

Limits to climate change adaptation in the Great Barrier Reef

Introduction

Adaptation is essential to address climate change impacts. However, the capacity of natural and human systems to adapt is limited, either by the severity of the climatic perturbation, or by vulnerabilities in the system. This is one of six regional case studies of the limits to adaptation that explore the underlying causes and potential to transcend these limits.

Context

Geographic

The 345,000 km² Great Barrier Reef (GBR) and its 425,964 km² catchment lie along 2100 km of the north Queensland coast.

Climatic

The region has experienced the effects of increased atmospheric concentrations of greenhouse gases, directly through ocean acidification and indirectly through sea-level rise and increased air and sea surface water temperatures. These effects are regarded as major long-term threats to the GBR and the communities and industries that depend on it.

Human: economic, social

The ecosystem services provided by the Reef, which underpin tourism, commercial fishing and cultural/recreational activities, contribute an estimated A\$6.9 billion to the Australian economy. The adjacent coast supports a population of approximately 850,000, expected to reach one million by 2026. The region has been designated as both a Marine Park (1975) and a World Heritage Area (1981).

Current stresses

The region supports activities including homes, transport, agriculture, tourism, recreation, and fisheries. Research identifies climate change, declining water quality, habitat loss from coastal development and impacts from fishing as major threats to the Reef system. There is evidence of a gradual decline in inshore coral reef habitat, increasing incidence of disease and pest outbreaks, and continued concern over vulnerable iconic species. Nevertheless, the GBR is still considered one of the best-managed reefs in the world.

Future climate

In this report, researchers developed four scenarios for 2050 to explore potential future climate change impacts on the Reef. The scenarios (Figure 1) are framed around two trends: 1) best-case, in which air temperatures rise by less than 1.5°C above 1990 levels (2°C above pre-industrial levels), and 2) worst-case, in which air temperatures rise by more than 2.5°C above 1990 levels (3°C above pre-industrial levels); and two adaptation pathways: 1) ideal ecological and social



adaptation, and 2) limited ecological and social adaptation. These scenarios have associated potential impacts, adaptation options, and outcomes, which were elicited through a process of scientific and stakeholder consultation.

Impacts of future climate change

Under Scenario 1 impacts are localised, the Reef experiences temperature spikes once per decade, mid-shelf reefs are more exposed to freshwater run-off, cyclone damage increases moderately, disease and pest outbreaks are more frequent, and ocean acidification slows productivity.

Under Scenario 2 impacts are widespread and extend to deeper waters, the Reef experiences severe hot temperature events at least twice a decade with coral bleaching occurring annually, mid-shelf reefs are increasingly exposed to freshwater run-off, cyclone damage increases substantially, disease and pest outbreaks are more frequent and extensive, and ocean acidification slows productivity and undermines reef structure.

Secondary impacts under Scenarios 1 and 2 depend on how ecological and social systems respond to the changing climate. Under Scenario 1, the Reef remains coral-dominated but, under limited adaptation, coral cover declines and composition shifts to less heat-sensitive corals. The numbers of fish fully dependent on heat-sensitive corals decline considerably and the abundance of other coral-dependent species decline. Mangrove habitat decreases due to chronic erosion and increased extreme events; but, with adaptation,

Figure 1. Summary of the climate change trends for 2050 underlying four climate change adaptation scenarios for the Great Barrier Reef. Projections are based on the GBRMPA vulnerability assessment (2007) and are within the ranges outlined in the Queensland Climate Change Centre of Excellence regional climate projections.

1. Best case climate scenario for 2050		2. Worst-case climate scenario for 2050	
Air temperature + <1.5° Sea surface temperature +1°C Sea level rise +0.13m pH reduced -0.15 Rainfall moderately more variable Cyclones more intense		Air temperature + >2.5° Sea surface temperature +2°C Sea level rise +0.68m pH reduced -0.25 Rainfall considerably more variable Cyclones much more intense	
a. Limited adaptation	b. Ideal adaptation	a. Limited adaptation	b. Ideal adaptation
1a	1b	2a	2b

some new habitat is established shore-ward and southward. Direct effects on fish lead to shifts in distribution southwards and to deeper waters. Under Scenario 2, the Reef fluctuates, depending on management and adaptation, between coral and algal dominance, and coral composition shifts to less heat-sensitive corals. Fish fully dependent on heat-sensitive corals decline and species may be lost; other coral-dependent species decline considerably. Some herbivorous fish benefit. Mangrove habitat decreases significantly, and under limited adaptation little new habitat is established. Direct effects on fish lead to significant shifts in distribution southwards and to deeper waters, increased variability in abundance of rainfall-dependent species and increased productivity and abundance in some other species.

