Tourism Management 58 (2017) 196–204

Contents lists available at ScienceDirect

Tourism Management

journal homepage: www.elsevier.com/locate/tourman

Using ski industry response to climatic variability to assess climate change risk: An analogue study in Eastern Canada

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HIGHLIGHTS

- The impact of climate change analogue conditions on ski operations is broader than reported in previous studies.
- Ski operations under anomalously warm temperatures are not binary, but a continuum of partial capacity.
- Differential vulnerabilities are recorded by ski resort size (i.e., small, intermediate and large resorts) and month.
- Ski demand is less sensitive to record warm conditions than supply-side operations.

ARTICLE INFO

Article history:
Received 3 March 2016
Received in revised form
6 September 2016
Accepted 24 October 2016
Available online 4 November 2016

Keywords:
Climate change
Ski tourism
Adaptation
Vulnerability
Analogue
Canada

ABSTRACT

To accurately characterize the ski industry's risk to future climate change and varied quality of snow conditions, it is important to assess how the industry has managed and adapted to contemporary anomalously warm ski seasons. This is the first temporal climate change analogue study to use higher resolution daily performance data at the individual ski area scale, including reported snow quality, ski lift operations, slope openings, and water usage for snowmaking. The record warm winter of 2011–2012 in the Ontario ski tourism market (Eastern Canada) is representative of projected future average winter conditions under a mid-century, high greenhouse gas emissions scenario (RCP 8.5), which was compared to the 2010–2011 season which was climatically normal (for the 1981–2010 period). Supply-side impacts across the 17 ski areas during the analogue winter included a total average decrease in the ski season length (−17% days), operating ski lifts (−3%), skiable terrain (−9%), reduced snow quality (e.g., -46% days with packed powder), snowmaking days (−18%), and an increase in water usage for snowmaking (e.g., +300% in December). Demand-side impacts include a 10% decrease in overall skier visits, with a resort size-correlation (small −20%, intermediate −14%, large −8%). With reduced operational ski terrain and more frequent marginal snow conditions, visitor experience is adversely affected more frequently. Collectively, these findings identify differential impacts in the ski tourism market and can assist ski area managers, communities, investors and governments with developing climate change adaptation plans.

1. Introduction

Perspectives on the importance of adaptation are evident, which is strengthened by an acknowledgement that additional future climate change is unavoidable, as well as an awareness that adaptation can bring benefits by reducing sensitivity to current climatic risks (e.g., Ford et al., 2010). There is also a growing acceptance that adaptation will be essential for the economic viability of individual businesses and economic sectors, including tourism (e.g., Field et al., 2012; Agrawala et al., 2011; Mercer, 2011; PwC, 2010). To drive adaptation initiatives forward, we must first understand the vulnerability of socio-economic systems to climate change (i.e., characterize who and what are vulnerable and how), as well as the

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http://dx.doi.org/10.1016/j.tourman.2016.10.020
0261-5177/

capacity to respond and adapt to changing conditions (Ford et al., 2010; IPCC, 2014a,b).

The ski industry is regarded as one of the tourism segments most directly and immediately affected by climate change, attracting much media and research attention for its risk (Scott, 2011; Scott, Gössling, & Hall, 2012). Key impacts include a decrease in natural snow cover, increased snowmaking requirements and costs, and more limited snowmaking prospects, resulting in shorter and more variable ski seasons, reduced visitation, and altered destination competition and sustainability (Abegg, Agrawala, Crick, & Montfalcon, 2007; Dawson & Scott, 2013; Hamilton, Brown, & Keim, 2007; Hendrikx, Zammit, Hreinsson, & Becken, 2013; Hennessy et al., 2008; Pons, Johnson, Rosas, & Jover, 2014; Scott, McBoyle, & Mills, 2003, 2006; Steiger & Stötter, 2013; Steiger, 2010). It has also been noted that there is much speculation on climate change risks for ski tourism in the media (see Scott, Hall, & Gössling, 2012).

Snow-based tourism has long been dealing with variability in natural snowfall and seasonal temperatures, which has led to early adaptive interventions and investments (Rutty, Scott, Steiger, & Johnson, 2014). A central climate adaptation strategy of the ski industry is snowmaking, with widespread uptake to both improve the reliability of, and lengthen, the ski season (Dawson & Scott, 2013; Scott, 2006; Scott et al., 2012). Studies reveal that since the mid-1980s, snowmaking has substantially decreased the climatic vulnerability of the ski industry, particularly during winters with low snowfall, helping to secure the economic viability of ski resorts (Dawson & Scott, 2013; Scott & McBoyle, 2007; Steiger & Stötter, 2013; Töglhofer, Eigner, & Prettenthaler, 2011). Studies that only examine change in natural snow (e.g., the entire literature before 2000s and more recently, Hendrikx et al., 2013; Endler & Matzarakis, 2011; Uhlmann, Goyette, & Beniston, 2009; Abegg et al., 2007; Moen & Fredman, 2007; Beniston, Keller, Koffi, & Goyette, 2003; Elasser & Messerli, 2001) overlook this current operational reality and future adaptive capacity, presenting a flawed perspective on climate change risk. Although this adaptation has enabled many ski areas to better withstand and recover from the impact of a poor season, snowmaking remains dependent on sufficiently cold temperatures for cost-effective snow production (i.e., snowmaking as a technical adaptation has physical and economic limits) (Scott & McBoyle, 2007). With current record warm seasons projected to become normal winter conditions in the decades ahead, the financial impact of isolated marginal seasons may no longer be cushioned by a succession of average or better than average seasons (Dawson & Scott, 2013).

