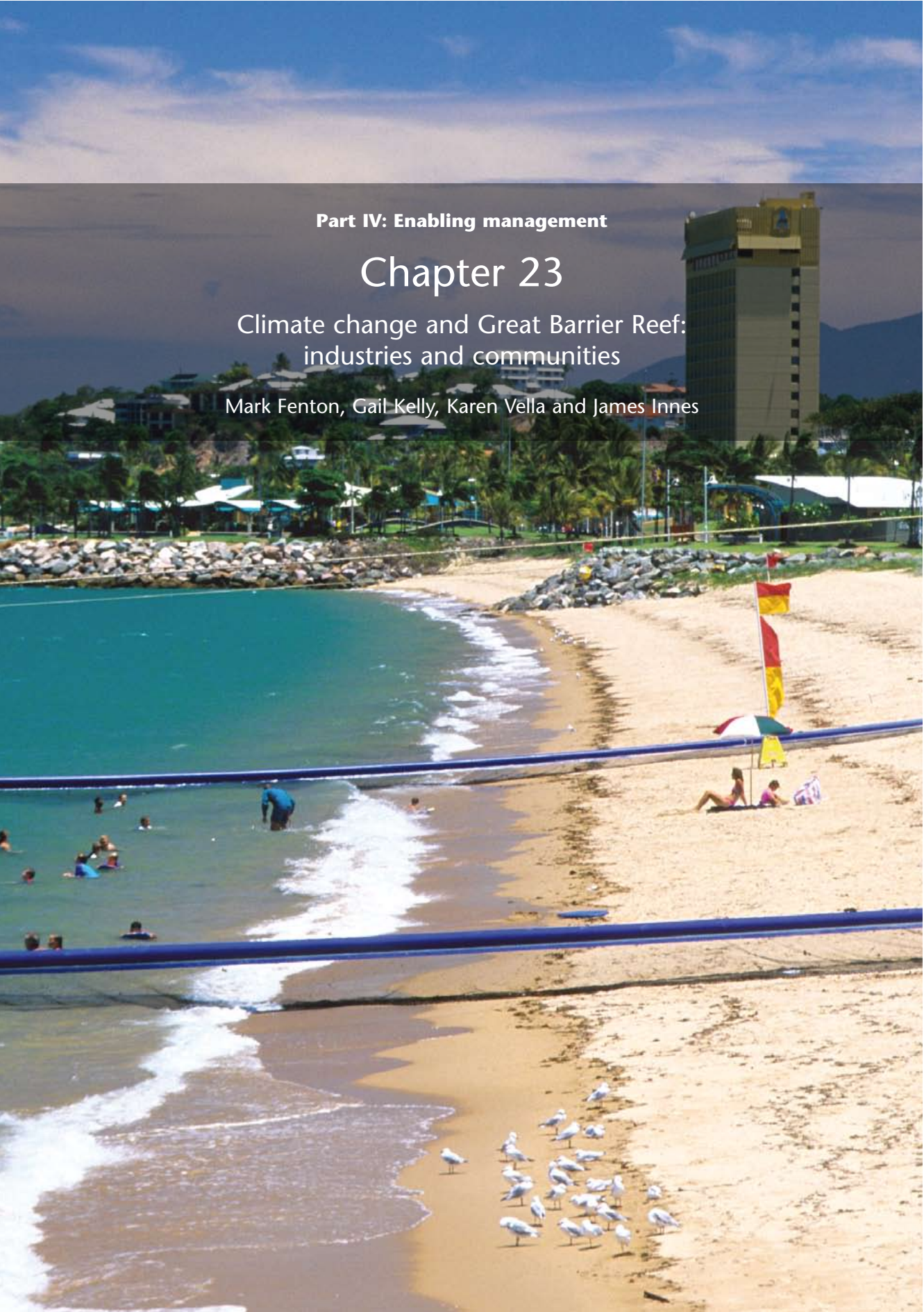

Part IV: Enabling management

Chapter 23

Climate change and Great Barrier Reef: industries and communities

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23.1 Introduction

Climate change is driving shifts in environmental conditions that, together with other human pressures, are impacting the Great Barrier Reef (GBR). Individuals, communities, and industries in the GBR catchment depend directly or indirectly on the GBR for ecosystem goods and services. These take the form of direct economic benefits (including commercial activities such as tourism and fishing), social services (including recreational activities and cultural linkages) and environmental services (including shoreline protection from barrier reefs and mangrove stands).

Although there is consensus within the global scientific community about the causes and potential impacts of climate change, stakeholders are less certain about the impacts and effects. Climate change is understood and acted upon as a subjective event that is constructed by different stakeholder groups and imbued with meanings derived from experience and the social and cultural context in which individuals, industries and communities find themselves. Individuals, stakeholders and communities' recognition and acknowledgement of climate change, how they construct and give meaning to climate change processes, and the content of their anticipatory schema in relation to climate change impacts and response, determine their vulnerability, adaptive capacity and adaptation, and resilience to climate change. There is a difference in preparedness amongst different stakeholder groups to climate change impacts.

Uncertainty by stakeholders and diversity in preparedness pose serious challenges for management. Climate change involves considerable uncertainty, the potential for irreversible damage, time lags between cause and effect, a long planning horizon and the need for systemic institutional change[14]. In addition, the GBR catchment is a highly contested environment. Issues include growing populations (which drive demands to access and use environmental resources), multiple and often conflicting value systems, multiple and often conflicting knowledge and belief systems and entrenched intergenerational patterns of resource use. Existing institutional regimes (formal and informal) governing resource use and access have complex structures involving rights, roles and responsibilities for environmental management and institutional change in the GBR catchment can be a long and difficult process. For example, ongoing effort over the past 10 years to improve institutional arrangements governing the Queensland Sugar Industry highlights the difficulties of achieving institutional change in the GBR catchment[17,30,16].

Despite the potential economic and social impacts from effects of climate change in the GBR, there has been only one assessment of climate change and communities and industries in the GBR. This chapter discusses concepts of vulnerability, adaptive capacity, adaptation and resilience, and identifies socio-economic characteristics of communities and factors relevant to understanding the social dimensions of climate change in the GBR. The chapter discusses the recent study by Fenton and Beeden[26] that examined community and stakeholder perceptions and beliefs about climate change and its social and economic impacts in the GBR. It raises a number of core issues associated with the adaptive capacity and resilience of community and industry to prepare for climate change in the GBR catchment. It finds that a single approach towards preparedness and management for climate change is unlikely to have an effective response with all groups. Management responses therefore, need to involve diverse community and industry stakeholders in the GBR catchment in the policy making process.

23.2 Definitions of social resilience

The preceding chapters provide detailed assessments of vulnerability, adaptive capacity and resilience in relation to species groups and habitats within the GBR. Before discussing GBR industries and communities, their vulnerability to climate change and stakeholder perceptions and beliefs about climate change in the GBR catchment, it is important to firstly discuss concepts of vulnerability, adaptive capacity, adaptation and resilience as they relate to social dimensions. These terms have emerged out of the ecological sciences and are becoming increasingly interwoven into discourse about the social dimensions of climate change. There are multiple and often competing definitions for these concepts and a number of different explanatory frameworks and definitions underpinning each of these concepts. While it is clear they are related, there is currently little consensus about the nature of these relationships.

