

# Garnaut Climate Change Review

## Climate impacts on the health of remote northern Australian Indigenous communities

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February 2008

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# 1 Summary

Climate change has already directly and indirectly impacted the health and well-being of thousands of people across Australia. However, these impacts are not spread equally across our society: vulnerability depends on a number of factors including the degree of exposure, sensitivity and adaptive capacity of the individual or community. Indigenous Australians living in remote communities in the north and central regions of the country are likely to be disproportionately disadvantaged by climate change. Their vulnerability is heightened due to at least two factors: existing non-climate stresses, and a culture that does not necessarily differentiate between natural and human systems in relation to the concept of 'health'. The first factor reduces a community's resilience to a changing environment, the second factor suggests that biophysical changes affecting the 'health' of an ecosystem are likely to also impact individuals' physical and mental well-being, as well as the 'health' of a community's cultural cohesion. This interconnection between Indigenous Australians' 'country' and community well-being means that assessments of how climate change is likely to affect Indigenous people's health must also factor in climate impacts on the land and marine ecosystems of their country.

In developing resilience-building activities to climate impacts, it is crucial that the socio-economic factors that have caused existing disadvantage in these communities be addressed simultaneously. For example, much of the inadequate and often culturally inappropriate health facilities and education infrastructure needs to be improved across the north. Other built infrastructure such as roads, airstrips and public buildings will need to be planned with not only 'climate-proofing' in mind, but with an eye on the increasing population in this region. On a positive note, there are some potential economic and employment advantages created by new national and international climate change policies. The West Arnhem land fire abatement project is one such example, that has taken a highly inclusive approach to working on country with the Traditional Owners.

A comprehensive assessment of the key health vulnerabilities and potential socio-economic opportunities is currently hindered by a lack of regional scale climate projections. Presently, these are not available beyond a state or territory level for many inhabited areas in Northern Australia. For regional projections to be performed and then communicated to the stakeholders in a meaningful way for adaptation policies to be decided upon and put in place, a highly participatory approach with the land owners needs to be taken from the outset. Collaboration between the Traditional Owners and scientists who are aware that they need to provide feedback in plain English will be a vital first stage to begin to explore the direct and indirect impacts in this region with the major stakeholders. Natural scientists need to recognise that traditional knowledge about climate change is potentially an important source of data. Efforts should be made to engage with the holders of this knowledge to consider its appropriateness for guiding adaptation strategies.

In coming years, the nature, scale and additional costs of climate change in adding to the health burden of remote Indigenous communities will depend significantly on emissions mitigation efforts, as well as what kind of anticipatory adaptation strategies are put in place. An assessment of the costs associated with the health impacts of climate change in these communities needs to include damage to intangible cultural assets, and an acknowledgement of the potential costs associated with reduction or loss of traditional environmental knowledge of local biodiversity, as well as the biodiversity itself.

## **2 Northern Australian regions covered in this assessment**

Many discrete Indigenous communities located in the north live on country that has been legally recognised as belonging to them, or is subject to native title determination. However, the influence of colonial policy on the location and distribution of these communities can still be clearly seen with many communities still located near former mission stations or government settlements (Arthur and Morphy, 2005). In recent decades, the 'outstation movement' has established a number of very small communities by people wanting to return to and care for their ancestral lands including in very remote areas of the Kimberley, central arid lands and across Arnhem land. This movement was also an expression of the dissatisfaction with overcrowded communities and former missions. As a consequence of this history, communities are currently distributed in a wide variety of ecosystems: from the Western Australia coastal regions of the Kimberley through to the central deserts; the low-lying salt and freshwater ecosystems of Kakadu and the stone escarpments of Arnhem land; along the low-lying coastline in Gulf of Carpentaria into the tropical rainforest areas of northern Queensland; and in the extreme northeast, on a number of small, low-lying islands in the Torres Strait. Approximate locations of these communities are shown in Figure 1.

### 3 Climate change projections

The Garnaut review has indicated a limited range of emission scenarios to be considered in this impact assessment.<sup>1</sup> Climate projections for the near-term (2030) show similar patterns of regional change with small variation between climate models due to the influence of greenhouse gases already emitted. However, for the longer term, climate projections show greater dependency on the emission scenario followed, and therefore, it is reasonable to assume that there would be a smaller health burden for the lower emission scenarios.

All projections indicate that the central and western deserts will have the greatest average warming in Australia. In the high emission scenarios, temperatures are raised by up to 6°C by 2070 with a significant number of regions feeling an increase in the number of hot spells (a three day period where the temperature is over 35°C) (Dunlop and Brown, 2007).

