of the management and policy development process, as illustrated in Figure 11.

Finally, given the projected rate of climate change through this century, trying to enhance resilience could actually become counterproductive later in the century. Species are responding individually to climate change, leading to new assemblages of species and thus to novel ecosystems. Trying to 'hang on' to existing ecosystems may not work; facilitating transformation may thus eventually become the preferred management option (Steffen et al 2009).

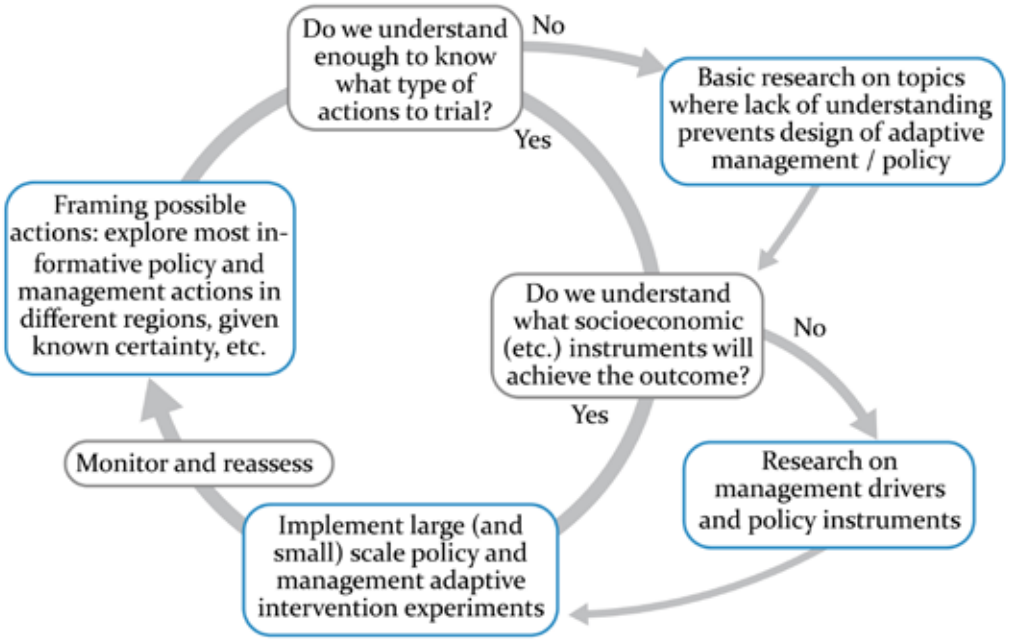


Figure 11: Schematic explaining how research may be partnered to assist adaptive management and policy interventions (after Fig. 3 in Hughes et al 2009)

Australia's Indigenous people have an especially important role to play in meeting the challenge of conserving our unique biodiversity, particularly in the north. One of the biggest constraints in being able to project the impacts of climate change on individual species is the lack of knowledge about species' characteristics, for example fecundity, food requirements, physiological tolerance to environmental factors and dispersal ability. Much of this information is part of the traditional knowledge base of Indigenous Australians and, to the extent that it is still accessible, is a valuable base on which to understand 'winners' and 'losers' amongst species in terms of responses to climate change.

Managing disturbance regimes to maximise resilience of natural ecosystems is a key response strategy, and one about which Indigenous Australians have much knowledge and understanding. This is especially important for northern Australia (Williams and Bradstock 2008), where changed fire regimes (in intensity and seasonality) could not only put pressure on vulnerable species, but also lead to changes in community composition and shifts in ecotones.

Finally, off-reserve conservation activities will become increasingly important as species migrate in response to a changing climate. The integration of the National Reserve System with off-reserve conservation will become a cornerstone of the efforts to support natural ecosystems to self-adapt to climate change. With large areas of northern Australia owned or managed by Indigenous Australians, they will likely have a disproportionately large role to play in reducing the vulnerability of biodiversity to climate change in that part of the continent.

Endnotes:

[1] www.environment.gov.au/Indigenous/ipa/map.html

[2] DCCEE is also currently funding a case study on the South Alligator River, including Yellow Waters, in Kakadu NP as part of the National Coastal Vulnerability Assessment. This is focusing on the impacts of salt water intrusion from sea-level rise, and includes an assessment of impacts on Indigenous communities expected publication date of mid 2009. The CRC for Sustainable Tourism has also prepared a report on climate change impacts on Kakadu, which is due to be released at a similar time.

[3] The economic and financial value of the GBR has been calculated by Access Economics (2005) as over $3.5 billion per annum with about 51,000 people employed.

[4] The identified risks to existing species are not well defined in the literature.

Summary

Northern Australia is an area of high biodiversity. There is, however, a general lack of knowledge concerning the direct or indirect impacts of climate change on the biodiversity in these ecosystems. Notwithstanding the need to understand the impact of climate change on individual species, the impact on ecosystems interactions is the crucial consideration in relation to the health of country and consequent impacts on Indigenous communities.

Nearly two-thirds of Australia's fresh water is carried by rivers and streams in the north. Extensive wetlands throughout the region are internationally recognised. Saltwater intrusion caused by rising sea levels and storm surges in low-lying floodplains presents a significant short-term coastal management problem.

Cyclones and tropical storms are important influences on coastal ecosystems. The potential impacts of increased cyclonic intensity on coastal and marine ecosystems are likely to be profoundly negative.

Coral reefs are expected to be strongly affected by ocean acidification. Increases in sea surface temperatures, irradiance, frequency of intense tropical storms and altered rainfall and river flood plumes are also likely to negatively impact marine ecosystems.

Rainforests are scattered in relatively small pockets over less than one per cent of the land area in northern Australia. Many of them face increased risks of fire encroachment, warmer weather, seasonal drying, as well as structural impacts from storms.

Mangroves are vital nurseries for fish and are very important for coastal protection against storms. They are likely to be negatively impacted by climate change.

Specific indirect impacts on natural systems from climate change that have been documented include: shifts in species' distribution and range, shifts in breeding patterns, changes to predator-prey relationships, greater susceptibility to disease, and community dynamics and ecosystem function.

Indirect impacts on human systems caused by ecosystem change have not been systematically explored to date. Indigenous cultural beliefs that connect the health of individuals and communities to their country suggest that unexpected changes in natural systems, or change in abundance or composition of flora and fauna are likely to impact on the well-being of these communities.

Mangrove systems are very important sources of traditional food for Indigenous people. It is very likely that traditional cultural activities reliant on mangrove systems will be indirectly impacted by climate change.

There are likely to be significant impacts from climate change on totemic species, such as turtles.

No matter what approach is taken to enhancing the adaptive capacity of natural ecosystems, there are intrinsic limits to how much and how fast ecosystems can adapt. Given the uncertainties surrounding the impacts of climate change on biodiversity, the most viable, near-term approach for resource managers is likely to increase their resilience towards a range of interacting stressors.

There are numerous opportunities for Indigenous people to engage with and manage landscape health through the expansion of ranger or other land-management programs to manage invasive species, monitor environmental change and revegetate degraded land. The benefits of greater Indigenous engagement extend beyond increasing employment opportunities – they can lead to increased connection to country, and strengthened cultural practice.

The traditional knowledge of Indigenous Australians is a valuable base from which western scientists and resource managers may be able to learn more about how species are likely to respond to climate change.

Chapter 4

Climate Change Impacts on Indigenous Health

Climate change impacts on human health have been documented for over a decade. The second assessment report of the IPCC devoted a full chapter to potential consequences, and this has been followed in subsequent reports (IPCC 1995; IPCC 2001; IPCC 2007b). A comprehensive review of literature by McMichael et al (2006) on the impacts of climate change on human health found that direct impacts from heat waves, physical impacts of storms and flooding, and influences on vector-borne diseases were most easily correlated with climatic conditions. Impacts from heat waves in combination with increasing humidity are also of significant concern (Kovats and Ebi 2006) although this has not been quantified for the north of Australia.

Changes in regional food yields, disruption of fisheries, loss of livelihoods, and population displacement due to sea level rise and water shortages, were highlighted as significant impacts for Indigenous communities in northern Australia, although these changes are not easily studied, and their causal processes and effects are yet to be quantified (McMichael et al 2006; Spickett et al 2007).

Climate change is expected to bring elevated risks of heat stress and dehydration in the study region, and conditions more conducive to both skin and gastrointestinal infections (Currie 2001). Respiratory illnesses such as asthma are expected to increase (McMichael et al 2008), and hotter and more humid conditions are likely to cause increased transferability of conditions such as melioidosis (Currie 2001). A regional stakeholder commented that "many cases of melioidosis occur in the wet season across northern Australia and can be fatal for immuno-compromised patients. If floodwaters are more prevalent, it is anticipated that the number of cases will increase."

Public health interventions to mitigate potential increases in infectious diseases, such as greater allocation of resources for Indigenous public health, are a key aspect of designing a robust anticipatory adaptation strategy (Currie pers. comm. 2009).

Possible shifts in climatic zones may alter the distribution of vectors for various mosquito-borne diseases such as dengue and Murray Valley encephalitis. A regional stakeholder noted that, "The Northern Territory has, through extensive surveillance and monitoring for *Aedes aegypti*, so far avoided the establishment of a vector for the transmission of dengue fever. Dengue can also be transmitted by *Aedes albopictus*, a mosquito restricted to the Torres Strait Islands. If this mosquito becomes established on [mainland] Australia, the number of dengue cases will increase significantly. The 200+ recent dengue cases in the Cairns region provide such evidence."

Malaria is unlikely to become re-established in Australia because of the ability of public health responses and available drug therapies to prevent spread following imported cases (Currie 2001). Furthermore, Russell et al (2009) noted that historically the dengue mosquito *Aedes aegypti* was able to survive in Australia as far south as New South Wales and southern Western Australia, however, public health interventions, such as the reticulation of water and removal of open water storage, saw its eradication from all regions of the country except far north Queensland by the mid 1900s. Russell also notes the complexities of mosquito life-cycles and survival, with the potential for higher temperatures without humidity to decrease mosquito longevity from desiccation (Russell 2009).

Indigenous Australians suffer a higher incidence of kidney disease, gastrointestinal illnesses, respiratory illnesses, skin sepsis and malnutrition than non-Indigenous Australians (Currie and Brewster 2001). Life expectancy is seventeen years below that of non-Indigenous Australians (AIHW 2008), and the health discrepancy between Indigenous and non-Indigenous Australians has widened in recent years (EHNS 2004; AIHIN 2008).

The discrepancy is caused by a complex combination over many generations. This includes poor nutrition, overcrowded housing, lack of good water and sewerage infrastructure, poor hygiene, lack of rewarding employment opportunities, as well as psycho-social health problems related to a history of dispossession, loss of capacity to care for ancestral lands, and life histories complicated by domestic violence and substance abuse (EHNS 2004; AIHW 2008).

While all Australians are likely to be vulnerable to the above conditions, the significant health discrepancies between Indigenous and non-Indigenous Australians means that the former are likely to be disproportionately affected.

Psycho-social health

Indigenous Australians have a holistic conception of human health, where the mind, body, spirit and land are seen as intimately interconnected (UNPFII 2007). The link between healthy landscapes and the Indigenous sense of well-being is well documented (Altman 2003; Altman 2004; Burgess 2005; Garnett and Sithole 2007) and there is growing interest in understanding the causal relationships between them. The holistic conception of human health articulated by many Indigenous people may be seen as a source of vulnerability where changes in the local environment of sacred sites or hunting grounds may be felt strongly, and may adversely affect psycho-social health as well as physical well-being (Green 2006a; Spickett et al 2007; Green et al 2009a).

Potential loss of totemic species such as the quoll, resulting from shifts in terrestrial and aquatic ecosystems in response to temperature and rainfall patterns (DEWHA 2007), and the spread of pests such as cane toads, could similarly distress Indigenous land-owners and custodians.

Climate change will bring more intense cyclones, flooding and storms (Hennessy et al 2004; McBride et al 2006). Indigenous communities generally have poor housing standards, and even houses that are cyclone-proofed are generally built to withstand a mid-level four cyclone. In a climate-changed world where level five cyclones are expected to be more frequent, this would require the significant redesign of existing and new building stock (Cook n.d.; Nicholls 2007). Indigenous communities also generally have significant amounts of derelict infrastructure and materials around the townships that may become damaging projectiles during cyclonic and storm events.

Physical injury from extreme weather events

Western Australian stakeholders have suggested that there may be a need for dedicated community-based cyclone shelters and better-resourced medical services. It is likely that this precaution would need to be considered for the Northern Territory and Queensland as well. A review of current cyclone categories and zones would be useful to assess the maintenance of existing (and erection of new) buildings and infrastructure in the relevant cyclone zones. This may also result in the updating of existing regional cyclone/disaster management and evacuation plans.

As extreme events are expected to increase in frequency and intensity due to climate change, COAG recommends that all levels of government develop counter disaster plans (COAG 2002). There is an additional consideration for Indigenous communities: they require tailored plans that are culturally appropriate (Braaf 1998). Shelters that can house the community during extreme weather events are provided in most communities. However, current research being carried out on Goulburn and Croker Islands reveals that Indigenous inhabitants will stay away from cyclone shelters where cultural-avoidance relationships cannot be respected (Veland pers. comm. 2008). Therefore in order to avoid additional emotional stress, physical injuries and deaths, there is a need for emergency shelters and emergency evacuation procedures to be designed that allow cultural protocols to be followed.

Emergency risk management

The *National Emergency Management Strategy for Remote Indigenous Communities* presents planning, education, resourcing and empowerment as priorities for Indigenous participation in emergency management (EMA 2007). Their strategy focuses on preparedness and prevention, and responds to a call for practical approaches to emergency management in Indigenous communities.

Both the Queensland Government Department of Emergency Services and the Northern Territory Emergency Services have developed practical and accessible guides in plain English for use by Indigenous communities in disaster risk management (QDES 2004; NTES 2005). The Western Australian Fire and Emergency Services Authority has developed the Local Community Emergency Management Arrangements Guide to assist communities formulate their emergency management arrangements (FESA 2004), and has developed a framework to "coordinate the

introduction of the emergency risk management process into West Australian Indigenous Communities" (Newman and Smith 2004, p.10). Plain English guidelines tailored for use in Western Australian Indigenous communities are yet to be developed.

With over 75 per cent of communities located within 50 kilometres from a coast, a special focus is clearly needed on coastal settlement in relation to storm surge, erosion and slow onset sea level rise.

Vector-borne diseases

The occurrence of vector-borne diseases is determined in large part by temperature and rainfall (Jacups et al 2008). Literature that deals with the impacts of climate change on infectious disease is summarised below.

To reduce the opportunities for increased mosquito breeding, the appropriate design and maintenance of water storage infrastructure is needed as well as information campaigns about reducing material around houses that can temporarily store water. Increased rainfall and storm activity may require changes to wastewater management due to septic tank and sewage lagoon flooding.

Mosquito-Borne Diseases

Ross River virus and BFV occur over the northern tropical coast of Australia. Ross River virus is the most common and widespread arboviral disease in Australia (Jacups et al 2008). More research has been done into its connection to climate variability than into the connection between climate variability and BFV (McMichael et al 2008). Yet BFV infections have seen a marked increase in recent years, with the summer 2005-2006 marking the largest BFV epidemic on record in Australia. The illness is not life-threatening, but infection may lead to arthritis, myalgia, and fatigue for six months or longer.

Murray Valley encephalitis and dengue are flaviviruses potentially impacted by climate change. Murray Valley encephalitis is endemic to the Kimberley region and parts of the Northern Territory (Cordova et al 2000), and is found across the northern half of Australia (particularly in the Kimberley and Pilbara regions), Papua New Guinea and eastern Indonesia (WADH 2008). Murray Valley encephalitis can be fatal but this is rare and currently, dengue fever only occurs on the east coast of tropical Australia, however, it is spreading in Australia and worldwide (McMichael et al 2008).

Japanese encephalitis is an arbovirus that currently occurs as an imported illness, but its range may spread into tropical Queensland as climate zones shift south (Currie and Brewster 2001). Malarial zones are also set to shift globally with climate change (IPCC 2007b); however its permanent establishment in Australia is considered highly unlikely (McMichael et al 2003).

Respiratory illness

Concentrations of atmospheric pollutants can rise during heat waves and are associated with bush fires. Haines and colleagues (Haines et al 2006) explain that more frequent heat waves resulting from climatic change may contribute to increased mortality in Indigenous communities during prolonged hot weather. A number of respiratory diseases, such as asthma, allergic rhinitis, and chronic obstructive pulmonary disease are expected to increase, as is mortality from other diseases such as cardiovascular diseases (McMichael et al 2008).

> "Current[ly there are] difficulties in recruiting health professionals, including Indigenous people, willing to work in regions experiencing increased number of days over 40 degrees Celsius. This problem is expected to be exacerbated by climate change and will have flow on impacts on delivery of health services to communities in the study area."
>
> - Regional stakeholder.

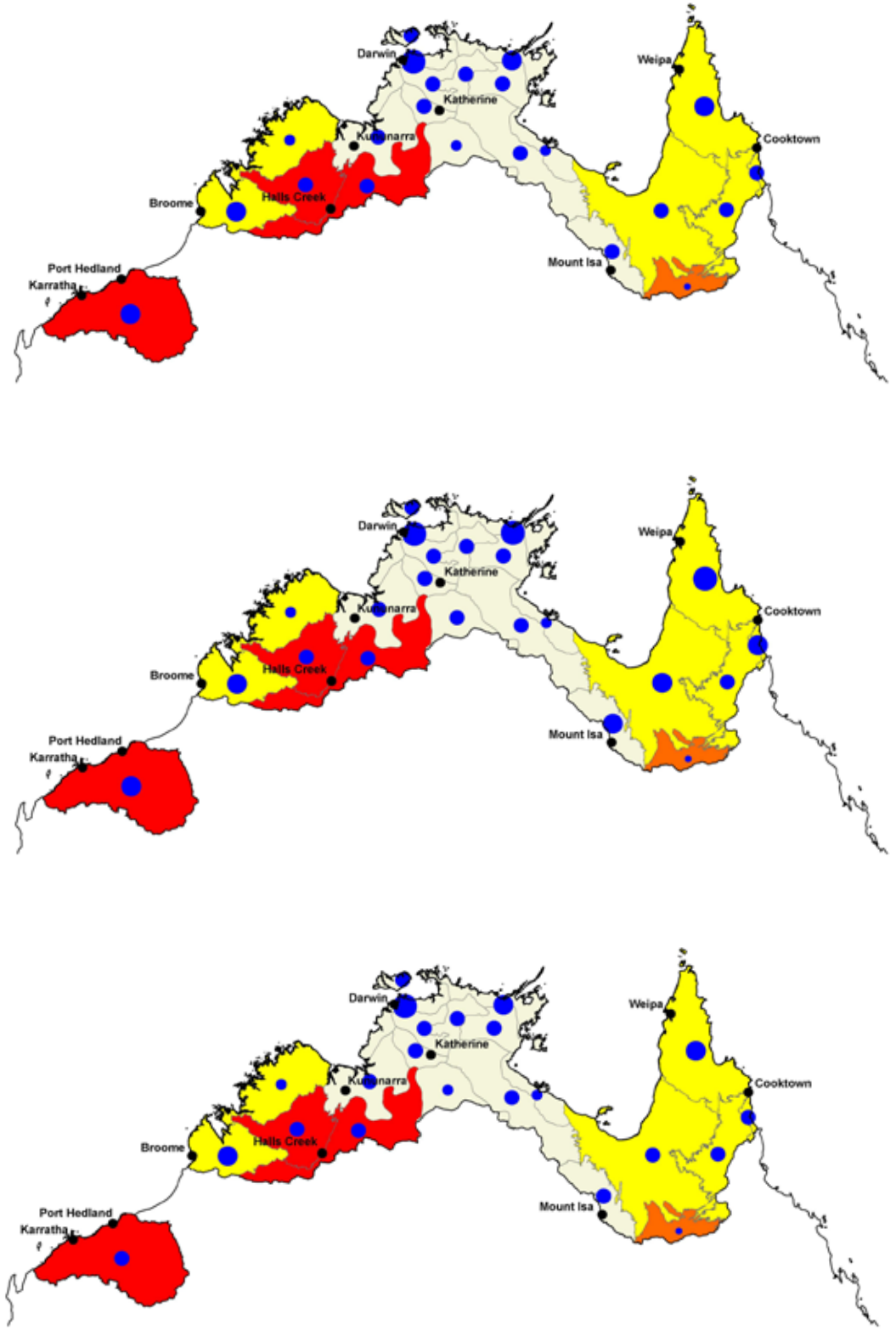
Gastrointestinal illness

Gastrointestinal illness is influenced by temperature, and is expected that warmer ambient temperatures would increase bacterial gastroenteritis (Bambrick et al 2008). Such illness is often easily prevented through washing hands and general hygiene, which may reduce occurrence by as much as 42-47 per cent (Curtis and Cairncross 2003).

Heat-related illness

Heat waves are one of the most predictable impacts of climate change (Lynch et al 2008). The IPCC (2007b) reports that heat-related morbidity may double by 2020 in major Australian cities. A lesser impact is expected in tropical areas, where people are accustomed to higher temperatures throughout the year (see the Yakanarra case study in Chapter 8 for further discussion of the human response to heat stress).

The frequency of hot spells (three consecutive days of over 35°C) may increase from one to ten events per year in coastal areas of the study region by 2030 (Hennessy et al 2004). During hot spells, morbidity



Vulnerable Indigenous population
(younger that 10 and over 65)
2030

- 0 - 100
- 100 - 500
- 500 - 2000
- 2000 - 5000
- 5000 - 7000

Maximum number of additional hot spells
(over 40°C)
2030

- 0
- > 0 - 2.5
- > 2.5 - 5
- > 5 - 7.5
- > 7.5 - 10

Figure 12: Location of vulnerable population and regions with increasing number of hot spells in 2030 (top figure based on assumption of no migration, middle figure based on scenario 1 and bottom figure based on scenario 2) see appendix 5 for more detail

increases and there is a higher risk of heat stress, heat cramps, heat rashes and in the most serious cases, potentially fatal heat stroke (AIHIN 2008; Green 2008). People with cardiovascular illness, as well as the elderly, young children (who cannot help themselves to water), overweight people, people with debilitating alcohol dependence, and those of low physical fitness are of particular risk of developing heat-related illnesses - see Figure 12 (Ferguson-Hill 2002; McMichael 2006).

Dehydration may lead to urinary tract infections which, while not life threatening can, through repeated illness, lead to kidney damage and eventually more serious renal problems, including end-stage renal disease (AIHIN 2008).

Access to health centres

For many remote communities, maintenance of airstrips is vital to ensure that critically ill patients can be transported from community clinics to regional hospitals via light aircraft, and other patients requiring less critical attention can be transported to regional centres when the community is isolated due to flooded roads. 147 communities in the tropical north reported having access to an airstrip (of a total of 1035 communities included in the survey), with 38 of these not having year-round access (CHINS 2006).

It is uncertain how climate change will affect access to health infrastructure, although it is likely that increases in extreme weather would reduce access generally.

Hospital access

Almost three quarters of remote communities in the study region travel over 100 kilometres to get to a hospital. When overlaid with the number of days when road access is not available, Indigenous communities in several locations throughout the study region are revealed as vulnerable (see Figure 13).

The spatial distribution of hospital access is significant because some climate impacts may have an uneven distribution across the study region. For example, temperature rise will be highest inland and therefore the inland communities without hospital access are relatively more vulnerable. In this case, communities in the southern Kimberley region are exposed to the greatest number of days of 40 degrees plus. A negligible number of these communities have good access to hospitals or medical centres.

It is important to remember, however, that hospitals are not the only health infrastructure for remote areas. If the data were available, further analysis of proximity to health centres and GPs would be a useful extension of this analysis. Access to air transport to regional centres would also need to be taken into account in any further analysis of this issue.

Figure 13 also shows that a very high proportion of communities needing to travel in excess of 100 kilometres to get to a hospital are located on or very near the coast, and it is in this zone that the projected increasingly intense cyclones are likely to have a greater impact. Higher rainfall and extreme events will likely compound this threat, because during extreme weather, emergency evacuation by air is very difficult. More data on the spatial extent of cyclones would assist in any further analysis.

Age is a predictor of vulnerability of human health to climate change, especially for heat stress. More information is required on the number of very young and aged Indigenous people, their location in relation to health and hospital facilities, and access to infrastructure, such as houses with air conditioning.

Nutrition

The general importance of bush foods in the diet of Indigenous people is noted in several studies (Turner 2003; Weladji and Holand 2003; Brimblecombe 2007; McMichael 2007; Trainor et al 2007). Few studies have specifically looked at the importance of bush foods for daily nutritional intake in Indigenous communities in Australia. Altman (1987) found that bush foods contributed on average 81 per cent of the protein for the residents of one outstation in North Western Arnhem Land. Altman et al (2006) later analysed National Aboriginal and Torres Strait Islander Social Survey data from 2002 and showed that over 80 per cent of adults living in discrete Indigenous communities fished or hunted for their livelihood. However, there are inconsistencies between these findings and those reported in Lee et al (1994) which suggest that the role of bush food in remote Indigenous community diets is much lower than these former studies suggest.

Campbell et al (2008) discuss the different socio-economic trajectories of all rangeland regions and suggest how a policy strategy might be developed in relation to health for each. This could provide the basis for a regionalised differentiation of approach for health, but also potentially a framework for other issues noted in this report. Their analysis was based on Holmes (1997) who identified regions whose futures were dominated by mining/urban developments, marginal pastoralism, tourism/urban development, and core Aboriginal homelands, among others (see figure 1 in Campbell et al 2008).

They noted that there was likely to be a different balance of health investment needs in each type of region, and a different balance of public and private sources for this investment. A further development of this typology with a focus on Indigenous needs would be highly informative.

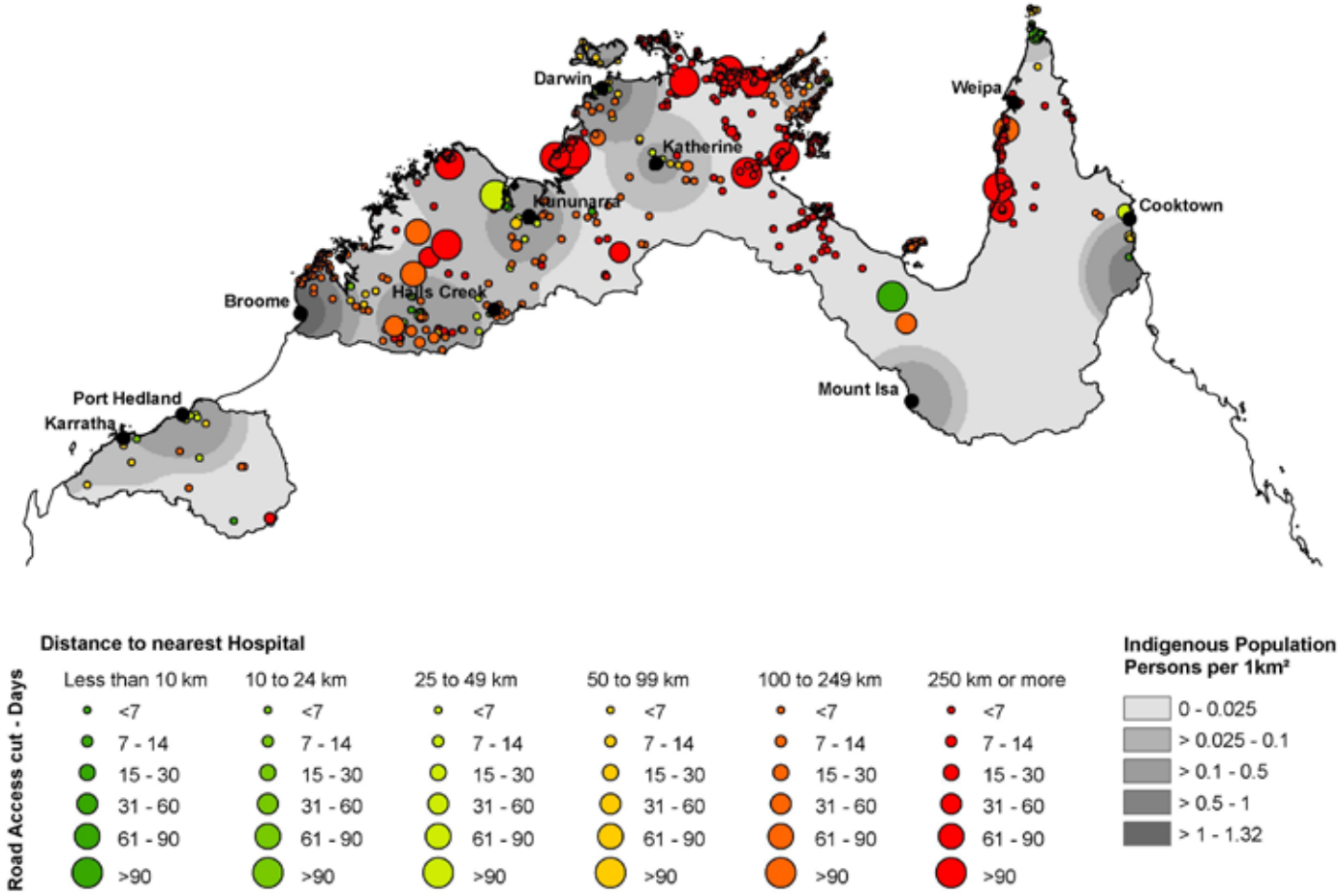


Figure 13: Hospital location, road access and Indigenous population density

Summary

Climate change is expected to elevate existing and create new health risks for Indigenous people. These include: increasing incidence of heat stress and dehydration, respiratory illnesses and increased transferability of disease such as melioidosis.

Poor nutrition, overcrowded housing, lack of adequate water supplies frequently found in Indigenous communities increase vulnerability and reduce adaptive capacity to climate change.

Indirect impacts such as reduction in bush food yields, disruption of fisheries, loss of livelihoods, and population displacement due to sea level rise are also clearly significant for physical health of Indigenous people, although no quantitative analysis of these impacts has been undertaken to date.

The holistic conception of human health articulated by many Indigenous people may be a source of vulnerability in that disruptions that affect sacred sites and hunting grounds may be felt strongly and adversely affect psycho-social as well as physical well-being.

A regional approach to the provision of health services would provide a framework to improve access for remote communities. Health systems are already under pressure to cope with existing health needs of Indigenous people in the study area and this may become a more difficult situation with climate change.

Climate change is likely to make emergency evacuation by air more common. Maintenance of airstrips is, therefore, vital to ensure that patients can be transported from community clinics to regional hospitals via light aircraft, and other patients requiring less critical attention can be transported to regional centres when the community is isolated due to flooded roads.

Chapter 5

Climate Change Impacts on Infrastructure

> "Fire and Emergency Services WA identifies an increased risk in high-intensity fires in the savanna areas and these have the potential to have a major impact on Indigenous communities. The question as to whether traditional burning practices can cope is not really the issue in a holistic approach because the traditional lifestyle/burning is restricted to a small percentage of the total area. A burgeoning problem is the issue of deliberately lit late-season fires and these are a major threat to remote and isolated communities and the attendant natural resources."
>
> - Regional stakeholder.

According to the IPCC, risks to major infrastructure in Australia are likely to increase due to climate change, whilst design criteria for extreme events are very likely to be exceeded more frequently by 2030 (Hennessy et al 2007). Risks include failure of floodplain levees and drainage systems, flooding of coastal towns near rivers, increased storm and fire damage and more frequent heat waves causing more deaths (Hennessy et al 2007; Bates 2008).

The Garnaut Report recognised that much coastal infrastructure under the early twenty-first century lines of settlement is likely to be at high risk of damage from storms and flooding, and that 'Queensland's coastal settlements are anticipated to suffer extreme infrastructure impacts from increased storm surge and localised flash flooding' (Garnaut 2008, p.126).

To date, no studies have looked into how climate change may impact on infrastructure in Indigenous communities in northern Australia. *The Assessment of Impacts of Climate Change on Australia's Physical Infrastructure Report* (ATSE 2008) includes some of the study area in north-east Queensland, but there is little depth of analysis relevant for remote communities.

The potential for sea level rise to damage existing coastal infrastructure needs to be considered in any future development planning. These issues are of concern to all coastal communities; however, due to the additional expense of getting materials to remote Indigenous coastal settlements, these issues are of greater significance to them. In addition, the displacement of communities due to sea level rise and storm surges would result in greater pressure on other communities and would have significant cultural impacts.

Housing infrastructure

Two prominent issues facing housing infrastructure in the north are the communities' capacity to deal with elevated temperatures and their resilience to extreme storms. Maunsell Australia (2008) assessed the ability of current building designs to maintain 'acceptable indoor temperature environments' under several scenarios, and found that the expected increase in the number of hot days and heat waves would reduce the ability of buildings to maintain acceptable indoor temperature environments without adjustments to design standards for insulation, shading and window glazing.

Improvements and changes in infrastructure design are required for houses and other buildings to reduce the demand for energy services such as air conditioning. Consequently, this will require improved and innovative design and building products that make houses and other buildings less expensive to cool. The ability of occupants to maintain reasonable living conditions is also of importance, especially with the likely impact of dramatically increased costs of producing and supplying electricity as well as energy security issues.

Cook (n.d.) suggests that the current Australian design criteria for buildings in areas affected by tropical cyclones are already insufficient. The current criteria are based on predictions of cyclones being no stronger than a category 4 along the north Australian coast, with the last ten years experiencing three strong category 5 cyclones affecting the Northern Territory coast alone. More information is needed

on the strength of Indigenous housing and shelters to withstand cyclones and other extreme weather events. One regional stakeholder commented that "new housing ... needs to be cyclone coded, to withstand the predicted increase in cyclone intensity and should be adopted as a policy principle in building design standards, such as Environmental Health Standards for Remote Communities in the Northern Territory and the National Indigenous Housing Guide."

In addition, the $672 million joint Australian and Northern Territory Government Strategic Indigenous Housing Infrastructure Program (SIHIP) aims to provide appropriate housing design in Indigenous communities in the Territory. The Program is working towards compliance with environmental rating related to energy, heat and water and is also examining appropriate architectural designs for remote communities.

Water supply and sewerage

In the context of projected climate change, water supply is one of the most vulnerable sectors in Australia (Bates et al 2008). Australia is already experiencing water supply problems due to climate change and longstanding allocation issues. Economic constraints in Indigenous communities often mean that they are only supplied with untreated water or that treatment is limited in extent and monitoring may be infrequent or absent (NHMRC and NRMMC 2004).

No study has yet determined the potential impact of climate change on water infrastructure in Indigenous communities in northern Australia. The CHINS (2006) reported that for the regions covered in the survey, 52 per cent of Indigenous people relied on bore water as their main source of water, and only 30 per cent were connected to a town supply. The potential for more rain suggests that water supply may be less of an issue for most regions considered in the study, however more extremes will increase the risk of flooding, which could potentially threaten water quality. A regional stakeholder noted that, "Groundwater-dependent communities and settlements in the north may experience lower water availability, at a time when water demand (and energy demand) may increase in an effort to keep residents cool and healthy. It is also anticipated that saltwater intrusion of coastal aquifers would occur due to sea level rise, which may also affect availability of drinking water for settlements."

The reliability of water systems is also a regionally specific issue for remote communities, particularly in the Kimberley region (O'Mullane 2003; Popic 2006) where around 160 small communities are affected (CHINS 2006). Beard (2006) found that water supply infrastructure, quality protection measures and the availability of baseline water resource information are ongoing issues for communities in the Malarabah region of the Kimberley. Residents expressed a desire to have more controls over local water quality and quantity, including contamination response measures, fire-response storage and ability to manage local water demand. Remote residents were conscious of their increased vulnerability due to distance and wet-season inaccessibility.

Most islands have a limited water supply that is particularly vulnerable to sea level rise and changes in rainfall. It is probable that water resources on small islands are likely to be seriously compromised under most climate change scenarios (IPCC 2007b). Securing a reliable year-round supply of freshwater is already proving to be a key issue for Aboriginal and Torres Strait Islanders living on low-lying islands.

In larger Indigenous communities[1] all permanent dwellings are connected to a sewerage system (CHINS 2006). 182 small communities reported that they have a sewerage system that is not connected to all permanent dwellings. Of these small communities, 69 were located in Western Australia, 61 in the Northern Territory, and 51 in Queensland. Where the sewerage is not connected centrally, septic tanks, with common effluent disposal, leach drains and pit toilets continue to be the prevalent sewerage systems. Sewage storage systems subject to flooding or inundation carry the potential for contamination of drinking water supplies and other health risks.

As yet no studies have investigated the risks to sewerage infrastructure resulting from climate change, although it is reasonable to conclude that communities near the coast or rivers are at greater risk from sea level rise, increased storm surges and potential for rainfall derived flooding.

Electricity supply

A number of remote communities across the north are not serviced by an electricity grid, which means that diesel is used extensively for power generation. Using diesel presents challenges for remote communities. Most communities are isolated by hundreds of kilometres of dirt roads, and many can be cut off by flooding, making access to a reliable supply of diesel difficult at certain times of the year. The cost of operation and maintenance of the generators, isolation from maintenance services, capacity of the systems to service the community's energy needs, and the lack of technical expertise among community residents to look after the

generators and use them safely all pose challenges.

A greater reliance on energy supplies is likely to become increasingly problematic in those areas of the north that will be impacted by extreme temperatures. Increases in peak energy demand due to increased air conditioner use may overstretch the ability of the electricity systems to cope, particularly if they are dependent on diesel generation to supply their energy needs.

In the 12 months prior to the CHINS survey, 32 per cent of Indigenous communities in Australia experienced interruptions to their power supply more than ten times a year (CHINS 2006). Over 40 per cent of Indigenous communities experienced interruptions resulting from equipment breakdown. No studies have yet investigated the impacts of climate change on power generation in Indigenous communities.

Case study: The Bushlight Program

In recent years, the Bushlight program has brought reliable electricity to remote communities using solar or solar diesel hybrid systems (Bushlight 2008). Integrating 'people' issues and 'technical' issues is an important aspect of the Bushlight project.

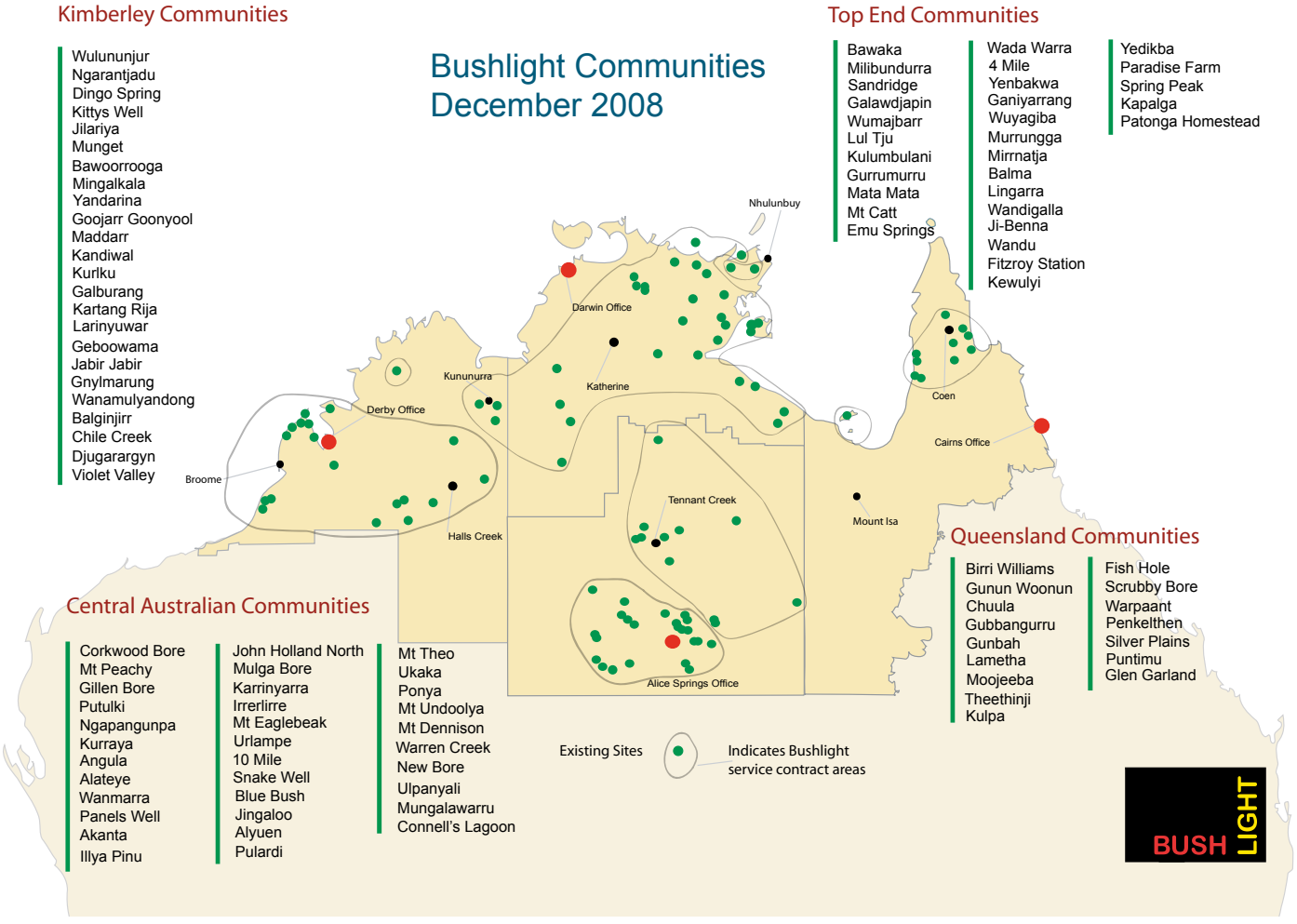


Figure 14: Bushlight communities (above) and a detail showing one of their system's operating board (top right)

A range of culturally appropriate resources designed specifically for local conditions support the process. Not being reliant on a grid connection nor totally dependent on diesel for electricity makes these communities more resilient during extreme weather events and to increasing fuel costs. (In addition to the Bushlight program, with support from the Australian Government, the Northern Territory's Power and Water Corporation has rolled out renewable energy power generation across six remote communities, including Bulman, Kings Canyon, Hermannsberg, Lajamanu, Yuendemu and Jilkminggan.)

