Introduction

On 20 March 2006, the Category 5 Tropical Cyclone Larry crossed the Queensland coast. Cyclone Larry caused extensive damage to the Wet Tropics regions in North Queensland, Australia. Areas highly affected included the regional towns of Tully, Innisfail and Babinda, as well as the Atherton Tablelands, with extensive flooding in the Gulf Country as the cyclone diminished into a tropical rainfall depression. Cyclone Larry was the most damaging cyclone to hit Queensland and had much greater impact than the Category 3 Cyclone Winifred that hit the same region in 1986. As the Far North Queensland economy relies heavily on both the tourism and primary industry sectors, the cyclone caused significant impacts on tourism operators and the primary industries of banana, sugar, beef, dairy, tree fruit, nut, lifestyle horticulture, forestry, pig, poultry, fishery, and aquaculture.

Initial estimates of lost gross value of agricultural production over the first 12-month period amounted to A\$473 million, representing 50 per cent of the forecast agricultural output of the region. The likely range of the total financial impact was between A\$365 and A\$545 million. As Cyclone Larry wiped out an estimated 80–90 per cent of banana production, Australia experienced significant shortages in banana supplies for the remainder of 2006 and price hikes of 400 to 500 per cent across the country. Cyclone Larry also caused significant damage to both private and public infrastructure in the region. Older (pre-1986) residential and commercial properties suffered the greatest damage while damage to structures built after Cyclone Winifred was less severe. Damage to private infrastructure ranged from 15 per cent of homes at Flying Fish Point to 99 per cent at Silkwood. This damage in total inflicted pressure on the consumer price index (CPI). While individual extreme weather events cannot be directly attributed to climate change, their impacts paint a picture of damages that are projected to increase in the future as the climate changes.

This book looks at the issues arising from climate change and weather extremes for organizational decision-makers and policy-makers, and suggests that a future key activity will be to create climate change resilient organizations (including private sector firms and industries, as

well as other types of organizations, such as not-for-profit organizations or local government). Even though public opinion is seemingly divided on the causes of and certainties around the occurrence of climate change, the scientific community has put forward a large and growing body of evidence which establishes that climate change is occurring, and that the resulting impacts are presenting very real, substantial, and tangible threats. Scientific data summarized by the Intergovernmental Panel on Climate Change (IPCC) shows that rising temperatures, changes in sea levels and melting glaciers are phenomena that are not occurring in a distant future, but outcomes of a changing climate that are already measurable in the present day (IPCC, 2007a; 2012; 2013). Impacts from climate change are expected to increase further in the future, particularly in vulnerable sectors and locations.

Even more concerning, it is expected that the greatest vulnerabilities of firms and industries, but also of settlement and society as a whole, will not occur due to gradual temperature increases alone (Wilbanks et al., 2007b). Projections show that the increasing surface temperature of the Earth will not only lead to gradual changes in mean climate conditions (for example, gradual increases in mean temperature), but also to larger climate variability and changes in the frequency, intensity, duration, spatial extent, and timing of extreme weather and climate events (IPCC, 2012; Meybeck et al., 2012). Impacts from climate change are expected to increase further in the future, particularly in vulnerable sectors and locations.

For industries and firms, the significance of any changes in the environment, particularly in the frequency or intensity in weather extremes, lies in their potential to bring about considerable adverse and unprecedented impacts on business activities (Hertin et al., 2003; Wilbanks et al., 2007b). These can occur in the form of direct impacts (direct exposure to damaging weather extremes) or can result from flow-on effects (indirect exposure, for example, from power outages, or impacts on important infrastructure) (Wilbanks et al., 2007b). The likely geographical distributions of such impacts, the timeframes over which they will occur, as well as the probabilities of the severity of impacts and particular future climate change scenarios are still surrounded by much uncertainty (Linnenluecke and Griffiths, 2011; Schneider et al., 2007; Wilbanks et al., 2007b). One issue that seems certain is that there are few areas and economies that will not be impacted upon by large-scale changes such as rising sea levels and coastal flooding, changes in patterns of extreme weather, as well as disruptions to agricultural systems (Brown and Funk, 2008; Smith et al., 2007).