Projections of precipitation for 2030 and 2070 indicate an increase in extremes: roughly translating to more rain in the rainy season and more extreme and longer dry/drought periods in the north.<sup>2</sup> For example, in some areas, monsoonal rain is projected to increase by 23 per cent, and the loss of nearly all precipitation in the dry season for the most severely affected regions (Green, 2007; Dunlop and Brown, 2007).

For many coastal communities, including those along coastal Arnhem land or the offshore islands of the Kimberley and Torres Strait, sea level rise as well as more intense or more frequent storm surges are one of their greatest concerns. Whilst the scientific debates around the increase in frequency or intensity of tropical cyclones (which affect storm surges heights) for coastal communities are not resolved (Walsh et al., 2008) the inevitable slow onset sea level rise caused by the thermal expansion of the oceans and melting land ice will make large sections of coastline, low-lying wetland areas and off-shore islands more susceptible to increased erosion and saltwater inundation (Rosenzweig et al., 2007).<sup>3</sup> Green (2007) provides online access to several maps of vulnerable inhabited low-lying coastal regions in Northern Australia (see Figure 2).

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<sup>1</sup> See main report for specific scenarios selected.

<sup>2</sup> The uncertainty around precipitation projections is greater than for that of temperature.

<sup>3</sup> These impacts are especially hard to quantify because sea level rise does not exhibit a uniform response globally due to variation in ocean density and circulation. Another difficulty is a lack of data from the southern hemisphere which makes the impact of long-term, non-climate-related trends usually associated with vertical land movements hard to understand.

Figure 1 Location of remote Indigenous communities in northern Australia with some climate impact 'hotspots'