Telecommunications

Reliable telecommunications services are vital in emergencies and are particularly important where communities are isolated for parts of the year due to wet-season flooding and have no means of evacuating by road when facing imminent dangers such as cyclones, see Figure 15. This figure shows the access to TV and radio in the study region (that could be used to learn of impending extreme weather) and the range of mobile phone reception available. Notably, extensive areas of the north have extremely limited mobile phone coverage. More information is required to ascertain the extent of access of telecommunications, and particularly access to emergency warning systems across the north.

A submission by Maunsell Australia (2008) to the Garnaut Climate Change Review assessed the potential impact upon telecommunications infrastructure in coastal areas under a range of climate change scenarios. In this report, State and Territory borders were used to define regions to determine the potential impact of storm surges from a combination of sea level rise and extreme rainfall. It is noted that these severe conditions could lead to 'major ramifications for fixed voice, mobile and data services, which often rely on analogue or digital transmission via subterranean cables' (Maunsell Australia 2008, p.10).

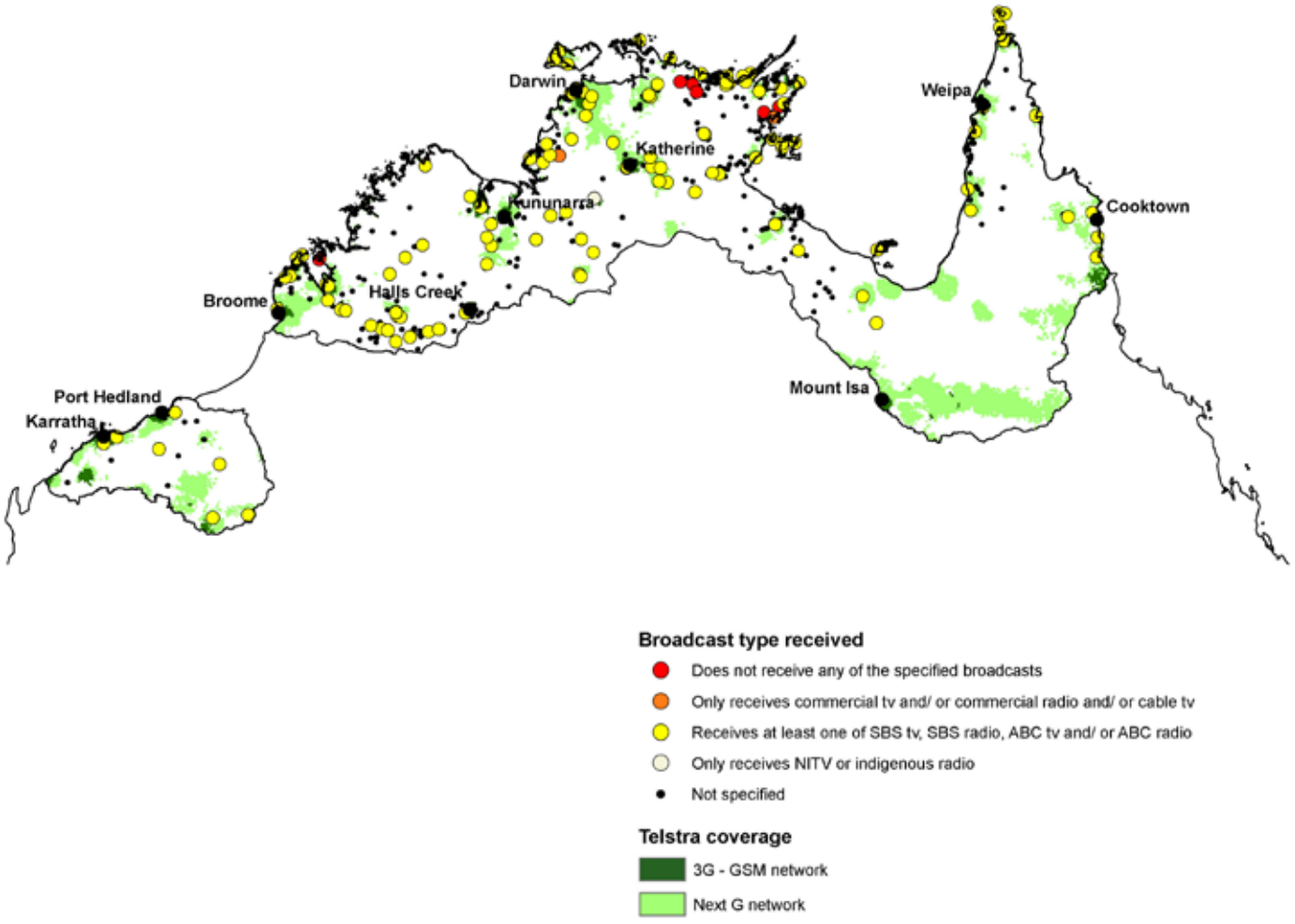


Figure 15: Broadcast type received in remote communities and mobile phone coverage

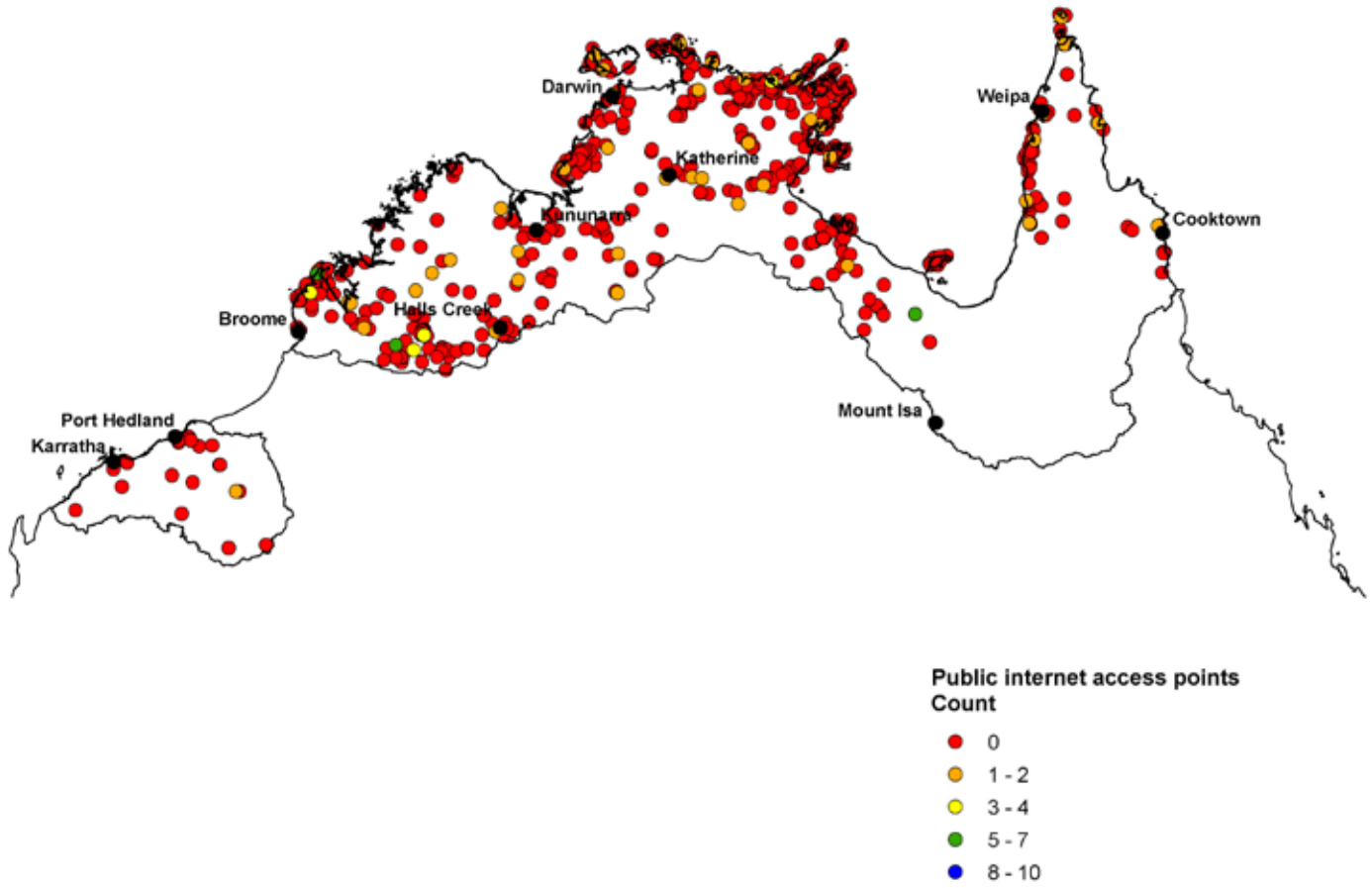


Figure 16: Public internet access points

Access to the internet within Indigenous communities has become vital to ensure delivery of services, particularly in education and health. Access to the internet also allows residents of remote places connection to real-time information such as the strength of a cyclone and its likely path. The CHINS data suggests that there are regions that do not have any public access points to the internet. For example at least eight places across the entire region have only 2-10 access points (see Figure 16). Experience suggests that some of these 'public' points may have limited access: for example, Fitzroy Crossing appears to have at least six public access points yet the authors know of only two computers located there that are semi-public. This figure shows that the majority of remote communities have very limited or effectively no public access to the internet.

Fibre-optic cable for high-speed internet was laid across Arnhem Land in 2008. The project was designed to provide high-speed broadband services to an Indigenous population of about 8,000 people with radio transmitters due to be installed to service a further four offshore communities, bringing internet access to another 2,000 people. Sixty million dollars is to be invested in improving regional communications through the Digital Regions Initiative for education, health and emergency services projects, in regions with remote Indigenous communities beginning in 2010. This investment is in response to the *Regional Telecommunications Review* (Glasson et al 2008).

Transport

Climate change is expected to increase the severity of severe tropical storms or cyclones that in turn will affect transport and access to areas in the north. To date, there has been no risk assessment of the impact of climate change on transport in northern Australia.

Figure 17 shows Australia's transport infrastructure in the north highlighting the rudimentary road networks of some of Australia's very remote regions. The map indicates there is only one small section of dual carriageway in Darwin. As a result, both regions rely heavily on air transport, and to a lesser extent shipping. Note that barge landings that service communities like Maningrida, Milingimbi and Ramingining are not shown but are an essential component of transport infrastructure. These landings are not reliable in rough weather and will be vulnerable under increased frequencies or greater intensities of storms, including events less extreme than cyclones.

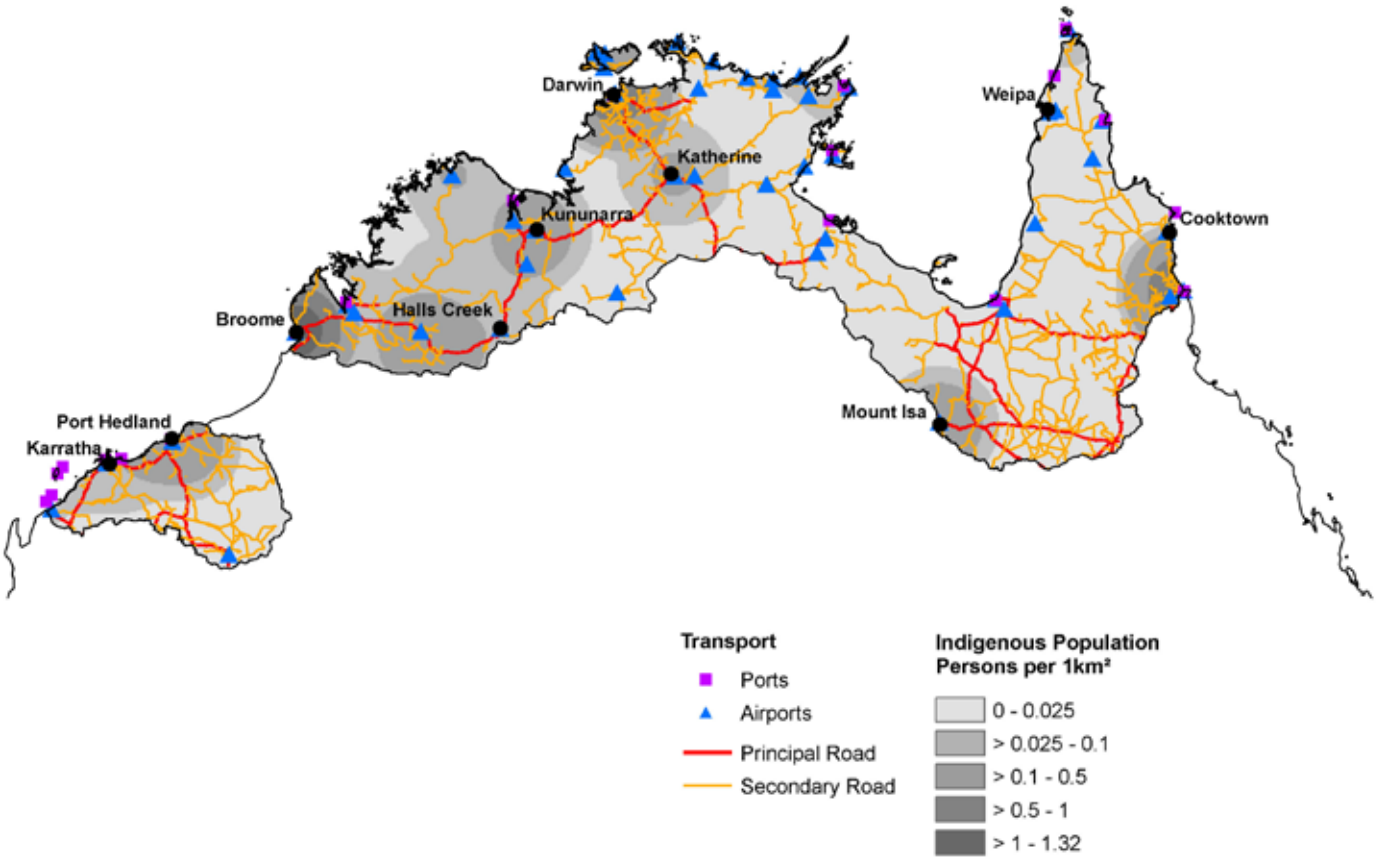


Figure 17: Location of transport facilities and Indigenous population density

Seven of the north's thirteen ports are in the Pilbara region serving the mining industry. The Pilbara region is subject to intense cyclonic activity. Stronger and more frequent storm conditions including cyclones could result in increased infrastructure and transport related damage at these ports, including to wharfs and boats. This could affect Indigenous enterprises or livelihoods where communities are involved in coastal and offshore aquaculture industries, or export industries relying on transport infrastructure.

There are no principal roads in Arnhem Land according to ABS classification. If the transport network was to be compromised due to climate change impacts such as flooding, increased transportation costs could further inflate the currently high prices of food and other goods and services.

People living in remote Indigenous communities frequently experience difficulty in accessing basic housing, infrastructure and community services due to their isolation from large population centres. Transport infrastructure in isolated regions is often vulnerable to more frequent wash-out and closure, thereby reducing the accessibility of townships. This will increase the costs of transport, but also the cost in repair and maintenance of existing roads. Significantly, access to emergency services could be compromised. Further qualitative information is required to assess the adequacy of this network and implications for responding to climate change.

Communities along major rivers such as the Fitzroy and Roper Rivers as well as wetland, coastal and inland floodplains suffer road cut-offs due to flooding ranging from a minimum of seven to a maximum of 90 days. Approximately ten communities in the tropical north were cut off for more than three months during 2006 (CHINS 2006). Further analysis should consider combined air and road access to identify those most at risk of future flood events. The relationship between population centres and critical infrastructure and flood vulnerability should be given further attention.

The current trends towards more self-sufficient and robust power systems are likely to increase settlement resilience and should be encouraged. The same trend is needed in other services such as water and sewerage – although there is little documented evidence of this kind of activity in the study region. Grey-Gardner (2008) documents similar work in arid regions that could be broadly applicable to other regions.

Endnotes:

[1] Community size as defined in the CHINS data dictionary.

Summary

It is not known how climate change may impact on transport infrastructure in Indigenous communities in the study area. However, transport networks to and between larger regional centres and isolated communities are likely to be affected by extreme weather, which will indirectly affect the provision of goods and services, and increase their costs.

There has been no risk assessment of road and airstrip closures or blocked access to coastal areas in the study area.

People living in remote Indigenous communities frequently experience difficulty in obtaining basic housing, sufficient basic service infrastructure and other community services due to their isolation from large population centres. Climate change is likely to exacerbate these problems.

The communication networks in remote communities located on or near the coast are likely to be impacted by more extreme weather events. Repair or replacement costs of hardware are likely to be high due to the difficulty and expense of getting goods and labour to remote areas.

The expected increase in the number of hot days and heat waves will reduce the ability of buildings to maintain acceptable indoor temperatures. Specific details of the significance of this problem are unknown. More information is also needed on the ability of Indigenous housing and shelters to withstand cyclones and other extreme weather.

The potential impact of climate change on water infrastructure in Indigenous communities is unknown. More extreme rainfall increases flooding risk, and potentially threatens water quality and the maintenance of sewerage systems.

Most islands in the tropical north have a limited water supply that is particularly vulnerable to sea level rise and change in rainfall patterns. It is probable that water resources in small islands are likely to be seriously compromised.

A greater reliance on energy supplies is likely to become increasingly problematic for areas that are projected to have increasing hot spells. No studies have yet investigated the impacts of climate change on power generation in Indigenous communities.

The internet is becoming a vital tool for Indigenous communities in the delivery of services, particularly in education and health. However, many communities in the study region do not have reliable access to the internet and are not serviced by mobile phone coverage. It remains to be seen whether the roll out of additional communications services to begin in 2010 will be sufficient to improve necessary communications and emergency warning systems across the north.

Chapter 6

Climate Change Impacts on Education

> "I was not surprised, but thought it of note that the Indigenous folk of today at Maningrida could confidently speak of the effects of sea level rise from 12,000 years ago. Seems like such a valuable learning is there to be had if we just engage Indigenous people properly."
>
> – Regional stakeholder.

For the purposes of this scoping study, the climate impacts on education are taken to include: (1) delivery of state/territory education services providing information on climate impacts; (2) impacts on education facilities and access to them; and (3) the role of Indigenous knowledge in climate adaptation. This literature review has found very little documented material in the first two categories specifically relating to Indigenous school communities. The literature on Indigenous knowledge points to an important role for Indigenous communities in developing locally relevant responses to climate adaptation. This suggests that there is a valuable role for traditional knowledge to be included in the formal education system.

Education services around Australia are currently engaging students in issues relating to climate change through informal channels as well as through some specific curriculum developments. The informal channels include several web sites that provide links to resources compiled by academics, NGOs and government departments that teachers can use for background materials and activity planning.[1] Other more 'hands on' educational activities include the work of organisations such as the Australian Climate Change Education Network,[2] which provides online material and sends out volunteers to work directly with schools, however, this service currently operates only in Melbourne.

The Western Australian government has developed education materials about climate change for use in primary and secondary education (GWA 2007), but this has not been specifically tailored for delivery to Indigenous children. The Curriculum Council for Western Australia includes a non-Indigenous focused climate change module in its Earth and Environment Science curriculum for year 12. Similarly, the NT government Department of Education has secondary school material in their curriculum on energy management although nothing tailored for remote communities. This includes the 'Energy Smart Schools Program' which is an energy efficiency program targeting 60 schools throughout the territory.

Queensland has also developed a number of climate change components in its secondary school curriculum. In addition, some pilot projects exploring multimedia educational activities have been set up in concert with the Queensland Climate Change Centre of Excellence,[3] however to date, none of these are culturally relevant to Indigenous Australians. Curricula that are of particular interest and relevance to regional Indigenous families, including the impacts of climate change, would be particularly important for attracting and securing Indigenous people's ongoing engagement in developing culturally appropriate adaptation strategies.

Other uncoordinated efforts by individual schools with a focus on climate impacts on Indigenous people have taken place: for example two classes of secondary school children participated in National Science Week in the Kimberley that focused on this issue in 2008.

The 2001 census indicated that almost half of the population in the Kimberley region is Indigenous, with a median age of 21 years. This region has a high number of Indigenous language speakers – a fact very significant to developing communication and education policy. The young age demographic in combination with the prevalence of Indigenous language speakers highlights the importance of proper consultation and interaction with Indigenous community groups in the development of culturally

relevant curricula with a climate change component.

Many more informal efforts no doubt exist, however there does not appear to be any formal effort to pool experience or standardise teaching content or methods. The Questacon program has developed an online tool, Burarra Gathering - Sharing IK – which has additional teachers' notes available online. Although this site does not contain climate change information, it does include information about Indigenous knowledge of seasonal weather patterns and is therefore highly relevant for establishing the legitimacy of different paradigms of knowledge about environmental change.

At a higher education level, there is some literature relevant to Indigenous Australia within the field of health education, for example relating to predicted increases in mosquito-borne diseases and improved Indigenous education about management and treatment in increasingly susceptible environments (Hays 2001). Two climate change posters have also been developed that are specifically relevant to Torres Strait communities as part of a climate resilience program.

There are some online tools, for example Coolmob,[4] which are focused on communities in northern Australia (largely Darwin), that provide general factsheets on climate change and energy saving practices, but these are not designed to be appropriate for school teachers specifically.

Clearly, none of these resources are specifically designed for the needs of remote Indigenous schools. The only known program specifically targeted to Indigenous students in Australia is a series of workshops on climate change for Indigenous student teachers developed by the Batchelor Institute of Indigenous Tertiary Education (Newling pers. comm. 2008). This is a very significant gap in education given the likely impacts of climate change on these communities in coming years.

Education infrastructure

There has yet to be a review that examines the effects of climate change on education provision in north Australia, particularly remote areas that already face significant difficulties in delivering education services. Consequently, this oversight presents a number of concerns. These concerns relate to the impacts from extreme weather on access, turnover of teachers unaccustomed to hotter conditions, and the ability of students to concentrate on studies in hotter weather.

In Western Australia, Northern Territory and Queensland, the distance to education facilities for secondary school students is already a significant problem. For primary education, 42 per cent of Indigenous communities are located 25 kilometres or more from the nearest school, with 38 per cent located 100 kilometres or more away, two thirds of which were located in the Northern Territory (CHINS 2006). For secondary education up to year ten, 62 per cent of Indigenous communities were located more than 25 kilometres away from the nearest school.

In the study area, the proportion of students living further away from secondary school increases substantially. Figure 18 shows that many communities have limited access to secondary schools with the closest one being over 100km away for over 55 per cent of the communities. However, the accessibility by foot or car of primary schools for remote communities is very high.

Pre-existing access issues for secondary schooling suggests that climate impacts may exacerbate access, but are unlikely to become the major component of the problem. Direct impacts that are likely to be major problems for education infrastructure relate to: potential damage to property, such as Maningrida school roof being ripped off during cyclone Monica, 2008; retention of school teachers due to increasingly uncomfortably hot weather; and difficulty in providing a comfortable temperature for students in the hotter months (for example see the Yakanarra case study in Chapter 8).

A useful exercise would be to identify which schools are currently located in flood plain areas, or coastal areas susceptible to storm surges (for example see the Saibai case study in Chapter 8). Future planning of education infrastructure should take into account the location of buildings out of flood plain areas and away from coasts vulnerable to storm surges.

Indigenous learning

Retention of Aboriginal language is of great significance to the maintenance of Indigenous culture. Figure 19 shows that the greatest density of language speakers can be found in the Arnhem Land region and the tip of Cape York. Through analysis of National Aboriginal and Torres Strait Islander Social Survey data, Dockery (2009) shows the relationship between maintaining Indigenous culture (of which language is a cornerstone) and the enhancement of socio-economic indicators.

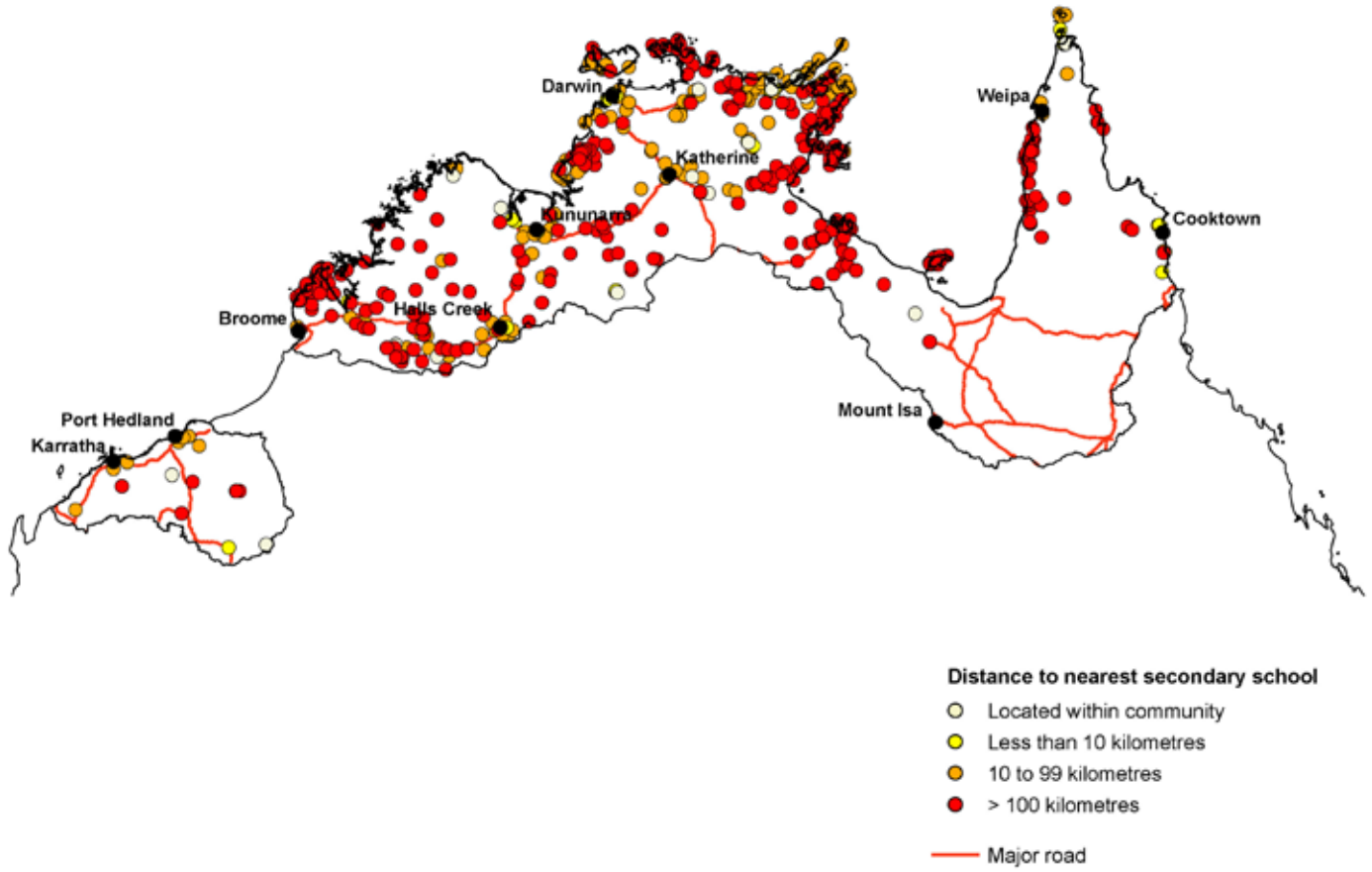


Figure 18: Distance to nearest secondary school

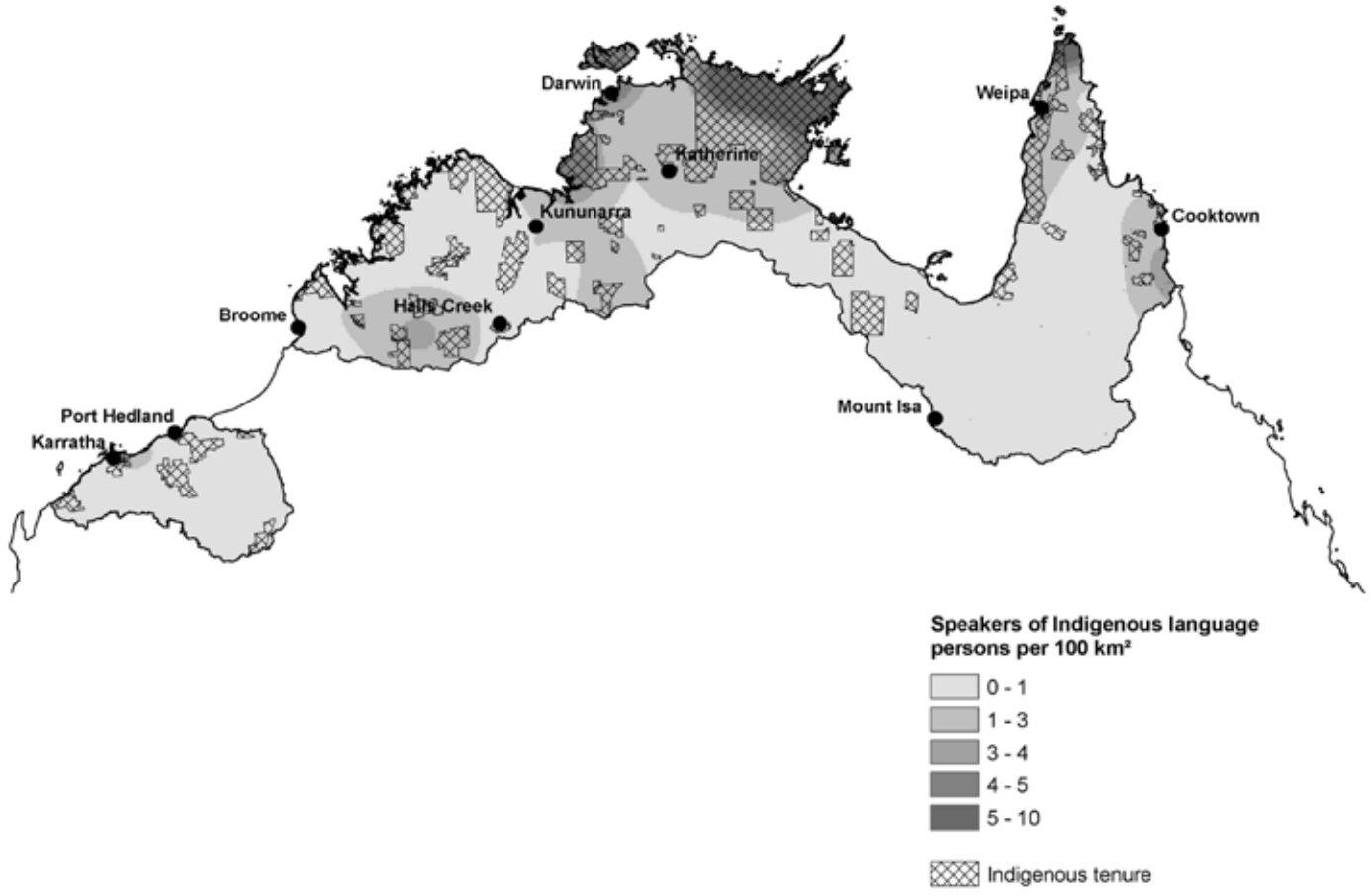


Figure 19: Density of Aboriginal language speakers

Indigenous knowledge and its role in natural resource management

> "Indigenous people have cultural memories (oral traditions) relating to climate change. They already know about cycles of climate change, but what many don't understand is that the impacts of climate change this time are likely to be significantly more severe than the climate change experiences in the past."
>
> - Regional stakeholder.

In the Tropical north, Indigenous people are actively managing vast tracts of both terrestrial and marine environments using age-old knowledge systems. Indigenous Knowledge (IK), also referred to as Traditional Ecological Knowledge or Traditional Knowledge, is a modern term associated with the body of knowledge or systems that encompass Indigenous beliefs, customs, rituals, and actions associated with natural resource use and management, which informs Indigenous societies. Indigenous people have a body of knowledge separate to western science, and one that could be used to respond to, or inform, issues that confront modern society including climate change.

It is clear that for many Indigenous people, particularly those that have remained on or near their ancestral country, knowledge is inextricably linked to land and sea and woven into the fabric of everyday social, environmental and economic life (Davis 1989). Where people live on their land, or enjoy regular access to it, they are able to fulfil their cultural obligations to care for country and kin. These obligations are discharged through ceremony, ritual, hunting, harvesting and a host of other associated activities. This well-being of country provides integrity to the social order. Conversely, where this connection with country is severed, cultural confidence is eroded and social capital is reduced (Rose 1996). In this context, cultural and natural concerns are inextricably linked.

The strength and resilience of IK is increasingly becoming recognised and acknowledged (NTG 2005) in the context of using and managing natural resources. Traditional owners, living on country, already provide IK for managing their lands. These services – ranging from fire management to biodiversity maintenance – are indispensable.

This innovative and evidence-based line of thinking has led to the concept of a culture-based economy (Altman 2003). In short, this concept rests on the well-supported premise that where Indigenous people remain on country, cultural and natural values are maintained, even enhanced, while the services traditional owners provide serve both local and national interests (Dhimurru 2006). Additionally, customary environmental services already make a significant contribution to both local and mainstream economies. As such, these contributions can demonstrate a clear market value (Barnsley and NAILSMA 2009).

Given the growing global emphasis on sustainable resource use, this contribution, provides a real possibility for future employment and economic development on the Indigenous estate. Appropriate recognition and remuneration for the essential services traditional owners already provide represent the logical first step toward this end. This approach could prove remarkably cost effective, reducing the need for expensive outside intervention for the provision of both environmental and social services.

Collaboration amongst Australian Indigenous communities

The inclusion of Indigenous observations into mainstream Australian climate science observation databases has been minimal. In April 2006, the first North Australian workshop on climate impacts on remote Indigenous communities was organised by CSIRO and the University of Melbourne in Darwin.[5] This was the first workshop that specifically brought together significant numbers of traditional owners and elders, scientists and policy makers to discuss and document Indigenous observations of climate change in collaboration with western scientists.

Other climate workshops have been organised by Indigenous participants who undertook the Al Gore training program in 2006-8. In Western Australia and the Torres Strait these workshops have been organised and run by Indigenous people.[6] A number of discrete discussions around climate change are being undertaken by individual traditional owner groups, with local projects relating to climate adaptation being developed as part of larger land management projects, but at this point there is little coordination among them.

Plans to organise a National Indigenous Climate Change working group are in their formative stages and are largely focused on adaptation strategies at this point (Ross and Morrison pers. comm. 2009).

In summary, work to document climate impacts on Australian Indigenous communities is far behind work in other countries and regions of the world. Collaborations between Indigenous Elders and western scientists in Australia are also not as well developed as in other regions such as the Arctic or New Zealand.

An Indigenous Australian experience connecting with international Indigenous communities. Report back from the Snowchange conference, New Zealand, 2008.

Around 40 Indigenous participants attended the Snowchange conference from Australia, Canada, Finland, India, New Zealand and Russia. The presentations were based on Indigenous experiences and concerns about climate change, along with western scientific perspectives that referred to Indigenous peoples and their knowledge systems.

All the participants in the conference strongly supported the belief that Indigenous Knowledge (IK) can provide a broader perspective to the changing climate in comparison to relying on western scientific observations alone. Furthermore, that use of IK could encourage practical adaptation strategies to reduce the negative impacts of climate change on people, their land and the natural resources found there.

Although the conference was largely focused on climate impacts in colder countries, the management issues concerning these locations were very similar to those experienced in warmer climates. All Indigenous groups demonstrated clear recognition of how climate change is affecting weather patterns and as a result, how animal and plant behaviours are responding. Other issues raised included how climate impacts exacerbated problems such as coastal erosion, access to traditional food sources and loss of cultural heritage.

There was a great deal of interest in the study, *Documenting Traditional Knowledge of Weather and Climate Change in the Torres Strait* that I presented.[7] This project shows that there are western scientists who are willing to engage in non-standard research methods to enable local observations of changing climates to be documented. In this project Elders' observations of weather and climate change, and past adaptation strategies are recorded on video. This knowledge is owned by and remains as a database in the community, with some of it able to be used as a source of data for local weather observations by western scientists.

Given the response of the other participants at the conference to this technique, it was clear that there is a great need to build the capacity of Indigenous-based research methods to enable Indigenous communities to effectively participate in environmental management and to work collaboratively with non-Indigenous science researchers.

All Indigenous groups acknowledged the important role of technology and western science during the meeting. A clear message from the participants with both Indigenous and scientific backgrounds was for the two knowledge systems to work together. This call was made to enable Indigenous research methods and recommendations resulting from them about natural resource management to be given equal respect and consideration as those of western science. The need to encourage ongoing networking between various Indigenous communities around the world was clearly demonstrated. It is hoped that with more capacity-building grassroots organisations, such as Snowchange, the capacity of community networks can expand to allow IK to be recorded and used in mainstream adaptation activities.

Report by Victor Steffensen, Traditional Knowledge Revival Pathways

Intergenerational transmission of traditional knowledge

The destruction of cultural sites inevitably impacts on traditional and ecological knowledge. This is recognised across a range of organisations, including NAILSMA, Aboriginal Areas Protection Authority (Northern Territory Government), Indigenous Land Councils, Native Title and other Indigenous representative bodies. However, there is a lack of research and analysis connecting traditional knowledge transmission, expected environmental degradation and other effects due to climatic changes. The impact of environmental change on traditional pedagogy is not properly understood, which exposes a key area of research required in light of predicted extreme events, including increased frequency of storms and fires.

Use of ecosystem resources for subsistence and ceremony is of great social and cultural importance to Indigenous people. Indigenous knowledge about the changing seasons, their capacity to predict species movements and breeding patterns, or their access to various bush foods and medicines, as well as various cultural practices are likely to be affected by climate impacts (Green 2006b; DEWHA 2007). The Bureau of Meteorology's Indigenous Weather Knowledge project provides information about weather and climate on its webpage from both Indigenous-based knowledge and western-based knowledge.[8]

According to Green (2009), Indigenous and local communities in northern Australia have begun noticing their seasons becoming more unpredictable, along with experiencing an increase in extreme weather. Henriksen (2006) writes that this phenomenon is being observed worldwide. In Sachs Harbour in Canada's western Arctic, the Inuit people are adjusting their seasonal calendar for hunting (Berkes and Jolly 2001). The need to adjust may relate to climatic drivers and the different responses between species, causing the loss of some of the present temporal links to climate change (IPCC 2007b).

Adult education in natural resources management programs

The synergy between ranger training programs in natural resource management, greenhouse gas mitigation and carbon sequestration strategies is recognised in Putnis et al (2007). Opportunities for Indigenous enterprises to become involved in greenhouse gas mitigation activities need to be provided and these activities need to be closely aligned with more customary interests of land management for healthy country, including fire management. Customary education can provide a locally meaningful framework for making sense of changing climatic conditions.

Some ranger programs are already engaging with climate change issues. Dhimurru Rangers in north-east Arnhem Land have engaged in climate change workshops and activities (Holmes pers. comm. 2008). The Kimberley Land Council has similarly developed locally appropriate material delivered through workshops on climate change to assist their constituents in understanding causes, impacts, mitigation and opportunity from a Western science perspective (Blackwood pers. comm. 2008).

Endnotes:

[1] www.climatechangematters.net.au

[2] www.ascent.org.au

[3] www.education.qld.gov.au/curriculum/area/science/enterprising.html

[4] www.coolmob.org

[5] Presentations from this workshop are available at sharingknowledge.net.au under the 'Australian resources' tab.

[6] In addition, as part of a federally funded project, through the Marine and Tropical Science Research Facility, six climate impact workshops have been held on several of the Torres Strait Islands in 2008.

[7] Supported by the Climate Change Research Centre, University of New South Wales and Traditional Knowledge Revival Pathways project. Funded by the Marine and Tropical Science Research Facility, an Initiative of the Australian Government.

[8] www.bom.gov.au/iwk

Summary

There is very little information about the impacts of climate change on the delivery of education services in the study region.

