Playing the climate game: climate change impacts, resilience and adaptation in the climate-dependent sport sector

Greg Dingle & Bob Stewart

To cite this article: Greg Dingle & Bob Stewart (2018) Playing the climate game: climate change impacts, resilience and adaptation in the climate-dependent sport sector, Managing Sport and Leisure, 23:4-6, 293-314, DOI: 10.1080/23750472.2018.1527715

To link to this article: https://doi.org/10.1080/23750472.2018.1527715

Abstract

The aims of this study were to understand any issues that climate change poses for major Australian sport stadia (MASS) and the organizations that manage them, and how and why these organisations respond to such issues. Like the climate-dependent agriculture and tourism industries, the sport sector is potentially vulnerable to climate change impacts, yet has largely been overlooked in empirical research. The results reveal four primary climate change issues: organizational uncertainty; greater management complexity and cost risks associated with water and energy resources, and waste outputs. No revenue opportunities were linked with climate change. The results demonstrate that while most physical impacts are manageable, the primacy of commercial and operational imperatives determine organizational responses ahead of government climate policy, and any direct climate "signal" to adapt. Ten factors shape three organizational responses that we have typed using Berkhout's (2012) adaptation framework. The results challenge the assumption that climate change impacts and responses are limited to non-sport and leisure industries.

Keywords: adaptation; climate change; mitigation; organization; risk; sport stadia; vulnerability.

Introduction

The impacts of climate change—a "long-term shift in the planet's weather patterns or average temperatures" (M.O., 2018)—present a range of strategic challenges for organizations. These challenges include the direct impacts of extreme weather events that can disrupt organization and industrial-level structures, and indirectly through regulatory and market responses to climate change (Linnenluecke, Stathakis, & Griffiths, 2011; Winn, Kirchgeorg, Griffiths, Linnenluecke, & Gunther, 2011). It has therefore been argued that organizations may be *vulnerable* to such impacts (Berkhout, 2012; Linnenluecke, Griffiths, & Winn, 2013; Winn et al., 2011), or *resilient* (Linnenluecke & Griffiths, 2010, 2012), or able to *adapt* their operations (Berkhout, 2012; Berkhout, Hertin, & Gann, 2006; Linnenluecke & Griffiths, 2010; Linnenluecke, Griffiths, & Winn, 2011; Linnenluecke et al., 2013; Linnenluecke, Stathakis, et al., 2011; Pinkse & Gasbarro, 2016). Organizations therefore have been described as "central actors" in the climate change adaptation process (Berkhout, 2012; Berkhout et al., 2006).

Whilst organizations play an important role in such adaptation, academic and media attention has to date focused on emerging carbon management regimes (Winn et al., 2011) and industrial sectors with significant greenhouse gas (GHG) emissions. In management research, much less attention has been paid to the vulnerability, resilience and adaptive capacity of industries and organizations that depend directly on the resources of a stable climate system for their success. Compared to energy-intensive industries such as oil, gas, and electricity-generation, industrial sectors with "climate-dependent assets" (Packard & Reinhardt, 2000, p. 130) that rely on a narrow range of climatic extremes (Winn et al., 2011), have received little attention. Climate-dependant industries that are most vulnerable—aquaculture, forestry and tourism—are accompanied by another under-researched industrial sector: climate-dependant sport.

Similar to agriculture and tourism, sport is a predominantly outdoor activity relying on a stable climate to supply appropriate environmental conditions—temperatures, rainfall, snowfall, ice, humidity or winds—to facilitate the provision of the core sport product: sport events. Examples of this climate-sport relationship are the cold climate-dependence of downhill skiing, snowboarding and a variety of football codes, and the warm climate-dependence of major sports such as tennis, golf, baseball and cricket. By extension, grass turf sport surfaces, and the organizations that manage them, also depend on a stable climate to produce sport events.

Existing research literature exploring the climate change-sport relationship has four important limitations. First, barely a handful of studies exist, and these have given scant attention to vulnerability, resilience and adaptation. Second, these studies are limited to a small number of sports and climate zones. Third, little is known about GHG emissions associated with sport with the studies so far being limited to soccer events, amateur ice hockey and university sport. Surprisingly, no studies have investigated *what* impacts climate change might have on major sport stadia—the sites of sport's biggest events—the organizations that manage them, or *how* and *why* such organizations might respond to them. This is despite major sport stadia's significant, although mostly indirect, relationship with GHG emissions through their use of electrical energy for broadcast-quality lighting and other stadium services. This represents an important knowledge gap for the sport management discipline. We argue that research into climate-dependent sport facilities and organizations is important for what it can reveal about corporate experiences of climate change, vulnerability, resilience, adaptation, and barriers to such adaptation. Such stadia are exemplars of climate-dependent facilities with the potential for operational disruption through either the physical impacts of climate change, or the regulatory and market responses to this phenomenon.

A fourth limitation is an absence of research on major sport stadia in national contexts with the potential for illuminating the sport management implications of climate change impacts. Accordingly, the major sport stadia sector in Australia was an ideal choice for this study for several reasons. First, Australia has an extensive and sophisticated stadia industry with climate-dependent playing surfaces, but which is also heavily reliant on carbon-intensive electrical energy production systems that are strongly associated with GHG emissions. Second, Australia is a nation that is both highly exposed to the physical impacts of climate change, and which has in recent years experienced significant public policy and regulatory change as a result. Defined as stadia with a seating capacity of 25,000 seats or greater that regularly host professional/commercial-level sport events, Australia's major sport stadia sector comprised 15 such facilities, that were managed by 12 organizations.

This paper therefore addresses the limitations of existing research by focusing on the bio-physical, regulatory and commercial impacts of climate change for such stadia, and the adaptive responses of the organizations that manage them. The broader *aim* of this study was to progress understanding of what climate change means when it intersects with climate-dependant sport. Within this general aim, our specific aims were to: (1) understand any *issues* that climate change poses for major Australian sport stadia (MASS) and the organizations that manage them; (2) explain *how,* and; (3) *why* MASS organizations respond to any climate change issues. This included any attempts at GHG mitigation. In doing so, we considered the implications of climate change in a wider sense, that included any potential direct physical impacts, and any potential indirect impacts on the management of MASS organizations.

The structure of this paper therefore is as follows. The first section presents a review of current literature where we consider the reasons why organizations in the major sport stadia sector might include climate change within their strategic thinking. In this review, we

integrate three bodies of literature pertaining to climate science, management, and sport management. Emerging from these literatures is the key argument of this paper: that the impacts of climate change present a range of strategic challenges for non-sport organizations, and for those in the major sport stadia industry. In particular, we focus on three concepts—*vulnerability*, *resilience*, and *adaptation*—that originated in climate science literature, and which have in recent years extended into management literature. Consideration is then given to the impacts of climate change on Australia, and why research on major sport stadia is important.

We then outline our research design and methods. For our study, we adopted a qualitative methodology and multiple-case design using both within-case and cross-case analysis. Our research design and methods section is followed by the presentation of the key findings of our research. In the discussion section that follows, we situate these findings within the prevailing literature. We conclude by discussing the implications for organizations that manage sport stadia, and potential avenues for future research.

Review of Literature: Climate change as a management issue for sport stadia

Climate change as a challenge for organizations managing major sport stadia is situated within a wider context of developments. Firstly, climate change is acknowledged to be a "wicked" problem on a global scale (Hulme, 2009; Winn et al., 2011). Human understanding of climate change is underpinned by a "vast preponderance of accumulated scientific evidence" (Mastrandrea & Schneider, 2010, p. 11) around which a clear "scientific consensus" has developed (Lewandowsky, Oreskes, Risbey, Newell, & Smithson, 2015). It is also now widely accepted that climate change is caused primarily by human activities (AASS, 2018; IPCC, 2014c; Steffen et al., 2015). Impacts of climate change include extreme weather events, sea-level rise, and coastal flooding (IPCC, 2014a, 2014c) that may be

"severe, pervasive and irreversible" (IPCC, 2014b, p. 41) if GHG emissions continue at current levels.

In response to the scientific analysis of climate change, vulnerability and adaptation literature is now well established, and since the mid-2000's, has been marked by improved conceptual clarity (e.g. Füssel, 2007a; Füssel, 2007b; Pinkse & Gasbarro, 2016). At the macro-level, climate change adaptation literature in particular is distinguished by a variety of foci. These include: types, societal sectors (industrial, civil, government), stakeholders, limits, barriers and conceptual linkages (e.g. Berkhout, 2012; Berkhout, 2014; Biagini, Bierbaum, Stults, Dobardzic, & McNeeley, 2014; Dow et al., 2013; Füssel, 2007a; Smit & Wandel, 2006). The emergence of risk-based frameworks have been an important development in the adaptation field (e.g. Arnell & Delaney, 2006; Berkhout, 2012; Berkhout et al., 2006; Dow et al., 2013; Hall, Berkhout, & Douglas, 2015).