Vulnerability

Definitions of vulnerability are generally based on three broad approaches: i) natural hazards and disasters, ii) social vulnerability, and iii) integration[54]. When adopting a natural hazards approach, the focus is on the actual physical hazard – its type (abrupt or chronic), frequency, duration, probability, intensity, severity and magnitude. This is used to determine the vulnerability of the exposed system[12]. Hazard-specific vulnerability is concerned with the amount of (potential) damage caused to a system by a particular event including human exposure to that risk[12]. Vulnerability is usually expressed in monetary cost, human mortality, production costs or ecosystem damage but importantly does not take into account the ability of the system to cope with, and respond to, the hazard when estimating vulnerability[54].

In contrast, social vulnerability refers to the social and political conditions within which a system is embedded[5], as well as the internal characteristics and processes that increase exposure of the system to the hazard – this includes its capacity to cope or respond. Social vulnerability can also include individual and community assessment of the hazard when considering response options and in this way can be described as the readiness of the social system to react to a certain situation[38].

Integrative approaches to vulnerability have emerged more recently from climate change research and necessarily take a systems view. Here vulnerability is both a function of the system's sensitivity and its capacity to cope and adapt, as well as the character, magnitude, and rate of climate variation (hazard) to which the system is exposed[54]. Brooks[12] argues that this is where the confusion with the vast array of similar and related terms, such as resilience, adaptive capacity, coping range, risk and sensitivity most often occurs. In attempting to untangle this confusion, Clarke et al.[18] state that vulnerability is a function of exposure (the risk of experiencing a hazardous event) and *coping ability* (which they equate with social vulnerability) that is, in turn, a function of resistance (ability to absorb impacts and continue functioning) and resilience (ability to recover from losses after an impact). Using a rural livelihoods framework at a household level, Ellis[23] describes vulnerability as high exposure to risk from both the external threat (hazard) and the level of internal coping capacity (assets and social support systems).

Adaptation and adaptive capacity

In relation to climate variability and change, the Intergovernmental Panel on Climate Change[31] defines adaptation as an adjustment within a system's ecological, economic or social sub-systems in response to actual or perceived change. Adaptation can be either autonomous (reactive response after initial impact without directed intervention from government agencies) or planned (anticipatory or reactive before impacts manifest).

Adaptive capacity is described as the ability or capability of a system to modify or change its characteristics or behaviour to cope better with actual or anticipated stresses[12]. Importantly, adaptation response can focus on building the capacity of individuals, groups and communities to adapt to change, as well as implementing adaptation strategies[3]. Evidence also suggests that previous exposure to climate events including cyclones[13] and bushfires[45] can lead to greater adaptive capacity through better preparedness.

Resilience

Walker et al.[52] define resilience as the potential of a system to absorb change and remain in a functioning state including the ability to reorganise itself following change. Resilience in social-ecological systems is concerned with how much shock the system can absorb and still remain within a desirable state, the degree to which the system is capable of self-organisation, and the degree to which the system can build capacity for learning and adaptation[28]. While resilience generally refers to a system's capacity to respond and bounce back, Folke's last point is critical; resilience of social systems includes adaptive capacity. This is emphasised by Paton[44] in the context of response to hazards, where he argues that social resilience is more than merely returning to a previous state, it includes the capacity of people and communities to learn and/or to recognise and benefit from the new possibilities that change brings.

The relationship between vulnerability and resilience is not clear. Some researchers see resilience and vulnerability as the other side of the same coin[13,31]. However, others argue that vulnerability factors co-exist with resilience characteristics that facilitate adaptive capacity[44]. Thus, resilience does not necessarily imply invulnerability; social resilience is relative (not absolute) and will change over time and vary in different situations.

While the concepts of vulnerability, adaptive capacity, adaptation, and resilience are useful in understanding human response to climate change, they need to be integrated and substantially grounded in the social and cultural context of the GBR.

23.3 GBR industries and communities

The GBR and its catchment is an integrated social-ecological system that is in a constant state of change, and which has a significant and long history of system interdependence and interaction.

The catchment adjacent to the GBR has a population of approximately 850,000 residents that is projected to increase to one million by 2026[19] (Figure 23.1). Along the length of the GBR, there are 21 local government areas and the major urbanised centres of Cairns, Townsville, Mackay, Rockhampton and Gladstone.

Management and protection of natural resources in the adjacent GBR catchment is the primary responsibility of the Queensland Government and seven regional Natural Resource Management (NRM) organisations, from Torres Strait in the north to Burnett Mary in the south (Figure 23.2). Within the last two to three years each NRM organisation has developed a natural resource management plan and investment strategy for the management of natural resources in their region, which includes estuarine, coastal and marine habitats. In the 2003–2004 financial year, A$12.2 million was spent by regional NRM organisations on the management of natural resources from Natural Heritage Trust funds alone.

Figure 23.1 *Great Barrier Reef catchment areas and urban centres*

Figure 23.2 *Regional Natural Resource Management boundaries within the GBR catchment*

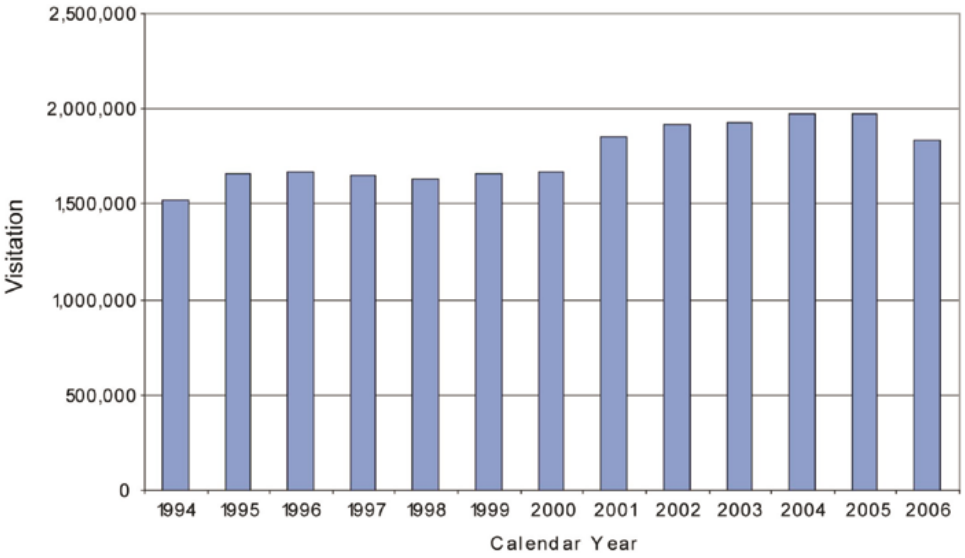
The GBR and adjacent catchment also supports considerable economic activity. The total (direct plus indirect) economic contribution of tourism, commercial fishing, and cultural and recreational activity in the GBR towards Australian gross product was A$6.9 billion in 2005–2006[1] (Table 23.1). Tourism dominates these economic contributions within the GBR. For value added and gross product, tourism's share is about 84 to 87 percent and for employment, tourism's share is about 81 to 84 percent[1]. This creates significant economic flow-on benefits to the broader population and local economies within the catchment. There is considerable diversity in tourism activities, which include: cruise ships, kayaking, diving and snorkelling, day tours, bare boat charters, fishing charters and water sports. In 2006, there were 1,831,609 visits to the GBR[a] (Figure 23.3).