Many communities already face significant difficulties in delivering adequate education services. Compounding these existing problems, key concerns from climate impacts relate to reduced access to schools due to more extreme weather, turnover of teachers unaccustomed to hotter conditions, and the ability of students to concentrate on studies in during extreme weather.

The distance to education facilities for secondary school students is already a significant problem in many communities. Climate change is likely to reduce access to larger towns and, therefore, is likely to cause additional difficulties.

A useful exercise would be to identify which schools are currently located in flood plain areas or coastal areas susceptible to storm surges. Future planning for education infrastructure should take into account the location of buildings preferably outside flood plain areas and coasts vulnerable to storm surges.

Limited literature is available on the role of IK in climate adaptation in Australia. There is however, international literature that points to an important role for Indigenous communities in developing locally relevant adaptation responses in collaboration with researchers and policy-makers.

Curricula that are of particular interest and relevance to Indigenous communities, including the impacts of climate change, would be particularly important for attracting and securing Indigenous people's ongoing engagement in this area.


PILOT

Chapter 7

Climate Change Impacts on Livelihoods

> "Increases in temperatures (i.e. increased number of days over 35 degrees) may also affect the economic viability of cattle stations operated by remote communities which in turn may (i) affect the independent economic viability of those same communities and (ii) result in them seeking additional financial support from government."
>
> – Regional stakeholder.

The economies of many remote Indigenous communities have an unusual feature: rather than having the post-industrial binary structure of market and state sectors that is seen as the norm in contemporary Australia, they are reliant on a third, non-market or customary sector. This has important implications, as the workings and sustainability of remote Indigenous economies cannot be adequately understood using standard models. The customary sector interacts with both market engagement and the state so that where the customary sector is overlooked, as it usually is, policy prescriptions will be inappropriate at best. At worst, such oversight exacerbates existing problems of economic under-development and stifles community capacity for creative and adaptive approaches to the challenges posed in remote regions.

The hybrid economy and climate change

An alternative to the standard model has been devised and is termed 'the hybrid economy'. This section focuses on an explanation of this model and its sustainability with, and adaptability to, climate change. The hybrid economy is highly reliant on natural resources and so will be profoundly affected by climate change. For example, arts production for the market depends on the availability of plant species such as pandanus that are dependent on freshwater and are susceptible to saltwater intrusion (see photo of 'merrepen' palm used by women of the Daly River region to make string bags). People's livelihoods often rely on a combination of income from arts sales or employment under the CDEP scheme and the customary harvest of wildlife (see photo of magpie geese). This customary reliance on wildlife will be interrupted by changing seasonal patterns of availability and the decline, or disappearance of some species.

Magpie geese

Photo credit: Sue Jackson

'Merrepen' palm

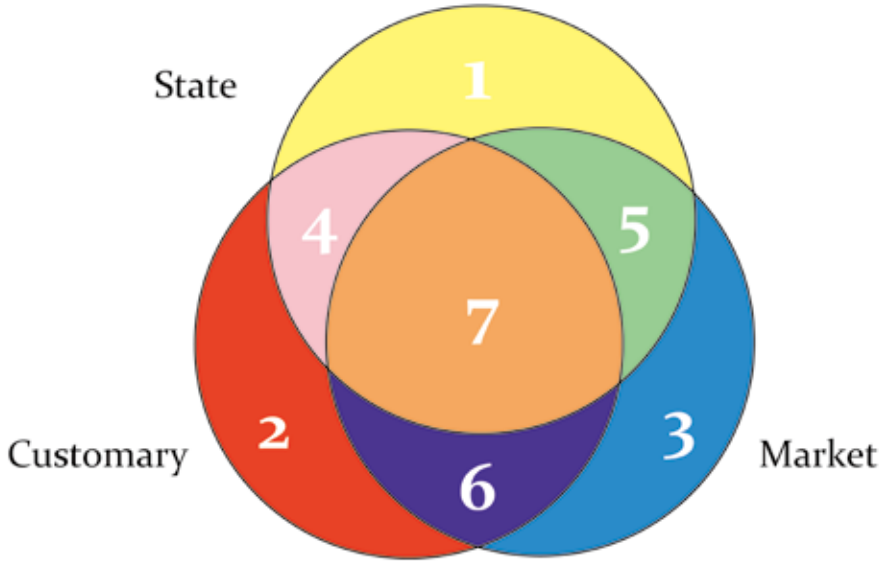


Figure 20: The hybrid economy (Altman 2008, p. 13)

While posing new challenges, climate change may also generate significant opportunities for hybrid economies. For example, Indigenous communities in Australia's tropical north will be well positioned to engage in projects that seek to minimise the adverse environmental consequences of climate change across much of the Indigenous-owned estate and beyond. The 'enabling' State's response to these opportunities will be crucial. While some Indigenous people in the tropical north may wish to relocate as they face the challenges of climate change, many others will seek to stay on their ancestral lands. The strengths of the hybrid economy are its diversity and adaptability, and therefore, there is a need to facilitate community-based creative responses to any emerging market and customary opportunities, while simultaneously underwriting communities with government support at all levels.

Nature of the hybrid economy

The hybrid economy describes the unusual economic structure of many remote Indigenous communities in the 21st century. It includes market, state and customary sectors that overlap and interlink significantly. The hybrid economy model is illustrated diagrammatically in Figure 20. Each sector and their interlinkages are discussed in turn.

State

The State is critical to the functioning of any economy in remote Australia. In Indigenous communities, as elsewhere, the State is the service provider, law enforcer, regulator and provider of a welfare safety net. The proportion of economic activity carried out or underwritten by the State in remote Indigenous communities may be relatively large since engagement with the market is often limited. While some have cautioned against what they see as an over-reliance on the State, particularly in the receipt of 'passive' welfare payments (see Pearson 2000), others have noted the funding shortfalls in many remote Indigenous communities (especially infrastructure backlogs), the problem of cost-shifting among levels of government or government departments and the divesting of responsibilities to non-State actors (see for example Dillon and Westbury 2007; Yu et al 2008).

While there is a tendency among some commentators to see the reliance of remote Indigenous communities on a relatively high degree of State support as indicative of their limited viability, the unusual historical, structural, cultural and locational characteristics of these communities mean that the State plays and will continue to play a crucially important role in their futures. It is unrealistic to expect these communities to become economically independent of the State even in the long term. However, the hybrid economy – based on an interdependence of the customary, market and State sectors – can be highly productive, adaptable and resilient.

Customary

The customary sector includes economic activity undertaken that does not lead to market exchange. This may include hunting, fishing and gathering, as well as unremunerated, natural resource management practices.[1] The nature of the customary economy and its significance to local communities varies considerably by location. In many Indigenous communities across Australia's tropical north,

particularly those in remote regions and where colonial and settler contact commenced recently, the reliance on the customary sector remains high (see for example Bomford and Caughley 1996; Kwan et al 2006). In research on the economy of Kuninjku speakers at Mumeka outstation near Maningrida in 2002-03, it was estimated that the customary sector constituted 32 per cent of the local economy, while market activity (in the form of arts and craft sales) accounted for 11 per cent and State support (in the form of social security payments) accounted for 57 per cent.

While the customary sector accounted for 64 per cent of the value of the local economy some twenty years earlier (based on estimates of market replacement value using social accounting and local prices), the change was indicative of the increasing proportional importance of the state sector rather than a decline in participation in the customary sector (Altman 2003). The level of reliance on the customary sector may also be significant in Indigenous townships in the tropical north. For example, recent research in Maningrida has shown the importance of the customary use of natural resources in sustaining livelihoods even in an 'urban' setting.[2] While customary production is generally regarded as self-provisioning (import substitution) it can also generate important positive externalities especially in environmental services provision.

Market

The market is generally understood as a system of commercial production, consumption and the exchange of goods and services. In many Indigenous communities across the tropical north, the main articulation with the market is consumptive rather than productive. However, commercial production of both goods and services (often highly dependent on natural resources) is an important feature of many hybrid economies. Indigenous engagement with the production of commodities for sale may include commercial harvesting of wildlife, arts production that involves the use of natural materials, and plant propagation that is climate dependent. Indigenous engagement with the commercial provision of services may include nature and cultural tourism, recreational (safari) hunting and fishing and natural resource management.

It is important to note that in many Indigenous communities' market activities are underwritten by the State and dependent on customary knowledge; blurring the boundaries between all three sectors of the hybrid economy.

Interlinkages

The three sectors of the hybrid economy are not discrete. Most of the livelihoods of Indigenous people in remote communities are generated in the intersecting spaces where sectoral overlaps occur. The linkages between the sectors are often complex but their interdependence can be highlighted by some examples. Figure 20 shows that there are four 'segments' of overlap between the customary, market and State sectors.

- Market, State and customary – for example, the marketing of arts through an art centre that relies on both State support and operating profits for its survival.
- Market and State – for example, commercial enterprises that are underwritten by the State, either through the CDEP scheme or direct enterprise support.
- Market and customary – for example, joint ventures that require customary involvement such as traditional natural resource management, but that do not receive State support.
- State and customary – for example, where customary use of wildlife is underwritten by income support from the State, either through the receipt of welfare or participation in a CDEP scheme.

Challenges and opportunities for the hybrid economy under climate change

As noted above, climate change poses challenges and presents opportunities for those participating in production systems termed here the hybrid economy'. Key challenges to the customary and market sectors will include direct impacts such as changes in biodiversity and the timing of seasonal events, increased frequency or intensity of extreme weather events, and the spread of disease vectors. Indirect impacts are harder to predict, but will likely include increasing costs of transport and greater difficulties in accessing markets in a timely manner. One result will be the need for creativity and adaptability for all actors in the tropical north if their responses to climate change are to be effective. Our knowledge of the challenges and opportunities that these communities might face will increase over time as more research is completed and the complex indirect impacts of climate change become clearer. However, some preliminary observations as they relate to the customary, market and state sectors, and the ways in which they interact, are outlined below.

The reliance of many remote Indigenous communities on natural resources both for customary use (subsistence) and commodity production means that they may be susceptible to changes in biodiversity and seasonality brought about by climate change. Customary production can be a crucial component of daily needs. For example, research among Kuninjku speakers in remote Arnhem Land in the mid-dry season of 2002 found that customary production included the harvesting of 1.6 kilograms of game per person per day. Harvesting for customary use at this time included 26 common species of animals and plants (Altman 2003). Game was shared across small communities: one 'exported' 50 per cent of its harvest while another 'imported' over six times its own production (Altman 2008). The reliance on the customary economy is not limited to Kuninjku-speaking people or to Arnhem Land. The National Aboriginal and Torres Strait Islander Social Survey 2002 asked people living in discrete Indigenous communities in remote Australia whether they had gone fishing or hunting in a group in the last three months. Over 82 per cent (of an estimated 47,800 people aged over 15 years) indicated that they had participated in one of these activities (Altman et al 2006). As well as providing for nutritional requirements, such customary use of wildlife substitutes for purchased bought foods and so inevitably frees up cash that can be saved or expended (Buchanan et al forthcoming).

Climate change will alter the customary use of natural resources as some species will decline or become extinct. This has already been observed with the harvesting of reptiles like goannas and monitors whose populations have declined by as much as 90 per cent owing to the impact of the 'invasion' of poisonous cane toads, invasions of which are likely to be impacted by climate change as discussed in Chapter 3 (Altman et al 2003). It is important to note though that remote Indigenous communities are adaptive and adaptable. Many communities currently harvest introduced species such as buffalo and there is evidence that the number and range of other species harvested has changed over time (Bowman and Robinson 2002; Altman 2003).

The customary use of natural resources may also have important cultural and symbolic meaning (Povinelli 1994). While a particular species currently used for nutritional purposes may be replaced, this is not the case for species with special cultural meaning. The loss or decline of symbolic or totemic species and ancestrally imbued landscapes may have significant impacts on Indigenous people's psycho-social health.

Challenges to commodity production include similar concerns about loss of biodiversity and changes in seasonality. These have the potential to severely disrupt the commercial harvesting of wildlife or native plants, possibly placing some existing enterprises at risk. While such industries will face challenges in maintaining supply, others such as tourism and recreational fishing and hunting will face demand pressures as they are highly dependent on the willingness and ability of visitors to travel to remote north Australia. Potential visitors may be deterred from travelling to these regions because of reduced access or the greater risk of personal injury (due to more frequent or intense weather events such as floods or cyclones) or because of more extreme temperatures and the spread of disease vectors and associated risks to personal health.

There will also be indirect impacts on many industries. For example, enterprises producing commodities for sale will face rising costs of fuel and transport in getting goods to market. While these challenges will also be faced by businesses in urban areas, they are likely to be exacerbated in remote regions. Enterprises in remote Indigenous communities may encounter more frequent or longer disruptions to accessibility as more intense cyclones or more frequent floods make access routes inoperable. Interdependencies between industries may also create indirect effects. For example, if tourist numbers decline or local consumers have to spend more of their limited income on fuel, retail stores in townships may experience reduced demand.

While climate change may make some existing industries less viable, it may also generate opportunities in new and emerging industries in reducing Australia's greenhouse emissions and managing the effects of climate change. For example, some Indigenous communities will be able to take advantage of opportunities in carbon trading as is already occurring in western Arnhem Land and biodiversity credits when and if trading schemes for such new forms of property emerge (ATSISJC 2007). In particular there may be opportunities in the tropical savannas along Australia's northern coast. There could be additional opportunities such as carbon sequestration in forests, feral animal management (to reduce methane emissions), and geo-sequestration that might arise on the 1.5 million sq km Indigenous estate. There will also be opportunities in biodiversity and/or conservation management as stresses on the natural environment inevitably become more acute (see Hill et al 2008; Steffen et al 2009).

The policy approach to these emerging

challenges will need to be carefully considered to take into account the complexities and interlinkages in the hybrid economy and the variability of the hybrid economy location by location. Well-meaning legislation may have unintended consequences. For example, where legislation seeks to protect species whose numbers decline as a result of climate change, this may have significant impacts on Indigenous communities by prohibiting customary use and placing increased economic strain on already stressed populations. Such attempts to protect species might also result in legal contestation given Indigenous people's prior legally-recognised customary rights. Environmental, cultural and economic considerations will need to be carefully balanced. While remote Indigenous communities across Australia's tropical north can be resilient and adaptable, government support is likely to be required for infrastructure and resources to maximise adaptive capacity.

The precise interlinkages that will unfold over time are difficult to predict, but two important observations need to be made.

(1) The current nature of interlinkages between customary, state and market sectors are generally either overlooked or not comprehended in policy. These interlinkages will be challenged by the negative impacts of climate change on species and environments, but it is likely that the hybrid economy will remain dominant in remote contexts.

(2) Because the environment and natural species loom large in Indigenous people's livelihoods, ontology and religious beliefs, it is likely that climate change impacts will result in enhanced Indigenous concern and engagement. There will be opportunity to mobilise Indigenous local knowledge as well as a need to use the latest climate science. Innovative work to incorporate both Indigenous and scientific knowledge systems in response to climate change is already underway in the Arctic region (Kruse et al 2004).

The existing interlinkages that are a fundamental feature of the hybrid economy framework might ensure that Indigenous people in the tropical north of Australia adapt better and make more significant contributions to national benefit when faced by the challenges posed by climate change.

Government reliance

Many Indigenous communities are heavily reliant on government services and welfare programs, particularly those in regions remote from markets. It is therefore important to consider the effects that government climate change policy may have on Indigenous livelihoods, as well as the direct climate change impacts on ecosystems. Altman and Jordan echo this concern, and agree with the House of Representatives Standing Committee on Aboriginal and Torres Strait Islander Affairs that whilst opportunities exist for greenhouse gas mitigation and impact management by Indigenous land managers, the opportunities to maintain and improve livelihoods associated with NRM could be diminished by adverse government policy developed in relation to climate change (Altman and Jordan 2008).

Climate change monitoring could be a means to extend Indigenous management responsibilities. A north Australian study that focussed on the vulnerability of wetlands and rivers to climate change recommends that monitoring for climate change by local communities be supported and encouraged (Eliot et al 2005). Eliot et al (2005) also recommend that a photographic inventory might be one way for communities to monitor change, or at least provide a baseline reference from which change might be documented.

Indigenous communities and settlements across the tropical north of Australia are potentially able to provide a range of environmental services to reduce the impacts of climate change. Already, an extensive network of land and sea management groups is operating across the North, managing fire, weeds and feral animals both within and external to IPAs (Baker et al 2001; Bauman and Smyth 2007; Hill et al 2007; Putnis et al 2007).

Opportunities to expand activities and take on contracts for the provision of environmental services including preventative burning regimes, weed infestation alert and control, introduction of foreign species alert, animal disease testing, illegal fishing, 'ghost net' searches etc are increasing (Davies 2006; Hill et al 2007; Putnis et al 2007). These activities are undertaken at the moment although not necessarily recompensed (NAILSMA 2007). This raises the opportunity for paid and recognised service in a sector of growing significance (Campbell et al 2007). The literature has not yet explored the potential role of biosecurity risks and border patrol, which may become issues with the migration of climate refugees from neighbouring countries.

Natural resource management sector

Agriculture and fisheries

Severe weather events, including bushfires, extreme heat, extended hot spells and flooding, are likely to

reduce agricultural production through effects on crop yields and stock losses (Garnaut 2008). The likely severity of impacts is noted by Campbell who writes that "climate change is not just another NRM [natural resources management] issue, but requires particular attention" (Campbell 2008, p.15). The agricultural sector accounts for about 18 per cent of Australia's total merchandise exports, and together with food manufacturing amounts to four per cent of GDP, employing around 500,000 people (Gunasekera et al 2008). It is uncertain how climate change will impact on agricultural employment in general, and on Indigenous employment in particular, although, as noted above, Indigenous employment within this sector is currently low.

Indigenous people comprised only 1.8 per cent of the total labour force across the agriculture, fisheries and forestry industries in Queensland, Northern Territory and Western Australia together, which comprises 2.7 per cent of the Indigenous labour force in those states (CHINS 2006). It is as yet unknown how climate change may impact on Indigenous employment in these sectors.

There is likely to be significant climate change impacts on the biological, economic and social aspects of fisheries over coming decades (Hobday et al 2008). Increased frequency and intensity of extreme events such as cyclones, storms and floods have potential consequences on coral reef, other marine ecosystems and related fisheries in the region through damage to infrastructure and stock losses (Voice et al 2006). The implications of climate change for Aboriginal and Torres Strait Islanders through potential reduction in available fish and other aquatic life for subsistence use, and through current and future potential commercial and other economic return, have not yet been explored.

Forestry

Thirteen per cent of Australia's forest resources are under Indigenous ownership, and there is good potential for economic involvement in the industry, despite low current employment (DAFF 2005). Department of Agriculture, Fisheries and Forestry (DAFF) took steps to encourage Indigenous participation in forestry through the National Indigenous Forestry Strategy (NIFS) recognising that Indigenous groups need to be involved in managing forest resources. According to DAFF (2005), cultural difference is one of the key hindrances for Indigenous involvement in forestry, and as such there is a need for some cultural change to allow full-time employment.

Significant involvement in forestry also may include alternate and 'non-wood' activities such as bark harvest, food and medicinal plant harvesting, collecting wood for didgeridoos, as well as eco-tourism, land management and cultural activities.

It is expected that climate change will have implications for forests through changed fire regimes and increased storm frequency and intensity (Garnaut 2008). These implications will likely have flow-on impacts on forestry, but have not been quantified.

Bush food industry

Indigenous people of Australia have a long and well-documented history of using native plants as an essential component of their customary economy (Gorman et al 2007). Bush products provide one of few prospects for new or expanded natural resource-based enterprise activities by Indigenous people across tropical northern Australia (Altman et al 2005; Cunningham et al 2008). Recently for instance, there has been an increasing interest in exploring options

Torres Strait Fisheries

In the Torres Strait, marine resources hold great cultural, environmental and economic value to the Islanders that live there, and climate change could have significant ramifications for the economy of Torres Strait communities. Fishing constitutes an important way of life, providing food, contributing to cultural occasions and providing Torres Strait Islanders with a significant source of income (Fairhead and Hohnen 2007).

According to data from the Australian Fisheries Management Authority (Fairhead and Hohnen 2007), almost 15 per cent of the working-age population of the Torres Strait engage in commercial fishing, with tropical rock lobster and fin-fish the key species targeted by the group.

The Australian and Queensland governments have taken steps to strengthen the position of Indigenous Australians in lobster fisheries. From 2007, the governments undertook a voluntary process to reduce the number of non-Islander licences in the Torres Strait Lobster Fishery. This resulted in the surrender of 30 per cent of the Australian allocation. Five per cent of the effort was reallocated to the traditional inhabitant boat sector (Torres Strait Islanders), and the remaining 25 per cent was secured for Papua New Guinea in line with catch-sharing obligations under the Torres Strait Treaty (Larcombe and McLoughlin 2007).

for the use of native plants for food, food additives, botanical medicines and related purposes (Gorman et al 2007). Trade in bush foods is currently limited, and opportunities for linking with markets to profit from the sale of bush foods have not yet been fully realised. Increased variability in climate as a result of climate change would impact on the ability to predict when food sources would become available for sale. This is particularly so given the abundance of fast-growing species after high rainfall, followed by the tendency for there to be very limited supplies in dry years (Cunningham et al 2008).

Indigenous participation in delivery of environmental services

The success of many economic activities in northern Australia – in tourism, fisheries, and agriculture - depends directly on the health of the environment. The manner in which catchments are managed influences estuarine and other near-coastal marine environments and their fisheries (Loneragon and Bunn 1999). The sound management of fire, given its influence on vegetation structure and resultant impacts on hydrology, landform stability and soils, is particularly important. In addition to carbon sequestration, Indigenous people are increasingly recognised for their contributions to protection of water catchments, biosecurity, quarantine, coastal surveillance and biodiversity conservation (NLC 2003).

If Indigenous people are to adapt their practices to maintain or increase their contribution to protection of ecosystem services, it is essential that policy and law support these adjustments. Over-prescriptive approaches to bushfire prevention in response to concerns about increased fire risk could, for example, compromise land management adaptation measures.

Government and private investments that build Indigenous capacity to manage the Indigenous estate for conservation and cultural values of national and international significance deliver important benefits to Indigenous landholders. There are also potential benefits from increasing opportunities to manage off-estate, off-reserve conservation. This assists Indigenous people to improve their well-being and, arguably, adaptation to climate change (Barnett et al 2008). However, dependence on this pathway alone is insufficient. In addition to the design of the Carbon Pollution Reduction Scheme (CPRS) and favourable treatment of other issues in carbon trading, all complementary or connected measures should be especially sensitive to Indigenous circumstances and make provisions to ensure that efforts to address Indigenous disadvantage are enhanced.

The carbon economy

Indigenous participation in the carbon economy through land management

Indigenous people in northern Australia may be able to make a substantial contribution to meeting national mitigation targets through the management of fire. In addition to options in fire management and forestry, there may be potential to increase bio-sequestration through active land management. Although, at this point, Australian government policy is not definitive about recognising and/or rewarding existing carbon stores (DCCEE pers. comm. 2009).

Australia has strongly promoted protection of forests in developing countries as a key strategy for effective mitigation and set out a comprehensive array of policy, technical and methodological approaches (Commonwealth of Australia 2008). Among these specifications are requirements to: ensure that benefits are maximised (for example that local communities receive real benefits from their contribution to reducing greenhouse gas emissions); and consult and engage with forest-dependent communities.

Further, Garnaut argues that better management of rangelands could sequester much more carbon than presently, to "greatly reduce the costs of mitigation in Australia". Accessing this benefit "would favourably transform the economic prospects of large parts of remote rural Australia" (2008 , p. 531). He describes full utilisation of bio-sequestration as an area where Australia could contribute much to the international system. The manner in which the nationally important issues of land clearing and bio-sequestration are handled is critically important for northern Australia, because the largest areas of unmodified native vegetation remain in this region (Woinsarksi et al 2007).

Risks (and potentially opportunities from activities such as revegetation) arise from possible constraints on options for economic development that may require land use change. Indigenous people aim to make productive use of recently recovered lands to reduce welfare dependence but these constraints may also rule out some of the most obvious development options, if they involve significant land clearing. Some Indigenous people in remote Australia are seeking to take up such options through initiatives like Centrefarm (Centrefarm 2004).

Opportunities emerge from new forms of land use and land management. This includes drawing on

markets in carbon and improved recognition of the work already done by Indigenous people to deliver ecosystem services like maintenance of biological diversity, water availability and water quality (Luckert et al 2007) as they also meet cultural obligations to Indigenous society and country.

Elements of the carbon economy

The Australian Government will invest up to $10 million over five years to support the participation of Indigenous communities in carbon markets (Barnsley and NAILSMA 2009). A part of this commitment will involve exploring the potential of altered fire management regimes in the northern savannas to deliver carbon abatement. In addition, this commitment has the potential to further facilitate Indigenous carbon market participation through the development of emissions accounting capabilities, capacity building and legal and governance frameworks. The commitment also includes a communication component to assist Indigenous people to better understand the potential implications and opportunities of climate change for their communities and assist Indigenous land managers with other options for carbon abatement and sequestration (Barnsley and NAILSMA 2009).

In a major project funded by Darwin Liquefied Natural Gas, a subsidiary of Conoco-Phillips, Indigenous people in Western Arnhem Land in the Top End of the Northern Territory have implemented fire management regimes over a large area. This was done through a well-planned and carefully executed program to create barriers to subsequent unmanaged fire by burning strategically early in the dry season to reduce the risk of extensive late dry-season wildfires. This type of management regime may reduce greenhouse gas emissions and the Government is supporting research to help determine actual emissions outcomes from fire management. Commercial trade in well-validated offsets is proposed, preferably including trade with the proposed CPRS. Other analyses indicate that viable arrangements are plausible in other settings, and 'rudimentary' estimates of the value of credits from Indigenous lands across the north could be substantial (Heckbert et al 2008).

Lands recovered by Indigenous people have been subjected to uninterrupted Indigenous management for very long periods. Their condition and hence the carbon they sequester is a legacy of Indigenous management. At present, there are no incentives for owners of areas of native vegetation to continue to protect existing carbon stocks or enhance bio-sequestration. This can be problematic as some economic opportunities in northern regions are often dependent on first clearing native vegetation to establish crops of various types.

The savannas of northern Australia are structured in part by human use of fire (Whitehead et al 2003a) and by grazing (Sharp and Whittaker 2003). Changes in management will alter the stocks of carbon stored in vegetation and soils, and their dynamics. Work in progress in the Northern Territory indicates that savannas may presently be acting as sinks for carbon (taking up more than they release) under prevailing fire regimes (Beringer et al 2007). More benign fire regimes could increase sequestration. Rehabilitation of rangelands by improved management of grazing could increase carbon stocks in pasture and soils (Heckbert et al 2008).

At present there are no direct incentives for Indigenous people to take up land use opportunities through management of their lands towards increased carbon sequestration, through fire use, stock management or otherwise. There may, however, be disincentives, including interference associated with customary obligations, conflict with hunting and other food gathering, and constraints on access due to thickening of vegetation.

Other employment options

Employment in Indigenous communities is found mainly across government institutions such as schools, health clinics and age care facilities, council offices and workshops (CHINS 2006). A large proportion of these jobs are supported by the CDEP.

Indirect links between climate change and the mining sector exist where improved income from employment may provide funds towards adaptation costs, or where structural damage to mining sites arising from climatic impacts affects Indigenous communities. Mining companies traditionally see their roles as employers of Indigenous people in mine hinterlands through the lens of social responsibility and licence to operate as well as, to a greater or lesser extent, an issue of securing a stable local workforce (Howitt 2001). Given the relative failure of such an employment regime to make the desired difference, the debate continues as to whether Indigenous livelihood improvements are to be achieved through mainstream jobs or through other forms of enterprise more closely related to customary interests and aspirations (Scambary 2007; O'Faircheallaigh 2008).

Literature on the impacts of climate change on mine operations around the north of Australia is limited. There is yet to be an assessment on the implications for Indigenous employment in the mining industry

and the flow-on impact on local economies.

Australia's natural landscapes are important to the Australian tourism industry. The Great Barrier Reef and Wet Tropics rainforest of tropical north Queensland and the wetlands of Kakadu are poignant examples of leading tourist attractions in northern Australia. These are World Heritage areas that Australia has international legal obligations to manage and protect (DEWHA 2007).

It is very likely that climate change will significantly affect these protected parks and many other less well-known sites (Dunlop and Brown 2008). Climate change may lead for example to: loss of attractions; reduced quality of attractions; high costs of adaptation; increased cost for repair, maintenance and replacement of tourism infrastructure; and increased cost for developing alternative attractions (Garnaut 2008).

In summary, Figure 21 identifies the major locations of Indigenous employment across the north.

Endnotes:

[1] The well-developed literature on Arctic Indigenous communities tends to refer to subsistence economies, a narrower concept than the customary economy (see for example Poppel 2006; Usher et al 2003).

[2] See *Wurridjal and Ors v The Commonwealth* High Court challenge to the compulsory acquisition of the Maningrida township lands.

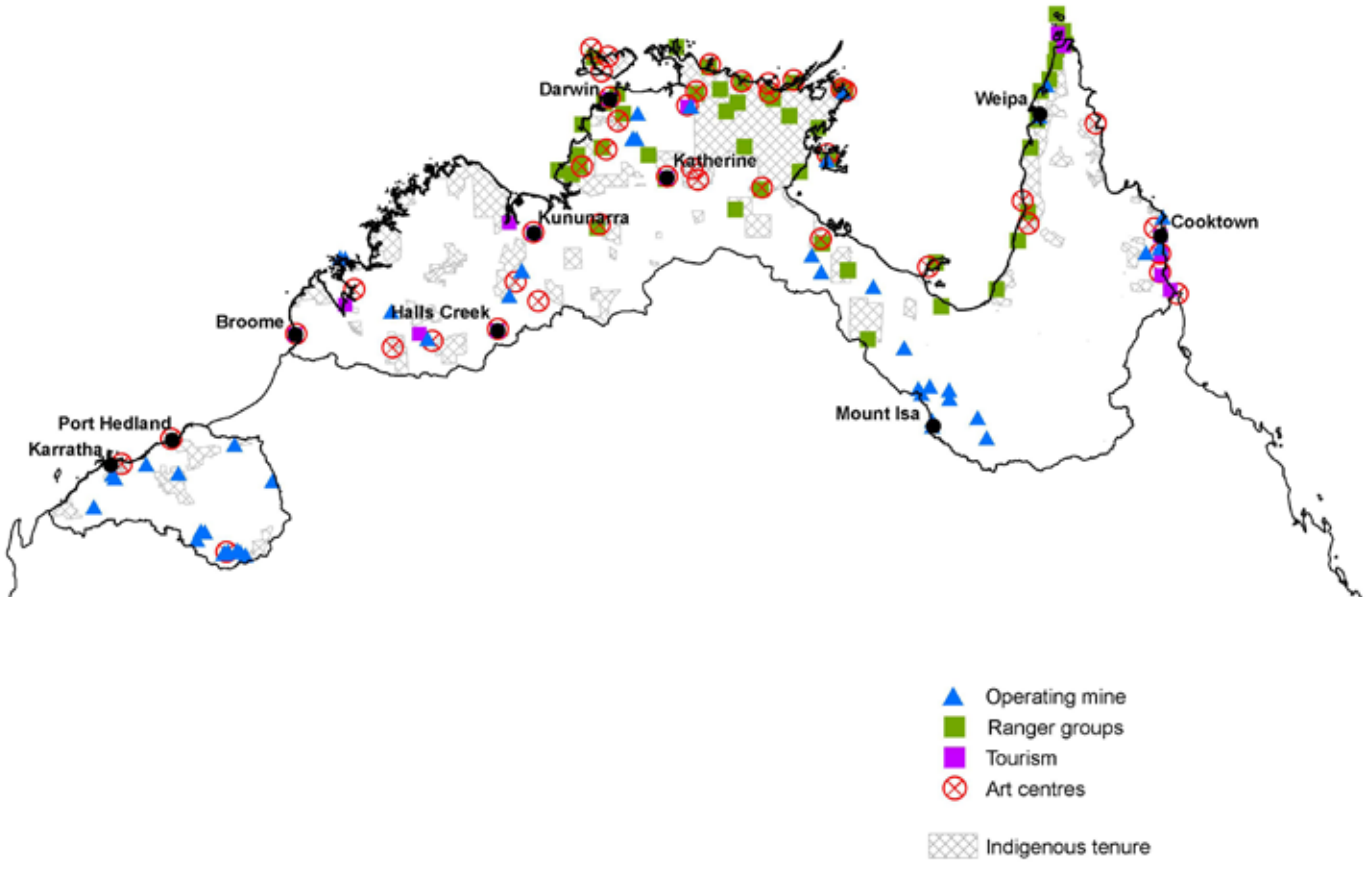


Figure 21: Locations of major employment opportunities for Indigenous people

Summary

Large areas of the north are managed by Indigenous Australians and they will have a disproportionately large role to play in reducing the vulnerability of biodiversity to climate change.

While climate change is expected to impact negatively on natural resources and related industries, there are some economic opportunities arising from the need to better manage, and in some cases restore, ecosystems for biodiversity conservation.

The economies of many remote Indigenous communities are reliant on a non-market or customary sector. This sector interacts with both market engagement and the State so that where the customary sector is overlooked, policy prescriptions will be inappropriate.

The hybrid economy is highly reliant on natural resources and so will be profoundly affected by climate change. It is likely that customary reliance of Indigenous communities on wildlife will be interrupted by changing seasonal patterns of availability, and the decline, or disappearance, of some species.

While posing new challenges, climate change may also generate significant opportunities for hybrid economies. Australian governments at all levels need to facilitate community-based responses to any emerging market and customary opportunities while simultaneously underwriting communities.

Indigenous enterprises and employment in tourism, recreational fishing and hunting will face demand pressures as they are highly dependent on the willingness and ability of visitors to travel to often remote regions of northern Australia.

Indirect impacts on enterprises producing commodities for sale have not been quantified. However it is likely that they will face rising costs of fuel and transport in getting goods to market. Enterprises in remote Indigenous communities may encounter more frequent or longer disruptions.

Climate change may generate opportunities in new and emerging industries in reducing Australia's greenhouse gas emissions. These have not been clearly quantified in the literature.

Some risks may arise for Indigenous people from possible constraints on options for economic development that may require land use change. Indigenous people aim to make productive use of recently recovered lands to reduce welfare dependence, but these constraints may also rule out some of the most obvious development options, particularly if they involve land clearing.

It is expected that climate change will have implications for large areas of land through changed fire regimes and increased storm frequency and intensity. Cultural difference is one of the key hindrances for Indigenous involvement in land management and highlights the need for some cultural change to allow full-time employment.

Trade in bush foods is currently limited, and opportunities for linking with markets to profit from the sale of bush foods have not yet been fully realised. Climate change would impact on the ability to predict when food sources from bush foods would become available for sale and likely affect the marketability of these products.

There is very little literature on the impacts of climate change on mine operations in the north of Australia and no research on the implications for Indigenous employment in the mining industry and the flow-on impact on local economies.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Chapter 8

Case Studies

Intoduction

The following eight case studies were selected to highlight the context specific nature of climate impacts in different communities. Due to resource and time constraints, authors with existing experience in the case study regions were asked to write the case study in collaboration with community members.

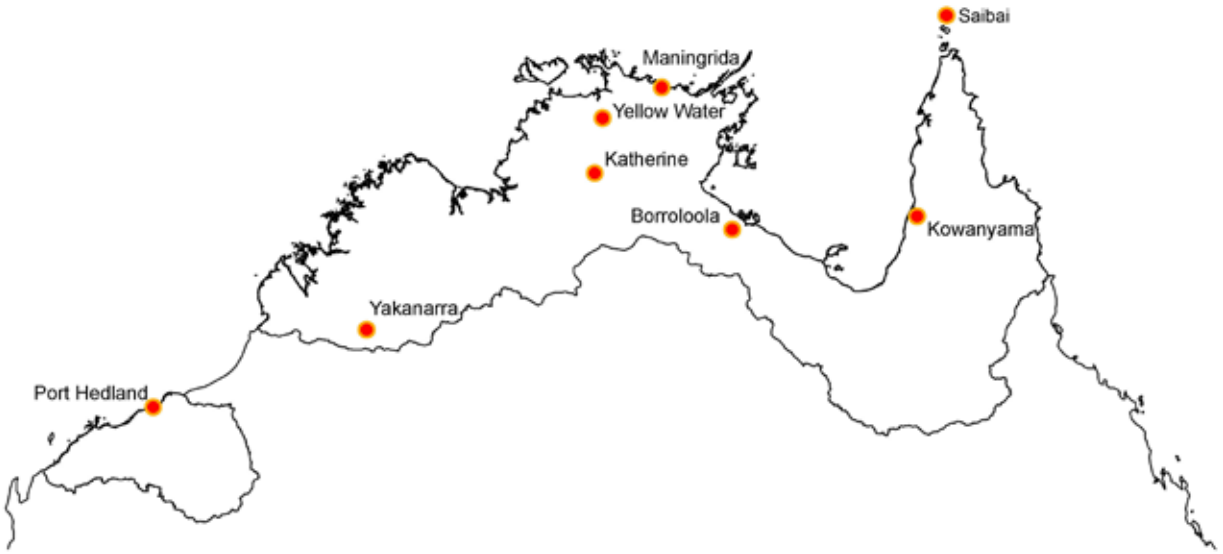
Methodology

With input from the expert group the study team developed an approach to the production of eight case studies. The aim was to design an approach that could address the diversity of Indigenous experiences across such a large area of Australia and to provide a level of detail to the context in which climate change issues should be considered. With the insights of researchers and community workers with strong relationships to the Indigenous groups concerned, the team would draw out specific vulnerabilities to natural hazards of similar character to anticipated climate impacts and elicit views on the ways in which past events had impacted the community, the level of resilience shown, and how similar future events were perceived. This approach would also allow for the consideration of indirect impacts and the interaction of non-climate stressors. A list of potential study sites was drawn up based on the intention to cover a range of locations (coastal, semi-desert), size (outstation dominated, major town with minority Indigenous population) and land uses/industry influences (mining, pastoral, coastal).

Potential authors were identified by the study team. Each case study author was presented with a set of topics to address, and information on the projected climate scenarios that would be most relevant to their particular case study site. The topics included:

- A brief snapshot of 'the place'
- Current constraints on community
- Response from the community to previous natural hazards that might be of a similar nature to future anticipated climate impacts
- Projected climate scenario
- Possible impact from scenario presented
- Level of knowledge about climate change in the community

The approach was discussed with the DCCEE in December 2008 and the case studies commenced soon after.



Case study locations

Port Hedland, Pilbara region, Western Australia

Port Hedland is the largest town in the Pilbara region and home to a major port which is used to export iron ore.

Between 2001 and 2006, Indigenous Australians in the Pilbara were found to have become worse off in terms of their socioeconomic outcomes relative to Australia as a whole, despite the resources boom in the Pilbara.

The Pilbara coast experiences more cyclones than any other part of Australia. Some of these cyclones are extremely intense, for example, Tropical Cyclone Joan in December 1975, 85 per cent of the houses in Port Hedland were damaged, the town's hospital was destroyed, and subsequent flooding damaged roads and sections of the iron ore railways.

The Pilbara region is well known for its very high temperatures in summer. The inland town of Marble Bar holds the world record for the most consecutive days with maximums above 100 degrees Fahrenheit (37.8 degrees Celsius).

Higher sea levels and flooding are a particular concern for Port Hedland and this problem is likely to become more pronounced in the future.

Residents of Port Hedland and the Pilbara region are typically better prepared for extreme events than in some other regions, due to relatively good warning systems and cyclone resistant infrastructure.

Past relocations due to extreme events highlight the difficulties involved. For example, when the Kiwirrkurra community in the East Pilbara was flooded and evacuated in 2001, it was 18 months before they could return. Kiwirrkurra is a 'dry community', so being evacuated to places without alcohol restrictions such as Alice Springs caused problems for some residents.

An increase in extreme events such as cyclonic activity will lead to increased flash flooding, strains on sewerage and drainage systems, greater insurance losses, possible blackouts, and challenges for emergency services.

Outside Port Hedland and other urban parts of the region, there is very little knowledge about the potential impact of climate change amongst Indigenous communities.

Snapshot of Port Hedland and the Pilbara region

The Pilbara region of Western Australia extends from the Indian Ocean in the west to the Northern Territory border in the east. Covering a total of 506,568 square kilometres, the Pilbara can be separated into three distinct regions: the coastal plain, inland ranges and an arid desert region extending into Australia's dry centre.

The town of Port Hedland is particularly susceptible to intense tropical cyclones. As the largest town in the region, it is the location for a number of services to surrounding outstations and plays a vital role in the Pilbara economy.

Acording to ABS figures in 2006, there were approximately 45,000 people living in the Pilbara region. Of this population, approximately 13,500 live in Port Hedland. At least since the beginning of large scale mining operations in the region (in the 1960s, before accurate census estimates were available), the Indigenous population has made up a minority of the region's population. This is substantially higher than the average for Australia as a whole and for Western Australia specifically. In Port Hedland, approximately 45 per cent of the Indigenous population is under the age of 20, while approximately 8 per cent of the population is above the age of 60. Both of these percentages are much higher than those for the non-Indigenous population.

