Impacts from Climate Change on Organizations: A Conceptual Foundation

Article *in* Business Strategy and the Environment · March 2011

DOI: 10.1002/bse.679

CITATIONS
320

READS
19,925

5 authors, including:

Monika Winn
University of Victoria
38 PUBLICATIONS **4,357** CITATIONS
SEE PROFILE

Manfred Kirchgeorg
HHL Leipzig Graduate School of Management
173 PUBLICATIONS **2,936** CITATIONS
SEE PROFILE

Andrew Griffiths
The University of Queensland
72 PUBLICATIONS **6,146** CITATIONS
SEE PROFILE

Martina K Linnenluecke
University of Technology Sydney
144 PUBLICATIONS **7,787** CITATIONS
SEE PROFILE

Business Strategy and the Environment
Bus. Strat. Env. **20**, 157–173 (2011)
Published online 31 May 2010 in Wiley Online Library
(wileyonlinelibrary.com) **DOI**: 10.1002/bse.679

Impacts from Climate Change on Organizations: a Conceptual Foundation

Monika I. Winn,[1]* Manfred Kirchgeorg,[2] Andrew Griffiths,[3] Martina K. Linnenluecke[3] and Elmar Günther[2]

[1] *Faculty of Business, University of Victoria, Victoria, BC, Canada*
[2] *HHL – Leipzig Graduate School of Management, Leipzig, Germany*
[3] *UQ Business School, The University of Queensland, Brisbane, Queensland, Australia*

ABSTRACT

Physical impacts from climate change already pose major challenges for organizations, and the trend is rising. Organization theorists, however, have barely begun to systematically consider the organizational impacts of more and increasingly intense storms, floods, droughts, fires, sea level rise or changing growing seasons as part of their domain of study. Eight organizationally relevant dimensions of climate impacts are identified: severity, temporal scale, spatial scale, predictability, mode, immediacy, state change potential and accelerating trend potential. Combined, their scale, scope and systemic uncertainty suggest future conditions of systemic hyperturbulence in organizational environments, defined here as 'massive discontinuous change' (MDC). To build a conceptual foundation for organizations to respond and adapt to MDC, the paper examines contributions from literatures on the management of sustainability, crisis, risk, resilience and adaptive organizational change. It highlights gaps for addressing both business challenges and opportunities from MDC, and suggests avenues for future research. Copyright © 2010 John Wiley & Sons, Ltd and ERP Environment.

Received 22 July 2009; revised 5 March 2010; accepted 11 March 2010

Keywords: climate change impact; hyperturbulence; environmental uncertainty; organizational resilience; organizational adaptation; sustainable development

Introduction

CLIMATE CHANGE IS GENERATING A HOST OF NEW STRATEGIC CHALLENGES AND OPPORTUNITIES FOR BUSINESS organizations, shifting competitive and regulatory environments *indirectly* through world-wide political efforts to constrain carbon emissions and *directly* through bio-physical impacts such as extreme weather events. However, while the effects of emerging global and regional carbon management regimes for business have been studied for some time (see, e.g., Kolk and Levy, 2001; Kolk and Pinkse, 2007; Nigel and Rice, 2010), the physical impacts of climate change on business have received relatively sparse attention in management research (Hoffman, 2006; Linnenluecke *et al.*, 2008; Winn and Kirchgeorg, 2005a).

* Correspondence to: Monika I. Winn, Faculty of Business, University of Victoria, P.O. Box 1700, Victoria, BC, Canada V8W 2Y2. Tel: 250-721-6071, Fax: 250-721-6067. E-mail: miwinn@uvic.ca

Among the more visible physical impacts are weather-related disasters. Indeed, recent years have witnessed a large number of catastrophic or *extreme weather events*, such as cyclones, droughts and bushfires in Australia; heat waves, flooding and several (uncharacteristic) storms in Europe; wildfires, flooding and the infamous 2005 hurricanes Katrina and Rita in the US. It may be difficult to link any one specific occurrence to climate change, but studies of the warming observed over the past century do show that the likelihood of extreme events such as heat waves has increased due to climate change, while the likelihood of other extremes, such as extremely cold nights, has decreased (Hegerl *et al.*, 2007). Such increases in climate variability tend to be regional. More *gradual impacts* from global warming, such as sea level rise or increasing ocean acidity, can have equally devastating effects and tend to occur at global scales. Furthermore, if gradual impacts exceed critical thresholds, they can prompt *abrupt large-system changes* with significant, widespread and sustained impacts, vastly amplifying the former, and with vastly more uncertain effects due to complex interactions and feedback loops at global scales (Scheffer *et al.*, 2001; Wilbanks *et al.*, 2007).

In light of the ominous nature of impending climate change impacts, it is both surprising and understandable that research on the bio-physical impacts of climate change on organizations has been slow to start. General public pessimism about future environmental conditions across 18 countries (Gifford *et al.*, 2009) – particularly notable since 'normal' biases lean toward optimism (see, e.g., Hatfield and Job, 2001) – could prompt either preventive and adaptive action, or feelings of helplessness. While it is not clear how such social–psychological phenomena might affect management science, a recent study by Goodall (2008) offers a number of institutional, political and theoretical explanations for the lack of attention to this topic in top management journals.

We suggest another reason: any comprehension of climate impacts on business is severely constrained by profound uncertainties associated with the type, the occurrence, the scale and the location of anticipated impacts. Reasons include that '[f]uture climate change will likely be fundamentally different from changes Earth experienced in the past because of the high temperatures that are projected, the rate of climate change, and the fact that climate change is occurring in a setting where human actions have already altered natural ecosystems in many other ways' (National Academy of Sciences, 2009, p. 26). Individual organizations are likely to experience such large-system dynamics as far-reaching, highly uncertain and difficult to predict disruptions, referred to here as 'massive discontinuous change' (MDC), explaining, in part, why climate change impacts have received little attention by organizational studies.

Biases and assumptions in organization science may further contribute to the dearth of studies on the negative impacts of and new opportunities from changing climate, environmental and social systems. Indeed, mainstream business models are based on the assumption that current economic and social conditions will continue to flourish regardless of unfavorable biophysical conditions in Earth's natural and climate systems (Gladwin *et al.*, 1995; Purser *et al.*, 1995). The convergence of two powerful factors makes the latter assumption difficult to challenge. One factor is a deeply rooted bias in current organization science toward the predominance of stable states and the linearity of change processes in organizations and their environments (Meyer *et al.*, 2005; Santos and Eisenhardt, 2005). The other relates to the externality of natural systems to organizational life, making it difficult for economic and management theories to recognize (and theorize) the co-dependency between firms and the natural environment (Purser *et al.*, 1995). As a result, adequate concepts of organizational environments that incorporate nature's functioning are in short supply, as are methods that can capture nonlinear change such as longitudinal or process-focused research methodologies (Meyer *et al.*, 2005). The combined shortage of concepts and methodologies creates formidable obstacles to research in this arena, but it also provides exciting opportunities to reconfigure future directions of management research.

Regardless of its status in management research, climate change is increasingly accepted as a fact of organizational life. Its effects are felt across a wide range of industries, such as the financial sector, tourism, construction, agriculture, the insurance industry and others (see, e.g., Hoffman, 2006; Hoffmann *et al.*, 2009; Wilbanks *et al.*, 2007). Even though it may be competing for attention with the current economic crisis, its salience for corporate strategy and planning is increasingly recognized (Schwartz, 2007), as a changing climate system forces business to adapt to impacts ranging from weather extremes to epidemics affecting crops.

The critical question is how business organizations can best prepare for, avoid, adapt to and take advantage of anticipated climate change impacts. However, for research to study organizational *responses* to impacts, it must first gain a better understanding of the phenomenon prompting responses. The purpose of this paper is

DOI: 10.1002/bse

therefore to provide a conceptual foundation for understanding the impacts of climate change on organizational environments.

We begin by examining whether and how climate change impacts differ from other turbulences in organizational environments. Based on research in management on environmental change (e.g. Meyer, 1982; Meyer *et al.*, 1993) and climate science (e.g. Meehl *et al.*, 2007; Rosenzweig *et al.*, 2008), we identify several dimensions, which, together, define climate change impacts as 'massive discontinuous change' (MDC) in organizational environments;[1] it is these types of MDC that are the primary focus of this paper. Next we draw out contributions from five streams of the management literature (sustainability, crisis, risk and resilience management, and adaptive organizational change) to shed light on the implications of MDC for organizational environments for firms. We highlight gaps, suggest directions for future research and close with implications for preparing organizations for climate change.

Understanding the Impacts of Climate Change on Organizations

Climate change has been described both as a 'predictable surprise' (Bazerman, 2006) and as a 'wicked' problem because it comprises open, complex and imperfectly understood systems (Prins and Rayner, 2007). There is considerable certainty about the occurrence of long-term climatic changes and resulting impacts, but there is considerably less certainty about their type, severity or time of onset. Cognitive, organizational and political barriers further hinder organizations from effectively mitigating against and adapting to these changes (Bazerman, 2006; Gifford *et al.*, 2009).