Insurance statistics have demonstrated a greater likelihood, magnitude and diversity of damages from weather extremes over the past decade (Munich Re, 2012). Climate change and weather extremes have been cited as contributing factors, along with a number of other circumstances that have been converging and leading to this trend. Population growth and migration into higher risk areas such as coastal zones and cities and the industrialization of these areas are exacerbating the exposure of human settlements, industries and corporations to weather extremes (Munich Re, 2009). Other contributing factors are societal trends towards a greater reliance on tightly-coupled infrastructure (for example, financial systems, communications, energy and transportation) that often operate within narrow margins and have an associated heightened risk for large-scale failure, breakdown and outage when an adverse event occurs (Perrow, 1984; Rinaldi et al., 2001).

Different schools of thought have emerged with regard to responding to climate change. The safest way to avert dangerous consequences of climate change would be to take immediate, decisive and effective action to reduce greenhouse gas (GHG) emissions – this has been referred to as *mitigation* (or a *limitationist* view) (Kates, 2000). Yet, despite the obvious urgency of mitigation, progress on a global scale has been slow at best, and overall GHG emissions continue to rise. Consequently, it is becoming increasingly important to develop strategies that will enable society to survive and thrive in a climate-changed world alongside mitigation mechanisms. Such strategies, aimed at measures to reduce the exposure and vulnerability of natural and human systems to actual or expected climate change impacts are commonly referred to as *adaptation* (Dow et al., 2013; IPPC, 2007). However, anticipated changes in climate and weather patterns put great pressure on organizations, industries and society to not only adapt to climate change impacts but also to build *resilience*, that is, the capacity to absorb, withstand and recover from adverse impacts from climate change (for example, climate and weather extremes) that are beyond the circumstances that organizations, industries and society are adapted to cope with (Linnenluecke and Griffiths, 2010).

This book looks at both efforts towards mitigating climate change (Chapters 3–4) to help avoid ‘dangerous anthropogenic interference with the climate system’ as specified in Article 2 of the United Nations Framework Convention on Climate Change (UNFCCC), as well as processes of adaptation and methods to integrate resilience into social systems with a particular focus on private sector organizations (Chapters 4–7) – as a response strategy to those impacts of climate change that cannot be (or are not) avoided under the projected different scenarios of climate change (Denton et al., 2014). Together with efforts to implement

sustainability, the integration of adaptation, mitigation and resilience can lead to climate-resilient pathways – through implementing strategies, choices and actions that reduce climate change and its impacts (Denton et al., 2014). Even though there is a conceptual distinction between adaptation and mitigation, both concepts are related to each other, and need to be treated as interrelated issues. Adaptation is a gradual process of adjustments undertaken over time to modify the coping range of an organization. A coping range is defined as those changes in climate-related variables (for example, warming or changes in precipitation) that an organization can tolerate without experiencing adverse consequences (Chapter 4). Resilience, on the other hand, is a characteristic of organizations that possess a sufficiently wide coping range and/or can quickly recover from situations that create vulnerability to their operations once the boundaries of the coping range have been exceeded (Linnenluecke and Griffiths, 2012). As noted by the 2007 IPCC *Synthesis Report*:

There is high confidence that neither adaptation nor mitigation alone can avoid all climate change impacts. Adaptation is necessary both in the short term and longer term to address impacts resulting from the warming that would occur even for the lowest stabilization scenarios assessed ... . Unmitigated climate change would, in the long term, be likely to exceed the capacity of natural, managed and human systems to adapt. Reliance on adaptation alone could eventually lead to a magnitude of climate change to which effective adaptation is not possible, or will only be available at very high social, environmental and economic costs. (Pachauri and Reisinger, 2007: 65)

More recently, the IPCC has concluded that even the most stringent GHG mitigation efforts cannot fully avoid further impacts of climate change over the next few decades, which makes adaptation inevitable (Denton et al., 2014; IPCC, 2013). Without mitigation efforts, however, a magnitude of climate change is likely to be reached that would make adaptation impossible for some natural systems, while for most human systems it would involve very high social and economic costs. Historically, studies such as those by Jared Diamond in his book *Collapse* indicate the fragility of social systems, and how rapidly they can break down under sustained environmental pressures.

In the organizational context, adaptation and resilience potentials are often context-specific and related to the characteristics of particular climate change impacts. While organizations may be able to undergo steady adaptations to gradual climate change (for example, gradual increases in mean temperatures), they might require resilience capacities to deal with disruptions that go beyond this gradual trend and are related to changes in extremes. For instance, consider an electricity utility

company that may need to upgrade maintenance systems to deal with the impact of an increasing number of record-temperature days on its distributions systems. Such a company can adapt over the long run by introducing infrastructure upgrades to deal with warmer temperatures, however, it is also exposed to impacts that it has not adapted to in time (such as prolonged heat waves and excessive energy demand).