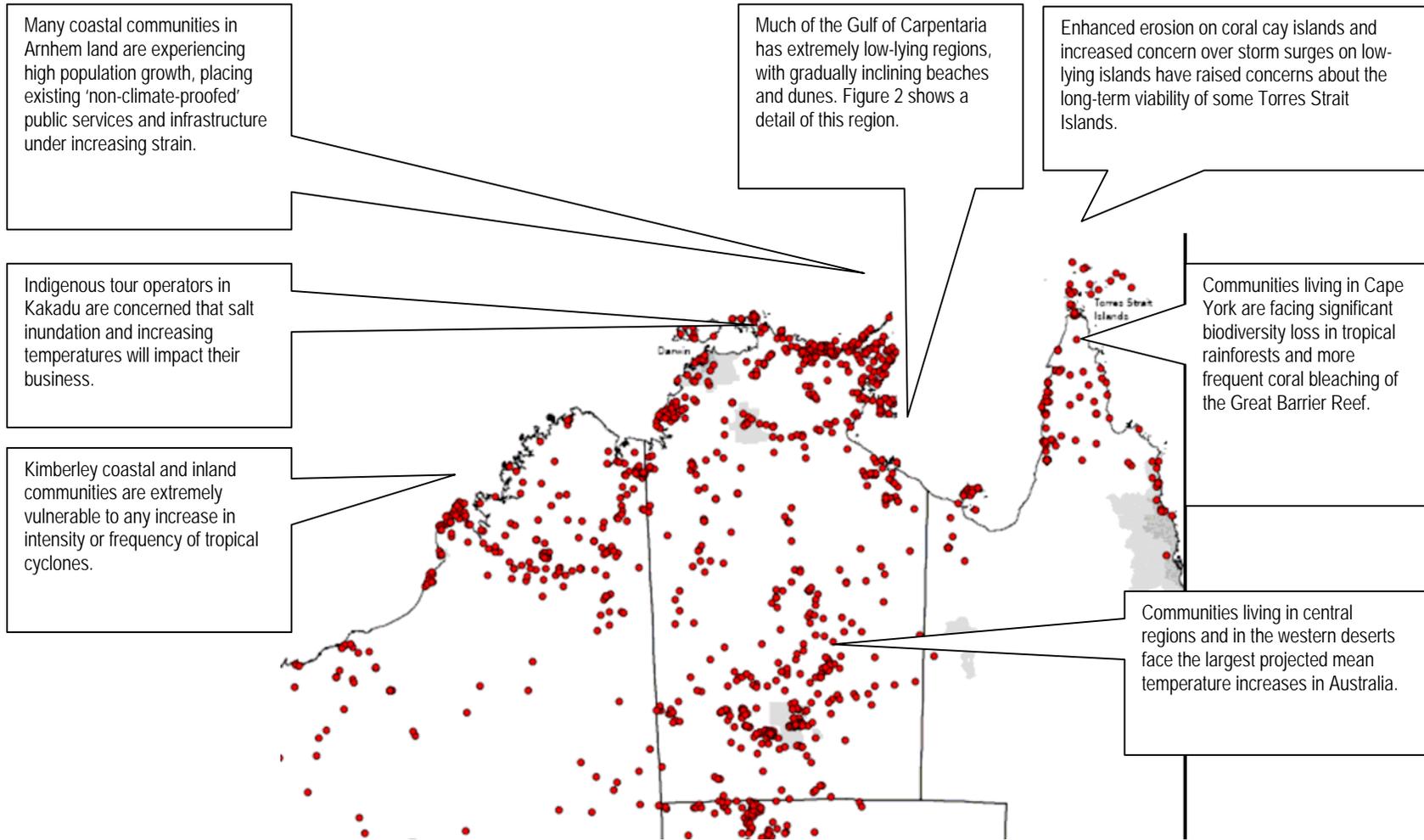
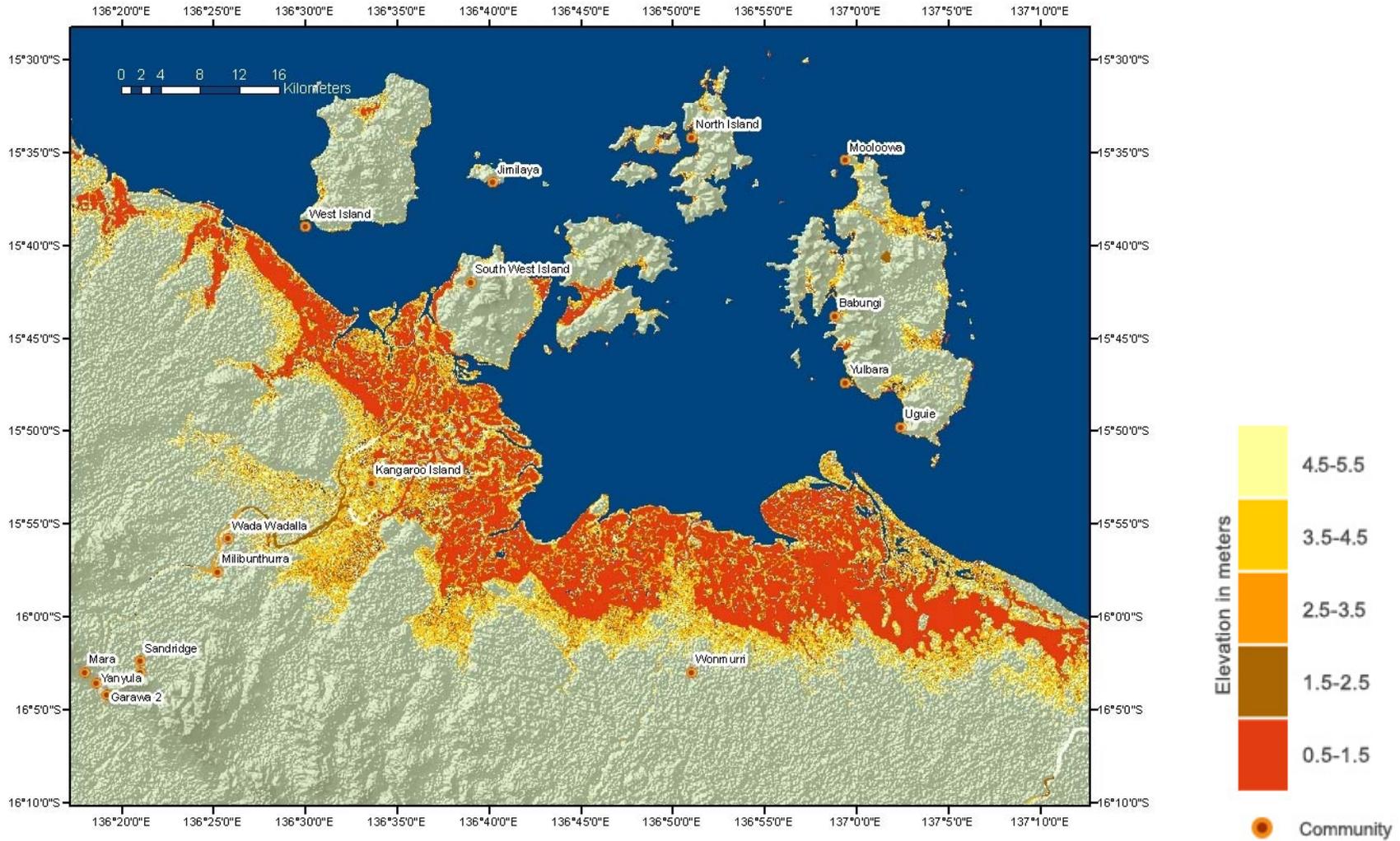