At the industrial and organizational-levels, business and management literature has increasingly noted higher operating costs associated with climate change, and organizational vulnerability to disruption from physical impacts. Indirect cost risks include added regulatory burden and/or reputational damage, particularly for "high-salience" industries (Kolk & Pinkse, 2011) such as the oil, gas, electricity and automobile sectors (e.g. Haigh & Griffiths, 2012; Kolk & Hoffman, 2007; Kolk & Levy, 2004; Pinkse & Gasbarro, 2016; Pinkse & Kolk, 2007). In addition, organizational disruption through physical impacts include damage to business infrastructure from "extreme weather events" (e.g. cyclones, droughts and bushfires); "gradual impacts" (e.g. sea-level rise and higher ocean acidity); and "large-system changes" where gradual impacts exceed "critical thresholds" (Pinkse & Gasbarro, 2016; Winn et al., 2011, p. 158). As a consequence, it has been argued that climate change, and adaptation to its physical impacts, should be included in the strategic thinking of

organizations (Hoffman, 2005; Kolk & Pinkse, 2011; Linnenluecke, Griffiths, & Mumby, 2015; Linnenluecke, Griffiths, et al., 2011; Winn et al., 2011).

Research on the vulnerability of organizations to climate change disruption is closely aligned with work on resilience, and adaptive capacity (e.g. Beermann, 2011; Charlton & Arnell, 2011; Hertin, Berkhout, Gann, & Barlow, 2003; Kiem & Austin, 2013). In particular, business research focused on organizational adaptation to climate change has seen important advances in recent years (e.g. Gasbarro, Rizzi, & Frey, 2016; Linnenluecke & Griffiths, 2010; Linnenluecke, Griffiths, et al., 2011; Weinhofer & Busch, 2013; Weinhofer & Hoffmann, 2010). A systematic review of existing studies has noted that they are spread across four levels of analysis (individual decision-maker, organizational, industry, and institutional), but that knowledge gaps remain for each (Linnenluecke et al., 2013). For example, organizational adaptation studies have been criticized for overlooking changes in the natural environment such as extreme weather events (Linnenluecke et al., 2013), and management scholars have called for more progress (Linnenluecke & Griffiths, 2013; Linnenluecke et al., 2015; Linnenluecke et al., 2013; Patenaude, 2011).

Adding to the deficiencies in management literature is a limited range of empirical work investigating climate change impacts on industries with *climate-dependent assets* (Packard & Reinhardt, 2000). Climate-dependent assets have been defined as those that rely on particular temperatures and seasonal conditions (Pinkse & Gasbarro, 2016), or natural resources provided by the climate system (e.g. rainwater). Climate-dependent industries include agriculture, tourism, water and forestry, and whilst these industries have been empirically examined (Linnenluecke et al., 2013), there is very little research on the climate-dependant segment of the sport industry.

Like climate-dependant agriculture and tourism (Amelung & Moreno, 2012; Linnenluecke et al., 2013; Scott, Gössling, & Hall, 2012), outdoor sports typically rely upon

the climate system for appropriate conditions (e.g. temperatures), but also for water resources. Specifically, the climate system—with the aid of water management infrastructure—provide sport facilities with the rainwater upon which they depend heavily (Kellett & Turner, 2009, 2011). However, modern sports' also rely heavily on energy resources for operations, lighting and transportation (Mallen & Chard, 2012; UNEP, 2018), and this illustrates another feature of the sport-climate relationship: indirect GHG emissions. In this context, the sport industry offers numerous opportunities to understand the vulnerability and/or resilience of sport infrastructure to climate change, *and* organisational adaptation, yet no studies have been carried out. This represents a significant knowledge gap for the sport management discipline.

The lack of empirical work about what climate change means for sport is particularly surprising given its cultural, commercial and historical significance. As a global commodity (Real, 1996), capturing the interest of billions of people across national, cultural and language boundaries (Miller, Lawrence, McKay, & Rowe, 2001), it has a market value of between $US620-700 billion, or approximately one per cent of global GDP (Collignon & Sultan, 2014). To date, existing studies into the climate change-sport relationship are limited to a handful of sports, issues and levels of analysis. Studies of sport with "climate-dependent assets" are limited to golf (Scott & Jones, 2006, 2007), snow and ice-based sports (e.g. Moen & Fredman, 2007; Scott & McBoyle, 2007; Wolfsegger, Gössling, & Scott, 2008), and the Winter Olympics (Scott, Steiger, Rutty, & Johnson, 2015). Aquatic facilities where swimming sport is staged is another example of such research (McDonald, Stewart, & Dingle, 2014). Other studies have overlooked vulnerability, resilience and adaptation (e.g. Chard & Mallen, 2012; Dolf & Teehan, 2015; Otto & Heath, 2010).

All but two of these studies were also limited geographically to the northern hemisphere—specifically, Europe and North America—and so little is known of the impact

of climate change on the sport industry in equatorial or southern hemisphere regions. This is despite southern hemisphere nations such as Australia being among the worlds' most exposed and sensitive to climate change (CSIRO, 2009; Reisinger et al., 2014). Australian climate has already changed with average surface temperatures increasing 0.9 ºC. since 1910 (CSIRO & BoM, 2015), and is projected to warm a further 0.6-1.3 ºC. by 2030, and 1-5 ºC. by 2070 (CSIRO & BoM, 2015; Reisinger et al., 2014). Climate change impacts include more frequent and hotter days, more frequent severe droughts, increased evaporation, harsher fire weather, and lower water supply reliability (CSIRO & BoM, 2015; Hennessy, 2011; Reisinger et al., 2014; Steffen & Hughes, 2013). The 12-year "Millennium Drought" of 1996-2008 was the worst in 110 years of meteorological records (Timbal, 2009). Against this background, Australia is an important site for researching the physical impacts on organizations, and adaptive organizational responses.

The research literature for sport stadia is rare, and consistently overlooks any direct or indirect impacts of climate change. Defined as, "athletic or sports ground(s) with tiers of seats for spectators" ("Stadium," 2017), the main purpose of major sport stadia is economic development, urban renewal and modernisation (Ahlfeldt & Maennig, 2010; Feddersen, Grötzinger, & Maennig, 2009). They are the sites of "mega events" (Dolles & Soderman, 2010) such as the Olympic Games, and exemplify "iconic architecture" (Horne, 2011, p. 210). However, only one study explored the potential climate change-stadia relationship (i.e. Chard & Mallen, 2013), and vulnerability, resilience or adaptive responses to climate change were not considered. Given their water and energy-intensive nature, we argue that major sport stadia are important sites for understanding the breadth and depth of organizational challenges posed by climate change.

The nature of managerial decision making in relation to organisational responses to climate change in the sport industry is also poorly understood. This is an important gap in

sport management literature because managerial decision making is central to any organisational responses to climate change. Whilst some sport management studies have canvassed managerial decision making more generally (eg. Kikulis, Slack, & Hinings, 1995; Merigó & Gil-Lafuente, 2011), and others have consider managerial decision making in relation to environmental sustainability (eg. Babiak & Trendafilova, 2011; Trendafilova, Babiak, & Heinze, 2013), none of have considered its role in sport organisations in response to climate change issues. In relation to major sport stadia specifically, no such studies are reported.

To address these knowledge gaps, we adopted a qualitative methodology and methods. Qualitative research is accepted as suitable for sport management research (Andrew, Pedersen, & McEvoy, 2011; Edwards & Skinner, 2009), is particularly suitable for answering complex "how" and "why" questions (Andrew et al., 2011; Yin, 2011), and has been applied previously in studies that have investigated impacts of climate change on climate-dependent assets (Kiem & Austin, 2013; Rickards, 2011). As a consequence, this study addresses knowledge gaps around climate change vulnerability, resilience and organisational adaptation in the climate-dependent major stadia segment of the sport industry.

Research design and method

Our study applied qualitative methods featuring a multiple-case, case study research design using replication logic. A multiple-case design was appropriate because it allows more powerful and valid conclusions to be drawn than a single-case design (Andrew et al., 2011; Miles, Huberman, & Saldana, 2014; Yin, 2009), and it expands external generalisability (Cresswell, 2009). The units of analysis for our study were organizations that own and/or manage MASS.

Sampling

To identify such organizations—and in the absence of a single, nationally or internationally agreed definition of major sport stadia—it was first necessary to create our own definition of MASS. Our definition was based on three criteria drawn from sport management literature, and a legislative definition of major sport stadia: (1) Sport stadia, where sport is defined as a *competitive, physical* activity *structured* according to rules or laws (Nicholson, Kerr, & Sherwood, 2015). (2) Stadia regularly host *professional/commercial level sport* (Hoye, Smith, Nicholson, & Stewart, 2015) such as national sport leagues, championships and international events, and; (3) Stadia with a *minimum seating capacity of 25,000 spectators*. This threshold was based on the Queensland (state) Government legislative definition of major sport events as being those having 25,000 or more spectators (QLDG, 2001). MASS organizations were therefore those that managed stadia meeting these criteria. MASS organizations are typically small to medium-sized enterprises (SME) as 11 of the 12 (92%) met the European Commission (2018) definition of SME's based on either turnover or staff "head count" criteria. The twelfth MASS organization met the definition of a large business.