a Great Barrier Reef Marine Park Authority (2007) www.gbrmpa.gov.au

Table 23.1 *Direct plus indirect contributions of selected Great Barrier Reef Catchment Area (GBRCA) activities to Australia, 2004–2005 and 2005–2006[1]. Money values in millions of Australian dollars and full time equivalent by the thousand (FTE 000)*

	2004–2005			2005–2006		
Total contribution (direct plus indirect)	Total value added ($)	Total GDP ($)	Total employ-ment (FTE 000)	Total value added ($)	Total GDP ($)	Total employ-ment (FTE 000)
Visitors from GBRCA	773	948	10	750	923	9
Visitors from rest of Qld	724	879	8	659	803	8
Interstate visitors	1,282	1,559	14	1,661	2,019	18
By GBRCA residents for travel outside GBRCA	211	254	2	228	276	2
International visitors	1,528	1,856	17	1,633	1,982	18
Total tourism	**4,518**	**5,496**	**52**	**4,932**	**6,004**	**55**
Commercial fishing	273	288	2	238	251	2
Recreational activity (net of tourism)	544	624	9	542	623	9
Total contribution to Australia	**5,335**	**6,408**	**63**	**5,712**	**6,877**	**66**

Figure 23.3 *Reef-wide total visitors to the GBR by year[b]*



b Great Barrier Reef Marine Park Authority (2007) www.gbrmpa.gov.au

In the past several years, the tourism industry has experienced significant changes in visitation to the GBR and has had to contend with changes in the quality of many reef sites affected by coral bleaching, poor water quality and the impacts of the crown-of-thorns starfish.

There are five main commercial fisheries operating in the GBR with a total gross value of A$251 million for production in Australia in 2005–2006[1]. In addition, there are estimated to be 800,000 recreational fishers in Queensland with those using the GBR catching an estimated 3500 to 4500 tonnes per year.

Along the coast from the Torres Strait to Bundaberg, there are some 70 Traditional Owner groups with an interest in, and connection to, coastal land and the GBR. In working with Traditional Owners, the Great Barrier Reef Marine Park Authority (GBRMPA) has identified 27 management areas along the GBR coast based on the way Traditional Owners work administratively within their groups and tribal lands. Traditional Owners associated with several regional NRM organisations have developed plans for the management of their country that has included the coastal and marine environment[c]. Access to country, maintaining cultural identity, and the continued maintenance of traditional hunting rights are three critical issues of current concern to Traditional Owners within the GBR catchment.

Climate change will affect communities and industries in the Great Barrier Reef Catchment Area[d] (GBRCA) that depend on natural resources for economic, social, and cultural wellbeing. Communities and industries within the GBR each face different industry, community and environmental issues and have differing access to resources. It is important to identify community and industry vulnerability, and if possible, social resilience to climate change and how GBR communities and industries might respond and adapt to climate change impacts. This information will assist policy makers develop policy processes and institutional tools that are appropriate and effective in addressing climate change issues given the social characteristics of communities and industries.

23.4 Vulnerability to climate change

Climate-related events such as floods, droughts and fire impact on the general public, businesses and the government sector by positively or negatively affecting agricultural production, forestry, tourism, the health and viability of fisheries and the quality and quantity of water resources[47]. The broad potential impacts of climate change on Australian agriculture, forestry and fisheries, settlements and industry, and human health have been identified by Pittock[47]. Information on the vulnerability of communities, and industries and the general population within the GBR is more limited.

From an industry viewpoint within the GBR, reef-based activities within the marine tourism industry are particularly susceptible to the effects of climate change, namely loss of coral reef due to bleaching, and changes to abundance and location of fish, marine mammals and other iconic species. Increasing frequency and intensity of storms and cyclones will impact passenger and tourism operator safety,

c Wet Tropics Aboriginal Plan Project Team (2005) *Caring for Country and Culture – The Wet Tropics Aboriginal Cultural and Natural Resource Management Plan*. Rainforest CRC and FNQ NRM Ltd Cairns
Traditional Custodians of Country in the Burdekin Dry Tropics Region (2005) *A Caring for Country Plan*. Burdekin Dry Tropics Board, Townsville

d GBRCA: Great Barrier Reef Catchment Area. The GBRCA include islands within the Great Barrier Reef Marine Park plus large areas of mainland Australia, mainly east of the ridge defined by the mountain summits of the Great Dividing Range

industry seasonality (and opportunities for reef experiences), tourism infrastructure and associated tourism industry development. The fishing industry is also heavily dependent on climatic conditions. Changes in ocean circulation, wave generation, cyclones and air and sea temperature may impact productivity with resultant effects for the fishing industry and aquaculture. In addition, declining water availability will greatly impact catchment industries such as agriculture, horticulture and mining, as well as the general population[4].

Human health and coastal development are other ways in which the GBR social system is vulnerable to climate change. Health risks related to climate change include heat-related stress and death, increases in water and vector borne diseases, and declining water availability. Towns and associated infrastructure will be affected by changes in demand for energy, changing land values and land use systems, changing liveability and lifestyle, and by direct impacts on buildings and structures from extreme weather[4].

Climate change may also impact cultural systems in Queensland. Although the extent and impact of climate change on traditional marine and land resources is unclear, a decline in the availability of traditional resources could disrupt customs and practices, leading to a loss of knowledge, skills and culture. Similarly, climate change may also impact recreational use opportunities in the GBR such as fishing and boating. This may lead to changes and possible reductions in traditional and indigenous identity and belonging, and impact quality of life for non-indigenous Australians through reduced cultural and recreational opportunities.

When considered at a broader level, the social and economic effects of climate change in the GBR region may include economic and social instability. This will be due to changing industry structure and presence, changing population and demographic characteristics, coastal vulnerability due to infrastructure pressures, human health risks, storm events, and pests and disease[20].

These social and economic effects are likely to also result in changed land use and other activities as industries, communities and other sectors respond to climate change. Storm events, pests and disease, coastal vulnerability, industry vulnerability, and population change will put different pressures on marine and terrestrial resources.

Land use changes that could occur include the intensification of agricultural activities (eg horticulture) and reduction in broad scale agriculture, growth of less climate-dependent industries such as mining, and growing pressure for residential development in upper catchment areas.

Overall, climate change, as an environmental risk, poses uncertainty for management and decision making for all stakeholders in the GBR. In an environment characterised by ecological and social uncertainty, adaptive strategies are required. Adaptive management approaches are flexible and treat management as an iterative process of review and revision in response to unexpected events, the accumulation of knowledge, and experiential learning. However, in order to develop management approaches and strategies that are appropriate in the social and economic environments within the GBR catchment, we need to better understand community and stakeholder perceptions and beliefs about climate change and its social and economic impacts in the GBR.

23.5 Exploring the impacts of climate change on communities and industries

There is limited research and literature assessing the impacts of climate change on communities, industries, and stakeholder vulnerability and resilience in the GBR. A study by Fenton and Beeden[26] of stakeholder beliefs about climate change in the GBR catchment is the only specific social assessment of climate change issues in the GBR. Outside the GBR, global climate change literature predominantly explores public understanding of climate change and there is limited literature describing social vulnerability and responses to climate change. This section will briefly review climate change literature relevant to understanding the impacts of climate change on communities and industries in the GBR.