As the original inhabitants and traditional owners of the area, Aboriginals make up an important part of this population. However, since first contact with the colonising population, the Indigenous population of Port Hedland and the Pilbara have been moved off their traditional lands and, especially in the first half of the 20th century, children were removed from families and placed in institutions or with non-Indigenous families.

There are around 31 Indigenous languages spoken in the Pilbara region, with many of these having between two and five distinct dialects. Although language use is not the only indication of attachment to Indigenous culture, it is an important indicator at a regional level.

Current constraints on community

Unlike other parts of remote and regional Australia, many of the economic constraints facing the Indigenous population in Port Hedland and the rest of the Pilbara region stem from issues to do with labour supply rather than labour demand. A discussion of the broader socioeconomic characteristics of the region is a useful way to understand this discrepancy.

Pilbara landscape
Photo credit: John Taylor

Indigenous employment in the Port Hedland and the Pilbara region

In 2006, only 44.3 per cent of the Indigenous population in the Pilbara who were aged 15 years and over were employed. This is only slightly lower than the proportion for Australia as a whole (46.1 per cent) but substantially lower than the proportion of the corresponding non-Indigenous population. Indeed, given the large difference between the non-Indigenous rate in the Pilbara and that for Australia as a whole in terms of both employment and unemployment, it is clear that Indigenous Australians were not benefiting from the highly favourable economic conditions that existed at the time of the 2006 Census.

A large part of the reason for the relatively poor employment outcomes experienced by Indigenous Australians in the Pilbara is likely to stem from their relatively low levels of human capital. This includes formal education and training qualifications but can also be taken more broadly to include labour market experience, health, the characteristics of one's networks (though this relates more to social capital) and exposure to the criminal justice system. What is important to note, however, is the slightly lower levels of Year 12 completion and degree qualifications for the non-Indigenous population in the Pilbara compared to Australia as a whole. This shows that there are a large number of jobs for which a high level of formal education is not required.

Looking at the level of income for the non-Indigenous population in the Pilbara, it is clear that relative to Australia as a whole, there were a large number of well paid jobs in the region. However, the relatively low median income for the Indigenous population shows that these jobs are not equitably distributed.

Major industries in Port Hedland and the Pilbara region

The main driver of economic activity in the Pilbara region is mining and related industries**.** This is clearly reflected by the non-Indigenous population in the region having relatively high rates of employment and high median income but moderate rates of formal education compared to Australia as a whole. This reliance on mining and, historically, on pastoral settlements, has had serious impacts on the ability of the Indigenous population in the region to maintain their culture.

According to the most recent census, the three industries that have a high concentration of Indigenous females in the Pilbara also have a relatively high concentration nationally. These are health care and social assistance, education and training as well as public administration and safety. For those Indigenous males who are employed in the Pilbara, 31.7 per cent are employed in mining. This is very high compared to the national Indigenous average and shows the importance of the sector to the Indigenous population of the region.

Potential future constraints on the Indigenous community

As major exporters, the mining industry is particularly influenced by international market conditions. Much of the recent economic growth in the Pilbara region has been driven by high world demand for commodities and the related highly favourable terms of trade. It is not surprising, therefore, that the region has been heavily exposed to the recent financial crisis and associated economic downturn. Already, a number of job losses have been reported in the region with a number of these likely to be Indigenous staff.

Community response to previous natural hazards

The Pilbara coast already experiences more cyclones than any other part of Australia. Between 1910 and 2007 there have been 49 cyclones that caused gale force winds at Port Hedland.

Tropical Cyclone Joan, which struck Port Hedland in December 1975, has been identified as one of the most significant cyclones in WA's history. About 85 per cent of Port Hedland's houses were damaged to some degree, especially along the ocean front, while the town's hospital was completely destroyed. Subsequent flooding damaged roads and sections of the iron ore railways, particularly that of Hamersley Iron. More recently, three people died near Port Hedland in 2007 as a result of Tropical Cyclone George. Schools in South Hedland remained closed for a number of days after the cyclone due to safety concerns.

On the one hand, a history of exposure to cyclones and other extreme weather events means that some adaptation has occurred with many of the warning systems and cyclone resistant infrastructure in place. However, for residents of Port Hedland and the Pilbara region a possible increase in cyclonic intensity will lead to more damage, increased flash flooding, strains on sewerage and drainage systems, and for more built up areas, greater insurance losses, possible blackouts, and challenges for emergency services.

An example of the impact of heavy rains on the Pilbara

Pilbara Mine
Photo credit: John Taylor

occurred in the Kiwirrkurra Aboriginal Community in the East Pilbara between 2000 and 2002. Three cyclones in 2000 caused the local water table to rise such that when heavy rains occurred in March 2001, the whole community had to be evacuated, returning only 18 months later. Because Kiwirrkurra is a 'dry community' in terms of alcohol restrictions, being evacuated to places like Alice Springs where there are no such restrictions, was particularly difficult for residents. While improvements to community infrastructure were made before the community returned, increased cyclonic intensity may make such events more common in this and other communities.

In addition to the potential loss of life and structural damage to towns, one of the major impacts of tropical cyclones is the impact on economic activity in the area.

Response to climate projections

The Pilbara region is already known for its very high temperatures for much of the summer. For example, the inland town of Marble Bar holds the world record for the most number of consecutive days with maximums above 37.8 degrees celcius (100 degrees farenheit). This temperature was reached or exceeded every day from the 31st of October 1923 to the 7th of April 1924, a total of 160 days. If temperatures increase into the future then this will obviously impact on the health and quality of life of the residents. Furthermore, it may make it much more difficult for companies and governments to provide services and infrastructure, directly impacting on the region's economy.

Increasing sea surface temperatures and sea level rise are major concerns for the region given the local topography where much of the economic activity occurs in Port Hedland, and where most people live in South Hedland which is only separated from the coast by approximately 20 kilometres of salt flats. These salt flats already flood regularly. Higher sea levels will increase the frequency with which this occurs, resulting in increased levels of saltwater intrusion and contamination of lower lying land surface areas and below ground aquifers.

An increase in the intensity of tropical cyclones will have large negative impacts on the local economy

given the importance of the mining industry to the Indigenous population in the region from the employment opportunities and royalties perspectives. This problem could potentially lead to disinvestment from the region in the longer term.

In addition to the direct impacts of climate change outlined above, the policy response both nationally and globally could have a potentially large effect on the Pilbara region broadly and the Indigenous population specifically. Policy responses to climate change are likely to involve a higher cost associated with carbon dioxide emitting activities, with mining likely to be an industry that is affected more than others in this regard.

Individuals and communities are also likely to be affected due to increasing petrol, diesel and electricity prices, especially given that they take up a relatively large proportion of the budget of many Indigenous Australians. Furthermore, the cost of fresh food is high because of transportation costs. Given the lack of potential additional sources of income generation, increases in the price of energy and food will disproportionately impact on Indigenous Australians.

Nationally, other green collar jobs or industries are likely to develop. However, these may not necessarily be located in the same regions or areas as those lost from the mining and associated industries. This may be less of an issue for the non-Indigenous population who live in the Pilbara, as they tend to be highly mobile and willing and able to move to other areas in search of economic opportunities. The Indigenous population, with its deeper ties to the area, may not be so readily mobile.

There are, of course, a number of opportunities that will also arise in the Pilbara that form part of the policy response to climate change. The potential role of the Indigenous estate in carbon abatement practices has been already noted in this report. However, the extent to which the Indigenous population in the Pilbara will be able to take advantage of these will be determined by the level of appropriate skills and business training as well as, potentially, the extent and efficacy of government assistance available.

There are also a number of potential impacts of climate change that are specific to the Indigenous population in this region. Climate change may have already caused alterations or destruction to geological formations or places and materials of ethnographic and archaeological significance. There may also be disruptions to seasonal or annual cultural programs and services, adding to the deterioration of the local Indigenous culture. There may also be a reduction of available native plant and animal species reducing access to traditional dietary, medicinal, ceremonial, arts and craft materials.

Level of knowledge about climate change in the community

Outside Port Hedland and other urban parts of the region, there is very little knowledge about the potential impact of climate change amongst Indigenous communities. Access to media in these areas is limited and, as noted above education levels are relatively low. For those who work in mining and related industries and for those in Port Hedland and other settled parts of the Pilbara, there is a greater level of awareness of the potential economic impacts of climate change. Furthermore, while they may or may not be directly related to climate change, heavy rains over the recent 2008/09 wet seasons have shown many residents of the region what the future may increasingly hold.

While there may be limited awareness of the potential impact of climate change amongst some Indigenous communities, the scale of mining in the region alongside the ubiquity of fly-in/fly-out workers creates a double-bind for the Indigenous population of the Pilbara. They have faced dislocation, competition for resources, and in many instances the destruction of their land without seeing the full benefits. However, it has not gone unnoticed that as the impacts of climate change become more real, many non-Indigenous Australians will simply leave the area for more favourable climates.

This case study was written by Nicholas Biddle, Research Fellow, CAEPR. (This paper benefited substantially from discussions from Dr John Taylor from CAEPR and Chris Coomer from the Department of Indigenous Affairs, WA, regarding Port Hedland and the Pilbara region in general.)

Yakanarra, Kimberley region, Western Australia

Yakanarra is a community of about 150 people situated roughly 100 kilometres south of Fitzroy Crossing in the Kimberley, close to the St George Range. The town of Yakanarra is in low-lying savanna close to two seasonal creeks that feed into the Fitzroy River.

The Indigenous people in this area have maintained strong knowledge of their local ecology and cultural sites.

Heat already has a significant impact on this community. In times of extreme heat, the community slows down. For example, productivity for professional staff and CDEP workers is reduced, while teaching staff often respond to very hot days by taking children to a billabong, which over time would affect the children's academic progress. There is also a tendency for increased disputes related to heat-stress, which may be violent.

Increased frequency and severity of heat waves due to climate change are a concern for the community. An increase in deaths of infants and old people can be expected. Air conditioning and refrigeration facilities are unlikely to cope well with higher temperatures, while productivity would be reduced.

The effect of high rainfall on the surrounding country can be severe. The community depends on the natural environment both for its cultural integrity and for supplementary food. High rainfall washes out degraded river banks, and undermines the root system of tall trees holding the banks together. The entire bank is gradually compromised, washing away with the river flood so that river systems become wider and shallower, retaining less water in billabongs during the dry season.

Unusual weather events and degradation of the landscape is usually interpreted by the elders of Yakanarra as a result of a lapse or wrongdoing in their relationship with the ancestral beings. In addition to physical stress and raised tensions between groups, a heightened level of anxiety, which can only be described as spiritual anxiety, can be expected.

Community members in Yakanarra are resilient and adaptive, but in emergency situations helicopter evacuations are essential. This typically falls initially on the town of Fitzroy Crossing, which may not be able to meet sudden widespread demands across its entire hinterland.

Snapshot of Yakanarra

Yakanarra is a community of about 150 people situated roughly 100 kilometres south of Fitzroy Crossing, close to the St George Range. It is in low lying savanna close to two seasonal creeks, Cherabun Creek and Christmas Creek, that feed the Fitzroy River. The Fitzroy only has seasonal flows. Community members participate in the widely shared cultural practices of desert fringe communities. They largely identify as Walmatjarri and many residents speak this as their first language.

The descendants of the Old Cherabun station community have grown up with intimate knowledge of the ecology and cultural sites of the regions. Apart from the many sites of localised mythological significance, and the tracks of mythic ancestors that traverse these desert areas, the people of Yakanarra have a particular affinity with the mythological beings associated with water sources, the Kalpurtu. Kalpurtu are snake-like beings considered to be the most ancient of all, which unite the land and sky through the medium of water. In the lead-up to the wet season Yakanarra elders dig out local spring or soak sites, gather 'rain stones' found in the vicinity, smear themselves with the mud of the soak, and sing particular songs belonging to the appropriate Kalpurtu. Women participate with song and dance to one side. The activity replenishes the soaks, brings rain, and fills the creeks, rockholes and claypans of the region. The Kalpurtu rain is said to 'seed' the renewed life of animal and plant species.

Apart from the local Kalpurtu site on the boundary of the present community, two other significant cultural sites are in the vicinity. One is a rock formation. The other is a ceremonial ground which often hosts culturally restricted rituals that draw Aboriginal people from a wide range of other communities.

The community has a strong sense of cohesion based in the knowledge they have established themselves from a camp of rough bough sheds to a fully developed township. Most adult community members receive income from some form of social security payment or from the Community Employment and Development Projects scheme. The present government has announced its intention to phase this scheme out and transition remote communities to mainstream employment. This would deprive the community of its principal workforce and meaningful occupation for many adults. Although the community workforce is within commuting distance of employment in the town of Fitzroy Crossing, employment opportunities there are few. Useful public employment in conservation and land management activities could be found since the area around Yakanarra is under environmental stress from cattle grazing. However, this would require a greater commitment from

Yakanarra Township
Photo credit: Western Australian Planning Commission, 2005

government agencies. Many community members participate in a hybrid economy in which bush foods supplement income and there is some involvement in commercial art and tourist markets.

Current constraints on community

This section looks at the vulnerability of the population and its physical infrastructure based on currently known hazards from climate events. These potential threats are identified from the author's knowledge of Yakanarra and hazards that have occurred from time to time in similar communities in the region over a period of many years. A draft of this case study was sent to Yakanarra and followed up with a visit in March 2009. This involved discussion with community members, and a tour of community infrastructure organised by members of the governing council. The draft has been updated as a result. In general, community members believe their infrastructure can withstand severe weather events. However, the March 2009 visit confirmed to the author that the community is vulnerable. The visit occurred in the last days of the wet season. Several problem areas, such as floods cutting off access to the airstrip and undermining housing and roads, were apparent. Several crucial facilities are only slightly raised from the level of the surrounding plain. More severe flooding in future years could well put this infrastructure at risk.

There are 30 houses in the community, of which seven are reserved for administrative and teaching staff. The internal roads of the community have recently been sealed, though many short-cut tracks remain. The road which enters the community and gives access to the airstrip is still unsealed. The houses accommodate an average of about seven individuals, but this is highly variable. Some houses have up to 17 residents. Population estimates are unreliable but indicate that some 65 per cent of the community is under the age of 24 with about half of these being under the age of 14. This is a typical remote-area demographic for Indigenous people which must be taken into account in planning for climate change. Raw population figures disguise the high proportion of people who are young or dependent.

The community draws its water from ground water sources with two electric powered bores. The water is stored in a tank of 190,000 litres capacity and pumped to a nine metre high header tank of 50,000 litres capacity for reticulation to the community. This facility is situated to the east of the community. The sewage evaporation pond, which feeds from septic tanks, is situated to the west of the community. The refuse tip is nearby. Public utility authorities

Typical Yakanarra Dwelling
Photo credit: Western Australian Planning Commission, 2005

estimate, but do not confirm, that the fresh water supply is situated upstream of the underground water flow in relation to the community.

Electricity is supplied by diesel powered generators. Diesel storage is close to the power station. However petrol for vehicles is situated close to the clinic and the shop and this is considered a hazard. A communications mast is in the central services area supplying the school, offices, staff housing, community houses and two public telephones by underground cable.

Yakanarra has an independent community school that educates to Year 10. It also has an adult education centre that concentrates on art skills. It has a shop, an office and a mechanical workshop. There is a basketball court and oval for recreation, as well as a play area in front of the shop.

In times of extreme heat everything in the community slows down. Productivity, both for professional staff and CDEP workers, is reduced. There are fewer visitors than in the cool dry season, including government officials with responsibility for development funding, and they stay for shorter periods. There is greater demand on the power supply for air conditioning and refrigeration of food. Proper recreation for the high proportion of youth in the community is difficult during the day. The basketball court is equipped with lights for this reason and increased demand for night activities is usual in the hot season. Increases in ambient temperature, increasing fuel prices, and consequent increased demand for electricity could be a drain on the community's finances as well as the physical capacity of its infrastructure.

Teaching staff often respond to very hot days by taking children to a billabong a short drive from the community in the ranges. This is an understandable response, but over time would affect the children's academic progress. There is also a tendency for increased disputes related to heat-stress, which may be violent. Heat stress increases work tensions among professional staff, increasing the pressure on staff to leave. Teacher training for members of the community could alleviate this, and a program is now under way in association with Nulungu College in Broome.

Hazards

Wind-borne dust in the hot season, which carries disease and exacerbates existing conditions of the eyes, ears and throat, is a hazard. This is reduced to some extent by internal sealed roads, but dust from open areas and the surrounding country is always a hazard. Extremely dry conditions and extreme weather, including wind storms, increases this hazard. At the end of the wet season the community is almost hidden in cane grass about 1 – 1.5 metres tall. As it dries, it presents a fire hazard.

The community suffers from the predations of feral animals when water in the surrounding country is scarce. Wild horses, donkeys and cattle can be a menace. In addition to looking for water, some feral animals enter houses to scavenge food and disrupt refuse containers outside the houses. Water buffalo sometimes follow the river systems from the Northern Territory in the wet season and become stranded in the dry. They could be a danger to vulnerable members of the community on fishing trips at creek waterholes. Animals with sharp hooves, such as donkeys, camels and pigs, can cause significant environmental damage during dry spells when digging for water and foraging for food, since this can be wide-ranging and disturbed dry ground is more readily blown away.

Erosion of the Fitzroy River banks
Photo credit: Patrick Sullivan

Another unknown factor is the point at which the sewage evaporation pond would flood into the community housing area. While the pond itself is an excavation, there is elevation of only a few metres between the land in which it lies and nearby housing. Community members believe that flooding back into the community is unlikely. Nevertheless, the pond does currently flood in the other direction, onto the road to Noonkanbah. It has also flooded into the adjacent rubbish tip, which community members have now closed. Flooding into the community housing area would mix sewage with water surrounding the houses and could contribute to bacterial and parasite infection borne by dogs, insects and bird faeces. There may also be potential for the contaminated water to seep into the ground water which the community depends on for its water supply.

The possibility of flood water compromising the electric bore pumps, which are near ground level, and the fuel tanks for the power station and for transport, must also be considered. These are situated on somewhat elevated ground and community members believe them to be safe. More precise projections of possible long periods of severe rain are needed before this confidence can be tested. If the ground is severely soaked, underground telecommunications cables could be affected, cutting the community off at a time of significant stress. During the wet season in early 2009 an optical fibre cable running along the side of the Great Northern Highway was severed by the collapse of a portion of the road, cutting telecommunication in the south-western Kimberley for many days. The bitumen roads at Yakanarra are already undercut by floodwater in places.

The effect of high rainfall on the surrounding country can be severe. The community depends on the natural environment both for its cultural integrity and for supplementary food. Natural food sources include bush turkey, kangaroo, emu and fish as well as yams, fruits and berries. Much of the area around Yakanarra has already been stressed by unfenced grazing of cattle. This has particularly severe consequences for the river banks, where cattle tracks begin the process of erosion. High rainfall washes out the banks where cattle have made tracks, and undermines the root system of the tall trees that hold the banks together. When these fall the entire bank is compromised, gradually washing away with the river flood so that river systems become wider and shallower and retain less water in billabongs during the dry season.

Yakanarra's Flooded Rubbish Tip
Photo credit: Patrick Sullivan

Low scrub and permanent swamp encourages feral pigs. There is a colony of pigs surrounding two uncapped running bores near Yakanarra. Their sharp hoofs and root-foraging practices further contribute to environmental damage.

Access to transport

During the wet season some community members relocate to Fitzroy Crossing, though most stay in place. Community members participating in discussion during the March 2009 visit indicated a strong desire to remain at Yakanarra. They experience the community as a socially healthy place to live.

Only a short section of the road between the Great Northern Highway and Yakanarra is bitumen. The rest of the road traverses creeks, such as Christmas Creek which has only a concrete crossing laid in the river bed. Rain followed by river flood periodically cuts the community off by road. The community normally receives its food supplies by air. The air strip has recently been upgraded by the army and is currently capable of landing a Hercules troop transport aircraft. Although it is currently in excellent condition, the capacity of the strip to sustain long periods of high rainfall depends on regular maintenance and is a potential hazard. The connecting road between the airstrip and the community frequently becomes impassable. It traverses a branch of Swordfish Creek, which often floods. This is also the main access road to the Great Northern Highway.

Roads connecting community housing and facilities are bituminised. However, the roads require maintenance and possibly better initial engineering. Already flood water along the sides of the roads has compromised the surface in some places. Run-off from the roads will also increase ponding of

Erosion of Yakanarra Main Road
Photo credit: Patrick Sullivan

rainwater in the open ground. When the rains cease this increases the risk of mosquito-borne diseases. There will also be an increased need to supervise young children because of the risk of drowning. Since Yakanarra is situated in quite level terrain the potential for water to back-flood into the houses is possible. If this occurred, the houses' septic tanks could flood, surrounding living areas with contaminated water. In one area a badly situated demountable house has been undercut by flood water, exposing an electrical conduit at ground level and rendering the house uninhabitable.

Spiritual dimensions

Unusual weather events and degradation of the landscape is usually interpreted by the elders of Yakanarra as a result of a lapse or wrongdoing in their relationship with the ancestral beings. There is a strong sense of unity between the ancestral beings celebrated in myth, the land which these beings continually recreate and in which they are embodied, and the people who inhabit the land. The people have responsibilities both to celebrate the ancestral beings in ritual and to respect them in their use of the land for sustenance. Extreme weather events and degradation of the land and waters

Clouds signal the coming of the Wet Season
Photo credit: Patrick Sullivan

signify a rupture in this relationship which is often attributed to the actions, or neglect, of a particular individual or group. In addition to physical stress and raised tensions between groups, a heightened level of anxiety, which can only be described as spiritual anxiety, can be expected. While possible physical detriment can be anticipated by plotting weather events against a known environment and infrastructure, cultural hazards can only be understood through extended communication with community members themselves.

Community response to previous natural hazards

Many of the events described above already occur in Yakanarra or in similar communities. The community members are resilient and adaptive, but control of unacceptable health consequences, particularly for vulnerable people, requires coordination of emergency services, often by helicopter. This usually falls initially on the town of Fitzroy Crossing, where the community-controlled service organisation looks after homeland communities. Fitzroy itself is well used to seasonal emergencies – parts of the town are frequently isolated from each other by flood water and from access in both directions to the Great Northern Highway. It is by any standard an impoverished town, with great human resources nurtured in a self-reliant culture, but few physical resources. It would not be able to meet sudden widespread demands across its entire hinterland.

Response to climate projections

Local responses to intensified weather events will vary. While 'a good Wet' is always welcomed, and most settlements and towns are used to being isolated for periods, intense flooding strains community resources and in some instances can be catastrophic. If the three per cent predicted increase in seasonal rainfall occurs over short periods the difficulties described above under 'current constraints on the community' will be intensified. It may be necessary to evacuate the population, which itself would be a protracted and hazardous exercise, and community infrastructure could be irreparably damaged.

In such a case, political, administrative and financial considerations could interfere to prevent the repopulation of the community, particularly if the same conditions affected the other hinterland communities of Fitzroy Crossing at the same time. The effects of a rapid rise in the population of Fitzroy Crossing, and to some extent the nearest towns of Derby and Halls Creek, at a time when they would also be coping with their response to the same weather events, could provoke a regional emergency.

Similar observations apply to projected higher temperatures in the dry season. If the projected average rise of two degrees, with longer periods over 35 degrees, is not evenly spread across the season, but occurs in peaks of several days of 40 – 45 degree heat, the effect on the community would be severe. An increase in deaths of infants and old people can be expected. An increase in grass fires would also limit the ability of community members to supplement their food sources from the surrounding countryside until the next wet season. Air conditioning and refrigeration facilities would not cope well with these temperatures, power consumption would be high, and productivity, including educational achievement is likely to be low.

The impact of more intense and/or more frequent tropical cyclones will vary depending on when they occur. Normally, cyclones are not a danger to people as far inland as Yakanarra, and can even be beneficial. If they occur in the hot 'build-up' months before the wet season (October to December), they can bring early rain and welcome cloud cover. The cloud cover extends to the horizon and can last for a week or two, producing marked cooling. Similarly, after the wet season, or if the season has been poor, cyclonic cloud cover and rain is beneficial. The period March/April/May can otherwise be very hot and dry. However, if tropical cyclones coincide with heavy monsoonal rains the risk of catastrophic flooding increases.

Pampila Hanson Boxer at Moankanambi Soak
Photo credit: Patrick Sullivan

This case study was written by Patrick Sullivan (Australian Institute of Aboriginal and Torres Strait Islander Studies) on the basis of a period of fieldwork around Yakanarra undertaken in 2000 with Hanson Boxer (Pampila), Warford Bujiman (Pajiman) and Doug Moor (Kordidi). The focus of that fieldwork was the community's cultural knowledge of water. The scenarios described here are an extrapolation from that experience, and experience with other similar communities visited over the last twenty-five years. The projections in the initial case study were followed up at Yakanarra in March 2009, again with Pampila and with community governance councillors. There was some understanding of current concern about climate change in the community, but no knowledge of how severe such changes might be in the future. It would be helpful to know whether older community members have experienced consistent changes in weather patterns during their lifetimes, but with the brevity of the visit to Yakanarra it was not possible to follow this up. Communication of climate change projections is important for communities like Yakanarra so that they can plan effectively and take necessary measures to protect their future.

Trip notes based on a visit to Yakanarra community in March 2009, grateful acknowledgement to Hanson Pampila Boxer, the community coordinators and councillors for their time during this and previous trips.

Yellow Water, Kakadu region, Northern Territory

The Yellow Water area within the Kakadu National Park is an iconic tourist destination. It is also home to Indigenous communities where cultural obligations are actively practised and Indigenous languages are widely spoken.

While Yellow Water has been at risk of saltwater intrusion for decades, additional sea level rise due to climate change is of great concern because even slight changes in sea level, river shape, tidal flow, vegetation cover or landform can result in the entry of saltwater into freshwater areas. This would change the wetlands and in doing so affect the availability of traditional food resources.

Communities in and around the Yellow Water area have been disrupted, damaged or cut off during a number of extreme weather events in recent years, including Cyclone Monica in 2006, which resulted in some nearby island communities being evacuated by air to Jabiru and then by bus to Pine Creek.

In 2007, Jabiru Airport was awash after nearly a metre of rain fell over a 72 hour period. Both highways into Kakadu were cut for more than a week as a result of the heavy rains, resulting in helicopter evacuations from the Cooinda guest lodge and Aboriginal outstations.

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Snapshot of Yellow Water (Ngurrungurrudjba)

The World Heritage-listed Kakadu National Park (KNP) covers an area of 19,804 square kilometres within the Alligator Rivers Region of the Northern Territory. It extends from the coast in the north to the southern hills and basins 150 square kilometres to the south, and 120 square kilometres from the Arnhem Land sandstone plateau in the east through wooded savannas to the western boundary.

Within KNP the main township is Jabiru, which was originally established as a mining town associated with the nearby Ranger Uranium mine. The town now serves as the administrative centre for the area and contains other services related to local government, tourism, education and health. Approximately 400 people live outside the township within the National Park either on Park Ranger Stations or Aboriginal outstations.

The Yellow Water area within Kakadu is one of the iconic tourist destinations in the Park due to its spectacular wetlands. The centre of the Yellow Water area is the Gagudju Lodge Cooinda and its associated tourism opportunities, in particular the Yellow Water Cruises. Other features of the area include the Warradjan Cultural Centre, the Jim Jim Ranger station, and several small Aboriginal outstations. It is estimated that approximately 60 people live in the Yellow Water area.

Unlike the adjacent Yellow Water Billabong, Gagudju Lodge Cooinda is a separate lease from the surrounding Kakadu National Park. Gagudju Lodge Cooinda is not part of the Park nor is it Aboriginal land as determined by the Aboriginal Land Rights Act 1976. The Traditional Owners of the area are of the Murumburr clan, many of whom live close by at Jim Jim Ranger Station or other outstations, of which there are 10 dotted throughout the park.

While some of the guests at the Gagudju Lodge Cooinda lodge may be Indigenous, they would be in the minority, so the percentage of Indigenous people in the area is typically quite low. However, the population of the outstations surrounding Yellow Water is predominantly Indigenous. This reflects the trend that the population of the broader Arnhem Land regions is predominantly Indigenous.

The Arnhem Land area including KNP has one of the strongest and most active areas of Indigenous culture in the country. Cultural obligations are actively practised and Indigenous languages are widely spoken. The most widely spoken languages in the Kakadu area are Kunwinjku, Gundjeihmi and Jawoyn.

Kakadu National Park is referred to in the Park's Management Plan as an Aboriginal living cultural landscape. A strong relationship exists between the traditional owners and their country, ongoing traditions, cultural practices, beliefs and knowledge.

Yellow Water

Aboriginal culture in Kakadu is diverse as there are many different clan groups with associations to country in the area. Each clan group is responsible for caring for their particular piece of country and this responsibility has been passed down from previous to present generations. KNP is managed jointly by the Federal Government and the traditional owners.

The cultural autonomy of the Yellow Water region is expressed through the Waradjan Cultural Centre. The majority of traditional owners and other Indigenous people residing in the area speak an Indigenous language and utilise the resources of the area in traditional ways.

In the Yellow Water area, the economic base is largely through employment in the tourism industry and the National Park. The Yellow Water Boat Cruise has been an icon in Kakadu tourism since the Park was proclaimed in 1979. The main accommodation at Yellow Waters is at Cooinda which remained a small enterprise until the Gagudju Association purchased the sublease in 1981, developing the lodge to the present day facility. In peak tourist season it is common to have more than 650 people staying at the lodge.

Matching Cooinda's expansion in recent years, the Yellow Water boat cruise has also seen major development of their tour vessels with several boats of 65 passenger capacity among the fleet. In peak tourist season, every available seat can be filled on a daily basis. It is estimated that annual turnover from Yellow Water boat cruise alone is in excess of $8 million, making it by far the most significant tourist enterprise in the region.

A major proportion of the residents in the area are dependent on welfare. Employment is problematic outside major population centres, not least because of distance and inaccessibility during the wet season. Some communities derive income from producing craft for sale in the major centres, and there has been a reliance on programs such as CDEP in the KNP region.

The Indigenous population of the Yellow Water area share the same social issues that exist throughout KNP. These include: health, housing, employment, maintenance of culture, and management of their country. These issues have been influenced greatly by recent significant events, including:

- the restructure of local government boundaries, reducing the number of smaller local shire councils to the larger West Arnhem Shire;
- new policies being formulated for the delivery of housing in Indigenous communities;
- a new direction in the delivery of services to homelands; and
- the Australian Government Intervention.

Deep cultural ties, both in the Yellow Water area and in the surrounding KNP, are a source of great strength for communities in dealing with the existing and emerging challenges that they face. The high priority given to caring for country, in combination with the naturally resilient landscape that continues to adapt to change, are also important strengths exhibited within the Yellow Water area.

Screw Pines in Kakadu National Park

Current constraints on community

Transport is a major constraint for the Yellow Water area, as the communities are largely accessed through unsealed roads that are severely affected each wet season, particularly in extreme weather events. All unsealed roads in the area are regularly cut off during the wet season, and the length of time that they are impassable will depend on the magnitude of the wet and associated stream flow. Residents of the area are also dependant on private access to transportation, as there is no public transport to the Yellow Water area.

Given the level of dependence of welfare in the Yellow Water area, residents have been concerned in recent times about proposed changes to CDEP funding and the potential impact on service delivery and maintenance of facilities.

During the dry season, phone and radio communications to the community are adequate, but during the wet season and in extreme climatic events phone and radio networks are frequently put out of commission.

Housing is a major issue in all residential areas in the KNP region. Lack of staff housing and other benefits make it difficult to attract applicants to fill positions, which has the potential to stifle employment opportunity and economic growth in the region. Further, all communities are under a critical shortage of housing. Emergency accommodation, such as safe houses for women and children; short term accommodation; and housing for groups with special needs are required throughout the area.

There have been some excellent initiatives within KNP to assist in the transfer of knowledge and school-based education opportunities. For example, at the Jabiru and Gunbalanya schools activities such as school cultural programs, school-based apprenticeships, and the Junior Ranger Program are integrated into the school curriculum.

Additionally, KNP has initiated several programs that involve young people and elders on country implementing various cultural programs including rock art maintenance and the recording of oral history. Despite these great initiatives, however, there remain significant issues in relation to education in the area that all parties are working towards improving.

However, there is concern that young people are not adequately prepared for life outside of remote communities, and improved education outcomes in the areas of writing, reading and arithmetic, and the re-introduction of manual arts and home economics into the school curriculum are desired.

Community response to previous natural hazards

During recent extreme events, communities in the Yellow Water area were cut off from surrounding communities. One outstation was particularly hard hit, with flooding affecting all houses, which meant that residents required assistance to evacuate to other areas. During this period residents had difficulty accessing food and other essential supplies for several days. The Gagudju Lodge Cooinda was also severely impacted and had to close for periods as rooms were flooded and essential services such as sewage were shut down.

Cyclone Monica became the first cyclone in living memory to cut a swathe through Kakadu as the system moved east toward Darwin. Forming several days earlier in the Arafura Sea, it crossed the coast west of Maningrida with winds gusting to 320 kilometres per hour, affecting central Kakadu in the early hours of 25th April 2006. Even though the category 5 cyclone lost energy once over land, wind speeds of 145 kilometres per hour were measured at Jabiru Airport. While rainfall was only in the vicinity of 100 millimetres, mainly due to the speed it crossed Kakadu, the system slowed substantially as it tracked west along the Arnhem Highway with over 300 millimetres in the rain gauge at the Bark Hut Inn.

Damage was confined to infrastructure on some outstations, minor local flooding, and large areas of uprooted trees. In the direct path of the cyclone, the centre of which tracked 14 kilometres north of Jabiru, most trees snapped in half and some were uprooted. The cyclone caused major social disruption in the region, with some adjacent island communities evacuated by air to Jabiru and then by bus to Pine Creek, outside the predicted affected area.

While Cyclone Monica didn't have the associated high rainfall one might expect from such an intense system, Kakadu did experience the highest rainfall event in living memory the following year. In March 2007, a tropical depression hovered over the Jabiru region for several days causing widespread flooding. Over 400 millimetres was recorded at Jabiru Airport on March 1st, with a total of 945 millimetres for the 72 hour period.

Houses that were built at Mudginberri (on the Magela Creek) in the early 1960s were flooded for the first time, with several other outstations having over two metres of water coursing through them, Patonga and Kurrajong communities among those most affected. Almost all Cooinda staff and guests were evacuated by helicopter, as were pregnant women on outstations, along with the frail and elderly.

Following both events, vehicular access to the Park was cut on both arterial roads, the Arnhem Highway east to Darwin, and Kakadu Highway south to Pine Creek. The 2007 event caused many logistical problems, with both highways inaccessible for over a week.

Response to climate projections

Increases in extreme weather events are likely to lead to more flooding, strains on sewerage and drainage systems, and for more built up areas, greater insurance losses, possible blackouts, impacts on the local tourist trade, and challenges for emergency services.

The concerns of the Indigenous residents of the Yellow Water area about potential climate impacts include potential impact of sea level rise on the wetlands and how it might affect cultural areas and food resources. If sea level rise impacts on the ecology of the area, it may also affect the local tourism industry, which would have a significant affect on the economic situation of these residents. Residents in the area are also concerned with the impacts of feral animals and weeds, which place additional pressure on native species.

However, the concerns of Indigenous people run deeper than short-term weather impacts, which is why this section raises concern about potential socio-ecological impacts of seal level rise and saltwater intrusion, which is a major issue for Yellow Water.

The South Alligator River system experiences a spring tidal range of up to 6m at its mouth and has a tidal influence extending 105 kilometres or more upstream, which includes the Ramsar-listed Yellow Water wetlands. Yellow Water has been at risk of saltwater intrusion for decades, possibly because of relic buffalo swim channels and/or increased boat activity associated with tourism.

The Indigenous community at Yellow Water are already seriously concerned about saltwater intrusion impacts, whether caused from an increase in intensity and frequency of storm surges on top of long-term average increases in sea level, or from boating activity. Additionally, Bininj are concerned about the cumulative impacts of all landscape-scale threats to their freshwater wetlands and not just climate change, for example, invasive species (e.g. pigs and weeds), human activity associated with tourism and mining, and the absence of traditional floodplain fire management practices.

A projected sea level rise of even 20 cm would be of great concern because while natural levees on the floodplain reduce the flow of saltwater into freshwater areas, even slight changes in sea level, river shape, tidal flow, vegetation cover or landform can result in the entry of saltwater into freshwater areas. This would irreversibly change the structure and composition of wetland vegetation and in doing so also affect the availability of important traditional food resources such as magpie geese, barramundi and freshwater turtles.

Darter bird in Yellow Water

Crucially, Indigenous custodians of Yellow Water recognise that the area cannot be assessed for climate change impact in isolation from other regions, because of complex cultural and ecological interactions running throughout the entire Kakadu region. For example, about 50 kilometres north of Yellow Water on the South Alligator River system is a wetland called Boggy Plain, which is actively managed by Bininj using traditional late dry season burning practices. Boggy Plain and the surrounding South Alligator River wetlands of the Noulangie Creek system support up to 80 per cent of the entire dry season magpie geese population in the territory, where they feed on the bulbs of extensive stands of Chinese water chestnut. Little is known about salinity tolerances of tropical freshwater plants in general, however the water chestnuts can apparently tolerate occasional saltwater flushes (say from spring high tides on the South Alligator River) and, in fact, may depend on them to maintain vigour. Nevertheless, there is concern that prolonged and more frequent saltwater flushes from sea level rise, in combination with more frequent and more intense storm surges,

may eventually kill these extensive stands of spike-rush on Boggy Plain causing a substantial decline in the abundance of magpie geese across the Territory, not just within KNP.

Magpie geese are a culturally significant food item and famous wildlife icon in the territory, home to most of the world's population. Hence, active management of saltwater intrusion at Yellow Water via barges/levees in isolation of other saltwater impact hot spots in the region will not protect regional waterbird populations and, by default, a sustainable waterbird tourism industry at Yellow Water. Kakadu Traditional Owners that help manage Boggy Plain also manage Yellow Water and so have a deep understanding of the connectivity between waterbirds and wetland health at regional landscape-scales.

In addition to saltwater intrusion impacts on floodplain vegetation and wildlife habitat, there is also concern about the extent and frequency of tree-fall damage in riparian, forest and savanna woodland habitats associated with strong cyclonic winds.

On the whole, KNP is better resourced in terms of communications infrastructure than more remote communities in Arnhem Land. The location and extent of potential sea level rises, channel changes and areas subject to undesirable saltwater intrusion within the Park, and the factors that cause or accelerate such changes, have been highlighted in the KNP Plan of Management (2007) as high priority. Hence, in the last two years there has been a plethora of workshops and symposia, and increased research interest, in climate change projections, impacts and adaptation.

Indigenous communities in the Kakadu region, particularly at Yellow Water, already have considerable experience in confronting the impacts of saltwater intrusion. For example, in some places artificial dams and levees were built to replace and stabilise damaged levees and, during the life of the 4th KNP Management Plan, boat access restrictions were put in place to decrease the potential for salt water intrusion into the Yellow Water area. There is also considerable experience to draw on in the territory coastal area generally, such as levee bank construction on the neighbouring Mary River to mitigate the impacts of saltwater intrusion.

Despite the high level of awareness, access to significant park resources and funds, and the existence of some practical experience in adaptation and mitigation of saltwater intrusion impacts on freshwater wetlands, it is unlikely that local Bininj would consider that they themselves or the park have good capacity to cope with average and extreme

events. This has been the contention even for contemporary non-climate landscape-scale threats to natural and cultural values such as invasive species and fire management, particularly at Yellow Water.

Focussed consultation at Yellow Water with the local Indigenous community with regards to this particular climate change scenario has not taken place and, hence, would be an essential next step. Additionally, there are major knowledge gaps on the ecological and socio-cultural impacts of increased salinity on tropical freshwater ecosystems and even estuarine ecosystems.

Combined landscape impacts, acting in combination with a range of socio-economic externalities such as fuel prices or the world economy in general, will substantially reduce much needed opportunities for developing future sustainable ecosystem-based livelihoods. Socio-ecological impacts of a range of climate change scenarios need to be examined in combination with other existing pressures and, concomitantly, adaptation options developed and implemented before local Indigenous communities are left with few or no options.

Level of knowledge about climate change in the community

The level of knowledge of climate impacts in the Kakadu community is considered to be high in general, relative to elsewhere in the Northern Territory. While some would feel that they are adequately informed about likely impacts, no doubt others would not, and this needs to be teased out by further consultation in a manner that does not overwhelm the community given the heightened level of activity in this area in the last two years.

Prior to the Climate Change Symposium in 2008, a survey was undertaken of key Traditional Owners and Indigenous residents in the Kakadu region to ensure that their views were adequately represented at the forum. The responses to this survey reflect a good level of understanding of potential climate change impacts at local scales.

The level of awareness about climate change impacts in the Kakadu region has increased substantially as a result of the Landscape Change symposia series. In contrast, however, there appears to be little understanding of uncertainties associated with climate change prediction, the problems of determining ecological effects across the landscape. Hence, there remains little understanding of the socio-ecological risks involved and, therefore, the true benefits and costs of adaptation, which is a challenge not only for this region, but for all sectors of the Australian community.