The Intergovernmental Panel on Climate Change (IPCC) defines climate change as 'a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer' (Baede, 2007, p. 943), and that occurs either due to natural processes or due to persistent anthropogenic changes in the composition of the Earth's atmosphere or in land use (IPCC, 2007). Despite scientific evidence for human contributions to increased CO_2 concentrations (e.g. Rosenzweig *et al.*, 2008), debate in public media continues.

Whether anthropogenic or not, however, climate change impacts are expected to bring about not only significant changes in climate and ecosystems, but also dramatic changes in social and economic system parameters (Holling, 2001). In some regions, climate change may reduce the carrying capacity of ecosystems and threaten basic production and consumption processes, in turn threatening the very survival of economic and social systems (see also Gunderson and Holling, 2002; Hay, 2002).

Extreme weather events are no longer isolated occurrences, but rather appear to be linked to underlying changes in the Earth's climate system (see, e.g., Folke *et al.*, 2002; Holling, 2001). Some of the consequences of climate change may be beneficial (such as extended growing seasons in Northern latitudes). Many more, however, are expected to be disastrous and even catastrophic. News media offer no shortage of climate-related disasters in the headlines. Examples in recent years from around the world include Victorian bushfires in Australia, wildfires, storms and infestations in the US and massive floods in Europe. Even though it is difficult to attribute the occurrence of individual weather events to climate change (see, e.g., Hegerl *et al.*, 2007), observed changes in patterns of extreme weather events point to larger, underlying climatic changes and climate variability (Trenberth *et al.*, 2007).

More gradual effects from global warming are the melting of polar ice caps and the rise of sea-levels. Such ecological discontinuities can have major, disastrous effects on socio-economic and political systems (IPCC, 2007; Stern, 2006; Garnaut, 2008). A study of islands in the South Pacific concludes that the entire region can expect total destruction of its current socio-economic structures due to climate change (Hay, 2002). Schwartz and Randall (2003) emphasize that it is not the threat from terrorism, but the vulnerability of countries and societies to natural catastrophes and climate change impacts, that offers the greatest future challenges to national security.

[1]Two features of climate change should be noted here, which will be examined further later in the paper, namely (1) not all climatic changes have massive or negative impacts, but, while some sectors may even benefit from positive effects, overall impacts will likely be negative; (2), smaller changes, when reaching thresholds, can trigger further abrupt and massive changes.

DOI: 10.1002/bse

Sector	Floods		Storms		Droughts		Extreme winters	
	short term	long term	short term	long term	short term	long term	short term	long term
Agriculture	–	––	––	–––	––	–––	+	++
Assembly	–	––	––	–––	–	––	+	++
Auto insurance	–	––	––	–––	–	––	+	++
Aviation	–	–	–	––	–	––	o	o
Commerce	–	––	––	–––	–	––	+	++
Construction	––	–––	––	–––	–	––	+	++
Event planning	––	–––	––	–––	–	––	––	–––
Manufacturing	–	––	––	–––	–	––	+	++
Private sector	–	––	––	–––	–	––	+	++
Transportation	–	––	––	–––	–	––	+	++

Table 1. Climate change impacts anticipated by industry sector
Key: – negative impact; + positive impact; –/+ low; ––/++ moderate; –––/+++ strong.
Adapted from Munich Re (2003).

Finally, climate change could lead to abrupt, large scale and irreversible shifts in the climate system (see, e.g., Alley *et al.*, 2003; Scheffer *et al.*, 2001; Stern, 2006), stemming from complex interactions and positive feedback effects, where impacts on natural *and* human systems may be mutually reinforcing (see, e.g., Meehl *et al.*, 2007). Simulation studies, for instance, show that gradual warming may cause an increase in freshwater inflow into the North Atlantic, potentially disrupt water fluctuations transporting warm water to eastern North America and western Europe and causing the climate in some regions to become dramatically colder (IPCC, 2007; Rahmstorf, 1995, 1996; Scheffer *et al.*, 2001).

At the macro-level then, the resilience of societal institutions and entire nation states is at stake, and the growing number of country-level scientific assessments (e.g. Garnaut, 2008; National Academy of Sciences, 2009) and regulatory initiatives suggests a shift in attention.

At the organizational level, the more comprehensive overviews of climate impacts on business come from the statistics and financial data of reinsurance companies, whose core business models are based on covering damages from property losses and business interruption due to natural disasters. In 2005, Swiss Re expected $83 billion losses from natural catastrophes (Hoffman, 2006). As Table 1 indicates, most economic sectors are affected by climate change impacts: manufacturing, commerce, construction, assembly, transportation, agriculture, car insurance, aviation, space travel and event planning (Munich Re, 2003, 2009), making such impacts truly a 'cross-industry phenomenon' (see, e.g., Alcamo *et al.*, 2007). While different economic sectors will be affected differentially, overall impacts are expected to grow significantly, both geographically and across all industries.

Particularly vulnerable are sectors that rely on relatively narrowly confined temperature and seasonal conditions, such as agriculture, aquaculture, fisheries, forestry and tourism (especially coastal and mountain destinations) (Alcamo *et al.*, 2007; Hamilton *et al.*, 2005). Other industries likely to suffer potentially devastating effects are those dependent on, and vulnerable to, the disruption of large scale infrastructure, such as energy, automotive and other transportation sectors, and financial markets. Associated financial and organizational risks, as yet poorly defined, further highlight the urgent need for a better understanding of climate related organizational impacts and for firm capability to prevent, respond or adapt to the impacts (Heal and Kriström, 2002; Willows and Connell, 2003.

From Discontinuities in Organization Studies to Massive Discontinuous Change

Much of management and organization theory is built on the 'open systems' concept of organizations and their ability to either influence or adjust to environmental change. We can look to extensive research on organizational

DOI: 10.1002/bse

fit, alignment with and adaptation to changes in organizational environments, themselves subject to extensive theorizing. Organizational strategies are influenced by decision makers' expectations about the future states of their relevant environments, as well as their perceptions about uncertainties associated with such future states. Milliken (1987) differentiates three types of perceived uncertainty about the environment, which are useful to categorize the topic of this paper. *State uncertainty* refers to uncertainty about future states of the climate system (which we saw to be exceedingly high due to limited knowledge and complex interactions and feedback loops at multiple levels between climate, ecological and social systems); *effect uncertainty* refers to uncertainty about the type of climate change impact (the starting point of this paper), and *response uncertainty* refers to 'the lack of knowledge of response options and/or an inability to predict the likely consequences of a response choice' (Milliken, 1987, p. 137), addressed further below.

Discontinuous environmental change is not a new concept for management studies (e.g. Meyer, 1982; Tushman and Anderson, 1986; Christensen, 1997), nor is managing in hyper-turbulent environments (McCann and Selsky, 1984; Meyer *et al.*, 1993; Brown and Eisenhardt, 1997) or managing organizational change (Huber and Glick, 1993; Gibson and Birkinshaw, 2004). Drucker (1969) spelled out risks and opportunities associated with societal, institutional and socio-economic discontinuities stemming from technological change, economic globalization, increasing socio-political pluralism and changes to a knowledge society; he was silent on ecological sources of discontinuities and tended to focus on incremental rather than massive discontinuities. Ansoff defined organizational discontinuities as '[…]sudden, urgent, unfamiliar changes in the firm's perspective which threaten either a major profit reversal or loss of a major opportunity' (1976, p. 131).

Building on the concept of discontinuities from the literature, we introduce the term 'massive discontinuous change' (MDC) to capture the scale, scope and systemic uncertainty associated with climate-induced disruptive change in the social and ecological (or biophysical) systems within which firms operate (Starik and Rands, 1995). Dynamics within and between these systems can lead to positive feedback loops and result in further direct and indirect impacts on organizations. Building on climate science, and drawing on classifications of risks, hazards and discontinuities, which typically specify their sources along with other criteria (such as an event's spatial extent of damage zone, intensity of impact, duration of impact, rate of onset, focus or target, and predictability of the damage to the affected industry; e.g. Smith, 1992), we define MDC due to climate change impacts along eight dimensions: *severity*, *temporal scale*, *spatial scale*, *predictability*, *mode*, *immediacy*, *state change potential* and *accelerating trend potential*. Taking these dimensions together suggests that MDC differs from other turbulences in organizational environments either qualitatively or in magnitude.

- Severity: magnitude (high), destructiveness (high).
- Temporal scale: suddenness (high), duration (variable; may range from short, extreme events to sustained long-term impacts).
- Spatial scale: geographic extent (regional, global).
- Predictability (low): uncertainty (high) and probability of occurrence (variable).
- Mode: pervasiveness (high), diversity (high), reversibility (low).
- Immediacy: direct (immediate) or indirect (mediated by ecological and/or social–economic system).
- State change potential: potential to exceed thresholds and tipping points (high).
- Accelerating trend potential: potential for runaway effects from feedback effects (e.g. collapsing economic activity in a region hit by a storm, such as New Orleans).