Public knowledge of climate change

Although the global scientific community speaks out essentially as a unified voice concerning the anthropogenic causes and potential devastating impacts of climate change at a global scale, many stakeholders still harbour considerable uncertainty about the problem itself[10]. Moreover, *'far from being stable and unitary, public understanding of environmental issues are 'fragmented and contradictory' and are used to convey a multitude of meanings concerning the relations between society and nature'*[15].

Public knowledge of climate change is commonly dismissed as incorrect and confused and the lack of public understanding of climate change attracts significant attention from all sides of the policy debate[15]. Community and industry understanding of climate change relates to people's knowledge of physical environmental processes as well as relationships between people and the environment. People's understanding of climate change involves diverse fundamental moral and religious views on the relationship between people and the environment, the rights of nature and other species, people's rights to change or manage nature, and society's responsibility for future generations[15].

There is broad variation in people's beliefs or 'mental models' about climate change[8]. Even modest social studies involving carefully conducted and analysed interviews on a small scale can identify the basic features of mental models and provide the necessary information to underpin public involvement in management[8]. An assessment of communication strategies of human health risks associated with climate change by Bostrom and Fishhoff[8] found that communication must reflect:

- The science of the risks they are describing
- The mental models that individuals bring to understanding that science
- The decisions facing individuals

Communication must focus on the information most relevant to those decisions, and present information in a way that is compatible with decision maker's information-processing strengths and weaknesses.

Measuring vulnerability

Measuring community and industry vulnerability to environmental change, such as climate change, is difficult because of the limited availability of useful research and data sets. Data sets that are broadly available to measure social and economic characteristics include the population census; however, these broad repeatable data sets are problematic for measuring vulnerability to environmental change because it is very difficult to identify the causal factors of change in socio-economic characteristics.

Problems with using population characteristics to measure community vulnerability to environmental change are identified in an assessment of community and industry vulnerability to natural hazards and disasters such as cyclones, storm surges and floods in Northern Australia[36]. One issue associated with using census population characteristics to measure community vulnerability relates to the size of the collection district. Collection district boundaries are small and geographically based; thus populations vary between districts and between censuses within the one district. Since collection districts are small, population data needs to be aggregated to avoid the identification of individual people. This makes spatial and temporal comparison difficult; socio-economic detail and precision is lost through the aggregation process, and causality of population migration in and out of a collection district is difficult to relate to issues such as environmental change[36].

Another issue relates to standardising data for comparison[36]. By standardising census data, the raw figures of numbers of people are lost when undertaking statistical analysis. For example, a high proportion of the elderly or single parent families may indicate high vulnerability for particular Collection Districts, whereas total numbers of these vulnerable groups may be much higher in Collection Districts with larger populations[36]. This is problematic when attempting to determine the impacts and effects of environmental change on communities and industries.

In addition, the Australian Bureau of Statistics socio-economic indicators for areas and weightings into indicators of socio-economic advantage or disadvantage are statistically reliable but have not been selected to yield information about vulnerability and resilience to environmental change. For example, *'persons aged 15 and over with no qualifications'* are identified as having a greater socio-economic disadvantage than *'dwellings with no motor car'*, however the relationship between these characteristics and disadvantage and environmental change is not clear[36].

Adaptation

A review of social-ecological resilience to climate change in a Canadian Western Arctic community identified that societies can adapt to climate change at multiple scales. This study found that societies can implement short-term adaptive strategies to cope with climate change. In the case of the Canadian Western Arctic community, short-term adaptive strategies included changes in land-based activities such as switching species and adjusting 'when, where and how' local people hunt. The study found that societies can implement long-term cultural and ecological adaptations in response to highly variable and uncertain environments, including the flexibility of seasonal hunting patterns, detailed traditional knowledge of the environment that enables the diversification of activity, and inter- and intra-community sharing networks[7].

The study found that the range and extent of both the short- and long-term responses defined the resilience of the community[7]. In terms of responding and adapting to climate change, it is not the gradual change that is important, but rather the disruptions due to uncertainties and extreme events, especially those that exceed a system's absorptive capacity. However, the study also found that not all extreme events are dangerous and not all ecological surprises are negative from the local point of view[7].

Great Barrier Reef communities and industries

Despite the important relationship between societal views and perspectives about climate change and public policy, relatively little is known about community and industry understanding and perceptions of climate change, particularly in the GBR.

Fenton and Beeden[26] undertook an analysis of qualitative interviews with 44 stakeholders including individuals from regional NRM organisations, State and Local Government, Traditional Owners, the tourism industry, the commercial fishing industry and the recreational fishing sector[e]. The study identified community and industry perceptions of climate change and perceptions of the impacts and effects of climate change in the GBR.

An interpretive approach was used to analyse interviews. This approach assumed that human understanding and action is based on the interpretation of information and events by the people experiencing them[49]. The information that people have about events is organised as a schema[42], which is an internal working model or cognitive representation through which an individual organises and describes the information they have about the world. Any individual's cognitive schema is in a constant state of change and adapts as new information about the world and the events they are experiencing are assimilated and/or accommodated into the existing schema[46]. The schema holds what is commonly referred to as a person's knowledge or beliefs about a concept or issue, and it is the schema itself that determines how individuals respond and behave in situations. The importance of cognitive schemas[f] is identified by Niemeyer et al.[43], who state in the context of climate change that *'facts do not determine behaviour so much as perceptions about those facts'*.

The Fenton and Beeden study did not seek to critically evaluate the knowledge of beliefs of participants in terms of their 'correctness', or whether they accord with existing scientific evidence or some objective assessment of environmental condition. It sought to understand the beliefs that are reported in their own right, independent of any objective yardstick that might be used as a measure of 'correctness' as it is the beliefs themselves and the organising schema in which they are embedded that are the best predictors of human attitudes, behaviour and adaptive capacity. We will now report the key findings of this study.

23.6 Stakeholder understanding of climate change in the Great Barrier Reef

Fenton and Beeden[26] examined community and stakeholder perceptions and beliefs about climate change and its social and economic impacts in the GBR. It identified three clusters of issues associated with participants understanding of climate change:

i) The recognition and acknowledgement of climate change

ii) Understanding climate change and climate change processes

iii) Identifying the consequences, impacts or responses to climate change

e A detailed description of the methodology and qualitative research findings is provided in Fenton and Beeden[26]

f In other literature, cognitive schemas are also referred to as mental models[33, 53]

The three clusters of issues are not independent and there are cumulative and causal (reciprocal and unidirectional) associations between each of the issues clusters. For instance, the study found that someone who does not recognise or acknowledge climate change will often also possess a relatively simple cognitive schema[21] about the climate change process and in turn will have difficulty identifying any consequences or impacts of climate change. In contrast, those who recognise or acknowledge climate change will often possess relatively complex cognitive schema to describe climate change processes and its consequences or impacts.

In addition, while it is important to understand and describe the schemas people hold in relation to climate change and the impacts of climate change, it is also important to understand what these schemas say in relation to the framework of social resilience and more specifically the key concepts of vulnerability, adaptive capacity and resilience.