Twelve MASS organizations, out of a total of 14, were chosen as our case studies using a two-stage purposeful sampling method (Miles et al., 2014; Sarantakos, 2013). These 12 organizations represented 85 per cent of the total study population. The first stage involved *selective sampling* (Coyne, 1997; Sandelowski, Holditch-Davis, & Harris, 1992) where a "preconceived, but reasonable initial set of criteria" (Sandelowski et al., 1992, p. 628) was used to select a sample of cases. Sport facilities more generally were of interest because their climate-dependence suggested that they would be the most likely to have sport organizations that could reveal insights about climate impacts and adaptation. MASS organizations were of particular interest for three reasons: (1) their grass playing surfaces depend on the climate to provide rainwater to maintain them; (2) they were thought likely to be large users of water resources, and; (3) electrical energy. Water use was of particular

interest because water availability is a key climate issue in Australia (CSIRO & BoM, 2015; Hennessy, 2011). Electrical energy use at MASS was also of interest because electricity in Australia is predominantly generated by fossil fuel-based, carbon-intensive, greenhouse gas-emitting generators (AEMO, 2018).

Our second stage of purposeful sampling involved *theoretical sampling* (Sandelowski et al., 1992). The typology revealed three potential theoretical categories of MASS organizations covering the entire MASS industrial sector: (1) public-ownership, not-for-profit; (2) private-ownership, not-for-profit, and; (3) private-ownership, for-profit. These three categories (conceptualisations) of MASS organizations were the "analytic grounds" (Sandelowski et al., 1992) for sampling the 12 MASS organizations. Replication logic (Andrew et al., 2011; Yin, 2009) was used to target a sample of MASS organizations within each of the three theoretical categories. The twelve replications/cases were spread across the three theoretical categories as follows: Category One (5 cases); Category Two (4 cases); Category Three (3 cases). With 85 per cent of the study population participating in the study, all theoretical categories had sufficient replications to enable confidence in our findings, and in the external generalisation of our findings. The geographic locations of our sample also spanned three of the six major Australian climate zones identified under the Köppen climate classification system (BoM, 2018). The cases were anonymous and we refer to them by alphabetical codes (i.e. "A", "B", "C", etc.). An overview of the MASS cases/replications is presented in Table 1.

Table 1: Overview of MASS organizations (cases)

Theoretical Categories (n = 3)	MASS organizations/cases (n = 12)	Types of MASS organization (n = 5)	No. of MASS owned (n = 13)	No. of MASS managed (n = 15)
Category One – Publically-owned, not-for-profit	Case A	Government-owned statutory authority	5	3
	Case D	Government-owned statutory authority	2	2
	Case E	Government-owned statutory authority	1	1
	Case I	Government-owned statutory authority	1	1
	Case J	Local government	1	1
Category Two – Privately-owned, not-for-profit	Case B	Not-for-profit governing body	0	1
	Case G	Not-for-profit governing body	1	1
	Case H	Not-for-profit governing body	1	1
	Case K	Not-for-profit, membership-based club	0	1
Category Three – Privately-owned, for-profit	Case C	Privately-owned for-profit company	0	1
	Case F	Privately-owned for-profit company	1	1
	Case L	Privately-owned for-profit company	0	1

Data collection and analysis

As advocated by Yin (2009), each organizational case was developed from multiple sources. This included "focused" (in-depth) interviews with well-placed informants, documents, and observation data. Interviews with 21 participants produced over 14 hours of data, and 63 historical documents were collected and analysed. All interviewees were given alphanumeric codes (i.e. "A1", "A2", "B1", "B2", etc.) to ensure their anonymity, and that of their organizations. Thematic coding (Miles et al., 2014) of interview transcripts and documents was used. Once the case studies were compiled, a further round of within-case, and cross-case analysis (Bazeley, 2007; Eisenhardt, 1989) was used to finalise the major themes.

Data reliability was achieved by using a case study protocol, checking data sample congruence with the research questions, and coding checks. External validity was achieved through the multiple case research design, thick description, and cross-case analysis, while internal validity was achieved by use of pattern matching (Yin, 2009, 2012). In addition, to

make sense of any adaptive responses to climate by MASS organizations, Berkhout's (2012) adaptation framework was applied.

Results

Physical impacts of climate change on MASS—and associated policy, regulatory and market impacts on MASS organizations—were evident in both interviews and organizational documents. Two direct climate change impacts on the stadia were consistently reported: (1) higher rates of water evaporation from the grass playing surfaces due to a warmer, drier climate; (2) the inadequacy of traditional grass varieties for coping with the persistently above average temperatures that now characterise the climate zones in which the stadia are located. Disruption from flooding caused by extreme weather events (i.e. storms) was reported by only two cases (A and L). The key organizational issues were uncertainty about long-term public policy for climate change; higher costs and added complexity for managing water and energy resources, and waste outputs. The three major organizational responses to these issues were water, energy and waste management strategies.

Organizational perceptions of climate change

Climate change has been a subject of intense debate in Australia in recent years, yet only just over half of the MASS cases (7/12) reported having discussed it as a management issue. The remaining five cases had not discussed it. The ownership-management categories of these organizations did not influence whether or not climate change had been discussed. In all cases, no formal corporate view of climate change was evident. For cases that had not explicitly discussed climate change, it was managed through environmental strategies. Nevertheless, climate change was consistently perceived as an important issue even if it wasn't the *most* important one.

All 12 MASS cases understood the basic science of climate change. That is, global climate was warming, and that this warming was caused principally by GHG's associated with human activities. This was evident across all three categories of MASS organizations. MASS organizations based their understanding of climate change overwhelmingly on media reportage, although other information sources were reported. Nine of the 12 cases were primarily influenced by media discussion of climate change, especially television and newspaper coverage. This was evident across all three categories of MASS organizations. Governments were the next most important influence. One-third of all cases reported state government agencies as an influence while a minority of cases cited the Australian Government (Case E) and local governments (Case B and H) as important influences. surprisingly, only one case cited the influence of the Australian Government Department of Environment (Case E), while none reported the influence of the Australian Bureau of Meteorology despite both agencies having extensive information about climate change on their websites. Significantly, all MASS organizations interpreted climate change through existing strategic frameworks. Although some plans provided for "sustainability" and "environmental" management, none were specific to climate change.

Limited vulnerability and significant resilience

Despite the reported physical climate change impacts on the stadia, only two MASS organizations thought their stadia were vulnerable (H & K). Such vulnerability was limited to Theoretical Category Two. In contrast, vulnerability's antithesis—resilience—was reported for 13 of the 15 stadia, and so was evident across all three theoretical categories of MASS organizations. Enabling factors for stadia resilience were stadium design, and water & energy management infrastructure. Organizational resilience to climate change impacts, as distinct from the resilience of the stadia, was reported by all 12 MASS cases. A summary of the key climate change issues is presented in Table 2.

Table 2: Key climate change issues

Issue	Description
Uncertainty about climate change implications	Uncertainty about long-term national government climate policy; carbon pricing; compliance obligations.
Water issues	Increased average temperatures; higher water evaporation from grass playing surfaces; traditional grass varieties inadequate for a warmer climate; higher water costs; limited flood risk.
Energy issues	Higher energy costs, largely indirect GHG emissions, carbon pricing, energy efficiency, energy and GHG emissions reporting compliance.
Waste issues	GHG emissions from landfill, higher solid waste disposal costs.

Issue 1: Organizational uncertainty about public policy for climate change

Whilst MASS organizations largely understood the basics of climate change, they were less certain about long-term government policy, and what that would mean commercially. This uncertainty was evident across all theoretical categories. In particular, most were uncertain about longer-term government policy for GHG emissions and carbon pricing.

Issue 2: Water issues

The major problems arising from the physical impacts of climate change for MASS involved water. This was true for all three categories of MASS organizations. As organizations that rely heavily on water resources, they were concerned about significantly reduced rainfall over the past two decades. Seven of the 12 MASS cases reported significant declines in rainfall in recent years, which they described as an issue of high importance. MASS managers described water shortages as "drought", a phenomenon linked by Australian climate experts to climate change (BoM & CSIRO, 2017). Restrictions on water supply, and increasing water costs associated with these restrictions, were vulnerabilities repeatedly identified by MASS interviewees. All 12 cases reported it as a climate change issue, with 80 per cent of interviewees (17/21) referring to it.

Water issues for MASS organizations were thus multi-dimensional. These issues spanned *physical impacts* (lower rainfall, higher evaporation, difficulty maintaining grass playing surfaces), *commercial impacts* (higher water prices, infrastructure & compliance costs), and the *policy, legislative and organizational responses* to climate change in Australia

(government-mandated water restrictions, harvesting, storage, efficiency, recycling, treatment and planning). All 12 cases reported major investment in water management infrastructure in response to government-mandated water efficiency laws that were introduced during the "Millennium Drought" (1996-2008), an unprecedented dry period in Australia. Case E's multi-million dollar water recycling plant was a notable illustration of such investment. Accordingly, water issues were strongly linked to higher costs.

Issue 3: Energy issues

All 12 MASS cases reported climate change issues around energy, and this was evident across the three categories of MASS organizations. MASS organizations consistently reported *electrical* energy use in particular, as a climate change issue. One major energy issue was the need to reduce energy consumption, with "energy conservation" being the strategy for minimising electrical energy costs. 11 of the 12 MASS cases recognised an indirect link between their energy use and GHG emissions. This suggests these organizations understand the problematic nature of electricity production in Australia where suppliers rely heavily on coal-fired electricity generators. 11 of the 12 MASS cases also reported direct GHG emissions, mainly from diesel or gas-powered vehicles and kitchens with gas cooking equipment. Such emissions were a small proportion of their total carbon footprint.