To characterize the ski industry's vulnerability to climate change, it is important to examine how the industry has managed and responded to marginal climatic conditions in the past. A climate anomaly from a former warm winter season may in turn become the normal operating conditions for the ski industry in the decades ahead. A temporal analogue approach allows climatic risk to be examined together in the context of concurrent stresses (e.g., socioeconomic, environmental and political conditions), revealing important information about adaptive responses that can then be used to make inferences about the future (Ford et al., 2010). Climate analogues serve as 'natural social experiments' (Scott, Gössling, & Hall, 2012), providing a window to observe climatic impacts, as well as the interactions and effectiveness of the full range of adaptive responses. By examining an anomalously warm winter season, we can capture a full range of short-term supply- and demand-side adaptations within the ski market, including the business decisions made by ski-area operators and the response of ski tourists to real climatic conditions.

Even though the past decade has had a number of record warm winters in all major regional ski tourism markets, the analogue approach continues to be under-utilized (Scott et al., 2012). To date, ski tourism analogue studies have been limited to two in North America (Dawson, Scott, & McBoyle, 2009; Scott, 2006), one in Europe (Steiger, 2011) and one in Australia (Pickering, 2011). The objective of this study is to examine the climate change vulnerability of the Ontario (Canada) ski tourism industry using a temporal analogue approach. Regional supply- and demand-side ski industry performance data from the record warm winter season of 2011–2012 are compared with the 2010–2011 season, which is representative of the region's climatically average conditions for the baseline period 1981–2010. This is the first study of its kind to use higher resolution daily operations data at the individual ski area scale, including resort level information on snow quality, ski lift operations, slope openings, and water usage for snowmaking. The results from this study are also being used together with skier surveys (Rutty et al., 2015b, 2015a and) to validate marketplace agent-based modelling. Collectively, this information can assist ski resort operators and local-provincial government, in developing adaptation plans and to mainstream climate change adaptation into other tourism planning processes.

2. Temporal analogues

Climate change vulnerability research has often focused on modelling the impacts of projected climate change. In this approach, global or regional circulation models are typically used as the starting point of analysis to assess vulnerability outcomes under different climate and adaptation scenarios (Burton, Huq, Lim, Pilifosova, & Schipper, 2002; Ford et al., 2010; O'Brien, Eriksen, Nygaard, & Schjolden, 2007). Although this approach has provided important insight into the possible impacts of climate change, it has been criticized for neglecting the dynamic human-climate relationship (e.g., Ford & Pearce, 2012; Smit. & Wandel, 2006; O'Brien et al., 2007). By relying on future scenarios, this approach overlooks the current stresses that are germane to the communities or economic sectors being examined.

Such modelling-based methodologies similarly dominate the ski tourism literature. Climate change scenarios or fixed thresholds of warming (i.e., arbitrary scenarios) are often used to estimate future changes in snow conditions and the impact this will have on the international ski industry (e.g., Abegg et al., 2007; Beniston et al., 2003; Breiling & Charamza, 1999; Dawson & Scott, 2007, 2013; Elsasser & Burki, 2002; Elsasser & Messerli, 2001; Galloway, 1988; Hendrikx et al., 2013; Koenig & Abegg, 1997; López-Moreno, Goyette, & Beniston, 2009; McBoyle & Wall, 1987, 1992; Moen & Fredman, 2007; Scott et al., 2003, 2006; Steiger & Abegg, 2013; Steiger, 2010). In so doing, these studies neglect to capture the wide range of adaptation strategies that are being implemented by ski resort operators (i.e., supply-side adaptation), as well as the potential behavioural adaptation of skiers (i.e., demand-side adaptation).

Glantz (1988) was the first to use a temporal analogue approach to understand human-climate experiences, which led to an evolution in the conceptual grounding of both climatic vulnerability and understanding sources of adaptive capacity (Ford et al., 2010). The use of analogues effectively shifted the focus from biophysical vulnerabilities to contextual vulnerabilities, whereby the analysis begins by understanding how human systems operate within a framework of coexisting stresses (e.g., Brooks, Grist, & Brown, 2009; Ford, Smit, Wandel, & MacDonald, 2006). The key strength of this approach is that it allows researchers to empirically ground the analysis of vulnerability to changing conditions based on an understanding of how climate and society interact (Hofmeijer et al., 2013). Focusing on present interactions is particularly useful within