This case study was written by Peter Bayliss, CSIRO Marine & Atmospheric Research; with contributions from Andy Ralph, Kakadu Culture Camp; and Steve Winderlich Department of Environment, Water, Heritage & the Arts, Parks Australia, Kakadu National Park.

Note: In discussions with area experts over the Yellow Water case study, concerns were raised that the potential impact of climate change on mines in the region were not discussed. These concerns include the the impact of extreme events, such as tropical cyclones and heavier rainfall, on the tailings dams and other mine infrastructure and consequent effects on the integrity of surrounding land and creeks out of the mining area but in Kakadu National Park.

Maningrida region, Arnhem Land, Northern Territory

The township of Maningrida and more than 30 outstations are located in Arnhem Land. Maningrida is one of the largest Aboriginal communities in the Northern Territory.

Key climate impacts include saltwater intrusion, which has accelerated since the 1980s. Several plant and animal specise that are central to Maningrida's customary economy are fresh-water dependent. One examples is pandanus, which is a key input into much arts production. Indirect impacts such as increased costs of goods and transport are also a concern.

Maningrida sits within Australia's tropical cyclone zone, and was most recently affected by severe Tropical Cyclone Monica in 2006, when around 75 per cent of houses suffered some damage. In contrast, 20 specially designed cyclone shelters were virtually untouched. Any projected increases in frequency or intensity of cyclones will be extremely problematic for the community.

The already hot and humid conditions in this area may become intolerable with rises of even a few degrees. As well as direct impacts on humans, locals are anxious about the impacts of temperature rise on animal species and marine resources.

There are emerging commercial opportunities in this region in response to climate change, such as carbon abatement, although the extent of their benefit to the broader Indigenous population remains unclear.

Existing socio-economic disadvantage is a constraint on the adaptive capacity of local Indigenous people. Yet the Indigenous community's response to extreme events like Tropical Cyclone Monica augers well for longer-term adaptation to the impacts of climate change.

The different response of Aboriginal and non-Aboriginal people to Tropical Cyclone Monica highlights the need for extensive consultation in preparing a policy response to climate change.

There is also a need to appropriately communicate up-to-date scientific projections of climate change to community agencies and residents in Maningrida.

Local Indigenous people possess valuable traditional knowledge. Access to and use of this knowledge must be appropriate and considered. It is likely that future weather patterns associated with climate change will be historically unprecedented and constitute challenges both for Indigenous knowledge and Western science.

Snapshot of the Maningrida

Maningrida township is around 500 kilometres east of Darwin, on the Arnhem Land coast, plus over 30 outstations in the town's hinterland. The township is situated alongside the estuary of the Liverpool River and the outstations are predominantly located along the coast and river inlets and tributaries. At the 2006 Census there were 2,066 people living at the township and 369 people living at outstations. Along with Wadeye, Maningrida is regarded as the equal largest Aboriginal community in the Northern Territory. The Aboriginal population of Maningrida is highly mobile, with people regularly moving between the township and outstations.

Like much of the remote north of Australia, the region has a relatively short history of contact with the colonial and settler state. The township was established by state authorities in 1957 as a medical centre and trading post. It was subsequently settled by Aboriginal people from diverse language groups from the surrounding hinterland who sought access to goods, services and employment. The Aboriginal population grew rapidly, reaching 330 within a year, and quickly outnumbered the small number of European officials and service-providers in the settlement. This pattern, whereby a small number of European workers live in a largely Aboriginal settlement, has continued to this day: at the 2006 census the large majority (over 92 per cent) of people living in the township were Indigenous.

While most Aboriginal groups in the region moved to the township within its first six years, some groups never centralised. Of those who did, many maintained contact with their traditional lands through regular, seasonal shifts to their homelands to perform ceremonies or customary activities such as hunting and land management. After a decade or more of living in the township, many of these groups returned to settle permanently on their homelands. In 2006, almost 99 per cent of residents at these outstations were Indigenous.

Partly because of the short history of contact with the state and settler society, distinct Aboriginal customs, languages, beliefs and institutions remain strong in this region. The 2006 census indicates that over 94 per cent of Indigenous people in the Maningrida township speak an Aboriginal language at home, while the equivalent figure for outstations is almost 97 per cent. There is social and linguistic mixing between linguistic communities but extraordinary cultural and linguistic diversity remains. Across the township and outstations at least 13 major Indigenous languages are spoken and over 50 languages are spoken in the region. Aboriginal people in the region are 'intercultural' in that they participate in both customary and western institutions and practices, with these two ways of living increasingly interconnected.

The land in the township, outstations and surrounding areas is held by Aboriginal owners under inalienable freehold title under the *Aboriginal Land Rights Act 1976* (ALRA). The township is serviced by Maningrida Council (which was absorbed into the Jabiru-based West Arnhem Shire Council in July 2008) and the outstations are serviced by a successful and longstanding Outstation Resource Agency, Bawinanga Aboriginal Corporation (BAC). It should be noted that there are a range of views on the effect and impact of the *Northern Territory National Emergency Response Act 2007,* including that the NTER has undermined Aboriginal autonomy in this region.

Residents of both the township and outstations participate in a hybrid economy comprising state, market and customary sectors. The nature of the hybrid economy varies significantly across the different settlements, but there are a number of key features. Most importantly, the majority of Aboriginal residents in the region make their livelihoods through a mix of activities across two or more sectors. For example, one individual may participate in the customary harvesting of wildlife to meet their nutritional needs, part-time employment in a CDEP scheme and the production of art for sale through the township's Aboriginal-owned commercial arts centre. Many commercial enterprises in the region, including the arts centre, are underwritten by state support, especially through the CDEP program.

Both subsistence and commercial production in the township and outstations are heavily dependent on natural resources. For example, in the mid-dry season of 2002 Kuninjku speakers near Mumeka outstation harvested 1.6 kilograms of game per person per day. The game harvested was shared across small communities and constituted an important part of dietary requirements. Recent research suggests that the use of natural resources to meet dietary needs or other customary uses may also be important in the urban setting of Maningrida township. Many commercial ventures in the region also rely on natural resources. For example, BAC supports commercial enterprises in arts (which often rely on the availability of plant species such as pandanus), cultural and nature tourism, natural resource management and recreational hunting and fishing. There are also emerging commercial

opportunities in this region in response to climate change through carbon abatement activities.

Key concerns about climate change

From the current state of knowledge about climate impacts in northern Australia, there are a number of specific concerns that relate to the Maningrida region. These include a projected increase in the intensity and/or frequency of tropical cyclones as well as saltwater intrusion and potential species loss. Maningrida sits well within Australia's tropical cyclone zone. In 2006 it suffered the effects of Cyclone Monica which passed just to the north of the township and made landfall 35 kilometres west of Maningrida as a Category 5 cyclone. The impacts of tropical cyclones include destructive winds, storm surges and heavy rain and the resultant risk of flooding. The latter may be a particular concern for many Maningrida outstations that lie along the region's rivers. Effects may also include damage to regional communications, possibly greater pressures to centralise, disruptions to accessing services, and damage to the regional road network.

Saltwater intrusion may also be a particular problem in the Maningrida region as people's livelihoods are heavily dependent on fresh water, whether from rivers, springs, billabongs or river pools. Several plant and animal species that are central to Maningrida's customary economy are freshwater-dependent and susceptible to saltwater intrusion. For example, pandanus, which is a key input into much arts production, grows around fresh water swamps. Saltwater intrusion, as well as the accelerated invasion of pests, weeds and feral animals, may cause the loss or decline of some species. This may have a major impact on Indigenous people in the Maningrida region by both limiting the resources available to sustain livelihoods and, where species are culturally and spiritually significant, undermining psycho-social health.

Despite these potential challenges it should be noted that residents of Maningrida township and outstations have demonstrated significant strengths in terms of their extraordinary adaptability – as shown by resilience in the face of rapid transformative pressures and extreme events such as Cyclone Monica – and an ability to put up with extreme hardship.

Current constraints on community

Transport infrastructure in Maningrida is relatively well developed but is limited in the wet season and there are emerging problems with the region's road network. Access to the main township is by both road and air. Road access is restricted in the wet season but usually accessible from June to November, although even then river-crossing depths can vary and a four-wheel-drive vehicle with a snorkel may be necessary. The drive to Darwin is usually six to eight hours. The regional airport has daily flights to Darwin and has a sealed landing strip and night lights. A barge from Darwin runs twice a week.

The township is connected to many of the region's outstations by formed roads and to others by tracks. Most vehicles are privately owned although there is some public assistance for an aged care vehicle. Most foodstuffs and manufactured goods are imported from Darwin and sold at Maningrida's two supermarkets. BAC does a weekly 'tucker run' to outstations to distribute basic foods, clothing, household goods, pay and cheques and to collect artworks. Maningrida has two fuel outlets (selling Opal and diesel), three mechanical workshops, a bank agency, a traditional credit union and a large community health centre. The Council maintains water supply from groundwater reserves and power supply through a diesel-generation power station (with fuel transported by barge). Maningrida's heavy reliance on goods from Darwin highlights the region's interdependence: if Darwin is affected by an extreme event such as a tropical cyclone, Maningrida may also bear the cost.

Constraints on communities in the Maningrida region also include recent changes to federal government policy, particularly changes to CDEP and other aspects of the Northern Territory Emergency Response (NTER). As at December 2007, there were 291 Indigenous people employed in Maningrida, with 84 per cent of those employed in CDEP positions. There were a further 130 non-Indigenous people in the local workforce.

Existing socio-economic disadvantage is also a constraint on the adaptive capacity of Indigenous people in Maningrida. Standard measures of disadvantage such as housing, employment, income and education may not accurately reflect the well-being of Indigenous people, particularly those in remote and very remote regions who participate in the hybrid economy and continue to live interculturally and in kin-based networks. However, adequate housing may be a key factor in the ability of Indigenous people in remote areas to either withstand some of the impacts of climate change, such as extreme weather events.

According to ABS figures, in 2006, just over one-quarter of Indigenous households at outstations either owned or were purchasing their own home, with the remainder in rental accommodation. In

Maningrida township, only six per cent of Indigenous households owned or were purchasing their own home, with the remaining 94 per cent renting. In many cases houses were significantly overcrowded. For example, among Maningrida township's Indigenous households, almost two-thirds of three-bedroom houses and over half of two-bedroom houses were usually occupied by 10 or more people. Overcrowding was less extreme at outstations.

Income may also be important in adaptive capacity. The Northern Territory Government suggests that Maningrida residents have a "greater proportion of individual discretionary expenditure"[1] than other comparable communities in the Northern Territory due to the success of BAC and other Aboriginal agencies. However, incomes are well below the national and territory averages. In 2006, the median weekly income of Indigenous people in Maningrida was $209 while at outstations it was $109.

Education and access to communications technologies may also be important in understanding potential hazards and getting access to the latest information. There is one school in Maningrida township and a number of small schools at outstations. In 2006, around 30 per cent of Indigenous people aged over 15 years in both Maningrida township and outstations had completed schooling to at least Year 10.

Under the Broadbanding the Top End project – funded by Telstra, the Northern Territory Government and Rio Tinto Alcan – Maningrida township was connected to high-speed broadband for the first time in December 2008. Internet access in the outstations remains very limited. In 2006, only five per cent of Indigenous households at outstations had internet access and all access was via a dial-up connection. Four television stations and four radio channels (including commercial, public and Indigenous broadcasters) are available in Maningrida.

Community response to previous natural hazards

As mentioned above, Maningrida experienced the impacts of Cyclone Monica in April 2006. The cyclone was small but very intense and passed just to the north of Maningrida before making landfall

Defoliation - Junction Bay
Photo credit: Bill Milne, Bureau of Meteorology, 2008

around 35 kilometres to the west at Junction Bay. While the cyclone made landfall in an unpopulated area, high winds and heavy rainfall caused damage up to 100 kilometres from the cyclone's path. Effects included widespread damage to trees and moderate damage to infrastructure along the Arnhem Land coast. At Junction Bay, wind gusts reached an estimated maximum of 360 kilometres per hour. There was severe vegetation damage, with 50 to 70 per cent of trees felled and most totally defoliated.

There was also evidence of a five to six metre storm surge zone. Several river catchments experienced major or moderate flooding, including the Adelaide, Daly, Katherine and Victoria River catchments.

At Maningrida township, reported wind gusts reached 148 kilometres per hour. A number of houses were destroyed by fallen trees and around 75 per cent of houses experienced some form of damage such as losing their roofs or minor damage from falling branches. The roof of the school was torn off and electricity supplies to some parts of the township were cut as powerlines fell. At Oenpelli, the water supply was also cut for several days, with bottled water being flown in by chartered aeroplane. While most homes and buildings in Maningrida were salvageable, there was some concern about an asbestos risk from damaged buildings.

Despite limited communications technologies, particularly at outstations, communities were warned of the approaching danger and encouraged to prepare, such as by clearing away loose materials and storing fresh water. As a result of active preparation by individuals and several agencies in Maningrida over the four days prior to the cyclone's arrival, damage was minimal and there were no reports of serious injury. The 20 or so specially-designed core-filled concrete block houses that were designated cyclone shelters also proved their resilience to high winds.

Following the cyclone, the Territory government accelerated funding for housing in Maningrida. Local agencies and individuals participated in the clean-up and agencies provided additional services (such as counselling) to those most affected. It should be

Damage to a Maningrida home during Severe Tropical Cyclone Monica
Photo credit: Lori Chappel, Bureau of Meteorology, 2008

noted that the perception of some within Maningrida was that the government response was quite slow (see community concerns below). Of course, had the cyclone made landfall closer to Maningrida the outcome would have been very different. However, the active and timely community response in both preparation and clean-up demonstrates the resilience, capacity and adaptability of the community in dealing with natural hazards.

Response to climate projections

In response to the projections and existing knowledge about climate change, representatives from the local community have identified particular areas of concern. These include the direct impacts of sea level rise, saltwater intrusion, increased average temperatures, and tropical cyclones. Importantly, they also include indirect impacts (such as increased costs of goods and services) and the impacts of government policies. However, they also highlight local peoples' capacity to adapt to change.

Local representatives consulted for this section were Ian Munro (CEO Bawinanga Aboriginal Corporation), Matthew Ryan (Deputy General Manager Bawinanga Aboriginal Corporation), and senior Maningrida resident Mark Mirikul. They note the physical, economic and cultural risks associated with sea level rise:

> *The threat posed by sea level rise is an obvious impact. Maningrida is a coastal community and the Traditional Owners are "saltwater people" with an historical knowledge of and reliance upon marine resources. Any environmental modification that impacts on access to food is a serious matter for these people. Significant sea level rise will lead to dispossession and dislocation of coastal inhabitants.*

Munro, Ryan and Mirikul are also concerned that sea level rise will increase the damage from tropical cyclones, with evidence that a three metre tidal surge hit Maningrida during Cyclone Monica:

> *Even moderate sea level rise exposes inhabitants to greater risk of tidal surge, as the footprint of the accepted surge zone already covers part of the community. Maningrida experienced a tidal surge during Monica. This occurred at approximately 11.00pm, at low tide, and when the centre of the system was well to the west of Maningrida. The surge was estimated at some three metres, and had it occurred at high tide would have caused destructive inundation of the lower parts of the community.*

Along with sea level rise goes saltwater intrusion. Concerns among the local community include the loss of some native species, with changes also predicted for feral animal populations:

> *Floodplains will succumb to saltwater intrusion, with serious consequences for wildlife and human inhabitants alike. Species such as magpie geese are likely to go extinct as nesting habitat is lost... Feral animals such as pigs and buffalo will likely decrease in number as their preferred habitat is consumed by saltwater.*

Munro, Ryan and Mirikul also express concern at the predicted changes in temperature, with "comfort levels" at risk as "the hot and humid conditions currently taken for granted may become intolerable with rises of a few degrees." As well as direct impacts on humans, there is anxiety over the impacts of temperature rise on animal species and marine resources. For example, it is perceived that "elevated ocean temperature is certain to have an impact on marine resources. It is unlikely that these impacts will be favourable." In addition, there is a concern that "temperature determined sex species such as saltwater crocodiles" are likely to go extinct in the wild as a consequence of temperature rise, "and may survive only in commercial environments where incubation takes place artificially."

Not surprisingly, local concerns also encompass the predicted increase in intensity of tropical cyclones, with Munro and colleagues noting that increases in ocean temperature will create "more favourable conditions for the propagation of tropical cyclones." They note both the immediate and long term effects of cyclone damage:

> *As climate modellers are predicting tropical cyclones of increasing frequency and intensity, coastal communities will undoubtedly be more commonly affected. The environmental destruction caused by Monica is without precedent, some 7000 square kilometres of country being severely damaged by destructive wind. The successful regeneration of flora in this area is threatened by changed patterns of occupancy, land use and fire regime. It is possible that large areas will never return to their pre-cyclone condition, and there are clear resource consequences.*

As well as apprehension about these direct impacts of climate change, there is a local concern about the "more immediate impacts of climate change [that] will stem from government policy and economic reaction to threats." For example, Munro and

colleagues note that:

> *Goods and services will increase in cost as a consequence of purchases of offsets in emission trading schemes and in direct price increase of fuel...Climate inspired Government policy will also influence the lives of Aboriginal people. It may be that relocation of entire communities becomes necessary as sea levels rise. Buildings may need to be strengthened to withstand the effects of cyclones. Food security in post-cyclone scenarios will need to be improved. Cyclone preparedness generally will undoubtedly be the subject of increased Government attention.*

In addition, Munro and colleagues highlight the ability of local Aboriginal people to utilise traditional knowledge and practices in the response to extreme events:

> *In former times, coastal Aboriginal people had little substantial shelter from tropical cyclones, and there must have been fatalities as a consequence of intense cyclones. On the eve of Monica, at least one Aboriginal family decamped from Maningrida and spent the afternoon and night in a cave in the sandstone country, thereby following the traditional practice of people from that place.*

They contrast the response of Aboriginal people to Cyclone Monica to that of the non-Indigenous population (Balanda):

> *Remarkably, by comparison to Balanda, Aboriginal people were largely unaffected by Monica. Certainly some people lost their houses, but there were no injuries, and life quickly returned to normal. By contrast, the vast majority of non-Aboriginal people were traumatised to some extent. Their preoccupation with cleaning up, restoring functionality and rebuilding was tangible, profound and exhausting. The government response was quite slow, and the Maningrida community was largely left without assistance. Strangely, this seemed to matter little. There were adequate food supplies, the barge service which resupplies the community was only slightly delayed, and telephone, power and water services were restored within a few days. Mattresses and bedding were dried out and normal routines resumed.*

The different response of Aboriginal and non-Aboriginal people to Cyclone Monica highlights the necessity of extensive consultation with the Aboriginal population in understanding local needs and preparing a policy response to climate change.

Level of knowledge about climate change in the community

Scientific knowledge about the impacts of climate change is only relatively new, and there is a need to communicate up-to-date projections to community agencies and the local Maningrida population. However, there is also valuable traditional knowledge about past and contemporary climate change events. Munro, Ryan and Mirikul note that "coastal Aboriginal people of the Northern Territory are amongst the first of the world's inhabitants to make observations about, and be affected by climate change." For example, they point out that:

> *The people of Maningrida are no strangers to sea level rise, and can name and describe with great authority sites that succumbed to the last sea level rise some twelve thousand years ago, and are now under several metres of water.*

This not only "confirms the opinion of geomorphologists," but also:

> *Tells us firstly that the current inhabitants are descended from the occupants of the land at that time, and that their oral history is intact and has spanned the passage of some five hundred generations.*

However, while Maningrida's Indigenous population have valuable insights into climate change impacts and events, the access to and use of this knowledge must be appropriate and considered. As Munro and colleagues state, Aboriginal people are not only affected by climate change itself, but also "by the desire for access to their country and their knowledge by the scientific and research communities." In addition, there are some concerns that while this knowledge is available, it has been ignored by the research community:

> *Certainly there are individual Aboriginal people who were early observers of climate change, and who expressed concern at the changing weather patterns and the failure of certain bush foods. These same people express frustration at the early failure of scientists to ignore their observations and warnings.*

There is no doubt that Indigenous historical knowledge could be invaluable in addressing the issues associated with climate change. However, it is also likely that future weather patterns associated with climate change will be historically unprecedented and constitute challenges for both Indigenous knowledge and Western science. The adaptability of the local Indigenous community to an

extreme event like Tropical Cyclone Monica augers well for a longer term adaptation to the impacts of climate change in this region.

Endnotes:

[1] Northern Territory Government (2009) *Maningrida Study*

This case study was written by Jon Altman and Kirrily Jordan, CAEPR in consultation with Ian Munro, CEO Bawinanga Aboriginal Corporation; Matthew Ryan, Deputy General Manager Bawinanga Aboriginal Corporation; and senior Maningrida resident Mark Mirikul.

Katherine, Northern Territory

Katherine is approximately 320 kilometres south south-east of Darwin and about 260 kilometres from the coastline. It is the NT's third largest centre and serves as a regional hub.

The Katherine River flows down a single channel through the township. Most of Katherine town is built on a flood plain.

Consistent schooling is an issue in the region and often related to transport access and the cost of returning to home communities.

Some town camps are already affected by frequent, if not annual, flooding of the Katherine River, triggering population movements into unaffected areas, putting pressure on health services, power supplies and other utilities, shops, aged care and schools.

Flooding will remain the most obvious concern in 2030 unless substantial - and perhaps prohibitively expensive - mitigation strategies are in place. Ground water availability and use under drought and 'normal' conditions is also likely to create greater stress.

The 'dry'/tourist season brings in the bulk of annual income for many businesses in and around Katherine. Shortening of the season and increased temperatures, along with a gradual shift from warm inland attractions to coastal and cooler southern ones would affect this.

The community seems confident that they can respond to flood warnings and avoid excessive fatalities. There is long experience of such events to guide immediate responses.

Should extreme floods occur more frequently, confidence in the business community to reinvest may suffer. With the entire north of the country affected by more severe climate, the ability to rebuild the town each time will become increasingly problematic.

It appears that limited knowledge of regional climate projections and little or no public money for major mitigation and adaptive measures are providing local Indigenous communities with little reassurance for their future.

Snapshot of Katherine

The town of Katherine is approximately 320 kilometres south south-east of Darwin and about 260 kilometres from the coastline. It is located in the northern part of the Northern Territory's savanna rangelands where pastoral leases and Aboriginal freehold title dominate land tenure. Katherine is the NT's third largest centre and serves as a regional service hub fed by activity along the Stuart, Victoria, Roper, Carpentaria and Buntine highways and the Central Arnhem road. It services much of the northern pastoral industry, an irrigated agriculture industry, a substantial seasonal tourism industry, some mining operations and over a dozen Aboriginal Land trusts and community living areas (CLAs), including much of southern Arnhem Land.

Katherine's climate has a typical sub-tropical 'wet' and 'dry' season. The wet (October to April) has day time temperatures from about 33 - 38 degrees with the 'dry' a little cooler on average, with day time temperatures between 29 - 35 degrees. Seasonal rainfall is around 1000 millimetres for the wet and around 50 millimetres for the dry, resulting in fairly extreme moisture conditions. The region as a whole is characterised by flood prone drainage patterns including big perennial rivers.

The Katherine River flows down a single channel through the township, fed by numerous tributaries from the escarpment to the east. Most of Katherine town is built on a flood plain with low undulations creating a shallow catchment. Drainage of this flood plain may be held up by further flooding downstream where other rivers with their own catchments converge and by high tides restricting this flow into the Daly River and out to sea. This pattern has occurred a number of times in the last 100 years, including 1998 and 2006.

The ABS recorded a total population of 9124 for the Katherine local government area in June 2007, with the Aboriginal population estimated to make up about 20 per cent. Around 30 per cent, or around 600 of the Aboriginal population reside in a few discrete Indigenous residential areas ranging in size from about 10 to 300; Mayali Brumby (Kalano), Warlpiri camp and Rockhole, and others in Gorge camp and Binjari located a few kilometres out of town. Around 70 per cent of Aboriginal people live within Katherine's suburbs.

About 25 per cent of the township of Katherine population is Indigenous, and like Indigenous people throughout Australia, their level of health is far below that of the non-Indigenous population. There are many reasons for this, including poverty and unemployment, poor education, sub-standard housing, psychological illness, malnutrition, substance misuse and excessive alcohol consumption.

The Federal Government's Northern Territory Emergency Response has seen an unusual increase in numbers coming to Katherine. More pressure on households and customary resources with increased potential for damage to sacred and significant sites is of concern to Aboriginal residents and traditional custodians of the land.

A significant number of Aboriginal people from the wider region spend periods of time camping informally within the town limits. Town council rangers estimate there were around 300 Aboriginal people camping around the town (including along the river channel) in December 2008. For many Indigenous visitors, their association with the town, although generally temporary and seasonal, serves to maintain historical networks with town based kin and other town residents. Indigenous people are drawn to the town for a variety of reasons: social (regional shows, community sports weekends etc), environmental (annual flooding in the region), health and medical, for goods and services and avoidance of problems in outlying communities.

Extensive customary, social and historical networks connect Aboriginal groups living in Katherine. Respect for traditional ownership of place is strong and language use is an indication of cultural autonomy. The Aboriginal lingua-franca is Kriol, although there are four or five languages commonly spoken and as many as 20 represented in the Katherine population.

Traditional ownership and Native Title interests in and around the town are primarily represented by the Northern Land Council on behalf of the Dagoman, but also by the Jawoyn Association, and to some extent the Kalano Association, the Wardaman Association, and the Aboriginal Areas Protection Authority. There are also three Aboriginal health centres and an Aboriginal legal aid service.

Aboriginal people are commonly employed in clerical work, supermarkets and shops, health and education, policing, tourism, Aboriginal representative bodies, and regionally in the pastoral industry, national parks and mining. The CDEP Program is the principal employer at Kalano, Warlpiri camp, Rockhole and in outlying communities. Other significant income sources include pensions and money from mining activities.

Historical association with the region is enhanced

by customary affiliation, encouraging strong familial connectedness, sense of place and a confidence in the knowledge held by traditional land owners. This connectedness provides a crucial dimension to the town's history and economy. The Indigenous contribution to Katherine's economy is critical to its survival and to its rebuilding after disasters like the 1998 flood.

Rights and representation secured through limited land tenure and discrete governance structures are strengths that are at times also in conflict with mainstream governance.

Current constraints on community

There is not just one Aboriginal population group in Katherine. Aboriginal groups are to varying degrees, part of the culture of Katherine but also divided in their purposes for being there by different governance structures and by affiliation with their particular homelands. Their representative bodies are over-burdened and inadequately supported in their pursuit of statutory, legal and customary rights, social and economic equity, and community wellbeing. Infrastructure service provision, governance and employment patterns (including CDEP) reflect varying degrees of autonomy, separateness and inclusion in the community of Katherine. Aboriginal autonomy in achieving specific aims or aspirations is often constrained under these circumstances.

Aboriginal population estimates may vary significantly from one organisation to another, depending largely on area of professional interest and responsibility. There is a dearth of coordinated information available on residence, visitation, motivations for in and out-migration and the like. This is vitally needed information for mitigation and adaptive community planning in Katherine and the region.

Unemployment among Aboriginal people was reported by the ABS to be around 19 per cent and 31 per cent for town and Aboriginal residential areas respectively, which is well above the non-Indigenous unemployment rates.

Consistent schooling for short and medium-term visitors' children is an issue, often related to transport access and cost of returning to home communities. Some town camps are already affected by frequent, if not annual flooding of the Katherine River. Most annual flooding to parts of Kalano, the bottom half of Binjari and Gorge camp trigger movement of these populations into unaffected areas. This movement creates additional social pressures.

Extreme weather events add to the challenges facing the local Aboriginal populations. Flooding has indirect as well as direct impacts. Annual flooding may last for weeks in one or more areas and affect the whole region for several months. Transport infrastructure is often cut and damaged, having a dramatic impact on business and livelihoods as well as widespread social and economic cost. As the region's service centre, Katherine becomes a safe haven and place of respite for flood-affected regional populations, even when flood-struck itself. Increased population may continue for some time in post-flood conditions, putting pressure on health services, power supplies and other utilities, shops, aged care and schools.

Community response to previous natural hazards

While there have been several significant floods over the past decade, the 1998 flood of the Katherine River was the biggest on record, with 98 per cent of businesses affected. Some infrastructure and planning upgrades have since occurred using that flood as the benchmark, such as higher capacity storm water pumps and Emergency Response Plans, however, the town remains vulnerable to many impacts of flooding.

After the 1998 flood, Aboriginal people visiting from regional towns and homelands did not tend to leave Katherine immediately to go home. In fact, because much of the wider region was flood affected, many people came to Katherine, some as part of an annual movement to avoid isolation in the wet and others to avoid major problems associated with cyclonic activity.

Concerns were expressed by some that by the time the town warning sirens sounded, the streets were already awash. Most people moved to Katherine East, an area that maintains power and water supplies and has access to the Tindal airfield operated by the Airforce, unless the flooding is extreme, as it was in 1998.

Katherine's Emergency Response Plan later adopted the use of local radio and television to broadcast flood warnings instead of the siren. Some argue that many Aboriginal people living in Aboriginal residential areas are not likely to hear these broadcasts, though there would be other indicators that they may notice, and information networks are good throughout Katherine and the region. Limited attention to local media may still be a problem.

Katherine's Emergency Response Plan was overhauled, being modelled on organisation level

Katherine River flooding
Photo credit: CSIRO, 2008

sub plans, putting responsibility for planning and immediate action at an organisation level. This strategy assumes to make the most of local agency knowledge of their constituents and hopefully to avoid shortfalls in whole of population information gaps (as described above).

Flood refugees eventually moved back to outlying communities and Katherine did not suffer lasting structural changes. The Katherine Hospital and Ambulance depot remain flood prone, awaiting response to a submission to Infrastructure Australia for $54 million to relocate them. It is difficult to know to what extent the 1998 flood affected permanent and seasonal in-migration. Katherine's Mayor and CEO and the Northern Land Council's Regional Manager said that it is a less obvious demographic factor in 2008 than the NTER Intervention, for example.

Response to climate projection

Climate projections for 2030 indicate greater extremes of 'wet' and 'dry' than currently occur. Flooding will remain the most obvious concern in 2030 unless substantial - and perhaps prohibitively expensive - mitigation strategies are in place, such as effective damming systems and/or town relocation. Ground water availability and use under drought and 'normal' conditions is also likely to create greater stress.

Physical isolation from resources and services during times of flood is a concern region-wide. Given that Katherine is the emergency, resource, service and social hub, climate impacts region-wide are of direct concern to Katherine town. This includes physical infrastructure impacts on transport, communications, housing, education and health, and flow-on social impacts. The Katherine Hospital and Ambulance Depots are in the immediate flood zone, as is the majority of town. Relocation of town infrastructure to higher ground is cost prohibitive. Damming the Katherine River has been mooted in the past.

The 1998 flood, caused by a convergence of cyclonic weather from the Gulf and the Timor Sea, was

Flooded Kalano Community, April 2006
Photo credit: Northern Territory Department of Health and Families

the most severe recorded for Katherine. Local government concern for reoccurrence is enhanced with the suggestion of more cyclonic and storm activity. Limited financial capacity for mitigation or adaptive response further magnifies concerns in this area, where annual infrastructure budgets for upgrade and repair are already constrained.

The community seems confident that they can respond to flood warnings and avoid excessive fatalities, with only two deaths caused by the 1998 flood. They have higher land on which to take refuge and there is long experience of such events to guide immediate responses. The town bounced back after 1998, as well as in 2002 and 2006, and appears defiantly robust. Should extreme floods occur more frequently, confidence in the business community to reinvest may suffer; for instance, the impact on insurance and insurers may be significant. With the entire north of the country affected by more severe climate, the ability to rebuild the town each time will become increasingly problematic.

The dry/tourist season brings in the bulk of annual income for many businesses in and around Katherine. Shortening of the season and increased temperatures, along with a predictable gradual shift from warm inland attractions to coastal and cooler southern ones could increase the sense of vulnerability in the tourism industry.

Indigenous groups will be affected should water availability change substantially in the future. The local horticultural and pastoral economies are reliant on groundwater supplies from the Tindal limestone aquifer. Aboriginal people in the region are a significant and reliable cornerstone of the Katherine economy; for their business patronage and employment, for the government and other services that grow up to support them and because of the valuable commodification of their culture to the tourist industry. They are also potential business investors who could develop interests for example, in commercial use of water from the underlying Tindal aquifer.

If not carefully managed, increased water use and over allocation of groundwater resources has the potential to damage hunting and sacred sites connected to the aquifer, potentially affecting the transmission of traditional and ecological knowledge. Resolving these issues of historical and political marginalisation may be more difficult a task than responding to the immediacy of floods, especially in times of economic hardship.

It seems likely that if climate projections are realised Katherine will see a gradual in-migration of Aboriginal people from the region. This may be an extension of the current seasonal pattern of avoiding regional isolation or may be of a more permanent nature, depending on other factors touched on above such as Government policy impacts. How various governing bodies in Katherine respond to growing infrastructure needs - such as schools, houses and health - and what the impact might be on depopulating hinterlands are important issues. Further, there is a perception in the community that deferral of responsibility and 'cost shifting' to semi-autonomous bodies like Kalano and outlying councils, along with other influences such as the Northern Territory Government review of outstations policy, may exacerbate resource stress and related social dysfunction.

Though the scenario presented will elicit particular and direct concerns it may be difficult when considering the secondary and social impacts of projected climate change in Katherine to distinguish what is an impact or response to a given climate event or trend from what may be primarily caused by other local influences such as government policy shift.

With more Aboriginal people coming to Katherine, there is apprehension that smaller communities may be judged as unviable and de-funded, particularly in light of the Northern Territory Government's review of outstations policy. Further unease surrounds the issue of social planning and infrastructure development to accommodate new inhabitants. It appears that limited knowledge of regional climate projections and little government support to effect major mitigation and adaptive measures are providing few reassurances for the future.

Level of knowledge about climate change in the community

There is a reasonable understanding of the mechanics of natural variability in the regional climate, including major flooding. For example, Aboriginal people and other long term locals have a good sense of the escarpment watershed for the Katherine River filling from the east and taking about 11 hours before flood waters hit town. They also know that high tides and storm surges at the mouth of the Daly River bank up and prevent it from draining its tributaries, including the Katherine River system.

Long experience of 'normal' - including disastrous - climate events informs local response. However, there is not an equivalent grasp of anthropogenic change in climate and its likely impacts for the region. At a local government level, concern is expressed about future impacts on infrastructure, for example, there is reference to 'global warming' in the Katherine Town Council's submission to Infrastructure Australia for relocating the hospital and ambulance station.

For Indigenous peoples in the Katherine region, experience of causality and effect are closely related to local cosmology. While more climatic extremes may be accommodated within a regional cosmology, there may well be increasing discontinuity between religious and anthropogenic explanations that may in turn impact on customary relations with ancestral landscapes and with culturally confident response to change.

Education about direct impacts of climate change on the region must be researched and applied in a culturally sensitive framework to better inform counter disaster planning and mitigation without further disempowerment of Aboriginal people. This is also important for a practical understanding of indirect impacts, though they are still not easily disentangled.

This case study was written by Glenn James, CSIRO Sustainable Ecosystems, with input from Sue Jackson, CSIRO.

Borroloola, Gulf of Carpenteria region, Northern Territory

Borroloola is located on the McArthur River, which runs through the township and out into the Gulf of Carpentaria. Borroloola is the largest town in the region, with a largely Aboriginal population, and a number of smaller Aboriginal communities and outstations in the area.

Borroloola suffers from socio-economic problems related to poverty, substance reliance, racism, and a lack of cultural autonomy.

Oral history from senior Yanyuwa men and women suggest that cyclones, wild wind storms and floods have always been a part of life in this area of the Gulf.

The present structures of Indigenous organisations such as Mabunji, while providing invaluable services to the various Indigenous families on their outstations, cannot be taken to represent the interests of 'the community' as a whole.

There are significant areas of disagreement in approach and understanding to certain issues, including the impact of mining and tourist development. There are no effective mechanisms by which these could be resolved within a community model of consultation.

The prospect for any form of community development are best when they touch on facilities and aspects of common interest and collective benefit to all members of the Indigenous population.

Any sense of collective 'community' identity may emerge more strongly over time but the basic separation of the community based upon cultural group and identity and their histories must be recognised as significant and worthy of deep respect and consideration.

Manankurra, Wearyan River
Photo credit: John Bradley

Snapshot of Borroloola

Borroloola is located on the McArthur River, which is one of the largest river systems in northern Australia. The river, runs for approximately 300 kilometres through the township of Borroloola and out into the Gulf of Carpentaria in a very remote region of Australia. The McArthur River is of immense cultural and spiritual importance to local Aboriginal people of the Gulf region, and a complex set of cultural responsibilities and obligations underpin this relationship. There are two other river systems that are important to this area of Australia, the Wearyan River and the Robinson River, both major systems to the east of Borroloola.

Borroloola is the largest town in the region, with a population of approximately 1000 people, the vast majority being Aboriginal. There are also a number of smaller Aboriginal communities and outstations in the area. The nearest town is Katherine, some 655 kilometres away, and Darwin is approximately 992 kilometres by road.

There are four language groups living in and around the town of the Borroloola. These groups represent distinct linguistic and cultural groups (Yanyuwa, Garrwa, Marra and Gudanji). All these languages are critically endangered or verging on complete extinction. Despite the decline in languages in this area of the Gulf country there has also been a remarkable persistence in regard to the importance of kinship, or 'family' in regard to day-to-day family structures, social understandings and obligations towards kin and country. There have also been consistent efforts to maintain control over some traditional lands and sea and uphold traditional law in regard to the management of these areas. All of the above language groups have been involved in long drawn out legal procedures under the Aboriginal Land Rights Act (NT) 1976, and all have had some success.

The greater part of the Sir Edward Pellew Islands and the immediate coastal fringe on the Limmen Bight are all Aboriginal lands. The constant and contemporary pressure over the mine on the

McArthur River are actions of very concerned land owners and guardians who have obligations to that country.

The Borroloola region has had a constant European presence since the 1880s. Many of the Garrwa, Yanyuwa, Gudanji and Marra people have long histories of their families seeking employment and life alongside non-Indigenous people in the pastoral industry, professional barramundi fishing and crabbing and increasingly, in seeking employment at the mine.

As a township, Borroloola suffers from socio-economic disruption and dissent related to poverty, substance reliance, racism, and for the Indigenous people, lack of cultural autonomy. Some of these issues become apparent in the discussions below, especially in regard to understandings of what constitutes community and how best negotiations may be carried out within it.

These comments should not only be read in regard to the physical and material development, as in housing, sewage, transport, communications and other infrastructural features, but also to the security of social and cultural identity. As mentioned above, various land claims have been lodged by the Yanyuwa, Marra, Garrwa and Gudanji people but these same people experience numerous obstacles in their efforts to maintain solidarity in the social and cultural lives. The reasons for this are complex, but they include: the decline of pastoral employment for Indigenous people in the region and the consequent lack of integration in a local productive community; the lack of any meaningful occupation for a whole generation of Indigenous people and almost complete dependence on welfare benefits for survival and increasing marginalisation in terms of effective power and decision-making.

Most Indigenous families at Borroloola will staunchly defend the need for Indigenous owned and managed organisations and most often prefer to deal with such organisations where possible. Much of this has to do with the style and accessibility of governance, but also perhaps more significantly, with the sense that Indigenous people are (or should be) in control. Indigenous control of non-Indigenous organisations is not likely to occur.

These issues have been closely linked to education and training programs in Borroloola, where certain key issues such as knowledge of family histories and situations are not taken seriously and the 'white' bureaucracy associated with education and training have ignored Indigenous teaching assistants and Indigenous people within the community and surrounding area to the detriment of the status of the school within the Indigenous community at Borroloola. While there are some recent signs that this situation is changing, it will take long term planning and perseverance to change entrenched attitudes.

Current constraints on community

Since early 2003, traditional owners of land located near Borroloola have been embroiled in a battle to halt the expansion of the existing McArthur River Mine from an underground lead and zinc mine to an open cut operation. The most controversial element of the proposed expansion is the diversion of the tropical McArthur River for approximately six kilometres to enable the open cut mining of a deposit, one of the largest of its kind in the world, located under the existing river bed. There is concern that any environmental mismanagement at the mine site could then pollute the McArthur River and also have huge consequences for the marine environment and the Sir Edward Pellew Islands at the mouth.

Other constraints on the Borroloola community, in particular the Indigenous community, are associated with the Federal Government intervention. There is much socio-economic disruption and dissent in this region, related to poverty, substance reliance, racism and lack of cultural autonomy for the Indigenous population.

One of the more serious consequences of these current realities is that in terms of education there are problems with low attendance, low retention, absenteeism, high student and staff turnover rates and the subsequent effects this has on funding, programming, teaching assessment and behavioural management. These are important factors in terms of having an educated Indigenous community, who are willing and able to deal with complex issues such as climate change.