Seven of the 12 MASS cases reported programs for reducing energy consumption as a response to climate change. These stadia are large users of electrical energy which peaks on event days but reduces dramatically on non-event days. Two MASS cases (A and E) used sufficient energy to meet the reporting thresholds of the *National Greenhouse and Energy Reporting* (NGER) *Act* (2007), a national law aimed at recording the GHG emissions of Australia's largest energy users. However, as only two MASS cases met the NGER thresholds, the emissions (direct and indirect) of most of these organizations are relatively

small compared to large non-sport facilities such as oil refineries, coal mines, airlines and waste disposal sites.

Interestingly, the desire of MASS organizations to conserve energy was not driven primarily by concerns about climate change. Rather, energy conservation was driven primarily by the need to reduce operating costs. Like water inputs, energy use was seen as a cost issue. However, most MASS organizations also identified energy conservation as a strategy for mitigating GHG emissions associated with energy use even if it was a *second-order* priority. Purchasing renewable energy was another strategy for mitigating GHG emissions, but with limited application. One-quarter of MASS cases (A, E & F) reported purchasing "green" energy from electricity suppliers to mitigate GHG emissions. Only one case (A) reported using solar panels, which met up to 20 per cent of electricity demand at their stadium.

Although MASS organizations clearly linked energy use as a climate change issue, the prioritization of reducing energy costs ahead of reducing GHG emissions related to energy use is highly significant. Whilst these organizations were consistent in stating their credentials as good corporate citizens (a *"responsibility"* to *"do the right thing"* for the *"community"*), they were also consistent in reporting that energy management programs and infrastructure spending had to be first justified to senior management with a strong "business case". Whilst climate change was a priority, it was only one of a range of issues to be managed, and it was largely secondary to operational imperatives (i.e. staging major sport events) and financial management. Energy use, while clearly linked to climate change, was framed primarily as a cost issue in much the same way as in other industries such as oil production, car manufacturing (Kolk & Levy, 2004), and aviation (Gössling & Upham, 2009).

Finally, five of the 12 MASS organizations reported that carbon pricing, through either a carbon tax or an Emissions Trading Scheme (ETS), as a cost issue. Carbon pricing is a cost issue for MASS organizations in two ways: (1) where their energy use is sufficient to meet the NGER thresholds, a direct carbon liability is created; (2) through higher electricity costs passed on by carbon-intensive electricity generators who themselves owe a carbon liability.

Issue 4: Waste issues

Nine of the 12 MASS cases reported stadium waste as a climate change issue. This was evident across all three categories of MASS organizations. The only exceptions were cases C, F and G. Waste is a climate change issue because of the link between waste disposal and GHG emissions such as methane (CH_4). Specifically, when solid waste is disposed of as landfill at Solid Waste Disposal Sites (SWDS), it decomposes and releases CH_4. This release of GHG emissions, sometimes referred to as "landfill gas", is a concern recognised by multiple domestic and international environment agencies (DCCEE, 2007; DEE, 2012; IEA, 2008; USEPA, 2018; VEPA, 2018). With the introduction of the carbon tax in 2012, SWDS began charging higher fees for waste to landfill, and such costs added to the commercial imperative to reduce solid waste.

10 of the 12 MASS organizations had sophisticated solid waste recycling systems that enabled them to reduce their solid waste, and thus their contribution to landfill gas/GHG emissions. One-third of MASS cases reported using a Closed Loop Recycling system where recyclable material is eliminated from disposal at SWDS. MASS organizations divert recyclable materials from landfill through recycling processes including metal and plastic drink containers, and all paper and cardboard waste.

Managerial agency

However, across all four climate change issues, the personal agency of middle-to-senior-level managers in adaptive responses was noteworthy. Managers at five of the 12 MASS cases were individually responsible for initiating water, energy and waste management processes that were reported as climate change responses. Examples of this managerial agency include: advocating for organizational consideration of climate change; developing a climate change adaptation strategy; researching and proposing a water treatment strategy; hiring energy consultants and; proposing a green ticketing system. Motivating such initiatives were concern for "doing the right thing" by the environment and society, although having a "business case" that led to lower costs was crucial to winning approval from senior management. A summary of the key climate change issues for MASS, and MASS organizations, is presented in Table 3 below.

Table 3: Climate change issues for MASS, and MASS organizations

Climate change issue	Cases and categories showing strong evidence	Illustrative quotes
Uncertainty about longer-term climate change policy.	Cases A, B, C, D, E, F, G, H, I, J, K and L. All theoretical categories.	*Well the uncertainty it causes me particularly is that we can't develop a strong strategic plan unless the government does so…* [Interviewer]: *So there's a policy uncertainty?* *Correct. There's a bit of a wait for us and the thing that I'm fearful of with us is while you've got this hiatus of [government] people trying to make up their mind how they're going to deal with the climate change, this organization could actually say well we don't think is an issue anymore* (E1, p. 9).
Water	All cases. All theoretical categories.	*The thing that we notice more than anything else with turf and some of those things on the ground is the level of evaporation we have. The humidity is much lower than what it was, we've got drying days here that, and it's something, it's a subject that never gets talked about in terms of environmental change. People talk about ºC increase and some of those things, but the air is much dryer... We're putting more water on than what we ever have in terms of that because the evaporation levels are so high* **(E1, p. 9).** *Well it is in the product of climate change so for example in..., we had a drought here last year and so there have been restrictions placed on local authorities relating to water management and so the good old days of just turning on the sprinkler and everything getting green are rapidly becoming a thing of the past* (B1, p. 1). *As it gets drier we need to water more, as we water more it increases the costs and it's not just a standard. As it's getting hotter, we have to water more* (H1, P. 2) *Yeah, our water bills are pretty high. Within the region we were considered an extremely high user. I think we were number two behind [company] only. So we were using somewhere around 20 mega litres a year on the field itself, just the field. All said and done, I think we were using about 50 mega litres a year. By taking the field offline we're down to 30 mega litres per year. So we've saved a massive amount of water just from that* (J1, p. 5).
Energy	All cases. All theoretical categories.	*I guess our organization sees climate change as important. Probably not of critical importance, but certainly elements of climate change as I mentioned before, the water initiatives and moving forward toward energy initiatives, we've recognised that they are important elements, issues that the organization needs to address and consider* (A1, p. 1). *Absolutely, as I say we report, we're over 25,000 tonnes [of GHG emissions] so that puts us in I think one of the top 700 or 800 contributors in the country* (E1, p. 14). [E1]: *At $20 a tonne, [a carbon price] would cost us about $600,000 a year.* [Interviewer]: *So that's $20 a tonne of CO_2…* [E1]: *If we wanted to then be… if we wanted to be carbon neutral, or I shouldn't...not carbon neutral. If we wanted to offset 100 per cent, that's what our cost would be* (E1, pp. 10-11). *We introduced [mobile] lighting rigs at the venue, the first to do it within Australia. Those lighting rigs use around $120,000 worth of power a year and we didn't want to be perceived as an organization that was having lights on*

		24 hours a day to stimulate grass growth without offsetting that grass growth with a green energy provider. So we use a green energy provider (F1, p. 1).
Waste	Cases A, B, D, E, H, I, J, K & L. All theoretical categories.	*Our things that we've looked at in regards to mitigating any emissions are reducing waste. So obviously with the recycling programmes and separating glass, cardboard and bulk recycling from waste which has been, I mean we were looking at moving around 40 cubic metres of just general waste beforehand, that's what we'd do after every AFL game. Now we move about 35 cubic metres of recycling in general and about 10m of rubbish or general waste. So that's probably where we're looking at mitigating greenhouse gas emissions* (J1, p. 11). *Waste management again is a big part of reducing that carbon footprint* (H1, p. 5)

Discussion

The results of this study point to a multifaceted picture of climate change issues and responses for MASS organizations. We found that all MASS cases—regardless of their ownership structure—interpreted climate change as a cost issue for water and energy resources, and waste outputs. Some additional management complexity was evident, but the key concern was higher operational and capital costs associated with these issues. These issues were consistently evident regardless of the organizational size, ownership structure, or fundamental purpose. Water, energy and waste management strategies were therefore key responses.

How organizations respond to climate change begins with how they interpret it. It has been argued that organizational responses to climate change are shaped by how its impact on their core business is perceived (Kolk & Pinkse, 2011; Porter & Reinhardt, 2007), and by management uncertainty about the external market and policy environments (Lee & Klassen, 2015). Consistent with these studies, MASS organizations perceived the physical impacts to the stadiums from climate change as risks to their core product: sport event management. However, these impacts were generally interpreted as manageable within existing management resources, capabilities and strategies. These organizations were also uncertain about the longer-term government climate policy. One study has also concluded that organizational responses are shaped by whether opportunities or risks are perceived in climate change (Kolk & Pinkse, 2005). For MASS organizations, most saw risks, especially commercial ones.