Some care is also required in distinguishing the use of schemas as guiding an individual's behavioural response to climate change from the use of schemas to describe behavioural response to climate change. For example, a commercial fisher may possess a relatively complex schema about climate change processes, the content of which guides their behaviour and response to climate change. The same individual may also use that schema to explain the resilience or vulnerability of their industry to climate change. In the former case, the schema is directing their behaviour while in the latter it is being used as a basis from which they can report their attitudes and beliefs about climate change.

23.6.1 Recognising and acknowledging climate change

The recognition and acknowledgement of climate change has to be understood within the context of each individual stakeholder's experience and knowledge of the marine ecosystem and the institutional and organisational structures associated with its management. Across the different interview participants, there was considerable variation in the level of experiential and scientific knowledge about the marine ecosystem and climate change. At one extreme, commercial fishers, Traditional Owners and to a lesser extent recreational fishers and tourism operators often had very detailed local knowledge and belief systems about how the ecology of the local area functioned.

In contrast, and although there are exceptions, much of the knowledge about marine ecosystems and climate change amongst Government agencies and regional NRM organisations was based on 'scientific data' and the knowledge of 'experts', which had been provided by others. The expression of this type of knowledge tended to be more abstract, general and applicable at a macro- rather than micro-scale. The study found that many in these organisations indicated a paralysis of action because of the lack of data or scientific knowledge on which to plan and develop effective strategies for climate change. In addition, and as climate change had become a topical area of scientific inquiry, several participants also expressed the view that there was no cohesion to the scientific research being undertaken.

While scientific knowledge provides important information about managing and responding to climate change, the type of experiential local knowledge held about the marine environment has obvious implications in relation to how people respond to climate change. The following quotation indicates how one commercial fisher conceptualised the causal relationship between droughts on the land and reduced catch rates.

'…if it is drought on the land we always say we have a drought at sea too…the water seems to be warmer. The boys always say the temperature is a lot warmer and it needs good rain to oxygenate the water… in long dry hot periods the fish go down deeper and your catch rate goes right down.'

While commercial and recreational fishers provide numerous examples that illustrate their beliefs about how ecological processes influence their fishery, there were also numerous examples of how ecological process had changed across time. While there was considerable consensus that significant change had occurred in the marine ecosystem, there was in contrast, often little consensus in the beliefs about the causal attributions for these changes and whether these changes could be attributed specifically to climate change processes.

While some participants attributed the changes they had experienced to climate change processes, several participants also considered these changes to be 'natural' processes or attributed the changes to other human actions such as overfishing, pollutants, sediment runoff and the use of agricultural fertilisers. As one Traditional Owner stated:

'I've always blamed the aerial sprays, the fertiliser in the land…the seepage from waterways here and it takes it to the reef…especially in the warmer climate.'

Some participants described a more complex belief system, which illustrated the causal relationship between the changes they were observing and the processes of climate change. In effect, these participants had developed their own cognitive model of the impacts of climate change that described for them the interrelationship between climate change process and ecological systems. As shown in the following quotation from a recreational fisher; climate change produces less rain, which produces less runoff, which leads to fewer sediments, which in turns leads to an increase in water clarity and an improvement in the spearfishing environment.

'…less rain…we're spearfishing under the lighthouse now at the mouth of the river where that waters never been clean ever because of sediments and that that came out…now you can actually spearfish there.'

Some Traditional Owners also emphasised the cyclic nature of natural processes, including climate change itself, and emphasised that while there may be significant impacts, their traditional stories tell of times when sea levels were much lower than today with many sacred and significant places now located undersea.

While there was considerable variation amongst participants in the attribution process, the attribution of change to climate change processes also depended upon the acknowledgement of climate change in the first instance. The acknowledgement of climate change appeared to be related to three core factors:

i) Beliefs about the uncertainty of scientific evidence

ii) Previous impact predictions (ie Y2K and SARS)

iii) Trust in organisations and institutions

Perhaps the most common issue associated with the acknowledgement of climate change was the belief that since there was uncertainty within the scientific community and amongst experts about climate change, lay people could only be expected to express an equal level of uncertainty about climate change.

'My understanding of the science is that the scientists don't really know what is going to happen with fish numbers and with fisheries as a result of climate change. They don't know that…so how should I know.'

Several participants also indicated that there had been warnings and predictions about the impacts of other catastrophic events in the past, such as the Y2K bug and SARS. The predicted impacts from these events had not occurred and they questioned why climate change impacts would be any different. This phenomena is similar to the 'crying wolf syndrome'[11] reported in the hazard perception literature, in which repeated false alarms may reduce the credibility of warning information and increase the vulnerability of populations to hazard events.

The uncertainty amongst experts and the failure of past predictions was reflected in some participants as a general lack of trust in science[32,37]. This was also identified by Fenton[24,25] and is becoming an increasingly common theme within rural and resource-dependent communities. A large survey of community attitudes towards risk undertaken in the United Kingdom in 2003 showed that in relation to climate change, 71 percent of the population trusted scientists working for universities or environmental groups as compared to only 42 percent trusting scientists who worked for Government[g].

In addition to a lack of trust in science, amongst some participants there was also a lack of trust expressed in the organisations that were advancing climate change as an issue[2]. Amongst some commercial fishers, and to a lesser extent recreational fishers, there was some cynicism about climate change impacts and a belief by many that the GBRMPA was raising this issue as another mechanism through which fishing effort on the reef could be reduced.

While some participants reported a lack of trust in the science and resource management organisations, others including many from the tourism industry, regional NRM organisations and Government expressed a contrary view of having considerable trust in the scientific community, management agencies and the science being undertaken.

Some participants didn't acknowledge climate change or didn't attribute climate change to the changes they were experiencing in the marine environment. There were others however, who not only acknowledged climate change as occurring, but also attributed the changes they were experiencing to climate change processes. To some extent those who had experiential knowledge[h] of changes in the ecology of the marine environment, tended to be more likely to report the immediacy of climate change impacts and that those impacts were occurring now. In contrast, amongst those with limited experiential knowledge of ecosystem change and who based their knowledge on independent scientific evidence, there was a tendency to view climate change as something that would happen as a scenario in the future. It may well be that those with greater experiential, local and day-to-day knowledge of the ecology of marine ecosystems are simply able to detect some of the more subtle changes than those without this knowledge. This noted however, the day-to-day use of technologies (eg irrigation for agriculture) may mediate the relationship between an individual and their knowledge of the local environment.

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g Ipsos MORI (Market and Research International) (2003). Trust in the Government Low. www.ipsos-mori.com/polls/2002/uea.shtml

h Experiential knowledge is defined as knowledge gained through 'affective and cognitive transactions with the biophysical and built environments[48], p443) or the process of direct interaction with environment through which meaning is discovered[6]

23.6.2 Conceptions of climate change

To understand how individuals, industries and communities prepare for and respond to climate change, it is critically important to understand how climate change is conceptualised and understood. In broad terms, we can ask: what is the content of people's cognitive constructions or schema representing climate change and how does this influence vulnerability, adaptive capacity, adaptation and resilience as expressed through preparedness and capability to respond? Of course, such an approach invokes a constructivist as opposed to a realist analysis[51], emphasising that humans prepare and respond not to 'real' or objective climate change processes, but to their own construction of climate change. This perception of climate change is influenced by a wide range of individual and socio-cultural factors. For instance, research on the use of affective and cognitive heuristics[35,50], social leaning theory[22] and explicit mental models of change events, all indicate that the construction or representation of risk is important in understanding both preparedness and response.