Figure 2 A section of the Gulf of Carpentaria showing inhabited low-lying areas and off shore islands



## 4 Health impacts

There is a limited literature on the health impacts caused by climate change for the Australian population. The report, *Climate Change Health Impacts in Australia*, does identify the impact of various greenhouse gas emission mitigation strategies on health, but does not specifically assess impacts for Indigenous populations (Woodruff et al., 2005). Of more relevance to Indigenous communities, Currie (2001) highlights the potential impacts of climate change in north specifically focusing on infectious disease patterns (Currie, 2001). Concerns have been raised that climate change could allow the increase of new diseases, such as avian influenza, to enter Australia from the north; and for new pests, such as screw fly, to infest feral animals, however these concerns have not yet been quantitatively assessed or documented (J. Morrison pers. comm., 2008). Green (2006a) provides the most up to date compilation of likely health impacts for Indigenous Australians; and a revised, summarised version of these findings follows (Green, 2006a).

Changes in temperature, humidity, amount and timing of rainfall and sea-level rise all potentially affect morbidity and mortality rates for Indigenous Australians, both directly and indirectly. A community's coping capacity is mediated by number of demographic and socio-economic factors that serve to amplify or mitigate the impacts of the changing climate. These non-climate stresses are discussed in the following section.

Climate impacts likely to be of most concern for remote Indigenous communities include: increases in the number of days of extreme heat, which cause heat stress and may affect disease vectors, reproduction and survival of infectious pathogens; increases in extreme rainfall events and flooding, which cause infrastructure damage and a likely increase in the number of emergency evacuations; salt inundation of freshwater aquifers and fresh water areas, which causes mangrove encroachment and other ecosystem changes; changing fire regimes; sea-level rise and coastal erosion (Hennessy et al., 2007). The following section details the some of the likely impacts on health caused by climate change.

**Temperature:** Across the north, climate change is expected to bring hotter day and night time temperatures. Continuous spells of hot days and nights along with more frequent and intense heat waves all contribute to physiological heat stress (Kovats et al., 2001; Hennessy et al., 2004; Green and Preston, 2006). Elevated temperatures and increases in hot spells are expected to be a major problem for Indigenous health in remote areas, with many elderly people lacking facilities to cope with the increased heat stress.

Other health concerns include increases in incidence of heat rashes, heat exhaustion and even heat stroke. Elderly people and those with poor cardiovascular health and low physical fitness are at highest risk (McMichael et al., 2003). The latter concerns are disproportionately prevalent in Indigenous communities. However, a positive impact may occur in southern central arid regions where the increase in night time winter temperatures is likely to result in fewer respiratory infections and deaths.

Indirect impacts of temperature change can also have significant impacts on health. The incidence of communicable diseases such as bacterial diarrhoea, which are more common in hot dry conditions, may increase, unless additional preventative actions are taken. One study suggests that an increase in temperature of 1.0–3.5°C by 2050 would lead to an estimated 5–18 per cent increase on diarrhoea cases in Alice Springs hospital (McMichael et al., 2003) although caution is needed with this estimate of diarrhoeal disease increase as it is very likely to be modified by many other factors (for example a new vaccine is now being used which would likely decrease these rates (B. Currie pers. comm., 2006)).

Dengue presents an obvious climate-related risk to Indigenous communities in northern Australia. Although the virus is not currently endemic, there are sporadic epidemics introduced, with occasional cycles over winter in the local mosquito populations in northern Queensland. Public health vigilance has, in recent years, precluded its occurrence in the Northern Territory. Scenario-based modelling of

the future transmissibility of dengue under conditions of climate change indicates its likely spread southwards along both the eastern and western coasts of Australia (Woodruff et al., 2005).

Mosquito-borne diseases, such as malaria, are likely to be affected by various combinations of changing temperatures, humidity and rainfall. A key concern for the Torres Strait and Far North Queensland is an increase in infected people entering the region and infecting the local mosquito population (B. Currie pers. comm., 2006).

Several other climate-sensitive infectious diseases, including leptospirosis and scrub typhus, also pose potential hazards—although there has been relatively little research done on how these particular diseases are affected by climatic conditions and variations.