Media reportage, especially in television and newspapers, was the primary influence on how MASS organizations understood climate change, especially their view that it was a cost issue. This cost-centric interpretation of climate change is consistent with much of the business media reportage in Australia that focuses on financial costs, rather than revenue

opportunities. It also is consistent with management research that confirms that media interpretations of climate change shape corporate understandings of climate change (Hertin et al., 2003), and corporate responses more generally (Bansal, 2005; Bansal & Clelland, 2004; Henriques & Sadorsky, 1996). Our finding is significant because it demonstrates that the media's influence on how organizations interpret climate change is wider than previously thought: it now extends to SME's and large organizations in the sport industry.

The link drawn by MASS organizations between climate change and water issues is also consistent with scientific work on climate change impacts in Australia (CSIRO & BoM, 2015; Reisinger et al., 2014). This link is explained by three factors: (1) their experience with the 12-year "Millennium Drought", Australia's longest and most severe in 110 years of meteorological records (Timbal, 2009); (2) state government regulatory responses to the resulting water scarcity requiring water efficiency and reporting for large water users, and; (3) higher water costs associated with such scarcity. Given the role of media coverage of climate change in shaping their corporate perceptions of this phenomenon, this link was likely reinforced by extensive media coverage of water scarcity during this period.

Together, these factors were the drivers of the most comprehensive of the adaptive responses by MASS organizations: major investment in water management infrastructure. The investment of millions of dollars in water harvesting, storage, efficiency, treatment and recycling reflects a sector-wide pattern of adaptation to Australia's hotter and mostly drier climate, and its emergent regulatory framework for water resources. All three factors are consistent with existing literature that argues adaptation to water scarcity is a key climate change issue, and that organizational adaptive responses are strongly influenced by market and regulatory contexts (Arnell, van Vuuren, & Isaac, 2011; Berkhout et al., 2006; Charlton & Arnell, 2011). Understanding water scarcity as a climate change issue is significant because it establishes that water-intensive and climate-dependent sport is vulnerable in the

longer term (Kellett & Turner, 2009, 2011; WADSR, 2007). It also confirms the importance of earlier studies of adaptive responses in sport (Rutty, Scott, Steiger, & Johnson, 2014; Scott & McBoyle, 2007).

Equally, the linking of climate change and energy issues by MASS organizations is a significant finding of this study for three reasons. First, the dependence of MASS on carbon-intensive Australian electricity suppliers establishes that they have a significant, although indirect, relationship with GHG emissions. The extent of this carbon footprint is illustrated by Cases A and E—whose largely indirect emissions use were smaller than large non-sport facilities such as oil refineries, coal mines, airlines and waste disposal sites—but were still sufficient to meet the reporting thresholds of the NGER legislation. Second, the climate-energy issues relationship establishes the primacy of costs, the absence of revenue opportunities, and confirms the secondary importance of GHG emissions for such organizations. Understanding this important managerial equation offers insight into the drivers of adaptive behaviours in service-based sectors of society. Thirdly, the climate-energy issues relationship establishes the sensitivity of such service-based organizations to carbon pricing. Although the change in carbon pricing legislation in 2014 reduced the cost impact of carbon pricing for MASS organizations, the results suggest that it is a new dimension for the management of operating costs for these sport industry organizations.

The link between climate change and waste issues made by MASS organizations is another significant finding of this study for different reasons. First, we have established a link between solid waste that accrues at MASS, its disposal, and landfill waste GHG emissions. Second, we have established that the overwhelming majority of MASS organizations understand this relationship. Third, it is now clear that MASS organizations use their existing solid waste recycling processes to manage indirect GHG emissions from their solid waste,

and to adapt to higher costs associated with carbon pricing. This study therefore extends existing studies that have addressed waste issues in sport, but not GHG impacts.

However, for water, energy and waste issues, the agency of senior-to-middle-level managers in adaptive responses was crucial. The internal advocacy of these managers for strategies to address climate change issues was consistent with research focused on small business (S. Williams & Schaefer, 2012), and other studies documenting the key role of managers in environmentally responsible management (Bansal & Roth, 2000; Winn, 1995).

MASS organizations and adaptation to climate change

Recent advances in adaptation literature offer deeper insights into these responses by MASS organizations. (2012). Berkhout's (2012) analysis of earlier adaptation literature revealed five possibilities that can all be seen as part of "deeper" organizational strategy that focuses on risk. (1) "Do nothing"/"wait and see"—a deferral strategy based on scepticism or uncertainty about the possible climate change impacts and benefits of adaptation. (2) "Assess" risk/"risk assessment and options appraisal"—a strategy of appraising options to prepare for adaptation of organizational routines. (3) "Reduce" risk/"bearing and managing risks"—a strategy for managing risks and opportunities arising from climate impacts using organizational resources and capabilities. (4) "Share" risk/"sharing and shifting risks"—externalising climate change risks through insurance and collaboration. (5) "Diversify risk" (Berkhout, 2012). A summary of these adaptation strategies and their application to MASS organizations is presented in Table 4 below.

Table 4: Responses by MASS organizations expressed in Berkhout et al's (2006) and Berkhout's (2012) terms

Adaptation Strategies		MASS Cases
Berkhout (2012)	**Berkhout et al. (2006)**	
Do nothing	Wait and see	G
Assess [risk]	Risk assessment and options appraisal	B, E and J
Reduce risk	Bearing and managing risks	A, B, C, D, E, F, H, I, J, K and L
Share risk	Sharing and shifting risks	Nil
Diversify		Nil

Responses to climate change by MASS organizations fall into three of the five types identified in Berkhout's (2012) typology, and are shaped by 10 factors. The three responses are: (1) do nothing (wait and see/business as usual); (2) adaptation/assess risk, and; (3) adaptation/reduce risk. The 10 factors shaping these organizational responses divide into seven internal and three external. The 10 factors are summarised in Table 5 below.

Table 5: Ten factors shaping organizational responses to climate change at Major Australian Sport Stadia

Types of Factors	Factors
External Factors (climate change issues)	1. Physical impacts (hotter, drier climate, water evaporation) 2. Market changes (increased supplier costs in business-to-business segment) 3. Stakeholder [external]: • Government legislation [GHG emissions reporting (e.g. NGER Act) & Emissions pricing (e.g. Carbon Tax/ETS)] • Government legislation (water & energy efficiency) • Attitudes to CC of sport governing bodies & commercial partners
Internal Factors (MASS organisations)	1. Energy use: • Big users, carbon intensive • Basis for GHG mitigation 2. Climate Change Sensemaking (interpretation): • Media as key influence shaping climate change interpretations • Uncertainty • Climate change perceived as cost issue • Outside-in over inside-out (CC as secondary issue) Waste as GHG issue 3. Resources (water, manufactured, financial, staff capabilities) 4. Stakeholders [internal]: • Managerial *agency* of staff 5. Corporate Social Responsibility (CSR) ethos: • Genuine commitment 6. Vulnerability & resilience to climate change 7. Barriers to climate change responses (money & uncertainty)

Only one MASS organization (Case G) adopted a “do nothing”/“wait and see” strategy. Case G had essentially no awareness of the actual or potential impacts of climate change on their organization or their stadium, direct and indirect, and showed little interest in the potential for strategic, commercial or technological adaptation. A lack of organizational resources was the key factor underlying this attitude.

For 10 of the 12 MASS cases, “reduce” risk/“bearing and managing risks” best describes their adaptive response. These 10 cases spanned all theoretical categories. To the extent that they adapted explicitly to climate change, they did so cautiously and within existing non-climate change specific strategic plans. Translated into Berkhout’s (2012) terms, these cases *reduce* risk by applying and adjusting existing commercial and environmental strategies. This finding is significant because it establishes for the first time that this climate-dependent and water and energy-intensive segment of the sport sector is responding in ways that are similar to non-sport industrial sectors elsewhere in the world.

However for 3 of these 11 cases (B, E & J), cautious water, energy, waste and cost management responses to climate change indicate they were moving beyond merely “bearing and managing risk” to undertaking “assess” risk/“risk assessment and options appraisal”. This response spanned theoretical categories 1 and 2 but not the privately-owned cases in Category 3. Case B did not have an integrated climate change plan, but their sustainability assessment, energy monitoring, and climate change adaptation strategy revealed their concerns about climate change. Similarly, while Case J—the largest of all MASS organizations—did not have an integrated climate change plan, after the prolonged “Millennium Drought” of the late 1990’s to mid-2000’s, they consciously adapted their water, energy and turf management practices to work in a hotter, drier climate where higher water, energy and turf risks were significant concerns.

Case E also appeared to be actively *assessing* the risks posed by climate change and its associated regulatory and market changes, and *appraising* strategic options. This is reflected in their clear understanding of climate change—the most sophisticated of all MASS organizations—and its associated regulatory impact on energy use, GHG emissions reporting, carbon liability, and their operating costs. Their significant investment in water management and energy efficiency occurred after extensive analysis of the direct and indirect climate change risks, and the preparation of a detailed business case that was later approved by senior management. Notably, Case E's *certainty* about climate change as a long-term management issue shaped their attitude to GHG mitigation, and facilitated their understanding of climate policy and its cost implications for their organization. This contrasts with the *uncertainty* about climate change of most of their peers in the stadia industry who prioritized reduction of energy-related costs over the mitigation of GHG emissions. These contrasting attitudes are consistent with Lee & Klassen's (2015) argument that management uncertainty about climate change shapes the adoption of carbon-specific mitigation practices.