Based on these parameters, we define MDC as *significant, sudden, disruptive change in the broader ecological or social systems of which organizations and economic systems are a part*. While this paper focuses primarily on climate change, the concept also applies to other sources of change. 'Now, big shocks in monetary policy, price of food, price of energy, combined with some severe climate events, are all coming together in a world with constraints on arable land, depleted fisheries, rising sea levels and changing climate. Periods of abrupt regional and global changes are likely to increase in frequency and magnitude, which poses new fundamental challenges for science, management, policy and governance in relation to sustainability' (Folke and Rockström, 2009, p. 1).

MDC differs from other types of change in organizational environments (e.g. environmental jolts, Meyer, 1982) by virtue of its massively greater scope and scale (both spatial and temporal), its systemic roots and effects, its

DOI: 10.1002/bse

non-linear, 'discontinuous' characteristics and associated unpredictability (coupled with limited controllability and manageability), its irreversibility and its destructive nature.

It also differs from the type of change captured in punctuated equilibrium approaches (e.g. Gersick, 1991) in several regards. The accumulation of multiple extreme values on these dimensions distinguishes MDC in scope and scale from other types of discontinuous change. Drawing on evidence from multiple scientific disciplines, Gersick introduced management and organizational theorists to 'punctuated events' that may reshape organizational environments before settling into a previous or new steady state. The punctuated equilibrium model is helpful to differentiate incremental from more radical change and it conceptualizes the idea of step-change, but it is based on assumptions of underlying system stability, subject to only temporary disturbance.

Meyer, Gaba and Colwell (2005) make a compelling case for pushing current conceptual boundaries beyond linearity and stability assumptions, and for organizational science to upgrade its methodological and conceptual 'toolbox' to include non-linear change. Such theoretical and empirical advances are certainly required to understand MDC, since systems subject to MDC do not necessarily return to an equilibrium or steady state. The concept also highlights the need for organization science to theorize dramatically heightened uncertainty and turbulence in organizational environments, and thus in organizations. Biases toward linearity, stability and incremental change run deep across many scientific and public domains, where '[t]heories, models and policies have to a large extent been developed for gradual or incremental changes often disregarding interactions across temporal and spatial scales' (Folke and Rockström, 2009, p. 1).

In organization theory, the concept of environmental 'hyperturbulence' perhaps most closely represents our concept of MDC (McCann and Selsky, 1984). Extending the work by Emery and Trist (1965) on 'causal texture' and 'relevant uncertainty', the authors postulate a fifth type of organizational environment: characterized by conditions of hyperturbulence and subject to endemic and escalating positive feedback cycles, it can be caused by 'serious climatic shifts, wars, and the failure of the global economic system' (McCann and Selsky, 1984, p. 465). The applicability of these concepts in light of the current global financial meltdown or the physical science of climate change 25 years later is quite remarkable. This work also points to massive ecological or social system discontinuities other than climate change, such as wars. It may be worthwhile to reexamine organizational environments according to their munificence, dynamism and complexity (see, e.g., Dess and Beard, 1984; Tushman and Anderson, 1986), along with conceptual distinctions between rates of change and unpredictability of change in light of the categories defining MDC in the ecological environment.

It is the interdependence of social–organizational systems and their biophysical 'root-systems', along with their complexity and potential for escalating positive feedback cycles, that lends MDC its magnitude and disruptiveness. Yet, while maladaptive processes lead to transformations in organizational systems that make their 'failure and collapse[…] significant prospects' (McCann and Selsky, 1984, p. 465), adaptive processes can either escalate climate change further or lead to vastly more desirable changes that are system correcting – in essence those massive and discontinuous changes required in current social–economic systems that slow climate change and stem its escalation.

Foundations for Future Research

We contend that organization studies need to be engaged broadly to fully understand the impact of MDC and design effective responses, and start this process by examining several research streams for their conceptual and empirical contributions. We are guided by the search for theory that allows us to more fully describe and explain these phenomena in the organizational context, so that both theoretically robust and practically effective *response* and *adaptation* strategies can be designed for firms to reduce disastrous impacts, and to *take advantage of* any opportunities arising from MDC. In addition to *preparing* an organization *for* MDC, a comprehensive and integrated set of strategies also needs to include those aimed at *prevention of* MDC (in the case of climate change commonly referred to as mitigation); the latter is part of the broader agenda of current sustainability or greening strategies aimed at mitigating environmental harm. In the remainder of this paper, we focus our attention on research applicable for *preparing* organizations for predictable (and unpleasant) surprises.

DOI: 10.1002/bse

Sustainability Management

A review of the growing literature on sustainability management indicates that attention is paid to the impact from economic and social systems on ecological systems, but, with few exceptions, very little attention has been paid to the reverse: the physical impacts of ecological (or climate) system disturbances on the economic or social system (e.g. Banerjee, 2003; Günther, 2009; King, 1995; Lash and Wellington, 2007; Linnenluecke *et al.*, 2008; Purser *et al.*, 1995). Current concepts and paradigms of sustainability management (see, e.g., Bansal and Gao, 2006; Gladwin *et al.*, 1995; Hart, 1995; Hart and Milstein, 2003; Shrivastava, 1995) focus primarily on the 'greening' of organizations and institutions, that is, on reducing environmental damage as a result of their activities along their value chain, thus reducing or even preventing environmental degradation (and the consequences of such degradation for social systems). Clearly, such work is crucial for building the types of organizational and institutional system that prevent further degradation; however, there is a risk that sustainability management's myopic focus on prevention blinds scholars to the need to also examine 'outside-in' strategies for effective response and adaptation to ecological disasters (Winn and Kirchgeorg, 2005a) or provides undue optimism about progress in reducing harm.

This literature includes work that examines how and why corporations respond to pressures for environmental responsibility and sustainability and to current environmental issues. Many of them document incremental change strategies, tools and processes that managers use to adopt a more proactive environmental stance. Much of the literature rests on assumptions of balance, integration and reduced impact on the natural environment (Winn and Kirchgeorg, 2005a). It does not examine in any depth the opposite cause–effect relationship, namely massive impacts from the environment on firms, nor does it include discontinuous and/or disastrous impacts. Aside from a few exceptions (e.g. Hoffman, 2006; Linnenluecke *et al.*, 2008), this literature provides little guidance for managers to respond to rapid, unpredictable and discontinuous change in ecological systems.

Closing this gap is made more difficult to the degree that there is little empirical basis for researchers to expand their focus. Indeed, firms that reduce their carbon footprint *and* recognize the strategic relevance of climate change impacts are the exception; an example is financial service provider and reinsurance giant Swiss Re, who declared that 'the potentially catastrophic effects of climate change pose a major risk to its industry and its customers, and is committed to combating it' (Way and Rendlen, 2007, p. 42).

One might argue that natural disasters have always occurred and have always been hard to predict. Examples are the Asian tsunami of December 2004 and earthquakes more generally. We agree, and suggest that their harmful effects can be hugely reduced by preparing effectively, for example with coordinated emergency responses (covered in the literature already). Such isolated events are different from MDC, however, in that they do not exhibit the underlying systemic changes in ecological or social system dynamics mentioned earlier, which lead to increases in frequency, severity, unpredictability and newness of disastrous events, and are behind their potential for driving continued changes in system dynamics. As systemic changes in the risk structure of the global insurance industry indicate, the development of effective preparedness, organizational responses and adaptation becomes a critical strategic and, for some organizations, moral mandate (similar to preventive and harm-reduction strategies addressed in the sustainability management literature).

We suggest that current sustainability management models need to be expanded from their focus on reducing negative impact on ecological systems to also include deliberate attention to preparing for adaptation to environmental impacts. We also fully acknowledge that it has never been more urgent to improve the effectiveness of environmental impact reduction in order to slow the degradation and unraveling of global ecosystem health more generally (Millennium Ecosystem Assessment, 2005) and to radically slow, and where possible reverse, the anthropogenic sources of climate change specifically (IPCC, 2007). Nor has the necessity ever been greater to harness innovation and ingenuity to generate new sustainable products, services and business models, while concurrently eliminating dysfunctional models (i.e. those contributing to system change).

Applying the notion of creative destruction and a theory of disruption (Christensen, 2006) to the sustainability management literature may offer fruitful directions for future research, for example in emerging markets at the bottom of the global economic pyramid (Kirchgeorg and Winn, 2006). Work on innovation and sustainable venturing can also help shift the focus from the greening of existing business organizations to identifying opportunities arising from market imperfections for sustainable entrepreneurship (e.g. Dean and McMullen, 2007; Cohen

DOI: 10.1002/bse

and Winn, 2007). It is less clear how these research directions can be applied to massive ecological disruptions associated with MDC. Overall, and despite work on corporate responses to emerging regulatory schemes to reduce carbon emissions (e.g. Kolk and Levy, 2001; Kolk and Pinkse, 2007; Nigel and Rice, 2010), little research in the sustainability management field has addressed this phenomenon from an outside-in perspective. Yet significant opportunities exist in this stream of research to examine how to create innovative, robust and resilient organizations.