As indicated in the previous section, the schemas individuals develop for climate change processes are based on and drawn from multiple sources of information, including both experiential knowledge and 'expert' information. However, as several regional NRM organisations indicated, there is a significant lack of scientific information about climate change, particularly at the local level, with many people simply being uninformed by science or attempting to fill the gaps they have in their knowledge through their own experience and beliefs about climate change. In addition, several participants had considerable difficulty in conceptualising and understanding the breadth of climate change processes and the potential impacts of climate change. This was particularly so when they considered the longer-term scenarios and may well explain why many of the participants interpreted climate change in the context of their current or recent past experiences.

Participants did not conceptualise climate change as a series of independent events, but in many instances described climate change as a series of interdependent and causally connected events occurring within the environment. The following core climate change processes were identified by participants[i]:

- Less rainfall (drier climate)
- Increase in land temperatures
- Increase in sea temperatures
- Changes in runoff and sediment flows
- Increase in water clarity
- Rise in sea level
- Changes in salinity
- Increase in the frequency and intensity of cyclones

i It should be noted that as this is not a survey of stakeholders or interest groups, it is not possible to identify the frequency or commonality of occurrence for these beliefs

Many participants described the interdependence of these processes. For example, with less rainfall there would be less runoff, which in turn would increase the salinity of the inshore marine environment. Similarly, with a rise in sea level, there would be an increase in erosion leading to increased sedimentation and runoff that again would impact on the marine ecosystem.

What was important for many participants was the magnitude or scale of climate change. While it was acknowledged by many that these processes would occur, there was significant variation across participants in their beliefs about the scale or magnitude of climate change. The following quotation illustrates a belief that the impacts of increases in sea temperature will be negligible.

> *'I can't imagine a one degree change in the average sea temperature can be that critical. Really…the water out here in winter goes down to about 19 degrees most winters…summer it can be 30 degrees. An enormous differential that the animals and plants already tolerate.'*

In contrast, for some participants, the impacts of climate change elicit a near panic response as is evident in the following quotation.

> *'…it is a profound affect…what people are saying by 2040…forget it…we are going to be in deep trouble by then… It's at a runaway point very soon. Its almost scary what will happen. Rainforests are affected, sea levels are affected, coral is affected, our fishing grounds, our farming, our climate, ourselves, our health and of course as that starts to run away so will law and order be effected.'*

23.6.3 Impacts of climate change on GBR social systems

Beliefs about the impacts of climate change focus on impacts to the marine ecosystem as well as impacts to social and economic systems. Impacts to the marine ecosystem were essentially the secondary or higher order ecological impacts of climate change, which in turn were seen to impact on the dependent social and economic systems. It was clear, as discussed elsewhere, that amongst those participants who acknowledged climate change, each participant possessed a cognitive model or schema which identified the climate change process and the causal attributions describing initial and flow-on impacts through ecological and social-economic systems.

While there was some commonality across participants in the content of individual's cognitive models of the impacts of climate change, there were also significant differences in the breadth and depth of knowledge about the potential impacts of climate change. The state of an individual's cognitive representation of climate change impacts was in some cases similar to the patchy state of scientific knowledge about climate change, as expressed by one regional NRM body.

It is often argued that the effectiveness of societal responses to climate change depends on how well it is understood by individual citizens[9]. However, it is also argued that rather than focus on the provision of information, policy efforts should address the social and institutional barriers that hinder community and industry involvement in addressing climate change[15]. The purpose of defining individual beliefs about climate change in the GBR is to support the development of policy processes and institutional tools that are appropriate, given the social characteristics of communities and industries, and effective in addressing climate change issues. Therefore, the following discussion identifies individual perceptions and beliefs about ecological, social and economic impacts, as well as impacts of climate change on industry in the GBR.

Ecological impacts

A common ecological theme amongst many participants was that warmer sea temperatures would be the primary climate change process that would give rise to an increase in the incidence of coral bleaching and changes in the geographic distribution of marine species. As might be expected given the media attention, coral bleaching was a commonly reported impact of climate change. Two issues were raised in relation to the ecosystem impacts of coral bleaching. Firstly, several participants questioned whether coral bleaching should be attributable to the general process of climate change or whether it was episodic and occurred in response to natural variations and changes in sea temperature. Secondly, while the process of coral bleaching was recognised, many participants also believed that corals were sufficiently resilient that they would return after a short time period[j].

> *'…the coral regrowth is quite astonishing. We killed off half the bay's coral reefs in 1991 when a monster flood came down…just obliterated it. You go out there today and you would not know that there was such an event 15 years ago. The coral has actually bounced back within 15 years.'*

Participants indicated the impact of rising sea level and temperatures also raised the possibility of a diverse range of potential ecological impacts, including the inundation of coastal mangroves and other fish habitat areas, impacts on turtle reproduction and breeding through increases in sand temperatures, and changes in the abundance, diversity and distribution of many marine species.

The belief that the marine ecosystem would be resilient to climate change or able to adapt to the effects of climate change was also a common theme identified by many participants. Corals for instance would simply adapt and move into deeper waters that were cooler. Corals and fish alike would change their geographic distribution and begin to grow or frequent areas further south in cooler waters.

While the belief that the marine ecosystem had the resilience and capacity to adapt to change was commonly held, some participants also expressed the view that coral reef habitats did not have the adaptive capacity to respond to the rapidity of the climate change process.

> *'I don't believe the reef is going to be able to adapt quickly enough to climate change, I mean there will be some adaptation but it's not going to be enough to maintain it as a tourist icon or biodiverse paradise as it is at the moment.'*

In terms of addressing the ecological impacts of climate change from the broader perspective of natural resource management, several regional NRM organisations indicated that while they may not have the resources to address the direct impacts of climate change, they could nevertheless improve the resilience of marine and natural ecosystems by addressing other stressors, such as improving water quality through better land use practices.

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j Some participants indicated that the GBRMPA in their management of the GBR and through the introduction of the representative areas program, had contributed to the development of a more resilient marine ecosystem and therefore any impacts from climate change would be reduced

Social and economic impacts

The social and economic impacts identified by participants include beliefs about the potential impacts of climate change to industry, communities and people's way of life. While participants discussed the potential social and economic impacts of climate change at a community or industry level, few participants discussed the impacts of climate change at an individual level. In other words, the impacts of climate change were often objectified and generally discussed in terms of what might happen to others, rather than to themselves as individuals. The displacement of potential impacts as something that will occur to others, as opposed to self, may be a coping mechanism or a way of resisting change[38,40]. For others, it may simply be that because of their age they have little interest in the impacts of climate change in the future.

Given that participants were drawn from a number of different stakeholder groups and industry sectors, beliefs about the social and economic impacts of climate change are described in relation to each group or sector.

Commercial and recreational fishing

Several fishers indicated that there was little preparedness amongst the commercial fishing industry and recreational fishing sector to respond to the impacts of climate change. This was because they had been preoccupied with other changes occurring in their industry or sector, including the trawl and reef line plan and the representative areas program. As shown in the following quotation, it could be argued that many in the commercial and recreational fisheries sectors, as a consequence of recent changes, have limited resources and adaptive capacity to respond to climate change issues, signalling a vulnerability to climate change.