Despite the insights afforded by the Berkhout (2012) and Berkhout et al. (2006) typologies, there is nothing in the actions of MASS organizations that is consistent with either of the "share risks"/"sharing and shifting risks", or with the "diversify" risks adaptation strategies. For them, it was inconceivable that they could share either direct or indirect climate change risks with their commercial or government partners, or diversify risk through their insurers. This finding is significant because it establishes for the first time a clear difference with non-sport industrial organizations who are either more aware, or more willing, to adapt in these ways.

Berkhout (2012, p. 92) noted that to understand what climate change means for organizations, analysis needs to start with the, "complex reality of organizations themselves, rather than starting with the climate signal and then seeking to trace its presumed influence

on organizational behaviour. The analysis needs to be done inside-out, rather than outside-in." For MASS organizations, their adaptations were a function of a complex interplay between multiple internal and external factors. That is, their adaptations are not explained solely by "direct signals" of climate change to adapt (Berkhout et al., 2006, p. 146) such as extended drought, higher temperatures and evaporation. As Berkhout (2012, p. 101) noted, organizations respond to "many stimuli, with climate risk and opportunity being but one." This was true for this industry: climate change was a priority, but it was only one of a range of issues to be managed, and so their adaptations typically occurred without climate change-specific strategies. A lack of financial resources at MASS organisations, and climate change-specific management capabilities, were the main barriers to having such strategies.

The influence of "indirect signals" like regulatory change, market change, and an industry trend toward "greener" technologies coupled with internal factors including strategic goals, culture, and managerial agency, illustrate a less "simple stimulus-response relationship" (Berkhout, 2012, p. 94) to climate change. Yet they also point to "incremental" (Pelling, 2011) adjustments for most MASS organizations rather than "transformational" changes that address the fundamental causes of climate change vulnerability (Agard et al., 2014; Eriksen, Nightingale, & Eakinc, 2015).

Finally, the scale and capabilities of these organizations must be factored into interpretation of the mostly cautious nature of their adaptive responses. 11 of the 12 organizations were SME's. All had relatively flat management structures, constrained financial resources, and little or no formal education about climate change, or potential adaptive responses such as carbon management. Unlike large businesses, such as banks, insurance companies and airlines, they did not have the resources or capabilities to develop climate-specific strategic plans. This situation is typical of SME's who have "a tendency towards short-term planning" in relation to climate change (Halkos & Skouloudis, 2016, p. 3;

Sarah Williams & Schaefer, 2013). This is significant because it suggests sport-industry SME's, as in other industries, would benefit from climate change-specific adaptation strategies.

Conclusion and implications for sport management

In this paper, we have argued that the phenomenon of climate change presents some strategic issues for the organizations that manage major Australian sport stadia. These issues are in the form of some physical impacts on the climate-dependent playing surfaces, and the water resources, of these stadia. However, the major issues are in the form of secondary impacts that flow from the climate change problem. These secondary impacts comprise a complex web of public policy, legislative and market responses to climate change that pose commercial risks in the form of higher operating costs for their water and energy resources, and waste outputs. Despite the climate-dependence of the grass playing surfaces of these stadia, major disruptions due to extreme whether events—of the kind experienced in other climate-dependent industries—were rare and perceived to be manageable within existing resources and strategies. These stadia therefore have considerable resilience to the direct physical impacts of climate change due to their design and infrastructure resources. Mitigation of GHG emissions is a second-order priority relative to operational and commercial imperatives.

Adaptation is occurring at most MASS organizations, albeit in ways constrained by their scale and available resources. Whilst doing nothing about these risks is an option for these organizations, most choose to actively manage their climate change risks, while a minority go further and evaluate their strategic options. The organizational responses occurred despite their uncertainty about long-term public policy for climate change, and in the absence of climate change-specific plans. A lack of financial resources, and climate change management capabilities, were key barriers to having climate change-specific

strategies. The findings of this paper suggest that climate change poses strategic issues for MASS organizations, and this challenges assumptions in the sport management discipline about the implications of climate change for sport organizations. Specifically, if climate change impacts and adaptation are occurring in the Australian stadia industry, is this happening in other national contexts?

Australia, as a nation that is among the worlds' most exposed and sensitive to climate change, but with a well-established and sophisticated sport stadia industry, was an ideal site for this study. And yet, a limitation of this research is that our findings are based on a single national context. We therefore conclude with some suggestions for future management research. First, the evidence of this study suggests that the impacts of climate change—both direct and indirect—on climate-dependent facilities and the organizations that manage them, are more widespread and complex than previously thought. So we argue that business researchers should extend the scope of climate change vulnerability, resilience, and adaptation inquiry to include other climate-dependent areas of the sport sector (e.g. professional sport staged outside of stadia, and community-level sport). Second, a pressing need for the organizations managing climate-dependent sport stadia are conceptual frameworks for preparing adaptation strategies that are both sport and climate change-specific, and practical tools for implementing them. Finally, as MASS organizations typically did not have the resources or capabilities to develop such strategies, further research isneeded on how sport organizations with climate-dependent facilities might include climate change in their strategic thinking. Research is needed in other national contexts, particularly in the northern hemisphere where most of the world's major sport stadia are located, and where different public policy and regulatory responses to climate change apply. This inquiry is important because interpretation of climate risks by sport managers is fundamental to informing effective adaptive responses.

Disclosure statement

No potential conflict of interest was reported by the authors.

References:

AASS. (2018, June 28, 2016). *Thirty-One Top Scientific Societies Speak with One Voice on Global Climate Change*. Retrieved from https://www.aaas.org/news/intersocietyclimateletter2016

AEMO. (2018). *Fact sheet: National electricity market*. Retrieved from http://www.aemo.com.au/About-the-Industry/Energy-Markets/National-Electricity-Market

Agard, J. E., Schipper, L. F., Birkmann, J., Campos, M., Dubeux, C., Nojiri, Y., . . . Clair, A. L. S. (2014). *Annex II Glossary, Climate Change 2014: Impacts, Adaptation, and Vulnerability. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.* . Retrieved from Cambridge, U.K.:

Ahlfeldt, G., & Maennig, W. (2010). Stadium architecture and urban development from the perspective of urban economics. *International Journal of Urban and Regional Research, 34*(3), 629-646.

Amelung, B., & Moreno, A. (2012). Costing the impact of climate change on tourism in Europe: results of the PESETA project. *Climatic Change, 112*(1), 83-100.

Andrew, D. P. S., Pedersen, P. M., & McEvoy, C. D. (2011). *Research methods and design in sport management*. Champaign, Il.: Human Kinetics.

Arnell, N. W., & Delaney, E. K. (2006). Adapting to climate change: public water supply in England and Wales. *Climatic Change, 78*(2-4), 227-255.

Arnell, N. W., van Vuuren, D. P., & Isaac, M. (2011). The implications of climate policy for the impacts of climate change on global water resources. *Global Environmental Change, 21*(2), 592-603.

Babiak, K., & Trendafilova, S. (2011). CSR and environmental responsibility: motives and pressures to adopt green management practices. *Corporate Social Responsibility and Environmental Management, 18*(1), 11-24.

Bansal, P. (2005). Evolving sustainably: A longitudinal study of corporate sustainable development. *Strategic Management Journal, 26*(3), 197-218.

Bansal, P., & Clelland, I. (2004). Talking trash: Legitimacy, impression management, and unsystematic risk in the context of the natural environment. *Academy of Management Journal, 47*(1), 93-103.

Bansal, P., & Roth, K. (2000). Why companies go green: a model of ecological responsiveness. *Academy of Management Journal, 43*(4), 717-736.

Bazeley, P. (2007). *Qualitative data analysis with nvivo*. Los Angeles, CA: Sage Publications.

Beermann, M. (2011). Linking corporate climate adaptation strategies with resilience thinking. *Journal of Cleaner Production, 19*(8), 836-842.

Berkhout, F. (2012). Adaptation to climate change by organizations. *Wiley Interdisciplinary Reviews: Climate Change, 3*(1), 91-106.

Berkhout, F. (2014). Adaptation to climate change by business organisations. In J. P. Palutikof, S. L. Boulter, J. Barnett, & D. Rissik (Eds.), *Applied Studies in Climate Adaptation* (pp. 417-421). New York, USA: John Wiley & Sons.

Berkhout, F., Hertin, J., & Gann, D. M. (2006). Learning to adapt: organisational adaptation to climate change impacts. *Climatic Change*(78), 135-156.

Biagini, B., Bierbaum, R., Stults, M., Dobardzic, S., & McNeeley, S. M. (2014). A typology of adaptation actions: a global look at climate adaptation actions financed through the Global Environment Facility. *Global Environmental Change, 25*, 97-108.