Crisis Management

A sizeable body of academic literature focuses on organizational crisis and disaster management. Topics include the identification, forecasting, prevention and avoidance of organizational crisis situations (which may be originating within the firm or externally) (see, e.g., Pauchant and Mitroff, 1988; Pearson and Mitroff, 1993; Roberts, 1989), preparedness planning (see, e.g., Quarantelli, 1985), immediate responses to crises and mitigation of risk and losses (see, e.g., Mitroff and Pearson, 1993; Mitroff *et al.*, 1996) and the role of perceived environmental control and associated costs (Smart and Vertinsky, 1984), with a more integrated approach offered by Pearson and Clair (1998). The application of crisis management and disaster research to organizational impacts from climate change specifically, and MDC more generally, however, is in a very early stage of theoretical development (see, e.g., Glaesser, 2003; Shrivastava, 1993; Suder, 2004; Waugh, 2000).

Crisis management approaches tend to focus primarily on dealing with the immediate impacts of disasters and their mitigation, and the literature offers insights into the phases and stages that an organization may experience immediately prior to, during and after a crisis event or disaster. The field provides valuable insights into the capabilities that organizations may require in order to respond to events, but, as others have pointed out, the capabilities associated with immediate crisis responses are only part of the adaptive capabilities required to develop long-term resilience to MDC (Linnenluecke *et al.*, 2008). Thus, while useful for immediate crisis response, the literature on crisis management does not lend itself to broader, integrated crisis management and long-term adaptive response (Borodzicz, 2005).

Early work on organizational crisis management focused on environmental disasters such as Bhopal (e.g. Mitroff, 1994; Mitroff *et al.*, 1987; Smart and Vertinsky, 1984), but research of crises related to climate change is sparse. Two recent studies examine the dynamics of coordinating expertise and knowledge among emergent groups responding to disasters such as hurricanes Katrina or Rita (Majchrzak *et al.*, 2007), and factors contributing to organizational preparation for major crises. These studies suggest that previous experience with or exposure to disasters and crises enhances the likelihood that an organization will prepare for future events (Kovoor-Misra *et al.*, 2000). This finding further highlights the difficult dilemmas inherent in preparing for surprise.

For research on MDC, organizational crisis management offers some interesting avenues of inquiry for scholars. One research stream might be to understand what kinds of organizational response strategy are robust enough to handle dislocations above and beyond those typically experienced. For instance, in the recent fires in Victoria, Australia, the weather conditions preceding and during the event rated well above the established fire index; organizational response, on the other hand, remained in the realm of typical crisis management approaches that had been effective in the past – and proved completely insufficient.

Examining how organizations use crisis management to understand and experience MDC could offer further valuable research contributions. Specific questions might be the following. Does crisis management work under conditions of MDC? What short-term crisis management capabilities lend themselves to dealing with long-term adaptive responses to MDC? Effective crisis management depends heavily on the continued functioning of information systems, suggesting fruitful research directions into the kinds of social infrastructure and culture necessary for the adequate functioning of disaster relevant technology, and the implications of the 'certainty of computer system-related disasters' (Quarantelli, 1997, p. 103). The latter provides an interesting example of cascading detrimental effects from multiple and interrelated system-failures likely to result from repeated crisis events associated with MDC.

Organizational crisis management research could also draw on interesting work from other social sciences. An example from political science highlights the critical role of political leaders and broader institutional settings in preparing critical infrastructure (such as water supply, road systems etc.) for catastrophic surprises, whether from

DOI: 10.1002/bse

social 'predators' (e.g. terrorists) or from climate change. The role of institutional stewards is to 'devise confident capacities to respond to those contingencies that *can* be imagined … and … they should develop "at the ready" institutional capacities to encounter *catastrophic surprises* that could overwhelm conventional capabilities' (LaPorte, 2007, p. 62). Coordinated responses under prolonged emergency conditions, and coordinated organizational *and* institutional capacity building, are further examples of future cross-disciplinary organizational research.

Risk Management

Similar to the crisis management literature, research on risk management offers important insights and tools for dealing with disruptions and disasters. Much of this work is prescriptive, and strategies for adaptive responses tend to focus on immediate or short-term impacts, not on those assisting with lasting, large-scale disruptions from MDC (e.g. crisis prevention, containment and recovery). Some might argue that crisis management is a subfield of risk management and that both fields should be treated together. The literature, however, suggests the existence of distinct research streams, discussed separately here.

Risk management tends to be concerned with the identification (early warning systems), the analysis (e.g. insurance mathematical models, risk-related cause-effect chains) and the perception of risk and crisis phenomena (see, e.g., Daniell, 2004; Hay, 2002; Smith, 1992; Meffert and Kirchgeorg, 1998; Munich Re, 2009). Risk management approaches provide practical strategies and processes for the avoidance, mitigation and transfer of risk, for instance via insurance (Mehr and Hedges, 1974). Recent years have witnessed calls for more work on the management of risks related to terrorism and natural disasters (e.g. Amendola *et al.*, 2007; Daniell, 2004; Hay, 2002; O'Brien *et al.*, 2006).

Similar to the 'greening' of business in the context of sustainability management, environmental risk management has typically focused on 'regulatory compliance, potential liability from industrial accidents, and pollutant release mitigation' (Lash and Wellington, 2007, p. 96). The authors further note that 'climate change, however, [...]presents business risks that are different in kind because the impact is global, the problem is long-term, and the harm is essentially irreversible' (p. 96), thus supporting the concept of MDC introduced here from the perspective of risk management.

A considerable amount of work has brought insights from risk management to climate change research (Brooks, 2003; Jones, 2001; Jones *et al.*, 2007). The insurance–mathematical perspectives on risk prevalent in the insurance sector define risks according to the expected damage and the probability of occurrence of an event (Adams, 1995; Downing *et al.*, 2001; Helm, 1996; Smith, 1992). In light of our earlier discussions of the nature and extent of uncertainty associated with climate-change impacts, however, probabilities for event occurrence cannot be assessed quantitatively and, as a result, the calculation of expected damage is similarly fraught with high levels of error (Jones, 2000; Prato, 2007; Winn and Kirchgeorg, 2005b). This same dilemma has been observed for managing the risk of other disasters, such as so-called technology enabled extreme events, where traditional risk-management strategies based on 'known' risks are deemed too outmoded to help companies contain 'catastrophic IT-linked risks' (Rosenoer and Scherlis, 2007, p. 26).

Lack of prior data and experience relating to climate change and associated extreme weather events make it difficult, even impossible, to calculate probabilities for the occurrence of events. Facing vastly greater uncertainty about both occurrence and impacts of MDC-related occurrences, insurance companies need new mathematical risk and occurrence models. Swiss Re, for example, has shifted its strategic focus to financial service innovations in light of climate change impacts (Way and Rendlen, 2007). The regional nature of extreme weather events, furthermore, implies that impacts are not concentrated on a single industry sector, but cut across sectors and institutions located in that region. Since damage within an affected region impacts different industries in varying ways and to varying degrees, the ability to develop accurate risk portfolios for MDC-related impacts becomes quite limited. This in turn has implications for insurability and the core business model of the re-insurance industry (Hoffman, 2006).

The selection and application of risk management instruments towards climate change is therefore limited to those impacts and changes that can be anticipated and quantified. This conclusion does not rule out the use of risk management instruments for climate change impacts generally, but it does highlight the need for additional conceptual advances for dealing with discontinuous change. For business practice, this also shows that

DOI: 10.1002/bse

the insurability against impacts from MDC is severely limited (Stern, 2006), further highlighting the necessity to develop a deeper understanding of such types of change, as well as the need for management frameworks that, for example, integrate planned adaptation approaches with risk management (Tol *et al.*, 1998). We note that, while still fairly general, some articles are beginning to link the types of climate impact to industry sector-specific risks (e.g. Lash and Wellington, 2007; Lemmen *et al.*, 2007; Schwartz, 2007).

Applying risk management perspectives to climate change at the level of an entire country in the South Pacific, Hay (2002) offers additional insights and ideas for future research, including linkages to sustainable development. Highlighting the need to integrate disaster risk management and climate change adaptation, Hay calls for greater attention to risks associated with ecological discontinuities along every step of applied risk management (i.e. risk identification, analysis, evaluation, management and organization) and argues for planned adaptation as an important conceptual complement to risk management processes: 'The most efficient and effective approach is to manage the risks in an integrated manner – through risk management and planned and proactive adaptation that involves "no regrets" strategies[2]. Many disaster and climate change response strategies are the same as those which contribute in a positive manner to sustainable development, sound environmental management, and wise resource use' (Hay, 2002, p. 12).

The growing number of national and regional reviews of climate impacts (e.g. Garnaut, 2008; Lemmen *et al.*, 2007; National Academy of Sciences, 2009; Stern, 2006) offers additional directions for future research on both organizational disaster management and climate risk. One valuable contribution is that they provide data that allow narrower specifications of climate change impacts expected to be most prevalent for a region and the vulnerabilities specific to certain geographic and socio-economic conditions. An example of a risk-based approach to adaptation at the supra-national level is the review of processes used to 'climate proof' several South Pacific island nations; the report documents the development and implementation of integrated risk-management strategies utilizing wide stakeholder participation and offers valuable lessons for research and practice (Asian Development Bank, 2005).