Other health problems likely to increase include asthma (McMichael et al., 2003) and an respiratory problems associated with an increase in bushfires (caused by higher temperatures) due to higher levels of airborne particulates, as well as the direct health risk of the fire itself (Johnston et al., 2002). These respiratory diseases can be exacerbated by changing ecosystems that result in vegetation loss and increases in wind blown dust (McTainsh and Lynch, 1996). Concerns have been raised that changes in rainfall intensity and average rainfall (in combination with higher average and extreme temperatures) could also produce more suitable environments for later, hotter burns of weedy species such as gamba grass and mission grass. If these fires occur in the Arnhem land region, winds blowing the smoke towards the west have the potential to increase asthma and other related respiratory diseases in communities around the Darwin region and Kakadu (J. Morrison pers. comm., 2008).

**Precipitation:** There are significant seasonal variations in precipitation for all the regions in the north. More rain in the monsoon season increases the chance of drowning or injury from being hit by heavy objects (McMichael et al., 2003). Flash flooding can also indirectly create health impacts through damaging building, telecommunication and transport infrastructure.

The combined impact of precipitation and temperature changes on a range of infectious disease transmission rates is complex because those rates tend to be very locally specific, depending on a combination of several physical factors and the presence of the necessary 'vector' host (for example: fleas, mosquitoes, birds or mammals). Increasing temperature and humidity is also likely to impact on the time taken for the pathogens to develop to an infectious stage in the vector host (Currie, 2001; Patz and Olson, 2006). For example, Murray Valley encephalitis (MVE) is endemic in northern Australia where humans become infected if bitten by infected mosquitoes. MVE has been shown to have significant association with heavy rainfall in Alice Springs and Tennant Creek (Whelan et al., 2003).

Storms and floods can facilitate the spread of infectious enteric diseases that cause diarrhoea in young children. More extreme rain could increase rates of melioidosis which is known to be associated with wet weather. Melioidosis is endemic to northern Australia and is associated with exposure to mud and pooled surface water. (Cheng et al., 2006) discusses several clustered cases that were found to be associated with extreme weather events and environmental contamination. (Currie and Jacups, 2003) suggests that an increase in heavy rain may result in a shift towards inhalation as the mode of infection which would lead to more severe illness.

The impacts of more extreme weather events on sacred sites have not been considered, despite the expressed concern of several Traditional Owners that these impacts having serious negative psychological effects (various at the Sharing Knowledge workshop, Darwin, pers. comm., 2006). A fully participatory approach with Traditional Owners to assesses priority areas for adaptation activities could help to identify and mitigate some of these impacts on sacred sites.

**Coastal issues:** Over the next century, a middle-of-the-road estimate suggests a global average sea-level rise of about 50cm. However, averages conceal local short to medium variations (White et al., 2005), which can be of significance to the viability of coastal communities. There are also more recent concerns over the underestimation of global average sea level rise projections (Rahmstorf, 2007).

Many coastal communities in the north of Australia are also vulnerable to storm surges created by tropical cyclones and low pressure systems, due to relatively shallow coastal waters that amplify a

storm surge's erosive properties. Communities living on small low-lying islands, such as those in the Torres Strait, are particularly vulnerable to these physical impacts (Mulrennan, 1992; Bessen, 2005; ARUP, 2006).

Coastal erosion and storm surges also threaten infrastructure vital to emergency rescues, reducing the capability of emergency management agencies to act quickly and effectively. For example, some of the smaller Torres Strait Islands have airstrips bisecting the island that are already at minimum length, with some airstrips ending right on the shoreline. Any further shoreline erosion or serious inundation events would affect access to some islands, potentially cutting off air transport at times of emergency. Even during the more frequent, but less severe inundation incidents, disruptions to water supplies can lead to an increase in the short-term risk of communicable disease transmission (McMichael et al., 2003).

**Associated ecosystem impacts:** Around much of coastal northern Australia, beach and mangrove areas are important habitats and nurseries for several significant species of marine animals. Turtles, dugongs, crocodiles, stingrays and sharks—amongst many other species—have a significant cultural roles for many Indigenous Australians; and for some, form a significant supplement to their diet. Some Indigenous leaders believe that there are major gaps in the knowledge base relating to impacts on the environment and subsequent impacts on the customary economy. For example, if there is an increase in cyclonic activity in coastal areas, sea grass beds could be devastated, which would have significant impacts on the populations of marine turtles and dugongs dependant on them. Impacts on the lifecycles of these animals would reduce the availability of a nutritious source of fresh food for many coastal communities that traditionally hunt these animals (J. Morrison pers. comm., 2008). For food-insecure communities, a change in the abundance of these animals may contribute to dietary imbalance or malnutrition. In combination with water shortages, this situation may become a potential ecological disaster for some isolated communities.