> *'I have to say [it] is not top priority on our radar. There are far more important threats to our industry, our leisure and our recreation than climate change.'*

In contrast, several commercial and recreational fishers believed they would adapt to the impacts of climate change because through the recent changes to their industry and sector, they had become more resilient by developing a greater capacity to adapt and respond to future changes.

While it was indicated that the live fish industry may have to change its methods for the storage of live fish given temperature increases, that there may be an increase in costs associated with cooling and refrigeration, and that the use of equipment to measure sea temperature may be more common, the most frequent response amongst both commercial and recreational fishers was that they would adapt their fishing patterns and methods to whatever the prevailing conditions were at the time. However, there was no indication from participants that the commercial and recreational fishing sectors were in any way preparing for the impacts of climate change.

Tourism

In contrast to fishers, who indicated they were more likely to respond and adapt to change as it occurred, participants from the tourism sector expressed far more concern about the impacts of climate change and indicated a willingness to prepare for any potential climate change impacts.

Of particular concern for many participants from the tourism sector, was the image climate change impacts on the GBR would create amongst potential visitors. For the tourism industry, coral bleaching may not only have a direct impact on the marine tourism experience, but the national and international publicity associated with coral bleaching and the image of the GBR as being 'damaged' by climate change could create a negative image of the GBR and effectively reduce visitor numbers. In this sense, the tourism industry was seen as being potentially vulnerable to negative messages about coral bleaching and the impacts of climate change.

On a somewhat related issue, there was also an emphasis on managing the impacts of climate change and the experience of climate change impacts by visitors, by ensuring that the product that represented the visitor experience of the GBR did not create expectations that were too high. Clearly any mismatch between the expectation of the reef experience and the actual experience itself could also have a significant negative impact on the reef experience by visitors[27].

In relation to reef tourism, several participants indicated the reef experience might become more staged, similar to the 'staged authenticity' of tourism experiences as described by MacCannell[41], with tour operators 'farming' individual sites to ensure a quality experience amongst reef visitors. The farming of reef sites would generally include the employment of specialists to manage sites, which participants suggested would include the maintenance and transplantation of the corals and fish feeding being used to attract the larger and more iconic species of fish. Other potential impacts and changes discussed by the tourism sector included operators relocating to sites with less visual impact and in more extreme cases, a possible shift from reef based tourism to water or ocean based water sports or other similar non-reef based activities. Increases in sea level were also perceived as having a potential impact on tourism infrastructure, particularly in the major coastal ports such as Port Douglas, Cairns and the Whitsunday Islands.

The projected increase in the frequency of intense cyclones was also seen as having a potential impact on the tourism industry. Quite apart from the direct impacts of cyclones on coral reefs and tourism infrastructure, participants indicated two possible issues associated with an increase in the intensity and duration of cyclones. Firstly, there was a belief that increased cyclonic activity may create a significant amount of negative publicity in the international tourism market, resulting in a decline in international visitors. Secondly, climate change may extend the cyclone season by commencing earlier or finishing later, which in itself may reduce the effective tourism season for international visitors.

Traditional Owners

One of the key areas of concern for Traditional Owners was the impact of increased sea temperatures and potential changes in seasonal patterns on the availability of plant and animal life for traditional uses. In addition, and of concern to several participants from coastal Traditional Owner groups, was the impact climate change may have on their totems[29]. Totems are used to identify Traditional Owner groups and may be represented in any number of marine animals and plants. As totems are an important part of Traditional Owner cultural identity and are especially significant in song and dance, any loss of totem animals or plants would have significant impacts on the cultural identity of Traditional Owners including their lore and kinship relationships.

'…we have sea creatures or animals that we know as our totem so we'd rather preserve and look after those animals so that we know that we are connected to the area…lore and our kinship and relationship with other groups within our tribes and neighbouring tribes. If we do lose some of these animals and coral species it would be a big blow for our cultural heritage and our stories.'

Several Traditional Owners believed climate change would have a significant impact on their communities, resulting in the displacement of people from coastal communities through increase in sea level. Examples were given of islands in the Torres Strait that are currently being affected by rising sea levels, and there was concern about the impacts of moving people in these communities from their home islands and country to other island communities.

While several Traditional Owners identified potential impacts from climate change on themselves and their culture, others accepted that change was inevitable and essentially part of the natural order of their country and had occurred in the past.

'I think we will adapt very easily. We don't complain a lot about stuff. We just watch things that happen then we go along with it because that is how we've worked for thousands of years. We just adapt. When one fish dies off and becomes obsolete, we eat the other. And they are all food…and the algae may bring other things around…other food into the area.'

Regional NRM organisations

A complex institutional environment deals with issues relating to climate change. Institutional arrangements such as plans and policy initiatives now deal with climate change either exclusively, or as part of addressing a range of NRM issues at national, state, regional and local levels. Key state agencies include the Queensland Environmental Protection Agency, and the Departments of Natural Resources and Water, Primary Industries and Fisheries, and Premier and Cabinet. Key federal agencies include the Department of Environment and Water Resources and the Great Barrier Reef Marine Park Authority. Industry groups and the private sector are also taking an active role in establishing arrangements to manage the uncertainties and risks posed by climate change.

Regional natural resource management organisations also have a responsibility for natural resources in the coastal catchments adjacent to the GBR. These organisations not only address coastal and marine water quality issues, but also a wide range of other critical NRM issues in each catchment. In Queensland, regional NRM organisations have been operational for the past five years and each organisation has developed a regional NRM plan in the last two to three years, which identifies management targets and associated actions they intend to implement to address the critical NRM issues in their region.

Several participants were from regional NRM organisations and while there was recognition and acknowledgement of climate change, the imperative to address climate change issues and the delivery of specific management actions associated with climate change was limited. NRM plans developed by regional NRM bodies will often include an array of several hundred management actions. However, many of the NRM plans did not appear to recognise climate change as a driver for their management actions, nor was it common for management actions to be included in response to climate change. Some regional NRM organisations have a relatively limited response in their plans to climate change.

'Within the plan itself…we do have one management action that primarily is focused on climate change… and it is to do some scenarios with Local Government…with the coastal councils for emerging issues.'

'…we just started to delve into what the organisation does about that.'

The lack of urgency in recognising and addressing climate change issues amongst regional NRM organisations appeared to be attributable to two core issues. Firstly, in developing their NRM plans and investment strategies these organisations were required to develop plans and strategies which were community based and which represented the NRM issues of concern to stakeholders and communities in each region[34]. Several years ago, when these plans and strategies were being developed, climate change was not a significant issue for many in the community. As a consequence, climate change issues appear only on the periphery of many NRM plans and it was rare that specific management actions were developed in response to climate change issues. Secondly, regional NRM organisations are locked into a three-year investment cycle for the delivery of their NRM plan and they do not necessarily have security beyond this. The dilemma is that while these organisations have a responsibility at a regional level for the management of natural resources, the short term institutional constraints on their funding and operation makes it exceedingly difficult for them to address longer-term issues associated with climate change. As one participant indicated, the best many regional NRM organisations can do is to improve the resilience of ecological systems in the short term, so that they are better able to absorb and potentially recover from climate change impacts in the future.

Coastal development and planning

While there was some recognition of the impacts of climate change for coastal development and planning, political and institutional constraints were identified as the key impediments to changes in existing coastal development and planning which would address climate change issues.