Several of these comprehensive reviews point to the need for more integrative, overarching research approaches, arguing that any effective response to climate change must address adaptation, mitigation *and* sustainable development paths concurrently (cf. Winn and Kirchgeorg, 2005b). Events such as sea level rise, extreme droughts or fires 'become security concerns for businesses when people are forced to flee, infrastructure is destroyed, ecosystems fail, agriculture is disrupted, economic volatility increases, and some regions become uninhabitable' (Schwartz, 2007, p. 26). Research on, organizational preparation for and adaptation to MDC thus also has to take into account emerging national policies and changes in firms' institutional and infrastructure environments, whether they react to, for example, extreme weather events, or proactively mainstream adaptation and mitigation into organizational strategy.

We conclude that, despite their diversity and their largely prescriptive nature, the various literatures on risk and crisis management offer many insights and starting points for future research on MDC in organizational studies.

Adaptive Organizational Change

We now turn to those theories on organizational change concerned with discontinuous change to draw out contributions for research on organizational adaptation to MDC. Organizational learning, an important mechanism for firms to adapt to changing internal or external organizational environments, can draw on a rich body of research (e.g. Levinthal and March, 1993; March, 1991), and it serves as the conceptual lens for one of the few theoretically grounded systematic studies examining organizational adaptation to climate change (Berkhout *et al.*, 2006). Processes of organizational learning are history dependent, routine based and build on an organization's own and others' prior experience (Levitt and March, 1988); as changing demands from organizational environments are translated into organizational changes, old routines must be discarded and new routines developed and codified. Myopic organizational behavior, particularly in light of ongoing efforts toward specialization and efficiency ('exploitation'), tends to reduce an organization's capacity to learn routines relevant for disruptive change. Tendencies 'to overlook distant times, distant places, and failures' (Levinthal and March, 1993, p. 95) appear to be particularly

[2] 'No regrets' strategies are those that result in net social benefits regardless of whether a climate change event occurs or not.

DOI: 10.1002/bse

salient barriers to developing adaptive capacity. Research on organizational variables that counter such tendencies and facilitate 'exploration' behavior may offer important insights on how firms may develop more effective responses to disruptive change.

In much of this literature, however, we detect the underlying assumption that future states will provide sufficient stability over a sufficient period of time for such new routines and repetitive collective behaviors to become established. Such assumed stability and linearity of change is in direct opposition to the discontinuous, highly uncertain and potentially escalating characteristics defining MDC, suggesting that many theorized organizational learning processes may be of limited application to climate change impacts.

It is also important to note that empirical studies of adaptive behavior, such as those by Berkhout *et al.* (2006) and Hoffmann *et al.* (2009), are necessarily limited in scope to adaptive firm behavior already observable – which is problematic if firms are no farther along in leading adaptive change than organizational science is in theorizing it. For reasons of non-linearity and futurity of the phenomena of interest, research methodologies will need to draw on and develop approaches unusual for the field. Several organizational scholars offer helpful suggestions (e.g. Davis *et al.*, 2007; Meyer *et al.*, 2005; Santos and Eisenhardt, 2005). Scenario-based approaches and '[s]imulation methods are … especially valuable in clarifying process nonlinearities [and] virtual environments' (Santos and Eisenhardt, 2005, p. 504).

Nevertheless, quantitative, case-based research has an important role in providing climate change-relevant insights that go beyond generic organizational change processes. Studying the determinants of adaptive behavior, for example, Hoffmann and colleagues (2009) found that the scope of adaptation was related to firms' awareness of, not vulnerability to, climate change impacts. This has important implications for the deliberate communication of climate science to organizational decision makers. It also highlights the role of climate education for adaptation more generally. How organizations and members at various levels in the organization make sense of climate impacts (or how they resist drawing conclusions that challenge existing frames of reference) will further affect organizational adaptation choices (Bazerman, 2006; Berkhout *et al.*, 2006). Developing and maintaining the dynamic capabilities that offer firms the skills to respond effectively to highly uncertain events in the future, then, is not only counter to organizational tendencies, it is also costly and difficult to legitimate.

Overall, we identify two limitations of organizational learning as a theoretical lens for studying responses to MDC: the underlying assumption of relative environmental stability inherent in routines and the field's reliance on prior experience. It may still be very useful for certain aspects of organizational adaptation to climate change, namely to those that do settle into sufficiently long, new steady states, but applies less to the kind of widespread, long-term, irreversible and highly uncertain changes that define MDC.

We now turn to theories that examine organizational strategies in the face of more radical or discontinuous change. We begin with strategic renewal, which relates 'to the long-term prospects of the company and has a critical influence on its success or failure', and where renewal is defined as the ability 'to continue growth after interruption or injury' (Agarwal and Helfat, 2009, pp. 281–282). Changes in, for example, product markets or technological discontinuities may well result from climate change impacts. Research into strategic renewal as a type of strategic change thus offers promising directions for future research into MDC, particularly since it applies at both organizational and above-organizational levels of analysis (such as managing alliances or networks).

Process issues relating to organizational structure, dynamic capabilities, cognitive factors and identity are likely to play an important role in research on MDC occurring in either climate systems, socio-economic systems or both. Floyd and Lane (2000), for instance, showed that dissent among managers about the need for change creates strategic role conflict. Highly dynamic environmental conditions such as hypercompetition or ecological discontinuities can be expected to heighten role conflict dramatically. Future research might look into factors that can channel such conflict into adaptive capacity, or into those interactions between top-down and bottom-up processes that determine how new information in organizations is processed and when such information leads to relevant changes in capabilities or routines. Considering also that 'building interpretations of the environment is a basic task of organizational members, especially in complex and/or ambiguous environments' (Santos and Eisenhardt, 2005, p. 500), research is also needed on the role of lower- and middle-level managers feeding confusing and difficult to interpret signals from a climate-disturbed and turbulent operating environment to top management.

Capacity for responding to disruptive change requires flexible, adaptive processes, resources and values. MDC in organizational environments appears to call for exactly the kind of agile organization suggested by Eisenhardt

DOI: 10.1002/bse

and Brown (1998, p. 787), the kind that is able to navigate 'at the "edge of chaos" between structure and anarchy'. Whether and how firms can deliberately apply the concepts and models of atomistic and time-pacing strategies suggested by the authors in the context of MDC then becomes subject to further research. Separate structures and entire independent organizations may help build more flexibility under multi-unit corporate umbrellas and allow firms to both respond to and drive disruptive change in technologies and markets (Christensen and Overdorf, 2000). It is less clear to what degree such structures for disruption or for strategic renewal can help firms respond to the specific (but largely unspecified and unspecifiable) challenges of MDC that are systemic, far-reaching and highly uncertain in terms of type and likelihood of occurrence, and in terms of the catastrophic and disruptive impacts across organizational systems, levels and members.

Organizational Resilience

Looking beyond the domain of organization theory, advances in resilience research from larger system perspectives offer promising approaches to prepare the considered system (organizational or ecological) for discontinuities. The mid-1990s witnessed an interest in applying chaos theory of complex adaptive systems in many fields (including organization theory and strategy; see, e.g., Stacey, 1995; Thietart and Forgues, 1995). Brown and Eisenhardt (1997) suggest that organizations need different strategies to cope with unpredictable and high velocity environments. But what kind of decision making system can recognize the complexity of organizational systems and align these with the complexities of environmental systems? And how might leaders go about transforming and changing their organizations to meet these complexities?

The interdisciplinary work that resulted in the Panarchy model uses analyses of the dynamics of change and transformation of ecological, social and economic systems to develop a meta-heuristic of change (see, e.g., Folke *et al.*, 2002; Holling, 2001). The goal of this work was to develop and test theories that explain transformational change of human and natural systems. Originally developed for ecological systems at multiple scales, efforts have been made to apply these models to social–ecological contexts at macro-levels. The social–ecological resilience approach offers powerful insights for organizational responses to MDC, since it 'emphasizes non-linear dynamics, thresholds, uncertainty and surprise, how periods of gradual change interplay with periods of rapid change and how such dynamics interact across temporal and spatial scales' (Folke, 2006). Future research needs to examine further how this work can be linked to organizational studies (Westley, 2002).

Resilience is an organization's ability to withstand external harm and to recover from negative external impacts (Günther, 2009; Linnenluecke *et al.*, 2008; Sheffi, 2005). Vulnerability refers to the organization's susceptibility to harm from a discontinuity, such as climate change, and is composed of the organization's sensitivity and exposure to stress and perturbation. Reducing vulnerability enhances an organization's resilience by reducing the outcome risk of climate change impacts (see, e.g., Timmerman, 1981) – a promising way to prepare organizations for MDC. Reducing vulnerability and enhancing resilience of an organization then becomes a critical component of an organization's preparation for climate change (Adger, 2000), even though unknown probabilities and types of impact generate high uncertainty.

It is the primary intent of this paper to provide the conceptual foundation for research on adaptive capacity by organizations to the very phenomenon to which organizations need to adapt, MDC. Although it is beyond the scope of this paper to offer a detailed discussion of adaptive capacity, important components include an organization's resources and capabilities to deal with climate change impact such that it can avoid or resist its impact, and moderate potential damage (Walker *et al.*, 2004). We would add that a further important component for business organizations is to take advantage of resulting opportunities.