While a clear imperative for building adaptation and resilience to climate change exists, many essential issues still remain unresolved (Linnenluecke, 2013a). First, against which criteria or baseline data can adaptation progress and attempts at building resilience be evaluated and monitored? Second, who should bear the responsibility for making adaptation decisions and for building resilience, and what type(s) of climate change impact(s) should be prioritized? Third, who is supposed to carry costs, and who will benefit?

The public sector, especially local governments, will certainly have a major role to play in meeting adaptation needs (Linnenluecke, 2013a). Indeed, adaptation decisions, such as land use planning or disaster management, are commonly regarded as issues that should be dealt with by the public, rather than the private sector. Governments, however, are often slow to agree on changes and even slower to implement them. While the short duration of political planning and election cycles is certainly a contributing factor, the divided public opinion on climate change does also not create any strong impetus for policy action. In addition, the difficulty to reach political agreements at a global scale directly conflicts with the urgency of making decisions on how to address climate change.

The private sector, on the other hand, might react quickly and efficiently in implementing solutions. It can, therefore, be a valuable partner to support adaptation policies and strategies. Governments often expect the private sector to adapt, yet few incentives exist to promote coherent adaptations. Individuals or organizations (especially those in more exposed sectors, such as tourism or agriculture) might respond to environmental changes or market signals brought about by climate change, which is also referred to as 'autonomous adaptation' (European Commission, 2009). However, this type of adaptation is unlikely to be optimal from a societal perspective, as individual actors will pursue their own adaptation goals and not integrate their actions. There are constraints to autonomous adaptation such as uncertainty about climate impacts and the costs of implementing adaptation decisions (European Commission, 2009). Few business decisions are directly targeted towards achieving societal adaptation to climate change and in alignment with their communities' adaptation needs. Private companies are often hamstrung

by short-planning timeframes, short market system rewards and the short-termism of chief executive officers (CEOs). It is noticeable that many corporations also have short life spans.

Overall, the private sector has not yet systematically considered the organizational implications of changes in the environment and the trends of weather extremes, for example, changes to the intensity and/or frequency of storms, floods and droughts. While some exposed companies, such as those in the reinsurance industry (for example, Munich Re, Swiss Re) have begun to undertake research into the risks associated with a changing climate and resulting impacts on their organizations, most current debates on climate change and the global corporate response are mainly focused on mitigation – that is, adjustments that organizations can take to reduce their GHG emissions, mostly in response to policy and legislative changes (Linnenluecke and Griffiths, 2010). The question of how organizations can cope with the physical impacts of global warming and more frequent and/or intense weather extremes has largely remained outside of these debates (Griffiths et al., 2012). A common argument is that the less effective mitigation efforts are, the more important adaptation will become. However, little is known about issues such as the synergies or trade-offs between adaptation/resilience, mitigation and possible other important objectives, for example, ecosystem protection (Kates et al., 2001). Little is also known about how these issues play out over different time scales in the future.

Advocating for greater attention to adaptation has not been without controversy. Critics have argued that a focus on adaptation can be interpreted as a tacit admission that mitigation efforts are no longer sufficient and/or worth pursuing (World Economic Forum, 2013). Critics have also argued that adaptation strategies might have unintended consequences and actually lead to maladaptive outcomes. For instance, a society that is prepared only for a narrow range of (anticipated) changes in climate might not be sufficiently resilient against the unexpected consequences of climate change, or changes in the frequency and intensity of extreme weather events (Linnenluecke et al., 2012). A well-adapted society might also be more complacent towards changing environmental conditions, as adverse impacts are not directly ‘felt’ and factored into decision-making. Furthermore, some adaptation actions may increase overall societal vulnerability rather than actually reduce it, and thus be maladaptive (European Commission, 2009). Examples of maladaptive outcomes are cooling technologies or water supply systems that increase energy consumption, or flood protection infrastructure that helps to reduce frequent, low-to-moderate magnitude losses, but does not protect against larger magnitude threats. Such defenses might also have

additional negative side effects, for instance, they might disturb coastal and river systems and take away natural defenses (European Commission, 2009; New et al., 2011).