In low-lying flood plain areas, including many areas of Kakadu and Arnhem land, communities are vulnerable to flash flooding as well as the more gradual effects of ecosystem change as wetland areas are encroached by brackish water and mangroves.

## 5 Non-climate stress factors

Climate change projections indicate that most remote Indigenous communities are physically exposed to direct climate impacts. However, it is the multiple and concomitant non-climate stresses that will exacerbate the impacts of climate change for many of them. The lack of adaptive capacity in these communities, due to pre-existing health problems and other socio-economic disadvantage, is likely to be one of the key factors in reducing their resilience to climate change enhanced health problems.

Vulnerability has somewhat of a dichotomous nature, depending on what aspects of environment, society and cultural are being considered. Therefore, it is important to acknowledge the inherent adaptability and resilience of many Indigenous communities where it exists, while still identifying the challenges that remain. There are factors that enhance vulnerability and factors that reduce vulnerability—interestingly, the former tend to be driven by external factors while the latter are a function of endogenous practices, knowledge and customs.

These pre-existing non-climate factors that reduce an individual's capacity to cope are starkly illustrated by the gap in life expectancy between Indigenous and non-Indigenous Australians. While other industrialised nations such as Canada, New Zealand and the United States have managed to roughly halve this gap to around five to seven years over the past two generations, the gap remains much larger here, with Indigenous male Australians still likely to die seventeen years before non-Indigenous Australians (Wakeman and Raymond, 2005).

A comprehensive discussion of the various determinants of the current level of inequity in Australia is beyond the scope of this report. However, the complex and entrenched nature of this inequality suggests that any strategy attempting to increase Indigenous resilience to climate impacts should be part of a wider strategy to reduce existing levels of unemployment, poverty and marginalisation. The ongoing racism, history of institutional paternalism, stigmatisation and social exclusion felt by many Indigenous Australians will require not only cultural sensitive policies, but fully participatory methods that genuinely engage local communities and their representative organisations in their development (Evans et al., 1994; Thompson, 2003; Marmot and Wilkinson, 2006).

Numerous reports detail extreme socio-economic disadvantage of many remote Indigenous communities (Altman, 2000; ABS, 2005). Understanding this background is essential to contextualise any biophysical changes that may impact communities and individuals from climate change (Woodward et al., 1998; Watson and McMichael, 2001). In comparison to non-Indigenous communities, indicators relating to education, employment, housing and access to water and electricity all show features of disadvantage in these communities (Pittock, 2003; ABS, 2005). For example, there were 1,882 temporary dwellings in discrete Indigenous communities in 2001, and of the permanent dwellings, 31 per cent needed major repairs or replacement. 153 of these dwellings had no organised sewerage supply (ABS, 2005). The average size of Indigenous households in very remote areas is 5.3 persons. This level of overcrowding is thought to particularly affect children's health (e.g. respiratory conditions, skin infections and meningitis) as well as mental health of the whole community (Currie and Brewster, 2001; ECU, 2006).

The living conditions in many of these communities are characterised not only by overcrowding, but by inadequate washing facilities, poor sanitation and sewage disposal, limited food storage and sub-optimal food preparation facilities. Poor quality water can increase the prevalence of gastroenteritis, diarrhoea (McMichael et al., 2003), typhoid fever and hepatitis (ECU, 2006) and potentially parasitic diseases (giardiasis, dysentery and diarrhoea) of which children are particularly at risk (Currie and Brewster, 2001).

Survey research shows that one-fifth of Indigenous communities with 50 or more residents who were not connected to town water had not had their supply tested within the previous year, while a quarter of the communities had drinking water of poor quality that had failed testing at least once within the previous year (Trewin and Madden, 2005). With projections for increasing droughts and temperatures in these regions, additional electricity demands (such as for running air conditioners) and water requirements (deeper bores, and greater bore maintenance) will place further strain on already

stretched financial resources in outback communities. (Marshall, 2006) suggests that without major investment in some of these communities, their overall 'liveability' might be under threat.

Geographic remoteness will amplify climate change health risks and presents an additional challenge for developing anticipatory adaptation strategies. The availability of up-to-date information about forecasted disasters (e.g. extreme weather warnings) is limited to phone in many communities. Access to and from many remote communities during extreme weather conditions or following disasters is limited by a lack of all-weather roads and 24 hour operational airstrips; currently many remote airstrips are only functional in daylight hours. Difficulties in accessing health care are frequently compounded by language translation problems.