The resilience approach suggests that an evolutionary and systemic understanding of business organizations is needed to cope with complex and dynamic climate change-induced impacts. Recognizing further an organization's ability to anticipate changes and risks in its environment, the reduction of vulnerability should be based on an anticipatory, decision-oriented approach. Such an approach highlights the need to advance and invest in the adaptive capacity of an organization (e.g., its learning capabilities, see above), including in redundant capacities, diversity in the organization and self-controlled organizational entities.

There are fruitful linkages to be made between social–ecological resilience research and organizational approaches. One avenue of inquiry could focus on the types of capabilities and resources that organizations require

DOI: 10.1002/bse

to make them less sensitive and thus less vulnerable to the impact of MDC. Others could examine the role of organizational resources (in particular 'slack resources') in enabling organizations to respond to MDC, thus allowing the organization to adjust to drastically changing environmental conditions and to minimize or avoid impacts from greater climate variability and weather extremes.

Interestingly, the resilience approach is also viewed as a usefully complementary concept to risk management (Paton *et al.*, 2000). For instance, questions need to be asked as to whether organizational decision makers see MDC events as impactful for their organizations, and whether they have access to the range of response strategies and capabilities needed to minimize resulting disruptions. Since current risk and crisis management approaches tend to focus on dealing with the immediate after-effects of an MDC, another question is what additional capabilities and responses are required to deal with events of the type and magnitude described here. Recent research has also begun to examine how competitive pressures to increase efficiency and specialization effectively reduce an organization's resilience and flexibility (Korhonen and Seager, 2008). This opens important new perspectives into the role of slack resources for dealing with MDC.

Conclusion and Implications for Management Studies

This paper argues that climate change presents a new, unprecedentedly disruptive, potentially cascading and profoundly uncertain type of change in organizational environments, and that business organizations are currently ill prepared to respond or adapt to such MDC. Drawing on the contributions from several streams of the organizational literature and the work on social–ecological resilience, the paper aims to provide a foundation for research on the capabilities and competences that organizations need to enhance their chances to survive and thrive under conditions of MDC. Future research directions are suggested for each. We close with some broad implications for research.

First, the literature on sustainability management is in need of an overarching framework which complements its current focus on reducing environmental damage and also encompasses adaptation to impacts from damaged ecological and social systems; this will provide the framework for a more comprehensive research agenda, one that adds survival, disaster management and long-term risk and business models to its current focus on prevention, reducing poverty and curbing environmental impact.

Second, while such an expansion of the sustainability management literature is important, it is perhaps more important to move its current trajectory on sustainability forward much more rapidly and to examine what prescriptive role needs to fall to this research and literature to prevent further and accelerating weakening of ecological systems. To date, a number of important articles and books have aimed at providing practitioners with practical tools and conceptual frameworks (Hart, 1995; Hart and Milstein, 2003, to name a few), along with a host of books. Much more work is needed in this arena.

Third, we note an urgent need to assess the implications of MDC and its anthropogenic sources, not only for management research, but also for management education in order to provide decision makers with the concepts and tools that not only aid the development of better organizational preparedness for 'surprise', but even more urgently assist in finding effective, cross-sectoral initiatives, policies and actions to depart from business as usual and radically reduce ecologically and socially damaging practices. Folke and Rockström ask a similar question: 'How can we prepare for and build capacity to make use of such periods in a constructive manner?' (2009, p. 1).

For management studies more generally, many important questions call for urgent attention. We have offered a number of these throughout the paper, including what kinds of non-traditional research methodology are available to organization studies; what capabilities and competencies enhance adaptive capacity; what forms of business organizations might be better equipped for survival than others, and whether some are better equipped than others to, following ecological discontinuities, minimize subsequent disruptions to ecological and social systems generally, and human suffering specifically. In the search for greater adaptive capacity and sustainable ways of doing business, novelty, creativity and positive innovation are bound to play a crucial role, opening up a host of further research questions.

Overall, 'progress towards developing a theoretical understanding of adaptation has been slow' (Berkhout *et al.*, 2006, p. 135), and even less research has focused on adaptation at the organizational level. Throughout this paper

DOI: 10.1002/bse

we offer a number of reasons for this paucity of research and examine several different theoretical lenses as starting points for research. While our focus here was deliberately 'organizational', research at the supra-organizational level of analysis, particularly in institutional theory, deserves similarly urgent attention and offers fruitful directions for research.

We have shown that some of the challenges in designing and researching organizational adaptation to MDC stem from difficulties in specifying impacts and uncertainties. The long-term futurity of expected effects combined with unknowable system dynamics and cognitive biases adds additional conceptual and practical hurdles to organizational adaptation processes, which are already constrained by their institutional contexts and internal dynamics under which the (climate) ground is expected to shift. Difficulties also arise from the limited capacity of current management studies to offer fruitful avenues for such wicked research problems, rooted in an 'amalgam of mutually reinforcing beliefs, theories and methods honoring the notion of equilibrium [that has] blocked the investigation of a family of interesting problems of great practical import' (Meyer *et al.*, 2005, p. 456). We close with a question by the same authors (2005, p. 456), which is especially pertinent for the topic of MDC: 'What might a social science of organizing-away-from-equilibrium look like?'.

References

Adams J. 1995. *Risk*. University College London Press: London.

Adger WN. 2000. Social and ecological resilience: are they related? *Progress in Human Geography* **24**: 347–364.

Agarwal R, Helfat CE. 2009. Strategic renewal of organizations. *Organization Science* **20**: 281–293.

Alcamo J, Moreno JM, Bindi M, Corobov R, Devoy R, Giannakopoulos C, Martin E, Olesen JE, Shvidenko A. 2007. Europe. In *Climate Change 2007: Impacts Adaptation and Vulnerability: Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, Parry ML, Canziani OF, Palutikof JP, van der Linden PJ, Hanson CE (eds). Cambridge University Press: Cambridge; 541–580.

Alley RB, Marotzke J, Nordhaus WD, Overpeck JT, Peteet DM, Pielke RA, Pierrehumbert RT, Rhines PB, Stocker TF, Talley LD, Wallace JM. 2003. Abrupt climate change. *Science* **299**(5615): 2005–2010.

Amendola A, Linnerooth-Bayer J, Okada N, Shi P. 2007. Towards integrated disaster risk management: case studies and trends from Asia. *Natural Hazards* **44**(2): 163–168.

Ansoff HI. 1976. Managing surprise and discontinuity: strategic response to weak signals. *Zeitschrift für betriebswirtschaftliche Forschung* **28**(3): 129–152.

Asian Development Bank. 2005. *Climate Proofing: a Risk-Based Approach to Adaptation*, Pacific Studies Series. Asian Development Bank. http://www.adb.org/Documents/Reports/Climate-Proofing/default.asp [24 May 2009].

Baede APM. 2007. Appendix I: Glossary. In *Climate Change 2007: the Physical ScienceBbasis: Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, Solomon S, Qin D, Manning M, Chen Z, Marquis M, Averyt KB, Tignor M, Miller HL (eds). Cambridge University Press: Cambridge; 941–988.

Banerjee SB. 2003. Who sustains whose development? Sustainable development and the reinvention of nature. *Organization Studies* **24**(1): 143–180.

Bansal P, Gao J. 2006. Building the future by looking to the past: examining research published on organizations and environment. *Organization and Environment* **19**(4): 458–478.

Bazerman MH. 2006. Climate change as predictable surprise. *Climatic Change* **77**(1/2): 179–193.

Berkhout F, Hertin J, Gann DM. 2006. Learning to adapt: organisational adaptation to climate change impacts. *Climatic Change* **78**: 135–156.

Borodzicz EP. 2005. *Risk Crisis and Security Management*. Wiley: Chichester.

Brooks N. 2003. *Vulnerability Risk and Adaptation: a Conceptual Framework*, Tyndall Centre for Climate Change Research Working Paper 38. Tyndall Centre for Climate Change Research: Norwich.

Brown S, Eisenhardt K. 1997. The art of continuous change: linking complexity theory and time paced evolution in relentlessly shifting organizations. *Administrative Science Quarterly* **42**: 1–34.

Christensen C. 1997. *The Innovator's Dilemma*. Harvard Business School Press: New York.

Christensen C. 2006. The ongoing process of building a theory of disruption. *Journal of Product Innovation Management* **23**: 39–55.

Christensen CM, Overdorf M. 2000. Meeting the challenge of disruptive change. *Harvard Business Review* **78**: 66–76.

Cohen B, Winn MI. 2007. Market imperfections opportunity and sustainable entrepreneurship. *Journal of Business Venturing* **22**(1): 29–49.

Daniell MH. 2004. *World of Risk: a New Approach to Global Strategy and Leadership*. World Scientific Publishing: New Jersey.

Davis JP, Bingham CB, Eisenhardt KM. 2007. Developing theory through simulation methods. *Academy of Management Review* **32**: 480–499.

Dean TJ, McMullen JS. 2007. Toward a theory of sustainable entrepreneurship: reducing environmental degradation through entrepreneurial action. *Journal of Business Venturing* **22**(1): 50–76.

Dess GG, Beard DW. 1984. Dimensions of organizational task environments. *Administrative Science Quarterly* **29**: 52–73.