Community response to previous natural hazards

Oral history gathered from senior Yanyuwa men and women in the early 1980s suggest that cyclones, wild wind storms and floods have always been part of life in this area of the Gulf. Song line, Dreaming sites, power songs and ceremonies also attest to the place that such weather phenomena are within the world view of the Indigenous people in the Gulf country.

On the 23rd of March, 1984 Cyclone Kathy came through the south west Gulf of Carpentaria, causing widespread damage to the vegetation on the Sir

Edward Pellew Islands and the fringing coastal mangrove forests. The township of Borroloola was also severely damaged. One of the more spectacular impacts associated with this cyclone was a major storm surge, estimated to have been between –four to six metres high, carrying with it a large number of marine animals including dugong, sea turtle, dolphins, sharks, rays and fish. The animals were washed far ashore and stranded on the supratidal mudflats inshore from the coast.

Some of the dugong and sea turtle were stranded up to nine kilometres inland and separated from any of the nearest waterways by stands of mangroves up to about three metres high. Eventually, a total of 161 turtles and 23 dugong were rescued due to the coordination of local Indigenous and non-Indigenous people and their supporters. At this time none of the oldest Indigenous people alive (approximately 90) had ever heard of these kinds of events, although this may be for other reasons which are discussed next.

In April 1985, Cyclone Sandy came through the area of the Sir Edward Pellew Islands and entered the mainland in the area of Bing Bong Station. While there was no repeat of mass wildlife stranding, the sea grass beds were severely damaged and over the following months starvation was witnessed amongst the dugong and marine turtle population.

There have been no repeat cyclonic experiences since the 1984 and 1985 cyclones. However, people have grave concerns about the potential damage that a future cyclone may cause. Bing Bong Station is the port facility for the shipping of the ore concentrate

Ranger measuring a nesting Flatback
Photo credit: John Bradley

from the McArthur River Mine, some 100 kilometres south of Borroloola. The ore concentrate is highly toxic and is stored in a shed that is on the low-lying coast. As a result, there is concern that if another cyclone of similar intensity to Kathy were to come through, major environmental damage may be caused by the dispersal of the ore concentrate, either due to a huge tidal surge or else the destruction of the building that houses the ore. Similar concerns are expressed in regard to extreme floods and the mine site, and whether the bund wall surrounding the open cut facility would survive large scale flood activity. It is difficult to see how any remedial action could assist in wide scale contamination of the local marine area.

The local community with the assistance of outside agencies have demonstrated the ability to take action on a local level with a specific crisis. This would probably now be somewhat easier given the location at Borroloola of one of the largest Indigenous sea ranger units in the NT, the li-Anthawirriyarra Sea Ranger Unit, as well as a much greater awareness of environmental impacts.

While the li-Anthawirriyarra Sea Ranger Unit undertakes constant monitoring of the coastal and island country, their work is constrained by the constant search for funding to keep them active. Such insecurity in regard to funding limits the capacity of this group to continually grow and demonstrate their value. It is fundamental that such local on-the-ground groups be given the capacity to function, because only by being given capacity are they going to be free to make necessary choices in regard to research priorities and assist in building greater community resilience to likely climate impacts. It is very difficult at the moment to see how such a valuable group can contribute to the necessary engagement with climate change when their capacity is severely limited.

Response to climate projection

Any increase in cyclonic intensity poses a number of threats to this area that were not in existence in the early 1980s. These threats are primarily associated with the activities of the mine and their river diversion at the mine site proper. There is a concern in Indigenous communities in this region over the potential of the mine to be responsible for widespread environmental damage. In an Indigenous world view, widespread spiritual damage has already occurred.

The cyclones in the early 1980s demonstrated two different kinds of environmental damage, the impact upon the local wildlife and the damage to the sea grass beds. While dugong and marine turtles are plentiful in this area, they are important species in this region and are endangered worldwide. Any increase in cyclonic activity could possibly see serious threats to the integrity of the local populations and sea grass beds.

The Pellew Islands are home to a number of important sea turtle nesting beaches and islets. While sea level rise may not have too severe an effect on nesting, an increase in temperature will have a severe affect on the sex proportions of the hatchlings, which would have a long-term impact on population numbers. A number of important sea bird rookeries also exist in the Sir Edward Pellew Islands and coastal mangrove fringes. Rising sea levels would most likely severely disrupt these habitats.

The bulk of the coastline of the south west Gulf of Carpentaria is very low lying. Even a small sea level rise would cause the sea to permanently cover a landscape that currently only sees inundation during major flood activity or cyclonic activity.

Level of knowledge about climate change in the community

At present, the statistics concerning school age education in Borroloola are dire. They indicate a highly mobile student population and a high rate of absenteeism. Such issues clearly have important consequences in terms of understanding a complex issue such as climate change, as well as people's capacity to be part of the process of making decisions about how best to respond to climate change.

Other factors also contribute to the generally low level of knowledge about climate change and it possible impacts. Much of the discussion occurs in Western-centric, highly developed English, which does not take into account that many people do not have the prerequisite knowledge to make sense of the arguments.

There is little concern at present from the Borroloola community for any of the possible scenarios associated with climate change. For example, in recent discussion with both senior Indigenous people, middle aged Indigenous people and children at Borroloola during a sea turtle education and tagging and monitoring program, it became obvious that few people had any idea what the issues associated with climate change and sea level rise might entail.

There is an important role for the community education centre at Borroloola to play in this regard.

Census results show that a high proportion of the population in the Borroloola area range between the ages of 5-24 years, but only half of this population has received or are receiving an education. One of the main reasons for such a low turnout is the need for education that is both wide ranging but also culturally appropriate.

At present, it appears that little attempt is being made to communicate effectively with Indigenous people living in remote communities. From the perspective of these Indigenous people, even well-intentioned scientists, government officials and bureaucrats all too often speak in jargon-heavy language, at the same time failing to understand important cultural differences, such as vastly different understandings of something as seemingly simple as the distinctions between land and sea. The end result among many Indigenous people is that there is often a certain hesitancy, awkwardness, embarrassment and at its worst, even an unwillingness to respond and engage. So while there is an educated elite of Indigenous people who understand the issues and can talk through them, this group is not the majority.

However, this hesitance in talking about climate change should be not be taken as evidence of ignorance. Many of these people are highly educated about their own culture, their country, the sea and have a vast amount of knowledge regarding their place within the environment. It may be that the way some of this knowledge is encoded is different from what the West might expect.

There is also the issue that for many of these people, English is a second or third language. Even for Indigenous people for whom a dialect of English is their first language, it does not necessarily follow that they will, can, or want to understand everything assumed in Western science.

The following example demonstrates how cultural knowledge is embedded in culture, and relates to how any conversation on sea level rise might have to be modified to account for different cultural meanings.

Technically, the West would call most of the space occupied by the intratidal zone and the associate mudflats as 'land', because it can be walked upon in the right season and comprises geographic and floral and faunal species that our western gaze believes to be land. But in Yanyuwa this area of land is called by a geographic term of *narnu-ruluruluwanka*. This term defies a simple word-for-word translation to English, because it is a word, like many in Indigenous languages, that has much attached to it.

But to give some sense of its complex meaning, a translation of the term *narnu-ruluruluwanka*: 'a geographic land unit that consists of saltpans, clay pans and samphire heath country. It is country that is flooded on the king tides or during cyclonic surges, it is proper saltwater country. It also has numerous small raised islets with sparse vegetation such a small melaleuca trees that provide good shade for resting and camping when moving through this country.' The country described by *narnu-ruluruluwanka* extends for some 13 kilometres from the sea, inland to a low uprise that meets with the savanna grasslands. In a Yanyuwa conception, this 13 kilometre region is still the sea.

Another Yanyuwa term for this area is *narnu-wuthan*, which literally means 'incompleteness', because it is country that is neither one thing or the other, only circumstances will tell, it is also the same term that is given to what the West would call the actual intertidal or intratidal zone. This is not to say that the Yanyuwa don't have words for sea, they do; *antha* the sea in its generic form, *walamakamaka* the open ocean and *kunjurrkunjurr* the line of the horizon and the sea, *narnu-ngawurruwurru*, the deep dark sea between, and to the north of the islands and *kurnmurr* the expanse of rolling sea between the islands and the horizon, but a Yanyuwa reckoning of the *narnu-wuthan* also allows it to be called antha, the sea, as well.

As mentioned above, this is country that can be flooded by the sea, and perhaps the most dramatic example of this was in April 1984 during Cyclone Kathy, when all of this country was inundated by a massive tidal surge. Just after Cyclone Kathy struck in 1984, a senior Yanyuwa elder, Old Tim Rakawurlma, talked about the dugong and sea turtle having been thrown "inland". I said to him, in Yanyuwa, *"Nya-mangaji lhambiji kinya-walima walya ankaya nyungku-mangaji mayangku*, the cyclonic winds threw the dugong and sea turtle onto the mainland". Tim's immediate response was, *"Waraba mayangku nyuwu-mangaji ki-awarawu ki-anthawu, antha nya-mangaji awara*, no it is not the mainland, that country is the sea, it is sea that country".

Similarly, during court proceedings of a land claim in 2000 involving a claim to the sea grass beds of Yanyuwa country, a middle aged Yanyuwa claimant, Nancy McDinny, was asked to indicate to the Judge the sea country under claim. The seemingly obvious expectation was that she would point to the coastline as marked on the map. Yet she immediately began to draw her finger along a line that was between 10 to 13 kilometres inland, because for her, this was the

Liwirndirndila, Sandy Head, Opposite Venderlin Island
Photo credit: John Bradley

boundary between the mainland and the sea.

Thus in a Yanyuwa sense the sea is conceptualised as something quite different to current Western concepts of land and sea. Therefore, any maps of projected sea level rise in regions such as this should be carefully developed, to account for different cultural understandings.

An understanding of culturally and morally important systems such as kinship also become critically important when trying to negotiate the concept of community in Borroloola and the surrounding region. There are marked differences in history and geographical orientation of the Yanyuwa, Garrwa, Marra and Gudanji peoples, so the application of this umbrella term is problematic. While there are certain events and contexts in which the Indigenous people may come together, such as for funerals and more generally speaking, in recent discussions over the mine, in many other respects different approaches and expectations apply.

Some significant consequences for consultation and negotiation are as follows:

- Large scale open community meetings are an inappropriate means for consultation and communication.
- The present structures of Indigenous organisations such as Mabunji, while providing invaluable services to the various Indigenous families on their outstations, cannot be taken to represent the interests of the community as a whole.
- There are significant areas of disagreement in approach and understanding to certain issues, including the impact of mining and tourism development. There are no effective mechanisms by which these could be resolved within a community model of consultation.
- Certain key individuals within the Indigenous population, by their access to information and resources such as vehicles, boats, local, state and federal government information are able to wield powerful influence in immediate consultation contexts even though their views may not represent those of the majority.
- The prospect for any form of community development is best when they touch on facilities and aspects of common interest and collective benefit to all members of the Indigenous population. There are certain issues which will seem to be the key interest of one group over another. Thus discussions of climate change and sea level rise are really seen to be of key interest to the saltwater people such as the Yanyuwa and Marra.
- Any sense of collective community identity may emerge more strongly over time but the basic separation of the community based upon cultural group and identity and their histories must be recognised as significant and worthy of deep respect and consideration.

If climate change and sea level rise are seen to be urgent matters then care must be taken to at least understand some of the multiple and complex knowledge systems that have existed in Australia for millennia. This is crucial is there is to be a much fuller dialogue with people who occupy many hundreds of kilometres of country that is at the forefront of likely climate impacts.

This case study was written by John Bradley, Centre for Australian Indigenous Studies, in collaboration with Steve Johnson and Graham Friday at the li-Anthawirriyarra sea ranger unit.

Saibai Island, Torres Strait, Queensland

Saibai Island is a large, low-lying island in the Torres Strait, in far north Queensland, four kilometres from the coast of Papua New Guinea. Saibai's village lies on a narrow, flat ridge of land about 1.7 to 2.5 metres above sea level.

Saibai Islanders have considerable experience of flooding and coastal erosion, and long-term knowledge of their environment. According to local elders, changes to the shoreline have been dramatic over recent decades.

More frequent extreme weather causing more inundation events, of greater duration, will increase the amount of sewage and other rubbish circulating through the village areas, as well as posing a risk to water supplies.

The availability of an adequate supply of potable water is expected to be greatly strained in the future due to climate change. The current dam is only adequate for the present population. While it fills relatively quickly during the wet season, dry-season water restrictions are often put in place to manage the limited supply.

Rising sea levels will result in greater flooding during king tide and/or storm surge events. The current sea wall is breached by very high tides; any future wall would have to be significantly higher to protect the village from sea level rise.

Sites of cultural heritage significance to the community would also be subject to increased threat, in particular, the village graveyard. This area is not protected by a sea wall and currently suffers flooding and erosion during high tide events. The prospect of graves washing away is of serious concern to Saibai people.

The impacts of more extreme droughts, greater wet season flooding, and higher sea levels on neighbouring Papua New Guinea would have a flow-on effect for Saibai.

There is also concern over the potential for climate change to impact on the marine environment, which supports subsistence fisheries, such as dugong and turtle hunting, and commercial fisheries such as crayfish.

There is apprehension and concern throughout the community, and regular discussion about the perceived changes, sea walls, and plans for the future.

Snapshot of Saibai Island

Saibai Island is a large, low-lying island in the Torres Strait, in far north Queensland, located just four kilometres from the coast of Papua New Guinea. It is roughly rectangular in shape, measuring approximately 22 kilometres long, and 7 kilometres at its widest point. The maximum height above sea level is about 2.7 metres.

Like nearby Boigu Island, Saibai was formed several thousand years ago by the deposition of alluvial sediments from rivers in New Guinea. Extensive mangrove communities fringe the island. The interior consists of seasonally inundated, fresh- and brackish-water sedge swamps, saltpans, and non-inundated claylands covered by grasslands and open woodland. A system of mangrove creeks connects the swamps to the sea.

The main village is situated on a narrow, flat ridge of land approximately 1.7 to 2.5 metres above sea level, lying on an east-west axis, located on the northwestern side of the island. The southern side of the embankment slopes down to swamps immediately behind the village; the village is only about 0.2 to 0.5 metres above the wet season water level of the swamp. Community expansion has been restricted to this small area, resulting in an esplanade some 1.7 kilometres long, only wide enough for a road and one row of houses at most locations.

The population of Saibai at the time of the 2006 census was 338, of which 317 identified as Indigenous. Approximately one quarter of the population comprises people of Papuan descent; these are people (and their descendants) who moved to the island from Papua New Guinea in the period following the Second World War.

The Torres Strait comprises several cultural-geographical groups or 'clusters' of islands. Saibai is part of the 'Top Western' or 'Northwestern' cluster, which also includes Boigu, which is similarly low-lying and swampy, and Dauan, a high, granitic island. Saibai Islanders call themselves the Saibailgal. The name for the wider group – Saibai, Boigu and Dauan people – is Guda Maluilgal. Like most Torres Strait Islanders, the Saibailgal were never dispossessed of their lands and waters. Guda Maluilgal speak Kala Lagaw Ya, a dialect of Western Torres Strait Language. Torres Strait Broken, a Creole language that is the lingua franca of the Torres Strait region, is also widely used.

The majority of residents are employed under the CDEP scheme or receive welfare payments. Economic opportunities on Saibai and in the larger region are largely restricted to the fishing industry. Some men engage in commercial fishing from dinghies, mostly for crayfish. Subsistence activity for use and exchange, including turtle and dugong hunting, and fishing, remains a vital part of the local economy. Gardening, once important, is not practiced on a large scale today, partly as a result of long-term access to social security payments, employment opportunities and store goods. There are several 'kitchen gardens' near people's houses which supplement store-bought food.

Although Saibailgal remain proud of their culture, many express concerns that their language and culture is under threat; for example, Torres Strait Creole is increasingly being spoken by children and younger people. Some people also worry that their cultural heritage – e.g. songs, dances and stories – are not being transmitted to the young, due to modern influences such as television and remote schooling.

In 2008, the various Island Community Councils in the region were amalgamated to form the Torres Strait Island Regional Council. There is concern about Saibai's ability to have its voice heard in the new structure. The new Council, like those it replaced, is almost completely dependent on outside funding, having no internal income, such as rates. There remains a desire by Saibai Islanders, like other Torres Strait Islanders, to continue to lobby for greater autonomy and control over their own affairs, at the State and Federal level; the amalgamation has been seen by some as an erosion of local control and decision-making.

Current constraints on community

Under the terms of the Torres Strait Treaty between Australia and Papua New Guinea (PNG), the traditional inhabitants of Torres Strait and adjoining coastal areas of PNG's Western Province are permitted free movement for traditional purposes, including fishing, trade and social and ceremonial activities. Most of the movement now occurring is by Papuans visiting the islands. Saibai has one of the highest rates of visitation by PNG villages, particularly from the Sigabaduru and Mabaduan communities. Saibailgal have complained that these visits place enormous pressures on existing services and infrastructure, including health, housing, water supplies and waste disposal, and pose a threat with respect to communicable diseases.

Saibai is located on a remote periphery of the Australian state, and is dependent on State and Commonwealth funding for most employment opportunities, social security benefits and

infrastructure development. Food, transportation and freight costs are very high. The community is small and experiences significant levels of outward migration, particularly among its young, educated people.

In responding to climate change, Saibai is faced with a number of obstacles. The village is located on some of the highest ground on the island, and further expansion is greatly restricted by the surrounding swamps and mangroves, a problem compounded by an increasing population and restricted supplies of potable water. Given the limited capacity to move to higher ground and the limited land area available for housing, houses in the village have been raised above the ground on steel piles and spaces under high-set buildings are now being enclosed to provide extra accommodation to alleviate overcrowding. Reports recommend concrete foundations under houses should be raised above the highest astronomical tide level, to reduce problems with this being used as a habitable area.

The majority of Saibai inhabitants wish to see the construction of a sea wall to protect the village. This would be an expensive undertaking and funding has not been forthcoming to date, other than for basic repairs to the existing wall. A recent report has noted the need to get access to adequate machinery to start re-building a properly engineered sea wall. A secondary concern is the lack of materials, which would need to be shipped in to build the sea wall and a bund wall.

More generally, Saibai is faced with a number of problems common to Indigenous communities elsewhere in Torres Strait and across Australia. Employment opportunities beyond the CDEP program are limited. There is a primary school on the island, but students must go to Thursday Island or the mainland to attend high school. Students find few opportunities for employment on the home island, and many subsequently move to the mainland to further their education and careers.

Other factors that impact on local capacity include limited access to further education and training, and consequent skills shortages; high turnover of outside technical staff; problems with technology up-take; and language and cross-cultural communication

Raised house with sea water inundation
Photo credit: Wendy Crowther

problems. The high cost of air transport is a burden on families, particularly those with children and relatives 'down south'. Regular Passenger Transport air services have a history of instability in the region, with operators sometimes departing with little notice, leaving local people with no other choice but to purchase high-cost charter airfares.

Health is also a major concern for the community. Torres Strait Islanders have a lower life expectancy than non-Indigenous Australians. Chronic diseases, including diabetes and heart disease, and sexually transmitted infections are particular problems. Mosquito-borne diseases, such as dengue fever and Japanese Encephalitis occur in the area as well, as outbreaks of the former appear to be occurring more commonly in Torres Strait and other parts of northern Queensland.

Local concerns over the public health problems with respect to water spreading disease through the village area during high tides appear in waste management project documents written by the island Environmental Health Officer and consultant. Increasingly, extreme weather causing more inundation events of greater duration will increase the amount of sewage and other rubbish circulating through the village. During the 2009 high tides, most of the sewerage manholes around the community were submerged, which resulted in the covers popping up under the pressure. Raw sewage escaped and some of the contaminated water filled nearby lagoons and ponds. Children were warned not to swim or play near these areas.

In recent years, the communities of Torres Strait have seen considerable infrastructure development, including waste management facilities, safe drainage, subdivisional developments, improved telecommunications, sealed airstrips and all-weather roads, covered dams and power stations. Much of this work has taken place under the Major Infrastructure Program, a capital works initiative jointly funded by the Queensland and Commonwealth governments. Delivery of these services on Saibai has required considerable land area, on an island where there is little available high ground for housing and amenities. Building costs are also extremely high, as much as twice as that in regional centres – a typical residential dwelling can cost in excess of half a million dollars. As native title exists on Saibai, it is necessary for the permission of traditional owners to be obtained before such works commence.

Sea wall breached
Photo credit: Garrick Hitchcock

Community response to previous natural hazards

> *The people...are concerned about the implications of sea-level rise and global warming to their community.*

Saibai Islanders have considerable experience of flooding and coastal erosion, and long-term knowledge of changes to their environment. According to elderly Saibailgal, changes to the shoreline in front of the settlement and other parts of the coast have been dramatic over past decades. For example, the edge of the present village beachline was once many metres to seaward. Consequently, the people have been worried about the potential effects of climate change for some time.

In 1947, the community experienced a particularly high king tide which flooded the village and destroyed many gardens. That same year, a number of families decided to leave Saibai to establish a new life on Cape York Peninsula, settling first at Mutee Heads and soon after establishing the township of Bamaga. To date this has been the only relocation of its kind in Torres Strait. Many other families, however, decided to stay on at Saibai.

In 1956, construction began on a sea wall in front of the village, with further work undertaken in the 1970s. Community members express concern over the deterioration of the present wall, which is constructed of coral rock and concrete, and maintained by the largely unskilled CDEP workforce.

Today, the local Spring tidal range is between 3.5 and 4.0 metres, making Saibai very vulnerable to flooding; these tides are worse when they occur in conjunction with storm surges and heavy onshore winds and waves during the north-westerly season. Major flooding events have occurred in January 2006, and more recently in January 2009, when king tides inundated parts of the village.

In 2006, the sea wall was breached in many places, and sections of the main road were flooded by ankle- to knee-deep water. Damage to the community, in particular homes, was not as great as in the past, as most houses are now built on steel piles, and gardening does not underpin subsistence. However, at least one ground-level residence was flooded, damage to the sea wall was extensive, and the cemetery was threatened. Considerable work was required to clean up the debris left scattered throughout the village.

School building surrounded by sea water
Photo credit: Wendy Crowther

The January 2009 king tide was of a similar height, leading to substantial problems with sewerage, as discussed above.

Most Saibailgal have close kin at Dauan, Bamaga on Cape York, Thursday Island, and in cities and towns in Australia, particularly along the Queensland seaboard. If climate change and sea-level rise are to result in further erosion and inundation, they would be able to relocate to these communities. Past experiences in Torres Strait indicate, however, that Islanders are extremely reluctant to leave their 'home islands', and would only do so when they have little or no choice.

A home island without a people is unthinkable to Torres Strait Islanders. The link between cultural identity and place is critical – for many, to be a Saibai Islander is to be born on Saibai, to live on Saibai, to die on Saibai. Even among those who have moved 'down south' to the mainland, many still return regularly to see family and to maintain cultural ties. People who pass away while living down south – even people who have lived there for many years – often request to be buried in the Island's cemetery.

Response to climate projections

Imagining the future in 60 years, based on the projected climate scenario, Saibai people are clear that the availability of adequate potable water supply will be greatly strained. The existing covered dam is only sufficient for the present population. While it fills relatively quickly during the wet season, dry-season water restrictions are often put in place to manage the limited supply. Prolonged droughts would also likely create dust problems worse than those currently experienced and people worry about the possibility of higher levels of eye and respiratory irritation.

Most of Saibai's rainfall occurs during the wet season, between December and April. Higher precipitation in 2070 may result in increased flooding in the swamps around Saibai village. Greater investment in flood mitigation works (e.g. culverts, drains, embankments, fill for future construction etc.) would probably be required. Freshwater and/or tidal flooding will pose risks to health, through contamination of the water supply system and overflow of sewage.

Higher sea levels than present will result in greater flooding during king tide and/or storm surge events. Low-lying community infrastructure will be more exposed to damage from the effects of such flooding, e.g. the sealed airstrip, concrete roads, and other ground-level facilities. The current sea wall is breached during very high tides, and any future wall would have to be significantly higher to protect the village from the 2070 sea level. More intense storm surges would exacerbate these problems. Saibai Islanders are committed to obtaining government funding to construct a "professionally built" sea wall, with the projected expense being in the millions of dollars. Others have identified the need for a 'swamp wall' to protect the village from rising waters in the extensive swamps to the rear of the village, leading some to joke about a potential future 'living in a ditch' between two walls, 'like fish in a lagoon' (Sol Aniba, pers. comm. January 2009).

Sites of cultural heritage significance to the community would also be subject to increased threat, in particular, the village graveyard, located at the western end of the settlement. This area is not protected by a sea wall and currently suffers flooding and erosion during high tide events, as it is situated close to a tidal creek. The prospect of graves washing away is of serious concern to Saibai people. Exhuming and relocating graves is a subject that has been considered by the Island's elders, although no decisions have been made to date.

The impacts of more extreme droughts, greater wet season flooding, and higher sea levels on neighbouring PNG (e.g. crop failures and inundation of villages) would have a flow-on effect for Saibai, as these people would undoubtedly look to the island to obtain fresh water and food supplies, and otherwise strain community resources, as has occurred during similar episodes in the recent past.

There is also concern over the potential for climate change to impact on the marine environment which supports subsistence fisheries, such as dugong and turtle hunting, and commercial fisheries such as crayfish. There are extensive seagrass beds to the east, west and south of Saibai; these support dugong and turtle populations, and are favoured hunting grounds of the Saibailgal. Increased outputs from nearby New Guinea rivers due to higher wet season rainfall may result in more frequent seagrass dieback events, which are caused by high turbidity levels leading to light deprivation. Higher sea temperatures may increase coral bleaching, further impacting on the local subsistence and commercial economy and eroding marine biodiversity across Torres Strait.

Saibai people identify the eastern end of the village as currently most susceptible to flooding. The houses here, and the adjoining airstrip, suffer most from flooding events, and the community would like to see an embankment built to protect them. It is thought that the airstrip might be unusable

Rebuilding the sea wall

during high flood events and/or become damaged by prolonged inundation.

Saibai people cite their attachment to their homeland, and in particular, sites of cultural significance, such as the cemetery, the resting place of their ancestors, and the church, built by their forefathers, a focal point of community identity and worship, as reasons why people do not want to leave, and why many chose to remain on the island while others left in the 1940s. However, there is acknowledgement that younger people today do not have such strong views, and would be more prepared to move if the situation on the island became less tenable.

Level of knowledge about climate change in the community

The Saibai people have noticed changes to the climate and environment in recent years. For example, some forest areas with tall trees are giving way to scrub; taller mangrove species have begun to die off; increasing high tide levels have been noticed; and beachfront erosion continues (Sol Aniba, pers. comm. January 2009). Flood events are said to be more frequent, with higher water levels than those experienced in the past. There is apprehension and concern throughout the community, and regular discussion about the perceived changes, sea walls, and plans for the future: "some want to stay, and some want to go" (Sol Aniba, pers. comm. January 2009).

Islanders want to begin discussions about alternative arrangements for their future, with governments and other stakeholders, including the traditional owners of their preferred future residency, should they decide to relocate as a community. This does not suggest that Saibai people want immediate relocation, but they do want to be prepared if and when the time comes to do so.

This case study was written by Garrick Hitchcock, in consultation with Sol Aniba, Dana Ober and Mebai Warusam.

Kowanyama, Queensland

Kowanyama is a predominantly Aboriginal community of 1200 people located on the Mitchell River delta wetlands of the Gulf of Carpentaria coast.

Kowanyama is a very active Aboriginal community that is known for doing things its own way, as well as for some outstanding young leaders, including 2007 Young Australian of the Year, Tania Major. Three younger Kowanyama land management agency staff have recently attended UN based forums in both Alaska and New York to represent their people.

Resilience and the future potential of developing social capital in the younger generations of Kowanyama in the face of serious social and cultural changes are Kowanyama's strengths.

Kowanyama was rebuilt as a European-style township with little consultation with Indigenous people in the 1960s, soon after Cyclone Dora. New houses were often built in physically and culturally inappropriate areas, with many homes later experiencing drainage problems during heavy rain.

Cyclones are the most feared weather phenomenon for the people of Kowanyama. People in Kowanyama consider them to be dangerous minya (animals) called Yo' ngart.

The adequacy of the three radar cyclone tracking systems now servicing the Gulf at Weipa, Gove and Mornington Island is questionable.

Routine preparations for cyclone season have become more efficient, however, relying on internet connections and television as the community's main source of up-to-date weather information is problematic for both Emergency Services staff and the public. With the onset of cyclonic weather, power lines and the Telstra owned communications tower are both vulnerable in the event of high winds. The township is also vulnerable to flooding.

Indirect impacts of more extreme weather could take a variety of forms. Predicted drier periods would make Kowanyama a haven for birds such as the little billed corella that have invaded the town before, damaging infrastructure.

Some people in Kowanyama still think of climate change as "whitefulla mumbo jumbo". However, leaders within the community are beginning to see the need for discussion about the changes they now see on their own country as well as the scientific projections for the future.

There is also concern over the potential for climate change to impact on the marine environment, which supports subsistence fisheries, such as dugong and turtle hunting, and commercial fisheries such as crayfish.

There is apprehension and concern throughout the community, and regular discussion about the perceived changes, sea walls, and plans for the future.

Snapshot of Kowanyama

Kowanyama is an Aboriginal community of 1200 people located on the Mitchell River delta wetlands of the Gulf of Carpentaria coast. The descendents of the tribes of the lower Mitchell River delta Aboriginal Trust Lands and neighbouring cattle stations comprise the predominant population of Kowanyama. Kowanyama Aboriginal Trust Lands cover an area of 2,590 square kilometres of original Aboriginal Reserve currently held by Kowanyama Aboriginal Shire Council as Trustees for the people of Kowanyama and 2,590 square kilometres of pastoral leases purchased by Kowanyama in the early to mid 1990s. The community is predominantly Aboriginal. Less than 10 per cent of the population is non-Indigenous, who are typically service agency staff working for local and state agencies or itinerant tradespeople.

The economy of Kowanyama is currently dependent upon the CDEP. Approximately 15 per cent of the Aboriginal population is in full time employment with local and state government service agencies and other work. The Kowanyama Cattle Company, run by a local Aboriginal board, grazes cattle on Aboriginal Lands with the consent of Traditional Owners and is only a very minor contributor to the overall economy.

Kowanyama has similar social issues to many developing Indigenous communities around the world, including high welfare dependency, poverty and lifestyle illnesses such as sugar diabetes, heart and kidney conditions and hypertension. Alcohol consumption has been radically reduced since the local hotel was closed. There is a high dependency upon a range of recreational drugs among young people.

Self governance as an Aboriginal local government authority became a key principle in the opening of Kowanyama's Land and Natural Resources Management Office in 1990. Since 1987, the Kowanyama community has been outspoken on a range of issues including management of country and pioneering the concept of Indigenous natural resource management agencies in Australia. Resilience and the future potential of developing social capital in the younger generations of Kowanyama in the face of serious social and cultural changes are Kowanyama's strengths.

Annual flooding of the Five Ways Mitchell River Delta
Photo credit: Jeff Shellburg, Kowanyama Archives 2008

Current constraints on community

Transport: Kowanyama is located in a northern Australian monsoonal environment. The community lies within the extensive Mitchell River delta system and is part of the marginal elevation of the Gulf of Carpentaria coastal plains. Kowanyama is exactly due west of Cooktown and nine hours by bush road to Cairns on the Eastern seaboard. Kowanyama Airport is 9.6 metres above sea level and has an all season sealed airstrip equipped with a non-directional beacon service that is over flown by international flights. Chartered air freighters supply perishable food goods to the store and several privately run small cafes. The Royal Flying Doctor Service provides medical support to the local health clinic with a weekly doctor service and medical evacuations to Cairns when required.

Roads are generally impassable to traffic for about four to five months of the year. In recent years considerable improvements to the road surface and the replacement of station gates by cattle grids have reduced travel from 12 hours in 1973 to nine hours in 2008. Approximately five hours of that travel is over an unsealed road surface that crosses a number of major streams with very low level road crossings. Heavy transport vehicles service Kowanyama during the dry season with food and essential supplies including construction materials. A five day a week air service from the east coast city of Cairns, the main business hub for the town, provides a mail and passenger service.

As in most remote areas of Cape York Peninsula, it is traditional for wet season stores of essential items to be stockpiled late in the dry season. This includes non-perishable food, diesel fuel for the town's electricity supply and fuel for transport vehicles.

Employment: Kowanyama is a sizeable remote community of Aboriginal residents still located relatively close or within their original homelands. The reality for the people of Kowanyama is that they reside in an area where economic opportunities are perceived to be limited. The major employers at Kowanyama are the services sector which includes Kowanyama Aboriginal Shire Council, Departments of Education, Health and Police. Kowanyama Aboriginal Shire Council and its Land Management Facility is one of Australia's leading Aboriginal land management agencies. The agency has developed its capacity to attract fees for environmental services and also raises internal revenue from a tightly

Kowanyama during the wet season
Photo credit: Roger Jaensch Collection Kowanyama Archives

regulated non-Indigenous recreational fishing and camping operation. This has allowed it to secure appropriate training and fulltime employment for two of its Aboriginal staff.

A limited number of young people are engaged in carpentry and plumbing apprenticeships and a small number are engaged in the cattle industry, both at Kowanyama and further afield.

Housing: The people of Kowanyama lived in villages of cabbage palm thatched dwellings until the devastation of Cyclone Dora in the 1964-65 wet season. After the cyclone, mission village life was transformed into a more planned European style community of wood and metal framed houses.

Significant State and Federal Government resources were secured by Kowanyama Aboriginal Shire Council to overcome the issues of overcrowding, drainage and other problems inherent in the hasty rebuild of the 1960s. A major housing program has been underway since. The major issues with the building program include ongoing funding, overcrowding, appropriate land and home tenure, cyclone building standards and a limited town area surrounded by major wetland complexes subject to extensive seasonal flooding.

Communications: In 1989, the construction of microwave link towers connected Kowanyama to the telephone communications network at Laura. Improved air services, the introduction of television broadcasting services and telephones have also resulted in significant changes to what was a relatively isolated northern community. Internet and email communication have replaced fax machines that revolutionised business communications. The introduction of mobile telephone services has further revolutionised both private and business communications with the outside world. UHF radio communications remain a valuable tool in the daily work of Aboriginal Rangers and other Land Office staff as well as Council employees and the residents of homelands living and working outside of the mobile phone reception area.

Community response to previous natural hazards

In late January 1964, Cyclone Dora moved slowly across the Central Gulf of Carpentaria and, with hurricane intensity, devastated the Edward and Mitchell River Missions. Wind damage was restricted to a 480 kilometre strip from Aurukun south to the Nassau River. The path of destruction varied from an eight kilometre width at Edward River, now known as Pormpuraaw, to a 48 kilometre swathe closer to the Nassau River at Inkerman Station. The path was marked by 20 per cent tree fall and almost total defoliation. Winds had reached in excess of 160 kilometre per hour crossing the Gulf coast at Wallaby Island on the mouth of the Main Mitchell River. At Wallaby Island where Dora made landfall thick areas of mangroves were completely destroyed.

Above: Chapman St, Kowanyama after Cyclone Dora Below: Kowanyama slaughter yard after Cyclone Dora

Photo credits: John Caine Collection Kowanyama Archives

Two decades later, Yir Yoront Elders recalled the dune woodlands and well site of Kun'amul where everyone camped at the mouth of the river on Nawr kothorr Saltwater Crocodile Clan country,

> *All different now, that freshwater well, ridge and all is gone, never looked anything like that before!*

The destruction of the mission was extensive with only a few of the sturdier mission buildings withstanding the winds. Kowanyama had been a mission village of palm thatched houses and would never look or indeed be the same again. In the rains that followed Gulf Rivers that included the Norman, Flinders, Leichardt and the Gregory represented a total discharge of 34.5 million cubic metres, which

represented more than the annual average runoff from all of the coastal streams of New South Wales and Victoria combined, or nearly double that of the Murray-Darling system's annual average discharge.

Unlike the Pormpuraaw community, Kowanyama is located approximately twenty kilometres inland from the coast with flooding subject to the complexities of stream flows resulting from both local and upper catchment precipitation, prevailing tides and storm surge effects. Records indicate that inundation of the delta is a regular occurrence for the Mitchell River system.

People who experienced cyclone Dora at Kowanyama more than thirty years ago recount huddling in what were considered safe houses. Senior men were out in the rain singing to the rainbow serpent, the creator of storms, lightning and cyclones. Their customary responsibilities were clear. When the cyclone was over everyone did what was necessary to clear away the tree limbs and broken buildings, surprised to find a few of the strongest palm thatched buildings and the old high blocked dormitory still standing and repairable. As an Aboriginal community, their needs were basic and they knew that the bush around them would quickly repair itself and provide an abundance of food. Familiarity with country allowed people to quickly adjust to the devastating changes to the landscape.

There have been other cyclones since then. In January 2009, Cyclone Charlotte crossed the coast at the Gilbert River well south of the Nassau. At Pormpuraaw, annual highest tides became storm tides, overtopping back dunes and burying camp infrastructure under a metre of sand deposited by the surge. If the combination of those highest annual tides and a cyclone of Dora's magnitude had coincided, the outcomes for Pormpuraaw would have been serious or catastrophic at worst.

Storm tides at the South Mitchell River mouth near Kowanyama surged across two chenier ridges to leave salt scalded surfaces and a debris line 1.75 metres up in mangrove branches. Elders described that beach front as having been a complete and mature dune woodland complex up to the 1920s that supported freshwater well supplies and a population of people and the grave sites of their ancestors. Not a single hardy Casuarina tree marks that part of the coast line now. Just kilometres south, an extensive coastal wetland is threatened with salination if the remaining back dune is breached and salt water enters the freshwater drainage system of the region located between coastal dune woodlands. Already extensive cultural heritage sites and their contents nearby have been obliterated by the same wind and wave action.

Response to climate projection

Kowanyama is no more than 10 metres above sea level and is 20 kilometres from the coast of the Gulf of Carpentaria. Given the low elevation of country, the two concerns at this time are impacts of more intense weather patterns upon the immediate coastal zone where changes could lead to salination of delta wetland systems and loss of cultural heritage values through the loss of resources and destruction of heritage sites and landscapes.

The second significant potential impact is perceived to be one of inundation and flooding of the township of Kowanyama during the monsoon season when higher energy events coincide with flooding resulting from precipitation in the eastern regions of the Wet Tropics. The immediate safety of people is the main concern at Kowanyama, so cyclonic wind and the impacts of local flooding are the priority concerns.

Seasonal flooding: The potential impacts of storm surges on the relatively unpopulated delta wetlands of the Mitchell River are understood by some people. High tides, cyclonic and onshore winds and upstream flooding driven by high precipitation in the upper catchment represent a serious concern to the township. Kowanyama is surrounded by vast wetlands and is located upon Magnificent Creek, a tributary of the Mitchell River system. Forecasts of an increase in rapid flooding and the damming effects of higher sea levels and tides with an increase in precipitation and weather intensity will make Kowanyama vulnerable to the seasonal flooding regime of one of Australia's largest tropical river systems.

Flood levels in the town proper have always been an issue, but they have never overtopped the levee banks. Forecasted changes to the weather regime combined with a coincidence of other conditions will require significant consideration. However, the priority in most people's minds is the threat of cyclonic winds.

Fear of cyclones: Cyclones are the most feared weather phenomenon for the people of Kowanyama. Cyclone Dora is still fresh in the minds of the middle aged population, some with relatives that lived in the bush as late as the early 1940s. Knowledge of Cyclone Larry and its destructive impact was made possible with the arrival of television in the area in the mid to late 1980s. Its impact was keenly observed and people know that cyclones are a very real part of life in Northern Australia.

Storm surges: The people of Kowanyama move from homelands either cut off or inundated during the wet season to live at Kowanyama well away from the coast until the onset of the dry season. They are aware of the damage caused by storm surges and were reminded this year by local reports of a surge that overtopped the chenier ridge systems on the coastal plain adjacent to the South Mitchell River mouth.

Communications: Cyclone warning systems have improved but for remote communities like Kowanyama, current computer internet technology, telephones and television communications are prone to the potential impact of storm weather events. Such effective public information systems can be easily lost and are dependent upon a few individuals with poor radio reception and satellite phones.

Kowanyama Aboriginal Shire Council, its Land and Natural Resources Office, State Department of Police, local State Emergency Services personnel and the local Department of Health run health clinic have recently engaged in upgrading an Emergency Action Plan. The effectiveness of the plan is dependent upon the initiative of a small and constantly changing, mostly non-aboriginal group and their capacity to effectively communicate with the town's population prior to, and during an emergency.

In recent years, routine preparations for cyclone season have become more efficient with Council providing a routine service of removal of unwanted materials with the potential to become dangerous in high winds. A system of efficient communication of information relating to current cyclone information and emergency evacuation procedures to the public is being developed.

While computer connection to internet is viable, the most up to date weather forecasts and warnings are available to key participants in the plan.