Adaptation: options and barriers

In consultation with representatives of state and local government, the fishing and tourism industries, non-government, and scientific institutions, researchers used the scenarios to investigate adaptation options for the fishing and tourism industries. They considered to what extent diversification, effort management, or migration might have desirable adaptation outcomes, identified by respondents as: ecological sustainability, economic viability and enjoyment of the Reef. They identified a range of limits - factors that render adaptation options ineffective as a response to risk - which hinder improved outcomes. They identified critical limits embedded in a wider political and socio-economic context which, while surmountable, were not easy to overcome at the operator or, in some cases, even the sector or industry scale.

Limits to the common good: Beneficial outcomes for Reef industries and individuals often cannot be achieved through individual action but necessitate co-operation within and between sectors, and with external stakeholders. In the recreational fishery the potential of *stewardship strategies* to improve outcomes is limited by poor co-ordination within the sector; in the reef finfish fishery the potential of *temporary effort reduction through voluntary quota cuts* is perceived to be limited by a lack of co-operation between the commercial and recreational fishery; for fishing as a whole, the potential of *stewardship and business management*, is limited by actions on land, including agriculture and coastal development.

Limits of a global market: The Reef's fishing and tourism industries operate in a competitive global market, which can constrain their economic viability. As such, some adaptation strategies are directly limited by market factors. In the reef finfish fishery the Chinese market prefers live, red coral trout and pays a premium for them. Trout species found in the more southern reefs are redder in colour. Technologies for live capture constrain the depths at which commercial fishers can harvest fish for this market, so demand for red,

live trout is perceived to limit the potential of *migration* north or to deeper reefs to reduce fishers' vulnerability following climatic events and climate change. In other cases, strategies, such as *effort reduction* in the trawl fishery, do not address the causes of fisher vulnerability, in this case, low prices for seafood driven by market competition, so fail to improve outcomes or avert climate change impacts.

Limited by reputation: The reputations of the Reef's fishing and tourism industries were identified as critical limits. In the tourism industry, maintaining the long-term and short-term (after bleaching or storm events) reputation of the Reef is essential to enable effective adaptation through *stewardship, business management and diversification*. If operators diversify their product they need the market to respond accordingly. However, the reputation of the Reef was perceived to be unfairly eroded by increased research and communication on the damage from bleaching, cyclone events, and other threats, which undermines benefits from adaptation.

Policy implications: limits to adaptation

Key policy implications from this study include:

- Respondents emphasised that other drivers of change including economic volatility, natural disasters, and policy and management decisions are more immediate concerns for the Reef's industries. Adaptation and limits to adaptation should apply to all types of risk and opportunity, including climate change.
- Policies on economic development, environmental management and adaptation to climate change should be integrated. Respondents highlighted that prioritising climate change research and action independent of other activities, risks undermining progress made on issues such as environmental sustainability. Business management and stewardship should be considered as core climate change adaptation strategies.
- The limits to adaptation identified in this study present real and considerable challenges to adaptation policy and action. They should be accounted for in management and adaptation planning exercises.
- Overcoming limits to adaptation in the Reef's fishing and tourism industries requires:
 - meaningful action in policy arenas outside these industry sectors
 - integrated regional approaches to coastal development and land-use.

This document summarises key findings from the NCCARF report '*Climate change adaptation in- the Great Barrier Reef*' by Louisa Evans, Pedro Fidelman, Christina Hicks, Charlotte Morgan, Allison Perry and Renae Tobin. Download the report at www.nccarf.edu.au

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