Downing TE, Butterfield R, Cohen S, Huq S, Moss R, Rahman A, Sokona Y, Stephen L. 2001. *Vulnerability Indices: Climate Change Impacts and Adaptation*. UNEP: Nairobi.

Drucker P. 1969. *The Age of Discontinuity: Guidelines to our Changing Society*. Harper and Row: New York.
Emery FE, Trist EL. 1965. The causal texture of organizational environments. *Human Relations* **18**: 21–32.
Eisenhardt KM, Brown SL. 1998. Competing on the edge: Strategy as structured chaos. *Long Range Planning* **31**(5): 786–789.
Floyd SW, Lane PL. 2000. Strategizing throughout the organization: managing role conflict in strategic renewal. *Academy of Management Review* **25**: 154–177.
Folke C. 2006. Resilience: the emergence of a perspective for social–ecological systems analyses. *Global Environmental Change* **16**: 253–267.
Folke C, Carpenter S, Elmqvist T, Gunderson L, Holling CS, Walker B. 2002. Resilience and sustainable development: building adaptive capacity in a world of transformations. *Ambio* **31**(5): 437–440.
Folke C, Rockström J. 2009. Turbulent times. *Global Environmental Change* **19**: 1–3.
Garnaut R. 2008. *The Garnaut Climate Change Review*. Cambridge University Press: Cambridge.
Gersick C. 1991. Revolutionary change theories: a multi level exploration of the punctuated equilibrium paradigm. *Academy of Management Review* **16**: 10–37.
Gibson C, Birkinshaw J. 2004. The antecedents consequences and mediating role of organizational ambidexterity. *Academy of Management Journal* **47**(2): 209–226.
Gifford R, Scannell L, Kormos C, Smolova L, Biel A, Boncu S, Corral V, Guenther H, Hanyu K, Hine D, Kaiser FG, Korpela K, Lima LM, Mertig AG, Mira RG, Moser G, Passafaro P, Pinheiro JQ, Saini S, Sako T, Sautkina E, Savina Y, Schmuck P, Schultz W, Sobeck K, Sundblad E-L, Uzzell D. 2009. Temporal pessimism and spatial optimism in environmental assessments: an 18-nation study. *Journal of Environmental Psychology* **29**: 1–12. DOI: 10.1016/j.jenvp.2008.06.001
Gladwin TN, Kennelly JJ, Krause TS. 1995. Shifting paradigms for sustainable development: implications for management theory and research. *Academy of Management Review* **20**(4): 874–907.
Glaesser D (ed.). 2003. *Crisis Management in the Tourism Industry*. Butterworth-Heineman: Amsterdam.
Goodall AH. 2008. Why have the leading journals in management (and other social sciences) failed to respond to climate change? *Journal of Management Inquiry* **17**: 408–420.
Gunderson LH, Holling CS (eds). 2002. *Panarchy: Understanding Transformation in Human and Natural Systems*. Island: Washington, DC.
Günther E. 2009. *Klimawandel und Resilience Management*. Gabler Edition Wissenschaft: Wiesbaden.
Hamilton JM, Maddison DJ, Tol RSJ. 2005. Effects of climate change on international tourism. *Climate Research* **29**: 245–254.
Hart SL. 1995. A natural-resource-based view of the firm. *Academy of Management Review* **20**(4): 986–1014.
Hart SL, Milstein MB. 2003. Creating sustainable value. *Academy of Management Executive* **17**(2): 56–14.
Hatfield J, Job RFS. 2001. Optimism bias about environmental degradation: the role of the range of impact on precautions. *Journal of Environmental Psychology* **21**: 17–30.
Hay J. 2002. Integrating disaster risk management and adaptation to climate variability and change: needs benefits and approaches from a South Pacific perspective. Paper presented at the UNDP Expert Group Meeting, Havana.
Heal G, Kriström B. 2002. Uncertainty and climate change. *Environmental and Resource Economics* **22**(1/2): 3–39.
Hegerl GC, Zwiers FW, Braconnot P, Gillett NP, Luo Y, Marengo, Orsini JA, Nicholls N, Penner JE, Stott PA. 2007. Understanding and attributing climate change. In Solomon S, Qin D, Manning M, Chen Z, Marquis M, Averyt KB, Tignor M, Miller HL (eds). *Climate Change 2007: the Physical Science Basis: Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press: Cambridge; 663–745.
Helm P. 1996. Integrated risk management for natural and technological disasters. *Tephra* **15**(1): 4–13.
Hoffman A. 2006. *Getting Ahead of the Curve: Corporate Strategies that Address Climate Change*. Pew Centre on Global Climate Change. http://www.pewclimate.org [28 January 2010].
Hoffmann VH, Sprengel DC, Ziegler A, Kolb M, Abegg B. 2009. Determinants of corporate adaptation to climate change in winter tourism: an econometric analysis. *Global Environmental Change* **19**: 256–264.
Holling CS. 2001. Understanding the complexity of economic ecological and social systems. *Ecosystems* **4**: 390–405.
Huber GP, Glick WH (eds). 1993. *Organizational Change and Redesign*. Oxford University Press: New York.
Intergovernmental Panel on Climate Change (IPCC). 2007. Summary for policymakers. In *Climate Change 2007: Impacts Adaptation and Vulnerability: Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, Parry ML, Canziani OF, Palutikof JP, van der Linden PJ, Hanson CE (eds). Cambridge University Press: Cambridge; 7–22.
Jones RN. 2000. Managing uncertainty in climate change projections: issues for impact assessment. *Climatic Change* **45**(3/4): 403–419.
Jones RN. 2001. An environmental risk assessment/management framework for climate change impact assessments. *Natural Hazards* **23**(2/3): 197–230.
Jones RN, Dettmann P, Park G, Rogers M, White T. 2007. The relationship between adaptation and mitigation in managing climate change risks: a regional response from North Central Victoria, Australia. *Mitigation and Adaptation Strategies for Global Change* **12**(5): 685–712.
King A. 1995. Avoiding ecological surprise: lessons from long-standing communities. *Academy of Management Review* **20**(4) 961–985.
Kirchgeorg M, Winn MI. 2006. Sustainability marketing for the poorest of the poor. *Business Strategy and the Environment* **15**: 171–184.
Kolk A, Levy D. 2001. Winds of change: corporate strategy, climate change and oil multinationals. *European Management Journal* **19**: 501–509.
Kolk A, Pinkse J. 2007. Multinationals' political activities on climate change. *Business and Society* **46**: 201–228.
Korhonen J, Seager TP. 2008. Beyond eco-efficiency: a resilience perspective. *Business Strategy and the Environment* **17**: 411–419.
Kovoor-Misra S, Zammuto RF, Mitroff II. 2000. Crisis preparation in organizations: prescription versus reality. *Technological Forecasting and Social Change* **63**: 43–62.
LaPorte TR. 2007. Critical infrastructure in the face of a predatory future: preparing for untoward surprise. *Journal of Contingencies and Crisis Management* **15**: 60–64.