BoM. (2018). *Bureau of Meteorology Climate Zones*. Retrieved from http://www.bom.gov.au/iwk/climate_zones/map_2.shtml

BoM, & CSIRO. (2017). *State of the climate 2016.* Retrieved from Collingwood: http://www.bom.gov.au/state-of-the-climate/

Chard, C., & Mallen, C. (2012). Examining the linkages between automobile use and carbon impacts of community-based ice hockey. *Sport Management Review, 15*(4), 476-484.

Chard, C., & Mallen, C. (2013). Renewable energy initiatives at Canadian sport stadiums: a content analysis of web-site communications. *Sustainability, 5*(12), 5119-5134.

Charlton, M. B., & Arnell, N. W. (2011). Adapting to climate change impacts on water resources in England: An assessment of draft Water Resources Management Plans. *Global Environmental Change, 21*(1), 238-248.

Collignon, H., & Sultan, N. (2014). *Winning in the business of sports*. Retrieved from Chicago, Ill.: https://www.atkearney.com/documents/10192/5258876/Winning+in+the+Business+of+Sports.pdf/ed85b644-7633-469d-8f7a-99e4a50aadc8

Commission, E. (2018). *What is an SME?* Retrieved from http://ec.europa.eu/growth/smes/business-friendly-environment/sme-definition_en

Coyne, I. T. (1997). Sampling in qualitative research. Purposeful and theoretical sampling; merging or clear boundaries? *Journal of Advanced Nursing, 26*(3), 623-630.

Cresswell, J. W. (2009). *Research design: Qualitative, quantitative and mixed method approaches* (3rd ed.). Thousand Oaks, CA Sage Publications.

CSIRO. (2009). *The science of tackling climate change.* (pp. 32). Retrieved from http://www.csiro.au/files/files/psvk.pdf

CSIRO, & BoM. (2015). *Climate change in Australia. Information for Australia's natural resource management regions: technical report*. Retrieved from Canberra, AUS:

DCCEE. (2007). *National greenhouse accounts: National inventory report 2007*. Retrieved from http://www.climatechange.gov.au/publications/greenhouse-acctg/~/media/publications/greenhouse-acctg/national-inventory-report-vol-2-part-h.ashx

DEE. (2012). *Waste emissions projections*. Retrieved from http://www.climatechange.gov.au/publications/projections/australias-emissions-projections/waste-emissions.aspx#solidwaste

Dolf, M., & Teehan, P. (2015). Reducing the carbon footprint of spectator and team travel at the University of British Columbia's varsity sports events. *Sport Management Review, 18*(2), 244-255.

Dolles, H., & Soderman, S. (2010). Addressing ecology and sustainability in mega-sporting events: The 2006 Football World Cup in Germany. *Journal of Management and Organization, 16*(2), 603–616.

Dow, K., Berkhout, F., Preston, B. L., Klein, R. J. T., Midgley, G., & Shaw, M. R. (2013). Limits to adaptation. *Nature Climate Change, 3*(4), 305-307.

Edwards, A., & Skinner, J. (2009). *Qualitative research in sport management*. Oxford: Butterworth-Heinnemann/Elsevier.

Eisenhardt, K. M. (1989). Building theories from case study research. *Academy of Management Review, 14*(4), 532-550.

Eriksen, S. H., Nightingale, A. J., & Eakinc, H. (2015). Reframing adaptation: ihe political nature of climate change adaptation. *Global Environmental Change, 35*, 523–533.

Feddersen, A., Grötzinger, A. L., & Maennig, W. (2009). Investment in stadia and regional economic development: Evidence from FIFA World Cup 2006. *International Journal of Sport Finance, 4*(4), 221-239.

Füssel, H.-M. (2007a). Adaptation planning for climate change: concepts, assessment approaches and key lessons. *Sustainability Science, 2*(2), 265-275.

Füssel, H.-M. (2007b). Vulnerability: A generally applicable conceptual framework for climate change research. *Global Environmental Change, 17*(2), 155-167.

Gasbarro, F., Rizzi, F., & Frey, M. (2016). Adaptation measures of energy and utility companies to cope with water scarcity induced by climate change. *Business Strategy and the Environment, 25*(1), 54-72.

Gössling, S., & Upham, P. (Eds.). (2009). *Climate change and aviation: Issues, challenges and solutions*. Sterling, VA: Earthscan.

Haigh, N. L., & Griffiths, A. (2012). Surprise as a catalyst for including climatic change in the strategic environment. *Business & Society, 51*(1), 89-120.

Halkos, G., & Skouloudis, A. (2016). Bouncing back from extreme weather events: some preliminary findings on resilience barriers facing small and medium-sized enterprises. *Munich Personal RePEc Archive*(December, Paper No. 75562).

Hall, J. W., Berkhout, F., & Douglas, R. (2015). Responding to adaptation emergencies. *Nature Climate Change, 5*(1), 6-7.

Hennessy, K. (2011). Climate change impacts. In H. Cleugh, M. Stafford Smith, M. Battaglia, & P. Graham (Eds.), *Climate change: science and solutions for Australia* (pp. 45-57). Collingwood, Vic.: CSIRO Publishing.

Henriques, I., & Sadorsky, P. (1996). The determinants of an environmentally responsive firm: an empirical approach. *Journal of Environmental Economics and Management, 30*(3), 381-395.

Hertin, J., Berkhout, F., Gann, D. M., & Barlow, J. (2003). Climate change and the UK house building sector: perceptions, impacts and adaptive capacity. *Building Research & Information, 31*(3-4), 278–290.

Hoffman, A. J. (2005). Climate change strategy: the business logic behind voluntary greenhouse gas reductions. *California Management Review, 47*(3), 21-46.

Horne, J. (2011). Architects, stadia and sport spectacles: Notes on the role of architects in the building of sport stadia and making of world-class cities. *International Review for the Sociology of Sport, 46*(2), 205-227.

Hoye, R., Smith, A. C. T., Nicholson, M., & Stewart, B. (2015). *Sport management: principles and applications*. London, UK: Routledge.

Hulme, M. (2009). *Why we disagree about climate change: understanding controversy, inaction and opportunity*. Cambridge, UK: Cambridge University Press.

IEA. (2008). *Turning a liability into an asset: landfill methane utilisation potential in India*. Retrieved from Paris, France: http://www.iea.org/publications/freepublications/publication/India_methane.pdf

IPCC. (2014a). *Climate Change 2013: The Physical Science Basis*. Retrieved from http://www.climatechange2013.org/

IPCC. (2014b). *Climate Change 2014: Synthesis Report. Approved Summary for Policymakers.* Retrieved from Geneva, Switzerland:

IPCC. (2014c). *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.* Retrieved from Geneva, Switzerland:

Kellett, P., & Turner, P. (2009). *Managing sport in drought-new stakeholders and new governance issues: a case study.* Paper presented at the *NASSAM 2009: North American Society for Sport Management Conference*, Columbia, South Carolina.

Kellett, P., & Turner, P. (2011). CSR and water management in the sport sector: a research agenda. *International Journal of Sport Management & Marketing, 10*(1/2), 142-160.

Kiem, A. S., & Austin, E. (2013). Drought and the future of rural communities: opportunities and challenges for climate change adaptation in regional Victoria, Australia. *Global Environmental Change, 23*, 1307-1316.

Kikulis, L. M., Slack, T., & Hinings, B. (1995). Does decision making make a difference? Patterns of change within Canadian national sport organizations. *Journal of Sport Management, 9*(3), 273-299.