Community capacity in coping:

- A major sports and recreational facility is currently under construction at Kowanyama and is a prototype for the State's new cyclone regulations. The building will have the capacity to house the better part of the Kowanyama population and its massive construction with eight metre pier foundations is expected to withstand the equal of Cyclone Larry's fury in 2006 at Innisfail.
- Kowanyama is generally prepared for the isolation from service centres on the east coast during the monsoon season. Basic essentials are stockpiled at the local government owned and operated store. Roads are closed to both Cairns and Normanton for significant periods during the wet season often not opening to road transport services until late April or early May.
- The airport is the highest location in Kowanyama at 9.6 metres above sea level. It has a sealed all weather surface. The airstrip has night landing facilities allowing night medical evacuations by the Royal Flying Doctor Service.
- The diesel power generation plant for the town is located on one of the higher levee banks of the Magnificent Creek adjacent to the airport. In the event of cyclonic winds, power lines are vulnerable to damage by flying debris as is the communications tower about five kilometres north. The facility is isolated from town during the wet by an unsealed and unpassable road cut in two places by the Magnificent Creek. The only feasible access to the site would be by helicopter.
- The hospital, police and a number of line agencies of the Kowanyama Shire Council have auxiliary power supplies to cope with emergencies. Support with auxiliary equipment by incoming Emergency Services personnel from the east coast is planned if major disaster relief is required.
- A recently upgraded water reticulation system has yet to prove itself in cyclonic conditions. In such a situation, medical staff anticipate the need to evacuate patients on home dialysis who require high water quality in anticipation of degraded services.

Kowanyama already experiences the problems of high cost housing due to its isolated location. The current development of the major sports and recreational complex has shown that added costs can be expected to accommodate the necessary upgrade of building regulations to comply with cyclone ratings. The additional hazard in the event of cyclonic weather remains overcrowding of many homes. Kowanyama has attracted funds for extensive building programs but the issue remains far from resolved.

The town drainage system has experienced problems and will need to take account of future predicted rain and flood events that are expected to be more intense in response to changing local and upper watershed climatic conditions.

The predicted drier periods will also make

Kowanyama a haven for pests such as the little billed corella that has threatened important infrastructure within the town area. Estimates of the last invasion totalled some ten thousand birds that came to roost in the town, wreaking damage upon housing, water reticulation and communications infrastructure.

Changes in wetland ecosystems due to altered rainfall regimes and salination of coastal freshwater wetlands will have consequences for the biodiversity and cultural values of country valued as an important subsistence resource by the people of Kowanyama. Some of these changes may well come long before higher sea levels predicted, and simply be the result of changed intensity of weather patterns.

Other more distant developments in the upper catchment of the Mitchell River will also impact upon the future supply of water to downstream systems. There are expanding interests in mining and intensive agriculture in the more fertile parts of the region.

Level of knowledge about climate change in the community

While Kowanyama is still a relatively isolated Aboriginal town, it is also a very forward-looking community. Modern technology has recently changed its world view, and brought knowledge of the affairs of the world to it. The issue of climate change has only recently become evident to Kowanyama people. The Kowanyama Land and Natural Resource Office has engaged in early community education strategies to help in the understanding of the key issues facing the town. Two of its staff recently attended the Indigenous People's Global Summit on Climate Change in Anchorage, Alaska.

Many people in Kowanyama are not fully informed on climate change but leaders within the community are beginning to see the need for discussion about the things they now see on their own country and what others are saying might happen in the future. However, it is generally viewed as a complex issue still debated by governments and scientists and the complexity of it all is sometimes shrugged off as so much "whitefulla mumbo jumbo". Despite this, the Kowanyama Land Office has made the issue of climate change an integral part of its business in a way that will help others understand the key issues that the town must plan for. A key objective of Land Office activities will lie in helping the general population to understand the complexities of climate change.

Kowanyama Aboriginal Shire Council and its partner agencies with State Emergency Services are currently reviewing their Counter Disaster Plan that will assist in the better coordination of information flow and the implementation of the necessary counter disaster actions. Part Five of the Plan addresses the need for an ongoing public awareness program.

Council is currently seeking funding for a study on the impacts of climate change upon its future town infrastructure planning.

This case study was written by Viv Sinnamon, Manager, Kowanyama Aboriginal Land and Natural Resources Management Office.

Synthesis commentary on case studies

Introduction

This synthesis has been undertaken using case study material available at the time for the coastal and inland communities of Kakadu, Maningrida, Saibai, Borroloola, Katherine and Yakanarra. The analysis and comments provided represent an 'expert judgment' and are framed by experience working in the field of natural hazard and disaster risk reduction in Australia and internationally as well as with Indigenous and non-Indigenous communities.

Overall observations

The places detailed in the case studies are quite diverse. Four are coastal and two are inland communities although what are referred to as a 'community' often include a specific place, associated outstations and satellite communities. Each settlement is quite different in terms of size, relationship to other nearby settlements, history of occupation, age, population size, local issues of concern to residents and so forth. Consequently, it would be unwise at this stage to attempt to draw broad conclusions from the case study material about the hazards and risks faced by Indigenous people and their adaptive capacity to climate change extremes or their resilience to them. However, best practice principles are discussed in the recommendations section of this document.

Common issues to all 'places'

The follow issues were noted by each case study:

1) Dependence on healthy ecosystem functioning and goods and services provided by those natural systems.

To varying degrees, each place has noted that Indigenous people derive some form of benefits from the ecosystems that surround them. In most cases, these include food for subsistence and resources for commercial activity and income generation. These are direct and easily measured benefits. In addition, and much more difficult for western science to understand and quantify, the natural environment provides enormous value to Indigenous people in respect of cultural, customary, ancestral and cosmological world views. Indigenous people have significant cultural obligations to care for their country. The health of their customs and culture is dependent on, and related to, the natural environment. It is therefore, clear that negative impacts on ecosystems from climate change and its associated hazards will have direct and measurable impacts on nutrition and capacity to generate income for many Indigenous people. Reductions in both these metrics would increase their vulnerability and reduce their resilience. A lack of alternatives for Indigenous people, including their strong attachment to residing on ancestral estates, reduces their capacity to adapt to climate change.

2) Loss of cultural identity, traditional practice, and spirituality.

Any process that causes the loss of cultural identity and its associated practices and customs for Indigenous people is catastrophic. Loss of culture and custom fundamentally destroys their world order, disconnects people from their country, ancestors and spiritual world. It results in increased personal and cultural stress and a reduced capacity to cope with everyday processes – including climate change. Concern for loss of culture and custom was expressed in varying degrees by every community in this study. There are many reasons for this loss and whilst not directly because of climate change, changes in climate can amplify the loss through feedback mechanisms (such as the damage of natural systems – see point 1 above).

3) Dependence on social welfare and or/limited options for income generation.

In only one community (Katherine) was it noted that Indigenous people are employed in multiple economic sectors and activities. In all other places, communities are so small that alternative and diverse livelihood options simply do not exist. In some places, Indigenous people are either exclusively dependent on state welfare or are employed by government development corporations. A lack of meaningful livelihood options is a pre-determinant of multiple problems for community and will inevitably lead to

Indigenous belief systems about water

Indigenous people's belief systems treat natural resources very differently to mainstream western thought, with implications for how policy and management might address climate change impacts. The case of water exemplifies many of the issues.

In the belief systems of Australian Indigenous peoples, water is a sacred and elemental source and symbol of life (Langton 2006) and aquatic resources constitute a vital part of the customary economy. Indigenous people hold distinct cultural perspectives on water, relating to identity and attachment to place, environmental knowledge and the exercise of custodial responsibilities to manage inter-related parts of customary estates (Langton 2002; Jackson et al 2005; Toussaint et al 2005; Jackson and O'Leary 2006). Studies reviewed elsewhere (Jackson 2006) observe that Aboriginal groups conceptualise water sources and rivers, as with the land, as having derived from the Dreaming, the time when the world attained its present shape (Yu 2000; Toussaint et al 2001; Langton 2002; Barber and Rumley 2003). Further, these studies emphasise the importance of mythic beings as significant to the origin and maintenance of all water sources.

Cultural affiliations to water are expressed in many different ways: through social etiquette, place-based knowledge, narratives, beliefs and daily practices (Toussaint et al 2001). Water's vitality is underscored in the studies from north Australia; it is often described as a living element that creates the defining shape and character of country (Yu 2000). In contexts where resources or places are under pressure or threat there is a tendency to focus on key places or sacred sites as people strive to retain their traditions (Kolig 1996). However, the affiliations to water are much broader than those encompassed by the conventional cultural heritage paradigm: these humanitarian values relate to notions of sociality, sacredness and identity.

The extent of Indigenous hydrological knowledge is evidenced by the richness of terms and concepts contained within Aboriginal languages (see for example the Borroloola case study in Chapter 8).

Indigenous systems of customary law dictate that traditional land-owners have a substantive role in land and water management and resource regulation. Therefore, Indigenous people expect to fully participate in management decisions. Indigenous communities across north Australia have identified numerous environmental threats and social problems associated with environmental change, increasing demand for water resources and changing environmental management systems (Whitehead et al 1999; Storrs et al 2001). A tropical rivers scoping study (Jackson and O'Leary 2006) found that strong interest in the diverse and relatively intact riverine and riparian systems motivates Indigenous communities to undertake management activities, to collaborate with government agencies and stakeholders, and to develop partnerships with researchers to exchange knowledge and solve identified problems.

Indigenous people encounter and seek to address the pervasive threats to riparian health within areas under their control and beyond: sedimentation from erosion, weed infestations (usually pasture grasses), deteriorating water quality, feral animal impacts, saltwater intrusion and other degrading processes (Jackson et al 2005). However, customary activity is 'largely unrecognised and ignored, despite its potential private and public benefit' (Altman and Whitehead 2003; Langton 2006).

reduced resilience. The hazards literature is full of examples where limited livelihood options and low overall income generation enhance the vulnerability of people and communities to hazards (including climate change).

4) Options to strengthen community resilience.

In most of the case study accounts, information is provided about how communities have been affected by previous extreme climate events. Statements are provided that the community is resilient to the impacts of climate events. It is true that communities 'survived' past events. However, surviving is not the same as being resilient. Further, almost no information is provided about 'why' the community was resilient in the face of previous extreme events. We know next to nothing about the characteristics of these communities that enabled them to survive. This is puzzling because in most of the case studies, details are provided about low absolute income and limited scope for income generation, dependence on government social welfare payments, remote locations, poorer health standards and lower overall education standards. Such characteristics are widely cited in the hazard-disaster literature as predictors of vulnerability and reduced resilience. Therefore, the 'survival' of Indigenous peoples and communities in the face of past events is counter intuitive to the current predictors of resilience. Explanations must be sought for this paradox. The fact that Indigenous communities have survived extreme climate hazard events and continued to maintain place-based relationships is highly significant and valuable lessons can be learned about how and why this has occurred. Once understood, those elements that provide resilience can be enhanced and shared with other remote communities.

5) Capacity to cope with more frequent and intense climate events.

Whilst most case studies have discussed resilience in the face of past events, very little information is available about the expected resilience of these communities to changes in the frequency and/or intensity of future hazard processes. In fact, where ever increased frequencies/intensities are mentioned in scenarios, concerns are raised about the likely capacity of Indigenous people to cope. This suggests that in a process of self assessment by Indigenous people, many feel that they would be increasingly vulnerable and less able to cope with future extreme events given the current conditions of the human-environment system in which they live.

6) Climate impacts in relation to other community priorities.

Why would climate change and its associated hazards be of any more concern in the minds of Indigenous people when their immediate daily lives are impacted by so many extraneous issues over which they frequently have little control? In many cases, the daily lives of Indigenous people here and now are challenging. In many cases it is difficult to deal with the core issues of daily life this week and next. The capacity to look forward to the medium future is lacking. Such constraints on forward planning raise barriers to implementing risk mitigation strategies.

7) Engagement with and capacity to influence decision making.

In some places, long term and/or on-going legal cases relating to land ownership may be associated with more or less resilient communities. In places where Indigenous people have been successful in gaining ownership and management rights over traditional lands, communities are described as being more resilient than places where Indigenous people lack meaningful land ownership rights. It is not clear why this is the case although it may be that communities that have been successful have learnt to work together, harness their resources, articulate their case and consequently, have become more cohesive. This process may inadvertently lead to greater resilience. Understanding and capturing the processes that govern this success will be important for horizontal transfer to other Indigenous communities.

8) Unintended consequences of the Northern Territory National Emergency Response Act (2007).

There are a range of views on the effect and impact of the *Northern Territory National Emergency Response Act* (2007), including that any alleged negative impacts would be expected to reduce the resilience of Indigenous peoples, increasing their vulnerability to future climate extremes.

Other issues emerging from the analysis

In reflecting upon the detail of the case studies, the following specific issues are evident but not necessarily across all places. The losses associated with and potential impacts of climate hazards of specific magnitudes in different places cannot be easily assessed at present. The level of 'exposure' in terms of people, homes, businesses, critical infrastructure, lifelines and other community assets varies significantly from place to place. Further, the vulnerability of those exposed assets varies for a variety of reasons. Without specific place-by-place assessment, quantifying probable maximum

losses for future events remains highly problematic. Work should be undertaken at specific locations/ communities of interest to gain a more sophisticated understanding of the exposure, and the vulnerability of that exposure.

At a broad level, decisions concerning alternative adaptation, management and protection options are usually based upon a cost-benefit analysis that seeks to balance the value of the assets (and the avoidance of loss costs) against the costs of the various protection measures. For some asset classes (such as the tangible economy and physical infrastructure), this is usually relatively easy to measure and quantify. However, when thinking about 'cultural heritage' values and human dignity and well being of Indigenous people, questions arise about how we quantify and value such assets.

The case study material from Yakanarra raises a very difficult issue. It notes that Indigenous people interpret unusual (i.e., extreme) weather events (hazards) as a result of a lapse or wrongdoing in their relationship with ancestral beings – it is a form of disharmony. The issue that comes to mind is, if Indigenous people do everything right in respect to traditional customs and practices and still 'unusual weather events' occur, how will they interpret these events? What might future more frequent and extreme events mean for their understanding of their cosmos and relationships with their ancestral beings?

Indirect or secondary effects of hazard processes/ events often have the longest lasting and greatest effects on communities. They 'ripple out' across coupled human-environmental landscapes amplifying the vulnerability of people and places that have been failed by a history of policy and response that have not understood Indigenous relationships to place. Much more work needs to be undertaken to understand the secondary, longer lasting effects of extreme events on remote Indigenous people and their communities.

Discussion

It is not possible to asses from the information provided whether existing risk management practices have been designed with current risks in mind or if they also include likely changes in frequency and intensity of future hazard events. Future events might well overwhelm existing risk management strategies, increasing vulnerability. There is potential that the Northern Territory National Emergency Response Act (2007) may have unintended consequences of disempowerment of Indigenous people and therefore, increase vulnerability to climate change and hazards. This should be specifically assessed.

Policy decisions and responses in relation to climate change and the allocation of resources to meet future needs may also be made well outside of local Indigenous communities. Such policy decisions may impact negatively or positively in relation to vulnerability. Such impacts need to be assessed using appropriate investigative tools such as the policy sciences approach.

The Borroloola case highlighted the difference between how local people and western decision makers define basic elements impacted by climate change. Indigenous people in this region have a more fluid view of the world, one that is broadly more capable of dealing with variation and uncertainty in comparison to western thinking. This active socio-cultural process represents a remarkable adaptive capacity of Indigenous people that is not well understood. Clearly, concepts of 'place' vary and misunderstandings may easily arise. Policy decision making must take account of, be informed by and sensitive to local meanings of 'place'.

Chapter 9

Discussion

This study has summarised the current knowledge of climate change impacts in northern Australia, and examined the implications of these compounded with indirect drivers on the natural environment, health, infrastructure, education and livelihoods of the region. Eight case studies of settlements from across the north were explored to further enrich these findings.

The existing social and economic disadvantage that exacerbates many remote Indigenous communities' vulnerability to climate change cannot be overstated. These existing challenges include: remoteness, poor health and education and unemployment, which all serve to reduce economic status for many communities. There are a large number of Indigenous people living principally on their Indigenous estates and in this context are disproportionately reliant on their land and natural resources for local livelihoods. This reliance extends to meet psycho-social needs associated with ancestral and contemporary spiritual connection to country.

Both the Federal and State/Territory governments – through the Close the Gap COAG initiative and an alliance of key NGOs through the Close the Gap campaign – are looking to address significant life expectancy, infant mortality and morbidity differentials between Indigenous and non-Indigenous Australians.

Historical legacies of enormous under-investment include too few, and frequently poor-quality houses, inadequate primary health care facilities, few cyclone shelters and fragile facilities for communications, and maintenance of power and water services that are prone to failure. In addition to exacerbating vulnerability, these deficiencies compromise adaptability in a changing climate. Such shortfalls will significantly reduce the ability of remote Indigenous communities to respond to many of the impacts of climate change.

It is likely that vector-borne diseases and heat-related stress will increase with climate change and access to bush foods may decrease. Indigenous people are already suffering from an array of chronic diseases and will be particularly vulnerable to the additional stresses associated with climate change. It will be necessary to act swiftly and decisively on these existing issues as well as emerging ones.

In a growing number of remote Indigenous communities, Indigenous livelihoods are being realised in a form of hybrid economy that combines state, market and customary sectors in diverse ways that vary from locality to locality. A commonality in this form of economy is a high level of reliance on natural resources that are used in important enterprises such as: the visual arts; niche commercial use of bush products; wildlife harvesting (including fisheries); cultural and nature-based tourism; recreational fisheries enterprises; and the provision of environmental services. This high reliance on natural resources make such economies extremely vulnerable to climate change shocks, but also generates considerable incentives for Indigenous stakeholders to ensure that biodiversity and access to resources are maintained.

In recent years, there has been a growing acceptance that western science alone cannot address the growing environmental and biodiversity conservation issues in the tropical savanna. In this context, there have been emerging alliances between the holders of Indigenous knowledge and western scientists. Given acceptance of climate change as a serious threat to tropical environments, there is an urgent need to mobilise the body of Indigenous knowledge that will assist in reducing the expected negative impacts of climate change, while at the same time recognising and enhancing any positive impacts. In such an environment of scientific uncertainty, it is imperative that Indigenous knowledge and human capital resources are used without the ideological and institutional barriers previously put in place that prevented proper and respectful partnerships.

Many Indigenous communities are located in

remote regions that have historically experienced poor market connectivity as a major constraint on economic development. Emerging opportunities in carbon abatement and bio-sequestration might provide these communities with in situ competitive advantage in engaging with emerging new post-industrial commercial opportunities using Indigenous knowledge as a niche market advantage.

There remains considerable uncertainty about ownership and marketability of new forms of property, including carbon credits, which exacerbate strategic investment in new and highly innovative opportunities for Indigenous people in rural and remote Australia. It is essential that such issues are identified and clarified promptly to ensure that there are no distortions or information asymmetries that will dampen new investment possibilities.

It is also important that any opportunity to allocate new forms of property and other arrangements to facilitate involvement of Indigenous landowners should be pursued to provide them with incentives to engage in carbon abatement, sequestration activities and biodiversity conservation. Offsets created from Indigenous-held lands and those where Native Title interests are recognised that might be traded with covered sectors of the CPRS should be examined, but be led in partnership by Indigenous institutions. Similarly, government should take steps to increase confidence in the robustness and credibility of voluntary markets on offsets and resolve ambiguities about 'additionality'.

There is considerable activity currently underway in the provision of environmental services under the umbrella of the Indigenous 'Caring for Country' community-based network. There is an emerging evidence base that Indigenous rangers, or their equivalent, are providing a range of environmental services that are enhancing the maintenance of biodiversity on lands and waters where Indigenous Australians hold title or have primary management responsibility. Such activity should be encouraged through long-term collaborative arrangements between state agencies, community and regionally-based groups to ensure positive biodiversity outcomes. These services can be deployed to deal with climate change pressures as well as other challenges.

A critically important lesson that has emerged from the Caring for Country movement and the WALFA case study is that robust Indigenous organisations and institutions are essential for the development and 'operationalisation' of new opportunities. There are grounds to believe that the expanding network of Indigenous community-based natural resource management groups has a growing capacity to provide environmental services on a significant landscape scale. Opportunities in bio-sequestration have not as yet been given sufficient consideration, although some scientific scoping work is being undertaken by a number of research groups. It is important that this avenue to pursue carbon sink opportunities is seriously considered through this emerging network.

Too many environmental policies and associated programs have historically been based on limited evidence. It is important that actions undertaken in the future are properly monitored so as to generate an evidence base for what is effective and what is not. In particular, there is a need to invest in proper monitoring of Indigenous land and sea management activities to ensure benchmarking of effectiveness both absolutely over time, and relative to other climate change abatement activities.

The broader policy setting associated with Indigenous people in the study region will require a new partnership with Indigenous institutions if any attempts to adapt and prepare for climate change are to be successful. The disconnected nature of policies associated with the environment, health, housing, roads, telecommunications and welfare reform tend to operate to a large extent in isolation, therefore attempts to create a new policy setting without establishing these connections may heighten the level of frustration felt by Indigenous communities.

Given the urgency of issues associated with climate change and the challenges that remote Indigenous communities will face, there is a clear case for investment in an Indigenous information 'climate change clearinghouse' for tropical northern Australia. Such a clearinghouse could provide a wide array of information ranging from the latest climate science to information on projects that are proving effective and a 'how to' manual for community groups seeking to take up opportunities in land management activities and carbon abatement and sequestration activities. The clearinghouse could also facilitate the fostering of collaborative relationships and partnerships between community, research, government and policy areas.

The attention paid to northern Australia, in particular Indigenous people, the natural environment and its development potential, will require a new approach. There is an urgent need to engage in a discourse with the Indigenous community in northern Australia about climate change and other closely related issues. Such an event would allow Indigenous people to

directly engage with other Indigenous communities whilst the latest information is discussed and appropriate actions suggested. Such an event would also allow open and transparent collaboration and partnerships to be fostered to ensure that research and policy settings are informed. It would be preferable that such an event take the form of one large event led by an Indigenous institution well placed to facilitate such a dialogue.

Noting the importance of natural resources to remote communities and opportunities that these create for livelihoods and cultural maintenance, there is a general need to prioritise opportunities for Indigenous people to engage in natural and cultural heritage activities. This highlights the importance of Caring for Country programs and IPAs, but also the need to further understand and value these contributions to the nation. A particular priority in this area of activities is to clarify the opportunities and rights of Indigenous people with regard to the emerging carbon economy, including the implications of the proposed CPRS for land management activities such as fire in the north.

At the same time, the existing commitment of increased resourcing to infrastructure and services for remote settlements in northern Australia under various approaches to 'closing the gap' needs to be planned in ways that maximise the opportunities for adaptation in the face of climate change. This requires a conscious effort to take climate change into account in planning new and maintaining existing infrastructure, health and education services, an effort that is required immediately if a great deal of investment is not to be misdirected.

Ensuring that these programs are aware of climate adaptation needs would be facilitated by further development of future scenarios in partnership with a variety of communities across the north, chosen to represent regions with different trajectories, and the differentiated needs and vulnerabilities of coastal as opposed to inland settlements of different sizes. The information and understanding emerging from such efforts should be made available across the north through the proposed clearinghouse.

Last, the inevitable uncertainties outlined in this report should not be allowed to hide the absolute certainty of major change in northern Australia in the next few decades from climate, development, demography and other global forces. The development of resilient, adaptive responses to these changes cannot be delayed.

These considerations and others noted in the report lead to the following key recommendations.

Overarching issues	Recommendation
There is an urgent need to engage with Indigenous communities on matters associated with climate change for communication purposes as well as the development of collaborative activities.	To host a northern summit on climate change related matters hosted by an Indigenous institution. Such a summit would: • Present the most recent knowledge associated with climate change directly to an Indigenous audience; • Allow Indigenous people to present climate change perspectives and adaptation strategies from a community based approach; • Allow the Federal, State and Territory, and Local governments to be engaged in partnership with communities; • Develop community based strategies and engagement methodologies to foster best practice approaches; • Conduct long-standing research partnerships.
There is a need to develop a climate change clearinghouse in partnership with Indigenous institutions.	Establish a clearinghouse that provides services to: • Boost the communication capacity between remote Indigenous communities and the scientific community; • Articulate community based initiatives to share knowledge and experiences relating to climate change; • Support the development of Indigenous climate change strategies through partnerships with institutions and experts.
Little attention has been given to the topic of Indigenous vulnerability to climate change in northern Australia by the research sector to date.	To develop well-articulated adaptation strategies for Indigenous people in the tropical north requires new collaborations, dedicated resources, and partnerships. The first-step, prior to the development of such strategies, would be to conduct an in-depth collaborative study to explore the following: a. Current determinants of vulnerability in a number of communities in northern Australia; b. The current adaptive capacity within these Indigenous communities; c. Opportunities for enhancing this adaptive capacity; and d. Future scenarios to determine what actions would improve the resilience of a number of sectors, for instance health, tourism, agriculture, natural resource management and education within and outside of Indigenous communities. All of the National Climate Change Adaptation Research Facility's Networks should be encouraged to integrate Indigenous interests into their respective research programs.
Each community has specific concerns, and therefore there is no 'one size fits all' approach to reducing vulnerability.	The literature to date on vulnerability of many of these communities to climate change is in dire need of more in-depth and empirical research. Moreover, in appreciating that 'one size will not fit all' in regards to developing resilience and adaptation strategies for these communities, it would be recommended that a number of regionally-specific, in-depth studies be conducted. It is expected that by adopting such a regionally-specific approach, the varying needs of remote communities would be captured. In addition, Indigenous communities should be consulted and fully engaged in climate change studies and associated decisions concerning their communities.

Health	Recommendation
Climate change is expected to elevate the health risks for Indigenous people in the north.	Anticipatory adaptation activities to reduce the impact of these risks are likely to lead to improvements to health more generally. Health strategies should include potential impacts from climate change, such as vector-borne diseases, heat related illness and psycho-social health. Policies need to be implemented to reduce the range of factors that are frequently found in Indigenous communities, such as poor nutrition, overcrowded housing, lack of adequate water supplies – all of which serve to reduce adaptive capacity.
Biodiversity (Sustainable Landscapes)	**Recommendation**
Dispossession and loss of access to traditional lands, waters and natural resources as well as a loss of ancestral, spiritual, totemic and language connections to lands are a major documented concern which have made Indigenous people more vulnerable to the effects of climate change.	Encouraging restitution of environmentally beneficial relationships with the land may contribute to reducing the vast differences in social outcomes between Indigenous and non-Indigenous Australians, and in greatly enhancing the adaptive capacity of Indigenous Australians. Climate change adaptation planning must take the negative historical experience of relocation of Indigenous people from their country into account.
Infrastructure	**Recommendation**
Transport and communication infrastructure is already extremely limited in many parts of the study region, climate change is expected to place further strain on these limited services.	Improving key access points, raising new and existing building standards against the impacts of extreme weather, and enhancing resilience of locally sourced energy and maintenance systems are critical investments that could also create employment for local Indigenous people. More generally, studies need to be carried out so priority areas can be identified and appropriate planning mechanisms developed.
Overcrowding and inappropriate building stock in many Indigenous communities may increase vulnerability to climate change, particularly if cyclones increase in intensity.	New buildings designed for remote Indigenous communities in northern Australia should take account of passive design, and energy and water efficiency principles. Dedicated community-based cyclone shelters need to be constructed in cyclone prone areas and they should take into account cultural avoidance protocols.
Sea level rise will have the most significant impact in the short to medium term when it is combined with extreme events such as king tides and storm surges.	The vulnerability of communities to sea level rise, storm surge etc requires further research across the north. Working with existing programs, vulnerable communities need to be identified and prioritised. New data may need to be collected and compiled to carry out this activity.

Education	Recommendation
While there is generally low public awareness about the potential impacts of climate change, it is likely that this is an even greater problem for Indigenous Australians owing to the recognised challenges of current forms of formal educational systems, remoteness and lack of appropriate educational materials.	Education could play an important role in enhancing the adaptive capacity of northern communities. However, there is a need to develop policies that enable and empower Indigenous communities to respond accordingly to climate change in a manner that supports local laws, language and customs. Maintenance of cultural practices to provide people with livelihoods and strengthen their resilience to future change is vital. Indigenous knowledge is a valuable but shrinking base from which western scientists may be able to learn more about how the environment could respond to climate change, and projects that engage with both forms of knowledge should be supported.
Livelihoods	**Recommendation**
Climate change will affect the 'natural' environment, with major flow-on implications for remote communities dependent on natural resources.	The role of people in the landscape helping to manage climate impacts will be crucial and presents a significant opportunity for Indigenous livelihoods. Economic opportunities arising from climate change for Indigenous people living on land may include the need to better manage and restore ecosystems, and the pursuit of carbon mitigation and sequestration activities.
Indigenous people, not connected to government programs, are actively managing vast tracts of both terrestrial and marine environments using age-old knowledge systems in northern Australia. Limited engagement has occurred in the past between natural resource managers and these traditional owners.	There is a lack of action-based research and analysis relating Indigenous knowledge transmission to expected environmental degradation and other effects due to climatic changes. Research and development should give priority to Indigenous institutions that can act as a means of facilitating the research, whilst maintaining strong direction and input from the community. The benefits of greater Indigenous engagement extend beyond increasing employment opportunities – they can lead to increased connection to country, improve health outcomes and strengthened cultural practice.

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Appendices

Appendix 1: Acronyms

ABS	Australian Bureau of Statistics
ALRA	Aboriginal Land Rights Act
ATSIC	Aboriginal and Torres Strait Islander Commission
BFV	Barmah Forest Virus
CBD	Convention on Biological Diversity
CDEP	Community Development and Employment Projects
CHINS	Community Housing and Infrastructure Needs Survey
COAG	Council of Australian Governments
CPRS	Carbon Pollution Reduction Scheme
DAFF	Department of Agriculture, Fisheries and Forestry
DCCEE	Department of Climate Change and Energy Efficiency
DEWHA	Department of Environment, Water, Heritage and the Arts
IK	Indigenous Knowledge
IPA	Indigenous Protected Area
IPCC	Intergovernmental Panel on Climate Change
MVE	Murray Valley Encephalitis
NAILSMA	North Australia Indigenous Land and Sea Management Alliance
NCCARP	National Climate Change Adaptation Research Program
NGO	Non-governmental organisation
NIFS	National Indigenous Forestry Strategy
NRM	National Resource Management
NRSP	National Reserve System Program
NTER	Northern Territory Emergency Response
RRV	Ross River Virus
UNPFII	United Nations Permanent Forum on Indigenous Issues
WALFA	West Arnhem Land Fire Abatement

Appendix 2: Glossary of terms

Adaptation: Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Various types of adaptation can be distinguished, including anticipatory, autonomous and planned adaptation.

Adaptive capacity: The ability of a system to adjust to climate change (including changes in variability and extremes) so as to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.

Biodiversity: The numbers and relative abundances of different genes, species and ecosystems in a particular area.

Capacity building: Developing the technical skills and institutional capabilities in all aspects of adaptation to, mitigation of, and research on climate change.

Carbon dioxide: A colourless, odourless gas that occurs naturally and is also emitted by fossil fuel combustion and land clearing. The atmospheric concentration of carbon dioxide has increased by about 31 per cent since the Industrial Revolution. It is the main anthropogenic-influenced greenhouse gas affecting climate change.

Carbon sink: Natural or human activity or mechanism that removes carbon dioxide from the atmosphere, such as the absorption of carbon dioxide by growing trees.

Catastrophic event: A climate-related event having sudden onset, with widely distributed and high magnitude impacts on human or natural systems, such as historically rapid sea level rise or sudden shifts (over a decade or less) in atmospheric or oceanic circulation patterns. Such events have occurred in the past due to natural causes.

Climate: Climate in a narrow sense is usually defined as the 'average weather'. The classical period is 30 years.

Climate change: A change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.

Climate model: A mathematical representation of the climate system based on the physical, chemical, and biological properties of its components, their interactions and feedback processes, and accounting for all or some of its known properties.

Climate projection: A projection of the response of the climate system to emission or concentration scenarios of greenhouse gases and aerosols, or radiative forcing scenarios, often based upon simulations by climate models.

Climate scenario: A plausible and often simplified representation of the future climate, based on an internally consistent set of climatological relationships, that has been constructed for explicit use in investigating the potential consequences of anthropogenic climate change, often serving as input to impact models.

Climate variability: Climate variability refers to variations in the mean state and other statistics of the climate on all temporal and spatial scales beyond that of individual weather events. Variability may be due to natural internal processes within the climate system (internal variability), or to variations in natural or anthropogenic external forcing (external variability).

Coral bleaching: The paling of corals and other animals with zooxanthellae caused by the expelling of these symbiotic algae under stress. Bleaching occurs in response to physiological shock due primarily to periods of increased water temperature coincident with high levels of light. Bleaching can also be caused by changed in salinity or turbidity.

Critical threshold: The point at which an activity faces an unacceptable level or harm, such as a change from profit to loss on a farm due to decreased water availability, or coastal flooding exceeding present planning limits. It occurs when a threshold is reached as which ecological or socio-economic change is damaging and requires a policy response.

Discrete Indigenous Community: A geographic location, bounded by physical or legal boundaries, and inhabited or intended to be inhabited predominantly (i.e. greater than 50 per cent of usual residents) by Aboriginal or Torres Strait Islander peoples, with housing or infrastructure that is managed on a community basis.

Downscaling: Statistical or dynamical methods of deriving finer regional detail of climate parameters from global and regional climate models. A method that derives local- to regional-scale (10 to 100 km) information from larger-scale models or data analyses.

Ecosystem services: Ecological processes or functions having monetary or non-monetary value to individual or society at large. There are (i) supporting services such as productivity or biodiversity maintenance, (ii) provisioning services such as food, fibre, or fish, (iii) regulating services such as climate regulation or carbon sequestration, and (iv) cultural services such as tourism or spiritual and aesthetic appreciation.

Emission scenario: A plausible representation of the future development of emissions of substances, based on a coherent and internally consistent set of assumptions about driving forces (such as demographic and socio-economic development, technological change) and their key relationships.

Endemic: Restricted to a particular region, people or country, such as a human disease prevalent in a population or locality.

Exposure: The nature and degree to which a system or species is exposed to significant climate variations. In a climate change context, it captures the important weather events and patterns that affect the system. Exposure represents the background climate conditions against which a system or species operates, and any changes in these conditions.

Extreme event: An extreme weather event refers to meteorological conditions that are rare for a particular place and/or time, such as an intense storm or heat wave. An extreme climate event is an unusual average over time of a number of weather events, for example heavy rainfall over a season.

Greenhouse gas emissions: The release of greenhouse gases and aerosols into the atmosphere. Emissions are usually measured in tons. About 25 per cent of carbon dioxide emissions are reabsorbed by the ocean and another 25 per cent by the terrestrial biosphere, leaving about 50 per cent in the atmosphere. Carbon dioxide emissions are mainly from the burning of fossil fuels and deforestation. These emissions have led to an increase in atmospheric greenhouse gas concentrations since the Industrial Revolution.

Impact assessment: The analysis of positive and negative consequences of climate changes on natural systems and human societies, both with and without adaptation to such changed conditions.

Infrastructure: The basic equipment, utilities, productive enterprises, installations and services essential for the development, operation and growth of an organisation, town, city or nation. In this report separated into transportation and communications.

Integrated assessment: An interdisciplinary process of combining, interpreting and communicating knowledge from diverse scientific disciplines so that all relevant aspects of a complex societal issue can be evaluated and considered for the benefit of decision-making.

Mitigation: Refers to those response strategies that reduce the sources of greenhouse gases or enhance their sinks, to subsequently reduce the probability of reaching a given level of climate change. Mitigation reduces the likelihood of exceeding the adaptive capacity of natural systems and human societies.

Resilience: The ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organisation, and the capacity to adapt to stress and change.

Risk: The probability that a situation will produce harm under specified conditions. It is a combination of two factors: the probability that an adverse event will occur; and the consequence of the adverse event. Risk encompasses impacts on human and natural systems, and arises from exposure and hazard. Hazard is determined by whether a particular situation or event has the potential to cause harmful effects.

Salt-water intrusion: Displacement of fresh surface water or groundwater by the advance of salt water due to its greater density. This usually occurs in coastal and estuarine areas due to reducing land-based influence (e.g. either from reduced runoff and associated groundwater recharge, or from excessive water withdrawals from aquifers) or increasing marine influence (e.g. relative sea level rise).

Sea-level rise: An increase in the mean level of the ocean. Eustatic sea-level rise is a change in global average sea level brought about by an increase in the volume of the world ocean. Relative sea level rise occurs where there is a local increase in the level of the ocean relative to the land, which might be due to ocean rise and/or land level subsidence. In areas subject to rapid land-level uplift, relative sea level can fall.

Sensitivity: The degree to which a system is affected, either adversely or beneficially, by climate related stimuli, including mean (i.e. average) climate characteristics, climate variability and the frequency and magnitude of extremes.

Stakeholder: A person or organisation that has a legitimate interest in a project or entity, or would be affected by a particular action or policy.

Storm surge: A region of elevated sea level at the coast caused by the combined influence of low pressure and high winds associated with a severe storm such as a tropical cyclone.

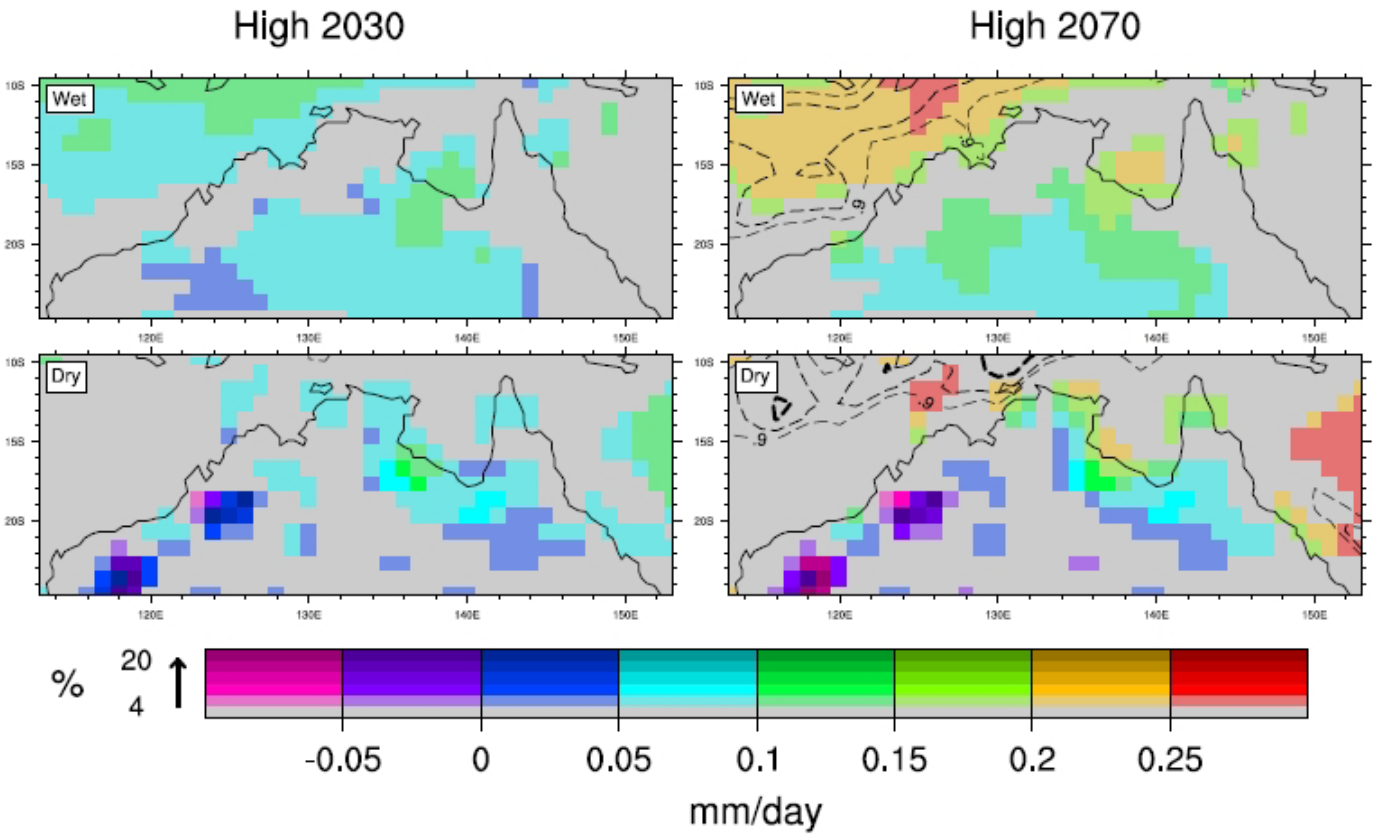
Uncertainty: The degree to which a value is unknown, expressed quantitatively (for example, a range of temperatures calculated by different models) or qualitatively (for example, the judgement of a team of experts on the likelihood of a collapse of the West Antarctic Ice Sheet).

Vulnerability: The extent to which a natural system or human society is unable to cope with the negative impacts of climate change, variability and extremes. It depends on changes in climate as well as the sensitivity and adaptive capacity of the system of society.

Glossary adapted from (Pittock 2003) and (Johnson and Marshall 2007).