Most importantly, these participants identified institutional constraints and barriers as frequently inhibiting their response to climate change. For example, several participants indicated that there clearly should be no development allowed in flood prone or storm surge areas of the coast. However, pressures for increased development of the coastal zone and the significant capital investment being made in coastal regions meant that it was difficult at a political level to resist these development demands. In many instances, agencies found themselves being only able to provide advice or guidelines for new developments or building structures to protect existing developments.

'I would be surprised if there's anything we can do about it…they are spending millions of dollars getting the absolute beachfront house and 90 percent of the population's dream is to do that. So the politicians are not going to stop them putting that sort of investment right on the front in the most prone areas. And when it comes to it they'll have enough political clout to get the politicians to see it their way. So I think the coast line in the urban areas will be strongly defended by lots of rock walls, which means the beaches will disappear and we will lose a lot of the values of the coastline.'

Several participants believed the State was only just obtaining controls over coastal development that were needed to limit liability in relation to storm surge or flood and as such there would be a continued emphasis on the development of engineering solutions, including the building of groynes and sea walls. However, as one participant indicated, the size of the sea walls required to prevent storm surges would most likely *'start blocking people's views…which will become an extremely political issue to manage.'*

While participants recognised there were significant institutional and political issues associated with addressing the impacts of rising sea level on coastal development within existing urban development areas, some participants found that they achieved greater success in relation to development control by focussing on new developments in non-urban areas.

23.7 Summary and recommendations

Climate change is driving shifts in environmental conditions that, together with other human pressures, are having synergistic effects on the GBR. Individuals, communities, and industries in the GBRCA depend directly or indirectly on the GBR for ecosystem goods and services. These take the form of direct economic benefits (including commercial activities such as tourism and fishing), social services (including recreational activities and cultural linkages) and environmental services (including shoreline protection from barrier reefs and mangrove stands).

There is limited research and literature assessing the impacts of climate change on communities, industries, and stakeholder vulnerability and resilience in the GBR. Outside the GBR, global climate change literature predominantly explores public understanding of climate change and there is limited literature describing social vulnerabilities to climate change and social responses to climate change. Based on the available social science literature:

- There is a wide variation in people's beliefs or 'mental models' about climate change.
- Measuring community and industry vulnerability to environmental change, such as climate change, is difficult because of the limited availability of useful research and datasets.
- Societies can adapt to climate change at multiple scales through short- and long-term adaptive strategies. The range and extent of both these responses defines the resilience of the community.

The study by Fenton and Beeden[26] of stakeholder beliefs about climate change in the GBR catchment is the only specific social assessment of climate change issues in the GBR. It identified a number of core issues associated with climate change in the GBR catchment.

- There is considerable variation in the recognition and acknowledgement of climate change across the spectrum of stakeholders in the GBR, both in the level of experiential and scientific knowledge about the marine ecosystem and climate change. Some stakeholders have very detailed local knowledge and belief systems about how the ecology of the local area functions. In contrast, much of the knowledge about marine ecosystems and climate change within government agencies and regional NRM organisations is based on 'scientific data' and the knowledge of 'experts'.
- Stakeholder understanding and perceptions of climate change are influenced by a wide range of individual and socio-cultural factors in the GBR. The schemas individuals develop for climate change processes are based on multiple sources of information, both experiential knowledge and 'expert' information. Climate change in the GBR is not conceptualised as a series of independent events, but rather as a series of interdependent and causally connected events occurring within the environment. There is a significant lack of scientific information about climate change, and individuals try to fill the gaps in their knowledge through their own experience and beliefs about climate change.

- Identifying the consequences, impacts or responses to climate change – while there is some commonality across individual cognitive models of the impacts of climate change, there are significant differences in the breadth and depth of knowledge about its potential impacts.

The study found that although climate change is an objective and measurable event, it is understood and acted upon as a subjective event. It is constructed by different stakeholder groups and imbued with meanings derived from experience and the social and cultural context in which individuals, industries and communities find themselves. Individuals, stakeholders and communities' recognition and acknowledgement of climate change, how they construct and give meaning to climate change processes, and the content of their anticipatory schema in relation to climate change impacts and response, essentially determine their vulnerability, adaptive capacity, adaptation, and resilience to climate change. This study clearly shows there is a difference in preparedness amongst different stakeholder groups to climate change impacts.

23.7.1 Potential management responses

Climate change presents considerable challenges for management because it involves considerable uncertainty, the potential for irreversible damage or cost, a very long planning horizon, time lag between cause and effect, and the need for systemic institutional change[14].

The implementation of management actions to address climate change is hindered by:

- Institutional complexity, confusion, poor coordination and integration of arrangements. This leads to a poor articulation of desired outcomes and the desired management actions of community and industry stakeholder s to deal with climate change.
- An insufficient overall framework for climate change and no framework for the delivery of programs or incentives.
- Insufficient opportunities for public involvement in developing policy and management responses.

Any management actions developed to increase preparedness for climate change needs to recognise the diversity of constructs used to define climate change and its impacts across different stakeholder groups. A single approach towards preparedness and management is unlikely to have an effective response with all groups therefore management responses need to involve diverse community and industry stakeholders in the process. Furthermore, across the different stakeholder groups, the level and quality of interaction with science 'experts' and the trust that underpins these relationships will need to be recognised and addressed to ensure equity in any management response.

While it is important, through good marine management, to maintain and ensure the natural resilience of marine ecosystems from human induced climate change, there is a question about whether it is equally appropriate to do the same for social systems. If the actions of existing social systems are reducing the resilience of the ecological system by contributing to climate change, then response strategies that build and maintain current behaviour patterns would be counterproductive and maladaptive. In terms of enhancing resilience in social systems, the focus must be on facilitating adaptation and building the adaptive capacity to proactively bring about transformation in the interaction of the social-ecological system. The role of natural resource management in the context of social systems is to increase the capacity of people and communities to recognise, learn and benefit from such change.

The capacity to cope with nonlinearities or other forms of surprise and uncertainty requires openness to learning, an acceptance of the inevitability of change, and the ability to treat interventions as experiments or adaptive management[39]. Rather than focus on the provision of information, policy efforts should address the social and institutional barriers that hinder community and industry, involvement in, and leadership of, efforts to address climate change[15].

23.7.2 Further research

More research into the social dimensions of climate change is needed to support institutional processes and management strategies that are appropriate and effective in dealing with climate change given the complex social environment of the GBR. Participatory and deliberative management approaches require a deeper understanding of the diverse stakeholder groups, their experiences, and the social and cultural context in which individuals, industries and communities find themselves.

There is a need for greater knowledge and understanding about community and industry vulnerability to climate change in the GBR, information showing how people and organisations have adapted to change in the past; and research into stakeholder and community attitudes and perspectives on management options that will facilitate effective change processes.

There is a need to combine socioeconomic characteristics that are currently available with more focused social and economic assessments of climate change to understand stakeholder attitudes and perspectives with respect to climate change and participation in management strategies and to understand stakeholder vulnerability, resilience and adaptive capacity to climate change in the GBR.

It is also important that science and the science of the 'experts' needs to be integrated with a better understanding of individuals' local knowledge of climate impacts and the cognitive models they possess of climate change. To maintain separation of these two knowledge systems will restrict our understanding of human response to climate change, impede the urgency of the community and industry action required to address climate change issues, and will maintain amongst some a continued mistrust of science and the organisations and institutions that disperse scientific information.

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