Many of these communities are fighting a number of devastating social problems, the result of decades of profound government mismanagement and neglect (Arthur and Morphy, 2005). Rates of suicide, diabetes and other basic and treatable diseases are heightened and a daily reality for many outstation communities (McMichael, 2006). Such widespread social ills have their roots in Indigenous Australians' forced dispossession from their country and the past active suppression of their cultural practices (Rose, 1996). In summary, climate impacts are likely to exacerbate the pre-existing social, economic and health issues found in many remote Indigenous communities.

## 6 Indigenous perceptions of health

The Indigenous concept of health is broad and multifaceted, reflecting a different world view to that of the Western biomedical model, which focuses mainly on physical disease. For many Indigenous Australians, a connection with ‘country’—a place of ancestry, identity, language, livelihood and community connection—is the largest determinant of ‘health’. This broader perspective addresses not just wellness of body but also that of mind, emotion, identity, community and spirit. If community-owned country becomes ‘sick’ through environmental degradation, impacts of climate extremes, or inability of the traditional owners to fulfil cultural obligations through ongoing management and habitation; the people of that land will feel this ‘sickness’ themselves. Indigenous people’s links with their country are in many ways health determining.

The life-death-life cycle at the heart of Indigenous understandings of health assumes an active and ongoing relationship with ‘healthy country’ (Couzos and Murray, 2007). Consequently, there are massive cultural ‘costs’ created by climate change. For example, some Indigenous communities still maintain traditional health practices, relying on locally available plants and animals for medicines. If climate change affects ranges of flora and fauna, or access to them (such as through changes in hibernation patterns, migration or flowering times) that traditional knowledge will become less reliable, increasing the likelihood of important cultural practices being lost.

A number of communities across northern Australia are already reporting that their traditional knowledge of their country cannot explain observed shifts in weather and wildlife migration patterns over recent decades. Those inexplicable shifts have caused some consternation and distress in some communities. This is likely to become a growing concern in more Indigenous communities, where the need to maintain the health of their land and sea country is considered a vital part of maintaining individuals’ well-being. Climate impacts and the associated loss of traditional knowledge is likely to cause serious distress and mental illness in many communities (Green, 2006b). In the Torres Strait Islands, many Islanders are stressed because they feel they do not know how they will maintain their cultural integrity if they need to relocate from their islands. While the vexed issue of relocation is being dealt with to some extent on other Pacific Islands, where long-term relocation strategies are being advanced (Preston et al., 2006), here in Australia it is yet to be considered by state or federal governments.

These cultural costs must be factored into any assessment of climate impacts on Indigenous health. Without successful and sustainable anticipatory adaptation strategies, Indigenous people’s health, on all its interrelated levels, is likely to suffer.

### Case study: the Torres Strait

There are several thousand people living on 17 small, low-lying islands spread between the tip of Cape York and Papua New Guinea. Many Islanders continue their traditional cultural practices of subsistence hunting on land and sea country that they own through successful native title claims.

However, recent inundation events and ongoing coastal erosion on many of the inhabited islands (EPA Qld, 2006) have led to recent discussions amongst Islanders and Island leaders about how best to adapt to climate change, what anticipatory action needs to be taken and when it needs to occur (Minchin, 2006; Michael, 2007).

Key concerns relate to enhanced natural erosion on the central coral cay islands and more intense storm surges throughout the region. The Islanders are concerned about the ability of their islands to withstand sea level rise and other indirect impacts. They have noticed that over recent years, coastal tracks have been washed away, and long-established graveyards and houses inundated in the largest inundations in living memory (see Figure 3 and Figure 4).

Figure 3 Damage to the sea wall caused by a storm surge on Saibai (photo credit: Donna Green)



Figure 4: Sandbagged graves on Saibai (photo credit: Andrew Meares)



In addition to the psychological distress caused by the flooding, their remoteness makes repairing this damage extremely expensive (Green, 2006b). Another difficulty is that Islanders lack access to the necessary resources to engage consultants to conduct assessments, or to carry out maintenance work. Although the full suite of indirect impacts is harder to assess and quantify, they are crucial to consider in designing comprehensive adaptation strategies.

The Islanders understand that the problem extends further than the initial flooding. They are concerned about indirect impacts of climate change, having seen firsthand how increasingly severe inundations could jeopardise public health due to contamination of fresh water supplies and flooding of their landfill rubbish tips (see Figure 5).

Crucial surface and ground water resources are also likely to be impacted by climate change, making resource management in the dry season increasingly difficult. In the past, many islands depended on fresh water lenses to provide drinking water, but overexploitation of this resource has caused problems and created the need for water desalination plants on many of the islands (Mulrennan, 1992). Rainwater tanks and large lined dams are now used to trap and store water for use in the dry season. An increase in salt-water intrusion of fresh water supplies and reduced availability of fresh water is likely to add to difficulties of Islanders attempting to revive traditional gardening practices. Reduction in these practices has compounded health problems in recent years because of the lack of availability of affordable, fresh vegetables on the islands (Beadle, 2005).