Appendix 3: Climate Projection Scenario Maps for evaporation and sea surface temperature

Figure 1: Change in mean evaporation from 1990 to 2030 and 2070 for high emission scenarios (A2)

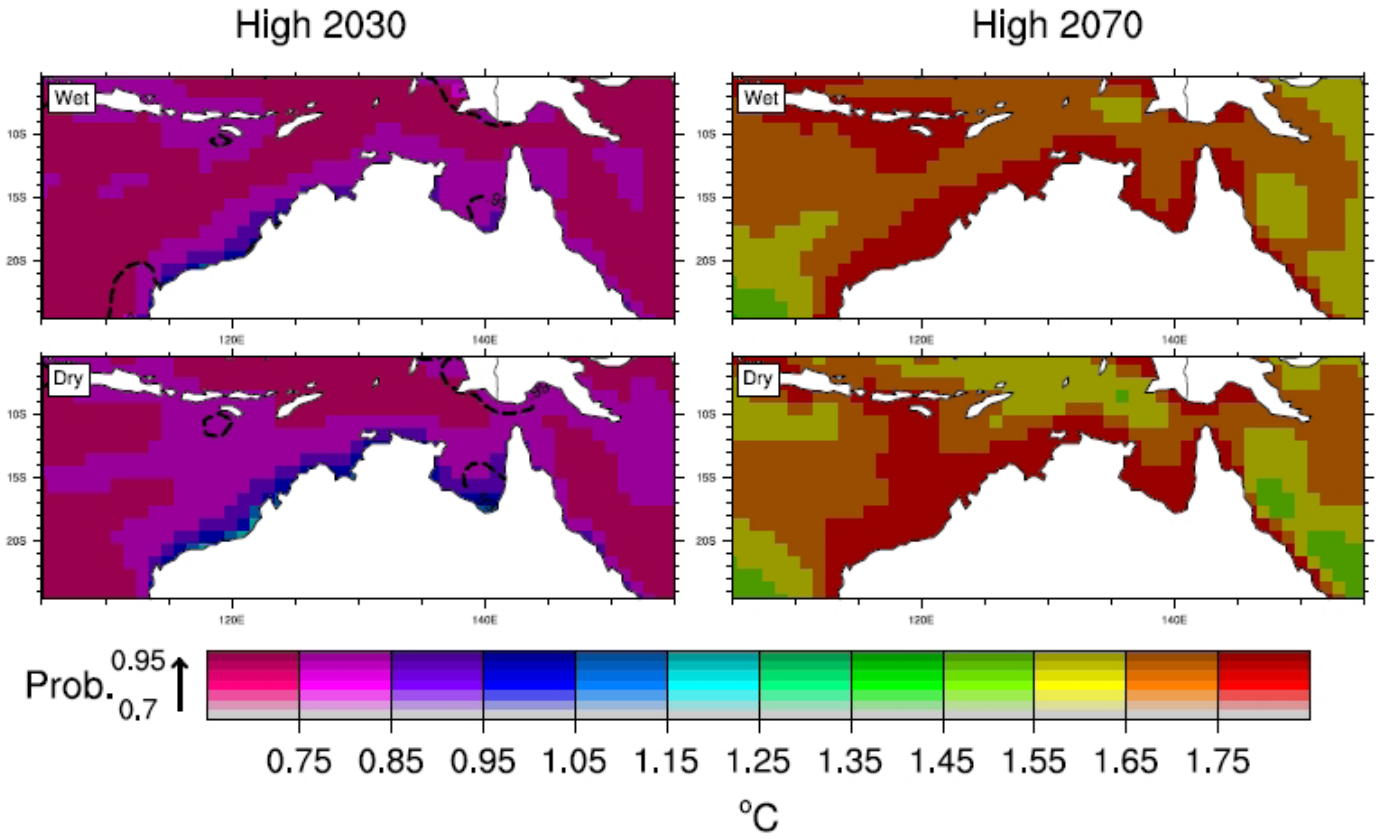


The hue represents the magnitude of the change, where red represents an increase of greater than 0.25 mm/day and pink represents a decrease of more than 0.05mm/day.

The saturation/intensity represents the change as the percent of 1990 levels, where grey represents a change of less than 4% of 1990 levels and the most intense (darkest) colour represents a change of greater than 20%.

Statistically significant areas are outlined by dashed contours representing the 0.9, 0.95 and 0.99 significance levels. In this case, no areas within Australia are significant.

Figure 2: Change in mean evaporation from 1990 to 2030 and 2070 for high emission scenarios (A2)



The hue represents the magnitude of the change where red represents an increase of more than 1.75°C and pink represents an increase of 0.75°C or less.

The saturation/intensity represents the statistical significance level of the change based on a Student's t-test of the GCM ensemble. Grey represents a statistical significance of less than 0.7, and the most intense (darkest) colours represent statistical significance of greater than 0.95.

Statistically significant areas are also outlined by dashed contours representing the 0.9, 0.95 and 0.99 significance levels. In this case, all sea surfaces have a statistical significance of greater than 0.99 except for a few coastal locations in 2030, which are still higher than the 0.95 significance level.

Appendix 4: Details provided to case study authors

Template:

A brief snapshot of 'the place'

- Total population of community
- Percent Indigenous in community
- Cultural autonomy – perhaps though strength of language
- Livelihood for majority of community (economic base)
- Social issues
- Strengths within community
- Potential climate impact concerns (from current state of knowledge)

Current constraints on community

- Transport infrastructure – does the community get cut off in the wet season? If so for how long, and is that a problem? Are their community buses linking to major service centre?
- Livelihood – have there been problems relating to changing CDEP status, the intervention etc.?
- Housing
- Communications
- Generational transfer of knowledge and school based educational opportunities

Response to previous natural hazards that might be of a similar nature to future anticipated climate impacts.

Previous natural hazards can be extreme weather events such as tropical cyclones or hot spells (3 consecutive days and nights above 35 degrees), or the effects of extreme events (storm surge, erosion, etc). The natural hazards used can be different region to region and more than one hazard may be used. The most important part of this section is the community response to a specific hazard, NOT a history of natural hazards for the area. The aim of this section is to identify the inherent resilience of communities to impacts.

Climate projections

For each nominated case study, a plausible selection of climate scenarios were developed from high emissions scenarios (A2) for either 2030 or 2070 using information from (Dunlop and Brown 2007) and (Hennessy et al 2007). The projection year was randomly assigned to each case study.

The climate scenarios developed included expected changes in average temperature and rainfall, sea surface temperature, sea level rise and examples of extreme weather events to consider such as tropical cyclones and changes to the length of the wet/dry seasons (if relevant to the region).

Authors were also provided with graphs of the average high and low temperatures for their region and the average rainfall for each month for use as visual aids regarding the projected lengthening of the dry season, and average temperature increases over the year.

	Port Hedland, Pilbara, WA	Yakanarra, Kimberley , WA	Borroloola, Gulf of Carpentaria, NT	Katherine, NT	Yellow Waters, Kakadu, NT	Maningrida, NT	Kowanyama, Cape York, QLD	Saibai Island, Torres Strait, QLD
year	2030	2030	2070	2030	2030	2070	2030	2070
Temperature change	avg 1.5 deg warmer over year	avg 2 deg warmer over year	avg 4 deg warmer over year	avg 1.5 deg warmer over year	avg 1.3 deg warmer over year	avg 4 deg warmer over year	avg 1.2 deg warmer over year	avg 4 deg warmer over year
Precipitation change	minus 4% in wet season, dry season ends 1 week later than usual	plus 3% in wet season, dry season starts 3 weeks earlier than usual	plus 15% in wet season, dry season ends 3 weeks later than usual	plus 3% in wet season, dry season ends 1 week later than usual	plus 10% in wet season, dry season ends 3 weeks earlier than usual	plus 10 % in wet season, dry season ends 2 weeks later than usual	plus 3% in wet season, dry season ends one week later than usual	minus 23% in dry season, plus 20% in wet season, dry season ends 3 weeks later than usual
Change in temperature extremes	40 additional days over 35 deg each year	45 additional days over 35 deg each year	no additional hot spells	no additional hot spells	50 additional days over 35 deg each year	no additional hot spells	no additional hot spells	no additional hot spells
Sea surface temperature change	1 deg warmer over year	n/a	1.5 deg warmer over year	n/a	n/a	1.7 deg warmer over year	0.8 deg warmer over year	0.8 deg warmer over year
Sea level rise	24cm higher	24cm higher	50cm higher	24cm higher	24cm higher	50cm higher	24cm higher	50cm higher
Past tropical cyclone to consider in response	Glenda and Ophelia	George	Ted and Cathy	George	Monica	Monica and Ingrid	Larry	Past tropical low in 2006

Suggested concern over scenario presented

This section should form a response to the projected climate scenario. Please consider the given the scenario presented, and discuss whether these impacts be problematic for the community to deal with. If so, which in particular – or is it the combination. If not, at what point is the community no longer able to deal with the given impacts if they got worse/more intense? Are there particular issues, such as extreme weather for e.g., that would cause concern?

Level of knowledge about climate change in the community

This section allows the community representative to add comments about the level of knowledge about climate impacts in the community, and whether they feel adequately informed about likely impacts. It would also be the appropriate place to add any other comments not fitting in any of the sections above.

Appendix 5: Population projections in the tropical north

Amongst those entering the labour force or undertaking post-compulsory education (aged 15 to 24 years), Indigenous Australians make up 33 per cent of the population of the tropical north. For females in peak childbearing age, roughly 20 to 39 years, Indigenous females make up 26.3 per cent of the population.

After applying fertility rates, there were a total of 10,175 births of Indigenous children to Indigenous mothers between 2006 and 2011 as well as 587 births of Indigenous children to non-Indigenous mothers (a total of 10,763 Indigenous children in total). This is compared to 21,242 non-Indigenous children born over the same period. So, while Indigenous Australians made up only 24.5 per cent of the population in the tropical north in 2006, around 33.6 per cent of births that were projected to occur over the next five year period were estimated to be identified as Indigenous. A small proportion of this was estimated to come from some children of non-Indigenous mothers being identified as Indigenous, however the main reason for such a high number of Indigenous births was the greater share of Indigenous females of childbearing age and the relatively high rates of fertility for most age groups.

It was estimated that 1,877 Indigenous males who were in the tropical north in 2006 will die over the five years that follow. This is much higher than the number of female deaths estimated to occur over the same period (1,488) reflecting the lower life expectancy of males relative to females. The corresponding number of deaths of non-Indigenous males was 4,812 and 3,034 non-Indigenous females. This much higher number of deaths of non-Indigenous males compared to females reflects the higher mortality rates as well as the higher number of males in the region.

Interestingly, there were a disproportionate number of non-Indigenous compared to Indigenous deaths over the period. What this means is that although age specific mortality rates are relatively high for the Indigenous compared to non-Indigenous population, this difference was not large enough to counterbalance the relatively young Indigenous population.

Table 1 below gives population estimates for the Indigenous and non-Indigenous populations for each five year period between 2006 and 2031. These are presented alongside the corresponding annualised growth rate (in percentage terms).

Table 1 Population projections in the tropical north assuming zero net internal mobility – Indigenous and non-Indigenous 2006 to 2031

	Population		Annualised growth rate (%)	
	Indigenous	Non-Indigenous	Indigenous	Non-Indigenous
2006	87,173	268,055		
2011	93,849	290,398	1.49	1.61
2016	101,645	309,437	1.61	1.28
2021	112,471	329,686	2.04	1.28
2026	122,966	347,277	1.80	1.05
2031	133,045	363,318	1.59	0.91

Between 2006 and 2011, the Indigenous population of the tropical north is projected to grow from 87,173 to 93,849 in the absence of internal migration. This is equivalent to an annual growth rate of 1.49 per cent per annum.

Over subsequent five year periods, the rate of growth of the Indigenous population is expected to increase (at least up until the five years between 2016 and 2021). This reflects the movement of the large cohort of 0 to 14 year old Indigenous females from Figure 1 into childbearing age. Over the entire 25 year period for which calculations were made, the Indigenous population is projected to grow at an annual rate of 1.71 per cent compared to an annual growth rate for the non-Indigenous population of 1.22 per cent. If these projections eventuate, then the population in the tropical north will become slightly more Indigenous with the share of the population rising from 24.5 per cent to 26.8 per cent.

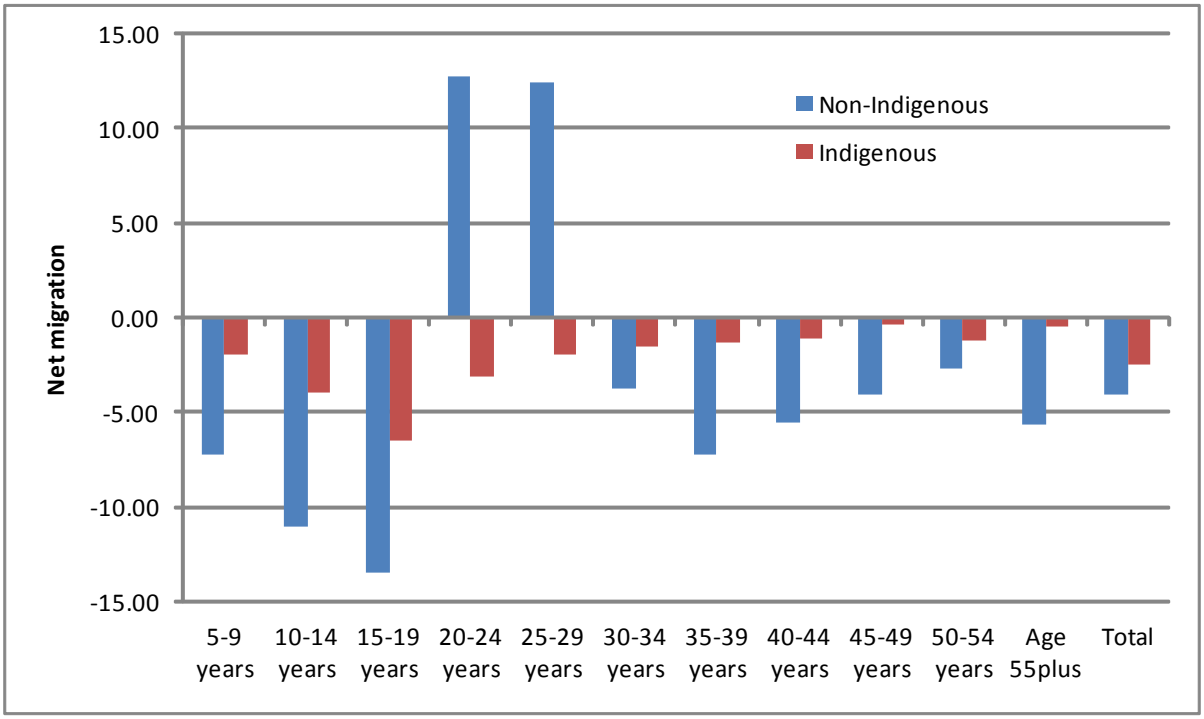
In terms of composition, it is projected that in 2031 there will be a slightly lower proportion of Indigenous Australians in the tropical north aged under 15 years than in 2006 (34.6 per cent compared to 35.9 per cent) but a substantially higher proportion of Indigenous Australians aged 55 years and over (12.1 per cent compared to 8.1 per cent).

Unless the external (or internal) migrants that arrive in the tropical north are substantially younger than the 2006 population, there will be the same issue of a rapidly aging non-Indigenous population in the tropical north as there is for Australia as a whole. An example of the economic impact of this relative aging can be found by comparing the share of the population of prime working age (20 to 54 years old) that were Indigenous in 2006 (21.2 per cent) with the projected share of the same population in 2031 (28.8 per cent). The labour force is projected to become much more Indigenous over the period.

Population projections under various assumptions on net migration

In this section, the migration rates that occurred between 2001 and 2006 by five year age cohort into and out of the tropical north are assumed to hold over the subsequent inter-censal periods. (Migration rates for those aged 55 years and over are pooled due to low sample sizes). These rates of migration are given in Figure 1 below for the tropical north with net migration rates for the rest of Australia calculated similarly.

Figure 1 Net migration into the tropical north between 2001 and 2006 – Indigenous and non-Indigenous by age



Using the above rates of net internal migration, Table 2 gives Indigenous and non-Indigenous population estimates as well as the corresponding annualised growth rate.

Table 2 Population projections in the tropical north assuming historic rates of net internal mobility – Indigenous and non-Indigenous 2006 to 2031

	Population		Annualised growth rate (%)	
	Indigenous	Non-Indigenous	Indigenous	Non-Indigenous
2006	87,173	268,055		
2011	91,655	280,403	1.01	0.90
2016	96,817	290,025	1.10	0.68
2021	104,302	301,305	1.50	0.77
2026	110,911	309,032	1.24	0.51
2031	116,606	313,251	1.01	0.27

If the patterns of migration that occurred between 2001 and 2006 were to hold over subsequent inter-censal periods then the results presented in Table 2 project that the Indigenous population will grow from 87,173 people in 2006 to 116,606 in 2031. While this represents a much slower rate of growth than that which was projected in the absence of net migration (1.17 per cent per annum over the period compared to 1.71 per cent) the difference is even greater for the non-Indigenous population.

The patterns of migration that occurred between 2001 and 2006 are likely to be influenced in part by the particular circumstances of that time period. This includes the economic conditions, government policy and the state of the environment (including climate). There is, of course, no guarantee that such conditions will prevail over the next inter-censal period, let alone the remainder of the 25 years for which projections have been made. As an example, the Northern Territory Emergency Response had not been conceived at the time of the 2006 Census, however there is every possibility that it had an impact on the level and composition of migration into and out of, as well as within the Northern Territory.

In order to test the sensitivity of the results to different migration assumptions, two alternative projections are created based on separate migration scenarios. These are outlined below:

• Scenario 1 – Major government investment in northern Australia resulting in sustained net inward migration. Under this scenario, for all age groups where there was a net outflow between 2001 and 2006, rates of migration are assumed to be of the same magnitude as in Figure 3 but in the opposite direction. For example, rather than there being a net outflow of Indigenous Australians aged 30 to 34 years of 1.51 per cent, a net inflow of 1.51 per cent is assumed. The rates of migration for non-Indigenous Australians aged 20 to 29 are assumed to be the same under this scenario as those presented in Figure 2.

• Scenario 2 – Sustained out migration of northern Australia due to rising temperatures and unpleasant conditions. Under this scenario, the two age groups with substantial positive net inward migration (non-Indigenous Australians aged 20 to 24 and 25 to 29) that replenished to a certain extent the outflows of the remainder of the population are assumed to have a zero rate of net migration. All other rates remain the same.

Under Scenario 1, the Indigenous population is projected to almost double from 87,173 in 2006 to 152,250 in 2031. This equates to an annual growth rate of 2.26 per cent. The non-Indigenous population, on the other hand, is expected to grow at an even faster rate – 2.52 per cent per annum on average – and expand from 268,055 to 498,898.

Under Scenario 2, the projections for the Indigenous population are the same as in Table 2. For the non-Indigenous population, on the other hand, growth over the period is projected to be negligible at 0.22 per cent per annum with a population at the end of the period of 283,126. Indeed, over the last inter-censal period for which projections are made (2026 to 2031) the non-Indigenous population is projected to decline slightly.

Clearly, the above two scenarios show that the assumptions that one makes regarding rates of net migration have a substantial impact on the projected population into the future. While neither of the scenarios represent forecasts with built in behavioural assumptions, they are nonetheless far from extreme assumptions and fit within the bounds of possibility.

In addition to populations in isolation which are given in Appendix Tables A1 and A2, the different scenarios also have very different impacts on the Indigenous share of the population.

This is summarised in Figure 2 below which gives the per cent of the population who are projected to identify as being Indigenous under the two scenarios outlined above, as well as the scenarios of zero net migration and historical (2001 to 2006) net migration rates.

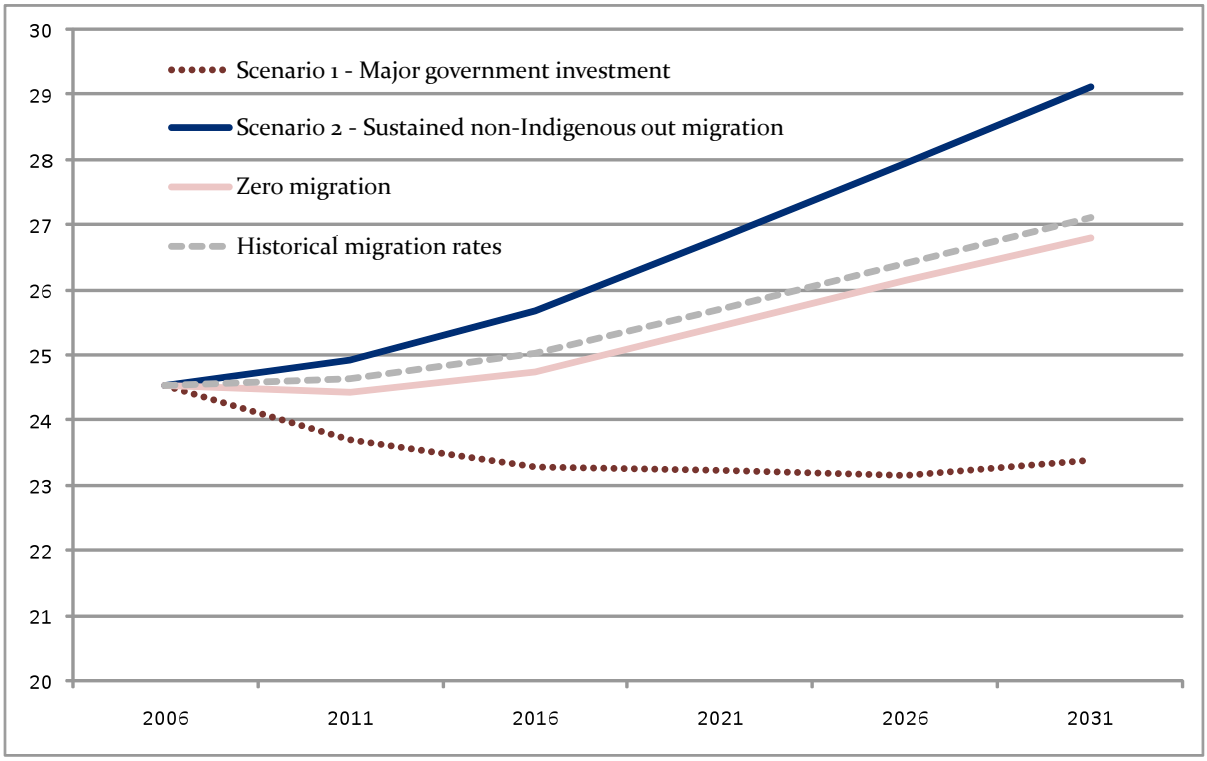


Figure 2 Percentage of population projected to identify as Indigenous

Under the zero migration and historical migration rates assumptions, the Indigenous share of the population is projected to increase steadily from 24.5 per cent to 26.8 per cent and 27.1 per cent respectively. Most of this growth comes from the higher rates of fertility of the Indigenous population as well as the younger age structure.

Under Scenario 1, a major government investment in northern Australia is projected to result in a decline in the Indigenous share of the population to 23.4 per cent. On the other hand, if there is sustained net out migration of the non-Indigenous population due to unfavourable climactic conditions, then this will clearly result in a greater share of the Indigenous population by the end of the period (29.1 per cent).

Appendix 6: Remote governance structural principles

Successful structural principles and institutional practices for remote governance, built on those recommended by the Indigenous Community Governance Project (from Hunt & Smith 2007), with key additional concepts in italics from sources as footnoted, and the italicised headings added to emphasise why these issues are particularly important in remote regions.[a]

Subsidiarity and scale – different operational models in sparsely populated areas
• **balancing** dispersed local residence with a larger-scale representative voice • *allowing different ways of operating in different localities, nested within a regional system that may also differ in detail between regions (**'polycentricity'**)* [b] • locating decision-making responsibility at the closest possible point of connection to the people affected, and making decisions at higher levels *only* when more inclusive matters require such consideration (i.e. '**subsidiarity**') • emphasising relatively **egalitarian relationships** between organisations, groups and kinship units, with each component of the network having relative autonomy while also having nodes of concentrated power and authority within networks (i.e. 'relational autonomy') • *recognising that service delivery may occur at a **different scale** and in different organisations to the governance of that service* [c]
Connectivity and networking – harder yet more important in remote areas
• networking governance so that arrangements encompass **layers** of groups, organisations and communities, each with its own roles, authority and responsibilities • working out governance by **first working out relationships** and shared connections, thereby giving effect to the interconnectedness needed for networked governance • working through the governance **histories** of the constituent social and organisational layers in order to reinforce or develop new connections • **strengthening** the connections (both internal and external) within and between networks, in order to support vulnerable components
Building capacity – particularly lacking or unstable in small communities
• **'nodal' leadership**, where key individuals are able to mobilise, rebuild and sustain networks and resources • **supporting** the capacity, role and responsibility of all the layers in a governance network, not just the 'top' or central levels • *emphasising **downwards accountability** to constituents over upwards accountability to higher level bureaucrats* [d] • a focus on **building** the institutions and internal 'culture of governance' needed within [Indigenous] organisations to sustain practical effectiveness and legitimacy

[a] Stafford Smith (2008), Stafford Smith & Cribb (2009).
[b] Ostrom (1999), Marshall (2008)
[c] Stafford Smith *et al.* (2008), Stafford Smith & Cribb (2009)
[d] Moran & Elvin (2009)

Appendix 7: Annotated bibliography

Climate change resources:

ACE-CRC, 2008. *Position analysis: climate change, sea-level rise and extreme events: impacts and adaptation issues*, Antarctic Climate and Ecosystems Cooperative Research Centre.

Outlines recent developments in science regarding rising sea level, related hazards, and the potential impact on Australia and neighbouring countries.

Adger, W.N., 2006. 'Vulnerability'. *Global Environmental Change*, 16(3), 268-281.

Considers historic research approaches to environmental vulnerability. Draws relationships between different disciplines approaches to framing vulnerability.

Garnaut, R., 2008. *Garnaut Climate Change Review,* Cambridge University Press, Melbourne.

Outlines Australia's responses to climate change and mitigation. Focuses primarily on mitigation for controlling climate change impacts and enhancing Australia's economic prospects.

Hennessy, K., Page, C., McInnes, K., Walsh, K., Pittock, B., Bathols, J. and Suppiah, R. 2004. *Climate change in the Northern Territory. Consultancy report for the Northern Territory Department of Infrastructure, Planning and Environment by CSIRO Atmospheric Research Climate Impact Group and Melbourne University School of Earth Sciences.* Northern Territory Government, Darwin.

Assessment of observed and projected climate change over the Northern Territory. Includes a sector-based risk assessment. Identifies knowledge gaps for further research.

Hennessy, K., Fitzharris, B. Bates, B.C., Harvey, N., Howden, S.M., Hughes, L., Salinger, J. and Warrick, R., 2007. 'Australia and New Zealand'. *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change,* In Parry, M.L., Canziani, O.F., Palutikof, J.P., van der Linden, P.J., and Hanson, C.E., (eds), Cambridge University Press, Cambridge, UK, 507-540.

Latest IPCC / government sanctioned document regarding Australian and New Zealand's climate sensitivities, vulnerabilities and impacts. Considers specific sector impacts and case studies for adaptation.

Johnson, J.E. and Marshall, P.A. (eds) 2007. *Climate Change and the Great Barrier Reef: A Vulnerability Assessment*, Great Barrier Reef Marine Park Authority and The Australian Greenhouse Office, Australia.

Definitive study of the vulnerability of the Great Barrier Reef to climate change. Considers exposure, sensitivity and impacts of various climate change related events.

Middelmann, M.H. (ed), 2007. *Natural Hazards in Australia: Identifying risk analysis requirements.* Geoscience Australia, Canberra.

Concise overview of the potential risks of natural hazards including cyclones, floods, severe storms and bushfires, which might be expected more frequently due to climate change.

Pearse, K., Holper, P., Hopkins, M., Bouma, W., Whetton, P., Hennessy, K., and Power, S., 2007. *Climate Change in Australia: technical report 2007*, CSIRO.

Technical report of observed climate changes over Australia. Also discusses past climate change, global and regional projections and their use in risk assessments.

Pittock, B., 2003. *Climate Change: An Australian Guide to the Science and Potential Impacts*. Australian Greenhouse Office, Canberra.

Review of climate change facts and uncertainties and the likely impacts in Australia. Considers vulnerability and adaptation potential and policy advice.

Queensland Department of Emergency Services, 2004. *A Guide to Disaster Risk Management in Queensland Aboriginal and Torres Strait Islander Communities Queensland Government*, Brisbane.

Plain English document guiding the reader through the development of a risk management strategy, focussing on Queensland's Indigenous communities.

Voice, M., Harvey, N. and Walsh, K. (eds), 2006. *Vulnerability to Climate Change of Australia's Coastal Zone: Analysis of gaps in methods, data and system thresholds*, Australian Greenhouse Office, Canberra.

Provides a concise summary of the extent of knowledge (including gaps) of: methods for assessing potential impacts of climate change on coastal systems; the data required to conduct such assessments; and the scientific understanding of the sensitivity of coastal systems to climate change, including climate related thresholds.

Indigenous resources:

ACIA, 2005. 'How will climate changes affect indigenous communities?'

Brief factsheet dealing with observations of Indigenous peoples regarding indications of climate change in the Arctic. Considers threats unique to the polar regions.

Aboriginal and Torres Strait Islander Social Justice Commissioner, 2008. *Native Title Report 2008*, Australian Human Rights Commission, Sydney.

Report focused to provide an overview of changes to native title law and policy and summarise native title cases that were heard during the reporting period. The second half of the report focuses on climate change and water policy.

Arthur, B. and Morphy, F. (eds), 2005. *Macquarie Atlas of Indigenous Australia*, Macquarie University, NSW.

Broad ranging geographical text on Indigenous Australians. Considers cultural, economic and political spaces through colonial and pre-colonial periods.

Indigenous Summit, 2009. 'Indigenous Peoples' Global Summit on Climate Change Declaration'.

Declaration of solidarity of Indigenous peoples in a call upon governments, states and the UN bodies to respond to climate change, and offering their relevant traditional knowledge practices in assistance.

Henriksen, J.B., 2007. *The Impacts of Climate Change and Accelerated Threats on Traditional Knowledge, Innovations and Practices: The Specific Vulnerabilities of Indigenous and Local Communities of the Arctic, Small Island States and High Altitudes*. Secretariat of the Convention on Biological Diversity. United Nations.

Provide examples of Indigenous traditional knowledge, innovations and practice and their vulnerabilities to climate change, as well options for mitigation and adaptation. Also considers issues specific to highly vulnerable regions.

Tebtebba, 2008. *Guide on Climate Change and Indigenous Peoples*, Tebtebba Foundation, Philippines.

Indigenous-authored guide for Indigenous peoples and others on the likely impacts of climate change, adaptation and mitigation on Indigenous peoples.

Education resources:

Barnsley, I., and NAILSMA, 2009. *A Carbon Guide for Northern Indigenous Australians*, United Nations University Institute of Advanced Studies, Japan.

Plain language guide outlining the development of carbon trading schemes and potential relevance to Northern Indigenous Australians. Outlines potential interactions between an emissions trading scheme and Indigenous controlled burning practices.

Biddle, N., 2007. *Does it pay to go to school? The benefits of and participation in education of Indigenous Australians,* PhD thesis, Australian National University.

This looks at education outcomes of Indigenous Australians. It considers two main questions: (I) the relative benefits of education for the Indigenous population and how higher education levels report better health outcomes and (II) what factors are associated with the decision to attend high school.

Hughes, H., 2008. Indigenous Education in the Northern Territory. *CIS Policy Monograph 83*, Centre for Independent Studies.

Argues that Indigenous disempowerment results from lack of mainstream (language) skills. Suggests bilingual education has failed thousands of Indigenous students by failing to prepare them for effective entry into the mainstream economy/society.

Biodiversity resources:

Campbell A., 2008. *Managing Australian Landscapes in a Changing Climate: A climate change primer for regional Natural Resource Management bodies.* Department of Climate Change, Canberra.

Primarily concerned with the development of NRM bodies. Considers challenges posed by climate change and their potential role in addressing these.

Dunlop, M. and Brown, P., 2008. *Implications of Climate Change for the National Reserve System*, CSIRO Sustainable Ecosystems.

Considers the likelihood of significant changes to Australia's natural reserves due to the impacts of climate change. Argues significant changes will need to be made to the natural reserve system for it to continue to be effective.

Jackson, S. & O'Leary, P., 2006. *Indigenous Interests in Tropical Rivers: Research & Management Issues; A Scoping Study for Land and Water Australia's Tropical Rivers Program prepared for the North Australian Indigenous Land and Sea Management Alliance (NAILSMA)*, CSIRO.

Investigation of concerns surrounding aquatic environments and their use in Australia's tropics. Makes recommendations for future studies and enterprises in this region.

Hilbert, D., Hughes, L., Johnson, J., Lough, J., Low, T., Pearson, R., Sutherst, R. and Whittaker, S., 2007. *Biodiversity conservation research in a changing climate*, Australian Government Department of the Environment and Water Resources, Canberra.

Assesses research and information needs for the implementation of the National Biodiversity and Climate Change Action Plan, noting the limitations of science and gaps in information.

Monaghan, J., 2004. *Living on Saltwater Country. Review of literature about Aboriginal rights, use, management and interests in northern Australian marine environments - Cape York Peninsula*, National Oceans Office.

Scoping study and literature review regarding Indigenous relations with the sea. Highly relevant as specific to northern Australia, Indigenous communities and their connection to coastal resources.

Steffen, W., Burbidge, A.A., Hughes, L., Kitching, R., Lindenmayer, D., Musgrave, W., Stafford Smith, M. and Werner, P., 2009. *Australia's Biodiversity and Climate Change*. CSIRO Publishing, in press.

Assessment of climate change vulnerability of (primarily) terrestrial Australian biodiversity. Considers future policy options and their strategic value.

Health resources:

AIHIN, 2008. Australian Indigenous HealthInfoNet, Available at: http://www.healthinfonet.ecu.edu.au/

Plain language review of Australian Indigenous health statistics, trends and patterns. Considers Indigenous wellbeing individually and in comparison to non-Indigenous groups.

Campbell, D., Stafford Smith, M., Davies, J., Kuipers, P., Wakerman, J., and McGregor, M.J., 2008. 'Responding to health impacts of climate change in the Australian desert', *Rural and Remote Health [online]*, 8, 1008.

Consideration of direct and indirect impacts of climate change on the Australian desert and desert community. Relevant for Pilbara region.

Currie, B., 2001. 'Environmental Change, Global Warming and Infectious Diseases in Northern Australia', *Environmental Health*, 1(4), 34-43.

Discusses likely health impacts of increased range and survival of pathogens due to climate change in Northern Australia. Identifies specific diseases likely to increase in transmission and severity.

Garnett, S. and Sithole, B., 2007. *Sustainable Northern Landscapes and the Nexus with Indigenous Health: Healthy Country Healthy People*, Land and Water Australia, Canberra.

Demonstrates a significant link between health of Indigenous land and Indigenous people. Areas covered note that lower rates of diabetes and cardiovascular disease, and better general health were observed in people taking part in customary and contemporary land and sea management practices, particularly those living in traditional homelands.

Green, D., 2006. *Climate Change and Health: impacts on remote Indigenous communities in northern Australia*, CSIRO Marine and Atmospheric Research. Available at: http://www.sharingknowledge.net.au/files/climateimpacts_health_report.pdf

Comprehensive review of likely Indigenous health impacts from climate change. Calls for a different approach to Indigenous health given integrated connections between health and landscapes.

McMichael, A.J., Woodruff, R.E. and Hales, S., 2006. 'Climate change and human health: present and future risks', *Lancet*, 367(9513), 859-869.

Investigates likely interactions between climate change and human health, and evidence for existing correlations. Considers the likely impacts of specific climate related events on health.

Weaver, H., Berry, H., Beggs, P., Currie, B., Higgins, J., Kelly, B., McDonald, J., Saverimuttu, T., and Tong, S., 2008. NCCARF National Adaptation Research Plan (Human Health) Consultation Draft.

Identifies gaps in knowledge on Indigenous health impacts. Call for research into impacts on living and cultural conditions, into intergenerational health and social inequality arising from climatic changes, and how community adaptation can be facilitated.

Infrastructure Resources:

ATSE, 2008. *Assessment of Impacts of Climate Change on Australia's Physical Infrastructure*, The Australian Academy of Technological Sciences and Engineering, Parkville, Victoria.

Qualitative study of the impacts of climate change on Australian infrastructure including in coastal settlements, electricity distribution and transmission, water supply, and port operations.

CHINS, 2006. *Community Housing and Infrastructure Needs Survey (CHINS)*, Australian Bureau of Statistics.

ABS study of community housing and infrastructure needs for Aboriginal and Torres Strait Islander communities. Principle requirement was to maintain consistency with 2001 study, so as to assess policies implemented since that time.

EMA, 2007. *Keeping Our Mob Safe: A national emergency management strategy for remote Indigenous communities*, Emergency Management Australia, Canberra.

Details strategy aiming to improve emergency management outcomes through the development of local Indigenous skills and appropriate emergency management services, capacity building, and effective partnerships between relevant organisations.

FaHCSIA, 2007. *National Indigenous Housing Guide: Improving the Living Environment for Safety, Health and Sustainability*, FaHCSIA, Canberra.

Resource designed to improve health and living environment standards for Aboriginal and Torres Strait Islander peoples through the development of housing standards for building and maintenance.

QDES, 2004. *A Guide to Disaster Risk Management in Queensland Aboriginal and Torres Strait Islander Communities*, Queensland Department of Emergency Services.

Plain language guide for considering disaster risk management in Aboriginal and Torres Strait Islander communities. Outlines concerns to be considered and basic matrices for identifying potential risks.

Yu, P., Duncan, M. & Gary, B., 2008. *Northern Territory Emergency Response: Report of the NTER Review Board, October 2008*, Commonwealth of Australia, Canberra.

2008 report on the effectiveness and success of the NTER. Despite concern that the objectives sought cannot be fully implemented without willing community participation, opines that the NTER needed to continue.

Livelihood resources:

Altman, J.C., 2001. 'Sustainable development options on Aboriginal land: The hybrid economy in the twenty-first century', *CAEPR Discussion Paper*, No.226/2001.

Paper seeks to broaden the notion of economy to include the customary economy. Discusses the articulations of the state, customary and private economies.

Altman, J.C. and Jackson, S., 2008. 'Indigenous land and sea management', In Lindenmayer, D., Dovers, S., Hariss Olson, M. and Morton, S. (eds). *Ten Commitments:reshaping the Luck Country's environment,* CSIRO, Victoria.

Argues for acknowledgement of the significance of Indigenous management of the environment and for a more integrated management approach between Indigenous and non-Indigenous peoples.

Altman, J.C. and Whitehead, P., 2003. 'Caring for country and sustainable Indigenous development: Opportunities, constraints and innovation', *CAEPR Working Paper, No. 20.*

Identifies links between Indigenous natural resource management, conservation and increasing economic benefits. Argues that land under Indigenous management receives ecological benefits while raising the possibility of economic benefits through land use.

Baker, R., Davies, J. & Young, E., 2001. *Working On Country: Contemporary Indigenous Management of Australia's Lands and Coastal Regions*, Oxford University Press, Melbourne.

A comprehensive account of Indigenous land and water management in Australia. Draws upon Indigenous solutions to emphasise practical methods to manage the country more sustainably.

Gerrard, E. 2008. *Impacts and opportunities of climate change: Indigenous participation in environmental markets,* Land, Rights, Laws: Issues of Native Title, Native Title Research Unit, AIATSIS, Canberra.

Discusses challenges of climate change and opportunities for Indigenous people under the Aboriginal Land Rights Act to participate in environmental markets.

House of Representatives Standing Committee on Aboriginal and Torres Strait Islander Affairs. 2008. *Open for Business: Developing Indigenous enterprises in Australia*, Australian Government, Canberra.

Report on strategies for increasing sustainable Indigenous enterprises. Discusses government policy support for land management as an economic opportunity in northern Australian savannas.

O'Faircheallaigh, C., 2008. Negotiating Cultural Heritage? Aboriginal-Mining Company Agreements in Australia. *Development and Change*, 39(1), 25-52.

Analyses agreements between mining companies and Indigenous groups for their potential to protect Indigenous interests. Argues that while under specific terms, agreements can provide economic benefits while protecting cultural interests, significant minorities fail to reconcile the two.

Putnis, A. et al. (2007). *Healthy Country, Healthy people: Supporting Indigenous Engagement in the Sustainable Management of Northern Territory Land and Seas: A Strategic Framework*, CSIRO Sustainable Ecosystems, Darwin.

Comprehensive discussion of the current state of affairs in the emerging Indigenous land and sea management sector in the Northern Territory, and the potential for its future investment and growth. Includes coverage of current fee-for-service opportunities and engagement with the conservation economy.

Taylor, J. and Scambary B, 2005. *Indigenous people and the Pilbara mining boom: A baseline for regional participation,* ANU E Press, Canberra.

Considers the ability of Indigenous-mining agreements in the Pilbara region to provide long term economic benefits to Indigenous communities, with or without the presence of training and education requirements.

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