Kolk, A., & Hoffman, V. (2007). Business, climate change and emissions trading. *European Management Journal, 25*(6), 411-414.
Kolk, A., & Levy, D. (2004). Multinationals and global climate change: issues for the automotive and oil industries. In S. Lundan (Ed.), *Multinationals, Environment and Global Competition* (pp. 171-193). Oxford: Elsevier.
Kolk, A., & Pinkse, J. (2005). Business responses to climate change: identifying emergent strategies. *California Management Review, 47*(3), 6-20.
Kolk, A., & Pinkse, J. (2011). Multinational enterprises and climate change strategies. In A. Verbeke & H. Merchant (Eds.), *Handbook of research on international strategic management*. Cheltenham, U.K.: Edward Elgar.
Lee, S. Y., & Klassen, R. D. (2015). Firms' response to climate change: the interplay of business uncertainty and organizational capabilities. *Business Strategy and the Environment*.
Lewandowsky, S., Oreskes, N., Risbey, J. S., Newell, B. R., & Smithson, M. (2015). Seepage: climate change denial and its effect on the scientific community. *Global Environmental Change, 33*, 1-13.
Linnenluecke, M. K., & Griffiths, A. (2010). Beyond adaptation: resilience for business in light of climate change and weather extremes. *Business & Society, 49*(3), 477-511.
Linnenluecke, M. K., & Griffiths, A. (2012). Assessing organizational resilience to climate and weather extremes: complexities and methodological pathways. *Climatic Change*.
Linnenluecke, M. K., & Griffiths, A. (2013). Firms and sustainability: mapping the intellectual origins and structure of the corporate sustainability field. *Global Environmental Change, 23*(1), 382-391.
Linnenluecke, M. K., Griffiths, A., & Mumby, P. (2015). Executives' engagement with climate science and perceived need for business adaptation to climate change. *Climatic Change, 131* (2), 321-333.
Linnenluecke, M. K., Griffiths, A., & Winn, M. I. (2011). Extreme weather events and the critical importance of anticipatory adaptation and organizational resilience in responding to impacts. *Business Strategy and the Environment, 21*(1), 123-133.
Linnenluecke, M. K., Griffiths, A., & Winn, M. I. (2013). Firm and industry adaptation to climate change: a review of climate adaptation studies in the business and management field. *Wiley Interdisciplinary Reviews: Climate Change*.
Linnenluecke, M. K., Stathakis, A., & Griffiths, A. (2011). Firm relocation as adaptive response to climate change and weather extremes. *Global Environmental Change, 21*(1), 123-133.
M.O. (2018). What is climate change? Retrieved from http://www.metoffice.gov.uk/climate-guide/climate-change
Mallen, C., & Chard, C. (2012). "What could be" in Canadian sport facility environmental sustainability. *Sport Management Review, 15*(2), 230-243.
Mastrandrea, M. D., & Schneider, S. H. (2010). Climate change science overview. In S. H. Schneider, A. Rosencranz, M. D. Mastrandrea, & K. Kuntz-Duriseti (Eds.), *Climate change science and policy* (pp. 11-27). Washington, USA: Island Press.
McDonald, K., Stewart, B., & Dingle, G. (2014). Managing multi-purpose leisure facilities in a time of climate change. *Managing Leisure, 19*(3), 212-225.
Merigó, J. M., & Gil-Lafuente, A. M. (2011). Decision-making in sport management based on the OWA operator. *Expert Systems with Applications, 38*(8), 10408-10413.
Miles, M., Huberman, A. M., & Saldana, J. (2014). *Qualitative data analysis: a methods sourcebook*. Thousand Oaks, CA: Sage Publications.
Miller, T., Lawrence, G., McKay, J., & Rowe, D. (2001). *Globalisation and sport: Playing the world*. London: Sage Publications.
Moen, J., & Fredman, P. (2007). Effects of climate change on alpine skiing in Sweden. *Journal of Sustainable Tourism, 15*(4), 418-437.

National Greenhouse and Energy Reporting Act 2007, 175 Stat. 60 (Commonwealth of Australia 2007 September 16 2008).

Nicholson, M., Kerr, A., & Sherwood, M. (2015). *Sport and the media* (2nd ed.). Oxford, UK: Taylor & Francis.

Otto, I., & Heath, E. T. (2010). The potential contribution of the 2010 Soccer World Cup to climate change: an exploratory study among tourism industry stakeholders in the Tshwane metropole of South Africa. *Journal of Sport & Tourism, 14*(2-3), 169-191.

Packard, K. O., & Reinhardt, F. (2000). What every executive needs to know about global warming. *Harvard Business Review, 78*(4), 129-135.

Patenaude, G. (2011). Climate change diffusion: While the world tips, business schools lag. *Global Environmental Change, 21*(1), 259-271.

Pelling, M. (2011). *Adaptation to climate change: from resilience to transformation*. London, U.K.: Routledge.

Pinkse, J., & Gasbarro, F. (2016). Managing physical impacts of climate change: an attentional perspective on corporate adaptation. *Business & Society*.

Pinkse, J., & Kolk, A. (2007). Multinational corporations and emissions trading: strategic responses to new institutional constraints. *European Management Journal, 25* (6), 441-452.

Porter, M. E., & Reinhardt, F. L. (2007). A strategic approach to climate. *Harvard Business Review, 85*(10), 22-26.

QLDG. (2001). *Major Sport Facilties Act 2001*. Brisbane: Queensland Government. Retrieved from http://www.legislation.qld.gov.au/LEGISLTN/CURRENT/M/MajorSpFacA01.pdf.

Real, M. R. (1996). The postmodern Olympics: Technology and the commodification of the Olympic movement. *Quest, 48*, 9-23.

Reisinger, A., Kitching, R. L., Chiew, F., Hughes, L., Newton, P. C. D., Schuster, S. S., . . . Whetton, P. (2014). Australasia. In V. R. Barros, C. B. Field, D. J. Dokken, M. D. Mastrandrea, & e. al. (Eds.), *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* (pp. 1371-1438). Cambridge, UK; New York, USA.: Cambridge University Press.

Rickards, L. (2011). Critical Breaking Point: the effects of climate variability, climate change and other pressures on farm households.

Rutty, M., Scott, D., Steiger, R., & Johnson, P. (2014). Weather risk management at the Olympic Winter Games. *Current Issues in Tourism, 18*(10), 931–946.

Sandelowski, M., Holditch-Davis, D., & Harris, B. G. (1992). Using qualitative and quantitative methods: The transition to parent-hood of infertile couples. In J. F. Gilgun, K. Daly, & G. Handel (Eds.), *Qualitative Methods in Family Research* (pp. 301–323). Newbury Park, California: Sage Publications.

Sarantakos, S. (2013). *Social research.* (4th ed.). Hampshire: Palgrave MacMillan.

Scott, D., Gössling, S., & Hall, C. M. (2012). International tourism and climate change. *Wiley Interdisciplinary Reviews: Climate Change, 3*(3), 213-232.

Scott, D., & Jones, B. (2006). The impact of climate change on golf participation in the Greater Toronto Area (GTA): a case study. *Journal of Leisure Research, 38*(3), 363-380.

Scott, D., & Jones, B. (2007). A regional comparison of the implications of climate change for the golf industry in Canada. *The Canadian Geographer/Le Géographe canadien, 51*(2), 219-232.

Scott, D., & McBoyle, G. (2007). Climate change adaptation in the ski industry. *Mitigation and Adaptation Strategies for Global Change, 12*(8), 1411-1431.

Scott, D., Steiger, R., Rutty, M., & Johnson, P. (2015). The future of the Olympic Winter Games in an era of climate change. *Current Issues in Tourism, 18*(10), 913-930.

Smit, B., & Wandel, J. (2006). Adaptation, adaptive capacity and vulnerability. *Global Environmental Change, 16*(3), 282-292.

Stadium. (2017). In J. Simpson (Ed.), *Oxford English Dictionary*. Oxford, U.K.: Oxford University Press.

Steffen, W., & Hughes, L. (2013). *The critical decade 2013: Climate change science, risks and responses*. Retrieved from Canberra, Aust.:

Steffen, W., Richardson, K., Rockström, J., Cornell, S. E., Fetzer, I., Bennett, E. M., . . . Sörlin, S. (2015). Planetary boundaries: guiding human development on a changing planet. *Science, 347*(6223), 736-748.

Timbal, B. (2009). *The continuing decline in South-East Australian rainfall: Update to May 2009.* Retrieved from Hobart, Aust.:

Trendafilova, S., Babiak, K., & Heinze, K. (2013). Corporate social responsibility and environmental sustainability: why professional sport is greening the playing field. *Sport Management Review, 16*(3), 298-313.

UNEP. (2018). *Impact of sport on the environment*. Retrieved from http://www.unep.org/sport_env/impactSport_Env.aspx

USEPA. (2018). *Methane*. Retrieved from http://www.epa.gov/methane/

VEPA. (2018). *Landfill gas: Factsheet.* Retrieved from http://www.epa.vic.gov.au/~/media/Publications/1479.pdf

WADSR. (2007). *Climate change is no longer just a concept: how climate change could affect sport and recreation now and in the future*. Perth, WA: Western Australia Department of Sport and Recreation (WADSR) Retrieved from http://www.dsr.wa.gov.au/assets/files/Research/Climate_Change.pdf.

Weinhofer, G., & Busch, T. (2013). Corporate strategies for managing climate risks. *Business Strategy and the Environment, 22*(2), 121-144.

Weinhofer, G., & Hoffmann, V. H. (2010). Mitigating climate change: how do corporate strategies differ? *Business Strategy and the Environment, 19*(2), 77-89.

Williams, S., & Schaefer, A. (2012). Small and medium-sized enterprises and sustainability: Managers' values and engagement with environmental and climate change Issues. *Business Strategy and the Environment, 22*(3), 173-186.

Williams, S., & Schaefer, A. (2013). Small and medium-sized enterprises and sustainability: managers' values and engagement with environmental and climate change issues. *Business Strategy and the Environment, 22*(3), 173-186.

Winn, M. I. (1995). Corporate leadership and policies for the natural environment. In D. Collins & M. Starik (Eds.), *Research in Corporate Social Performance and Policy* (pp. 127-161). Greenwich, CT: JAI Press.

Winn, M. I., Kirchgeorg, M., Griffiths, A., Linnenluecke, M. K., & Gunther, E. (2011). Impacts from climate change on organizations: a conceptual foundation. *Business Strategy & Environment, 20*, 157-173.

Wolfsegger, C., Gössling, S., & Scott, D. (2008). Climate change risk appraisal in the Austrian ski industry. *Tourism Review International, 12*(1), 13-23.

Yin, R. K. (2009). *Case study research: design and methods* (4th ed.). Thousand Oaks, CA: Sage Publications.

Yin, R. K. (2011). *Qualitative research from start to finish* (1st ed.). New York, USA: Guilford Press.

Yin, R. K. (2012). *Applications of case study research* (3rd ed.). Thousand Oaks, CA: Sage Publications.