Figure 5 Saibai village after inundation in 2006 (photo credit: Rick Parmenter)



Torres Strait Islanders are a traditional seafaring people, who pride themselves on their intimate understanding of the seasonal shifts in the ocean and weather. Events such as the timing of the king tides are predictable for the Islanders. However, they had noticed that in recent years the waves occurring in these king tides seemed higher and more powerful (J. Warusam pers. comm., 2007). A concern of the Islanders is that their own observations and weather forecasting may become less useful due to climate change.

At a workshop discussing climate impacts held in 2006, Islanders also reported shifts in animal and plant behaviour that did not accord with their past experience. These traditional environmental knowledge observations showed that Islanders were acutely aware of perceived changing temperatures and rainfall patterns, of shifting bird migrations and breeding seasons, and of changing abundance and distribution of particular species. For instance, a new species of mosquito had appeared on some islands, while perceived changes in marine habitats were thought to be disrupting Islanders' traditional subsistence hunting patterns. Given the profound cultural importance of totemic sea animals—such as turtle and dugong—for many Islanders, this issue takes on particular significance (Sharp, 1993; Sutherland, 1996; DEH, 2005; Marine and Coastal Committee, 2005).

Traditional environmental knowledge in the form of oral history has already been identified by natural scientists as an under-used resource for climate impact and adaptation assessment (Parry et al., 2007). Recognition is slowly beginning to grow in of the untapped resource of Indigenous knowledge about past climate change in Australia and internationally, which could be used to inform adaptation options (Rose, 1996; Lewis, 2002; Orlove, 2003). However, the oral tradition of recording this knowledge has, until recently, largely hindered non-Indigenous scientists from using this expertise to inform their science (Webb, 1997; Hill, 2004).

## **7 Promoting autonomous and anticipatory adaptation**

- Use participatory methods to communicate the complex challenges and opportunities faced by Indigenous communities around climate change.
- Use culturally appropriate methods to evaluate adaptation strategies that strengthen cultural, economic and social resilience of the communities and the ecosystems found on their country. These processes could include identifying effective approaches informed by past adaptation experiences, including the use of traditional environmental knowledge.
- Perform downscaled climate projections for northern regions. Consider the potential of performing storm surge modelling for the Torres Strait region.
- Provide scientific information and analysis in an easily comprehensible form—including in Indigenous languages where appropriate—to allow communities to identify their priorities for dealing with climate impacts.
- Systematically identify the most vulnerable communities. Work with community leaders to provide assistance to plan and prepare for climate risks including the development of emergency management systems for evacuation.
- Engage Indigenous community representatives into regional strategies for climate adaptation and link this work into broader social, economic and cultural policy planning for northern Australia.
- Identify any employment and economic opportunities that may result from climate change policy.

## 8 Conclusion

This paper outlines what is known about how climate change is likely to affect the health of Indigenous communities in remote parts of northern Australia under a limited range of scenarios, and suggests areas for further research that could be used to guide climate adaptation and resilience-building strategies.

The health status of remote Indigenous communities is likely to be adversely affected by climate change in a number of direct and indirect ways. This reflects both the vulnerability of Indigenous communities to environmental change and their reduced adaptive capacity. This situation presents a challenge to national, state, territory and local governments to provide adequate levels of advance planning, management and care to reduce climate-related risks.

Factors leading to remote Indigenous communities' vulnerability relate to Indigenous people's exposure to climate hazards and their high reliance on natural systems to sustain their traditional livelihoods and cultural practices. Many of these communities have significant vulnerability to climate change due to their sensitivity to the direct and indirect impacts of climatic change on various aspects of their lives, including through climate impacts on their country, in combination with their low adaptive capacity.

Therefore, strategies that seek to manage physical risks to Indigenous Australians' health without also accounting for the risks to their country and culture are likely to be of limited effectiveness.

The factors that make this situation more complex include the lack of public health infrastructure appropriate to the likely scale of the problem. There is need for more funding for primary health care programs, more doctors and nurses in communities with cross-cultural awareness, more preventative facilities to lower existing burden of disease and increase resilience, improvement of infrastructure in outstations and communities (such as water supplies, telecommunication, electricity, housing, waste disposal), and greater education and resources to reduce chronic health problems.

**Acknowledgements:** Many thanks to L. Webb for producing Figure 2, and for insightful comments from U. King, J. Morrison, A. Pitman and B. Preston and two anonymous reviewers.

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