Lash J, Wellington F. 2007. Competitive advantage on a warming planet. *Harvard Business Review* **85**(10): 94–102.
Lemmen DS, Warren F, Bush E, Lacroix J (eds). 2007. *From Impacts to Adaptation: Canada in a Changing Climate*. Government of Canada: Ottawa.
Levinthal D, March JG. 1993. The myopia of learning. *Strategic Management Journal* **14**(winter special issue): 95–112.
Levitt B, March J. 1988. Organizational learning. *Annual Review of Sociology* **14**: 319–340.
Linnenluecke M, Griffiths A, Winn MI. 2008. Organizational adaptation and resilience to extreme weather events. Paper presented at the Annual Meeting of the Academy of Management, Anaheim, CA, and recipient of the Carolyn Dexter Best International Paper Award.
Majchrzak A, Jarvenpaa SL, Hollingshead AB. 2007. Coordinating expertise among emergent groups responding to disaster. *Organization Science* **18**: 147–161.
March JG. 1991. Exploration and exploitation in organizational learning. *Organization Science* **2**: 71–87.
McCann JE, Selsky J. 1984. Hyperturbulence and the emergence of type 5 environments. *Academy of Management Review* **9**(3): 460–470.
Meffert H, Kirchgeorg M. 1998. *Marktorientiertes Umweltmanagement: Konzeption – Strategie – Implementierumg mit Praxisfaellen* (3rd edn). Schäffer-Poeschel: Stuttgart.
Meehl GA, Stocker TF, Collins WD, Friedlingstein P, Gaye AT, Gregory JM, Kitoh A, Knutti R, Murphy JM, Noda A, Raper SCB, Watterson IG, Weaver AJ, Zhao ZC. 2007. Global climate projections. In *Climate Change 2007: the Physical Science Basis Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, Solomon S, Qin D, Manning M, Chen Z, Marquis M, Averyt KB, Tignor M, Miller HL (eds). Cambridge University Press: Cambridge; 747–846.
Mehr RI, Hedges BA. 1974. *Risk Management: Concepts and Applications*. Irwin: Homewood, IL.
Meyer AD. 1982. Adapting to environmental jolts. *Administrative Science Quarterly* **27**: 515–537.
Meyer AD, Gaba V, Colwell KA. 2005. Organizing far from equilibrium: nonlinear change in organizational fields. *Organization Science* **16**: 456–473.
Meyer AD, Goes JB, Brooks GR. 1993. Organizations reacting to hyperturbulance. In *Organizational Change and Redesign*, Huber GP, Glick WH (eds). Oxford University Press: New York; 66–111.
Millennium Ecosystem Assessment (MEA). 2005. *Living Beyond Our Means: Natural Assets and Human Well-Being*. http://wwwmillenniumassessmentorg/en/Reportsaspx# [6 August 2008].
Milliken FJ. 1987. Three types of perceived uncertainty about the environment: state, effect, and response uncertainty. *Academy of Management Review* **12**: 133–143.
Mitroff II. 1994. Crisis management and environmentalism: a natural fit. *California Management Review* **36**(2): 101–113.
Mitroff II, Pearson CM. 1993. *Crisis Management*. Jossey-Bass: San Francisco.
Mitroff II, Pearson CM, Harrigan LK. 1996. *The Essential Guide to Managing Corporate Crises*. Oxford University Press: New York.
Mitroff II, Shrivastava P, Udwadia FE. 1987. Effective crisis management. *Academy of Management Executive* **1**(4): 283–292.
Munich Re. 2003. *Topics Geo 2003*. Munich Re: Munich.
Munich Re. 2009. *Topics Geo Natural Catastrophes 2008*. Munich Re: Munich.
National Academy of Sciences. 2009. *Ecological Impacts of Climate Change*. www.nas.edu/climatechange [19 January 2010].
Nigel M, Rice J. 2010. Analysing emission intensive firms as regulatory stakeholders: a role for adaptable business strategy. *Business Strategy and the Environment* **19**: 64–75.
O'Brien G, O'Keefe P, Rose J, Wisner B. 2006. Climate change and disaster management. *Disasters* **30**(1): 64–80.
Paton D, Smith L, Violanti J. 2000. Disaster response: risk vulnerability and resilience. *Disaster Prevention and Management* **9**(3): 173–179.
Pauchant TC, Mitroff II. 1988. Crisis prone versus crisis avoiding organizations: is your company's culture its own worst enemy in creating crises? *Organization and Environment* **2**(1): 53–63.
Pearson CM, Clair JA. 1998. Reframing crisis management. *Academy of Management Review* **23**(1): 59–76.
Pearson CM, Mitroff II. 1993. From crisis prone to crisis prepared: a framework for crisis management. *Academy of Management Executive* **7**(1): 48–59.
Prato T. 2007. Accounting for risk and uncertainty in determining preferred strategies for adapting to future climate change. *Mitigation and Adaptation Strategies for Global Change* **13**(1): 47–60.
Prins G, Rayner S. 2007. *The Wrong Trousers: Radically Rethinking Climate Policy*, joint discussion paper of the James Martin Institute for Science and Civilization, University of Oxford and the MacKinder Centre for the Study of Long-Wave Events. London School of Economics and Political Science: Oxford.
Purser RE, Park C, Montuori A. 1995. Limits to anthropocentrism: toward an ecocentric organization paradigm? *Academy of Management Review* **20**(4): 1053–1089.
Quarantelli EL. 1985. *Organizational Behavior in Disasters and Implications for Disaster Planning*. Disaster Research Center University of Delaware: Newark, DE.
Quarantelli EL. 1997. Problematical aspects of the information/communication revolution for disaster planning and research: ten non-technical issues and questions. *Disaster Prevention and Management* **6**(2): 94–106.
Rahmstorf S. 1995. Bifurcations of the Atlantic thermohaline circulation in response to changes in the hydrological cycle. *Nature* **378**: 145–149.
Rahmstorf S. 1996. Bifurcations of the Atlantic thermohaline circulation in response to changes in the hydrological cycle (erratum). *Nature* **379**: 847.
Roberts KH. 1989. New challenges in organizational research: high reliability organizations. *Industrial Crisis Quarterly* **3**: 111–125.
Rosenoer J, Scherlis W. 2007. Risk gone wild. *Harvard Business Review* **87**(5): 26.
Rosenzweig C, Karoly D, Vicarelli M, Neofotis P, Wu Q, Casassa G, Menzel A, Root TL, Estrella N, Sequin B, Tryjanowski P, Liu C, Rawlins S, Imeson A. 2008. Attributing physical and biological impacts to anthropogenic climate change. *Nature* **453**: 353–358.

DOI: 10.1002/bse

Santos FM, Eisenhardt KM. 2005. Organizational boundaries and theories of organization. *Organization Science* **16**: 491–508.
Scheffer M, Carpenter S, Foley JA, Folke C, Walker B. 2001. Catastrophic shifts in ecosystems. *Nature* **418**: 591–596.
Schwartz P. 2007. Investing in global security. *Harvard Business Review* **85**(10): 26–28.
Schwartz P, Randall D. 2003. *An Abrupt Climate Change Scenario and its Implications for United States National Security*. Global Business Network, Emeryville, CA.
Sheffi Y. 2005. *The Resilient Enterprise: Overcoming Vulnerability for Competitive Advantage*. MIT Press: Boston, MA.
Shrivastava P. 1993. Crisis theory/practice: towards a sustainability future. *Organization & Environment* **7**(1): 23–42.
Shrivastava P. 1995. The role of corporations in achieving ecological sustainability. *Academy of Management Review* **20**(4): 936–960.
Smart C, Vertinsky I. 1984. Strategy and the environment: a study of corporate responses to crisis. *Strategic Management Journal* **5**: 199–213.
Smith K. 1992. *Environmental Hazards: Assessing Risk and Reducing Disaster*. Routledge: New York.
Stacey RD. 1995. The science of complexity: an alternative perspective for strategic change processes. *Strategic Management Journal* **16**(6): 477–495.
Starik M, Rands GP. 1995. Weaving an integrated web: multilevel and multisystem perspectives of ecologically sustainable organizations. *Academy of Management Review* **20**(4): 908–935.
Stern N. 2006. *The Economics of Climate Change: the Stern Review*. Cambridge University Press: Cambridge.
Suder GGS (ed.). 2004. *Terrorism and the International Business Environment*. Elgar: Northampton, MA.
Thietart RA, Forgues B. 1995. Chaos theory and organization. *Organization Science* **6**(1): 19–31.
Timmerman P. 1981. *Vulnerability, Resilience and the Collapse of Society: a Review of Models and Possible Climatic Applications*. Institute for Environmental Studies: Toronto.
Tol RSJ, Fankhauser S, Smith JB. 1998. The scope for adaptation to climate change: what can we learn from the impact literature? *Global Environmental Change* **8**(2): 109–123.
Trenberth KE, Jones PD, Ambenje P, Bojariu R, Easterling D, Klein, Tank A, Parker D, Rahimzadeh F, Renwick JA, Rusticucci M, Soden B, Zhai P. 2007. Observations: surface and atmospheric climate change. In *Climate Change 2007: the Physical Science Basis: Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, Solomon S, Qin D, Manning M, Chen Z, Marquis M, Averyt KB, Tignor M, Miller HL (eds). Cambridge University Press: Cambridge; 235–336.
Tushman ML, Anderson P. 1986. Technological discontinuities and organizational environments. *Administrative Science Quarterly* **31**(3) 439–466.
Walker BH, Holling CS, Carpenter SR, Kinzig A. 2004. Resilience adaptability and transformability in social–ecological systems. *Ecology and Society*: **9**(2): 5.
WaughWI Jr. 2000. *Living with Hazards, Dealing with Disasters*. Sharpe: Armonk NY.
Way M, Rendlen B. 2007. Walking the talk at Swiss Re. *Harvard Business Review* **85**(10): 42.
Westley F. 2002. The devil in the dynamics: adaptive management on the front lines. In *Panarchy: Understanding Transformation in Human and Natural Systems*, Gunderson LH, Holling CS (eds). Island Press: Washington, DC; 333–360.
Wilbanks TJ, Romero, Lankao P, Bao M, Berkhout F, Cairncross S, Ceron J-P, Kapshe M, Muir-Wood R, Zapata-Marti R. 2007. Industry settlement and society. In *Climate Change 2007: Impacts Adaptation and Vulnerability: Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, Parry ML, Canziani OF, Palutikof JP, van der Linden PJ, Hanson CE (eds). Cambridge University Press: Cambridge; 357–390.
Willows R, Connell R. 2003. *Climate Adaptation: Risk Uncertainty and Decision-Making*. UK Climate Impacts Programme: Oxford.
Winn MI, Kirchgeorg M. 2005a. Herausforderungen an das Nachhaltigkeitsmanagement bei zunehmenden ökologischen Diskontinuitäten. In *Management von Ad Hoc-Krisen*, Burmann C, Freiling J, Hülsmann M (eds). Gabler: Wiesbaden; 245–268.
Winn MI, Kirchgeorg M. 2005b. The siesta is over: a rude awakening from sustainability myopia. In *Corporate Environmental Strategy and Competitive Advantage*, Sharma S, Aragón-Correa JA (eds). Elgar: Cheltenham, UK.

DOI: 10.1002/bse