Given the observations and projections outlined above, the key aim of the book is to develop an understanding of how organizations can develop strategic responses to climate change and changes in the frequency and/or intensity of weather extremes. The frameworks presented here move beyond typical risk and crisis management perspectives. Since 2005, our Business School has offered a suite of education strategies on climate change and management. Over 100 corporate leaders completed a formal course, over 400 postgraduate students elected a Masters subject, and over 550 executives took part in two-day workshops. These courses showed that the key difficulty for executives lies not in accepting the reality of climate change once confronted with the scientific evidence, but in determining company-specific contributions to climate change and the impacts of climate change on their operations, in addition to the overall economic impacts of policy measures, for example, a price on carbon. Executives are faced with the challenge to not only determine their organization's carbon intensity and forge transition paths to alternative low-carbon business models – but also to consider adaptation and resilience measures. Most organizations are accustomed to deal with some climate variability such as seasonal changes or wet and dry seasons (Carter et al., 2007), but are usually challenged to accommodate conditions that occur with a much greater magnitude, frequency and/or rate of change (Linnenluecke et al., 2012; Wilbanks et al., 2007b). Determining strategic approaches to climate change is a complex task, especially in the construction, energy and infrastructure sectors.

Included in the book are several chapters that seek to provide a foundation for understanding, assessing and evaluating organizational responses to climate change and more frequent and/or intense weather extremes. The first chapters serve as an introduction to the topic, assess the risks (and potential opportunities) posed by climate change and outline how this topic has to date received little attention in both policy-making and organizational practice. We see a twofold role for policy developments and scientific research to support organizational engagement with climate change: organizational-level mitigation targets need to be clearly linked to global emission targets, and climate models need to inform organizational-level adaptation. Mitigation efforts require knowledge on how to establish verifiable and auditable emission inventories, and on how to implement abatement measures through changes in organizational policies, infrastructure and processes. Adaptation requires

knowledge on how to evaluate future climate impacts on organizations on a relatively fine-grained geographic and sectoral scale (Linnenluecke et al., 2012; Wilbanks et al., 2007b). Executive responses will depend on a clear understanding of options for emission reductions and organizational transformation.

The remainder of the book looks at the concepts of organizational adaptation and resilience to both impacts from gradual climate change and changes that occur with greater magnitude, frequency and/or rate of change than expected. We cover methodological and assessment issues – for instance, innovative methods and pathways to study adaptation needs – and the development of organizational resilience potentials under different climate change scenarios. The book thereby directly addresses issues associated with uncertainties about future climate change outcomes across temporal and spatial scales. The book also seeks to provide insights into what leads to the resilience of organizations, industry or society, and into the variables that should be considered in a decision-making context (Linnenluecke and Griffiths, 2012). Last, we also discuss the potential inability of organizations to adjust to changes in climate and weather extremes, and implications in terms of a necessity of a geographical shift of organizational and industrial activities. The key contribution of the book is that it extends existing debates on mitigation and addresses adaptation and resilience, and the connection between these concepts – and provides practical tools and frameworks that come from empirical evidence. The book seeks to close gaps in our understanding of organizational challenges associated with a changing climate.

Structure of this Book

This book is based on the premise that there is a twofold role for policy developments and scientific research to support organizational adaptation, mitigation and resilience to climate change impacts. First, organizational-level mitigation targets need to be clearly linked to global emission targets to avoid the worst consequences of climate change. At the same time, and given that not all adverse impacts of climate change can be mitigated, even with significant emissions cuts, models and projections about future climate impacts are required to inform societal and organizational-level adaptation targets. The most appreciable positive results can be made when integrating adaptation decisions into large-scale infrastructure developments and long-term planning frameworks, especially in regions that are rapidly developing and/or are highly vulnerable to climate impacts.

The book's aims are as follows:

- Explore organizational issues resulting from global environmental change, especially climate change.
- Provide an understanding of climate policy developments and their effectiveness.
- Develop insights into effective adaptation, resilience and response strategies of organizations.
- Discuss the innovative responses of organizations and the development of climate-resilient pathways as an impetus to promote change.

This book sets out to address these aims in Parts I and II. Part I starts by analyzing the impacts brought about by the aggregate levels of industrial activities, and outlines how the local manifestations of global changes impact organizations and industries. We also turn our attention to the policy-level of analysis and international progress on adaptation policy. Part II translates scientific knowledge on global climate change processes into information that has relevance to local decision-makers, recognizing that effective solutions require the involvement of actors across multiple scales and levels.