Climate change acknowledgement and responses of summer (glacier) ski visitors in Norway

O. Cenk Demiroglu a, Halvor Dannevig b and Carlo Aall b

aDepartment of Geography and Economic History, Umeå University, Umeå, Sweden; bWestern Norway Research Institute, Sogndal, Norway

ABSTRACT
The mutual interaction of climate change and the highly weather-dependent ski tourism business is drawing increasing attention from the academic, commercial and political arenas. Changes in the cryosphere are becoming major determinants of the sustainability of ski areas. Therefore, there is a great deal of literature entailing impact and adaptation studies regarding ski areas, resorts, and destinations; however, research on the demand side of the issue is relatively limited. In this paper, the relationship between climate change and a niche segment of ski tourism, summer skiing, is discussed with regard to the awareness, perceptions, and mitigation and substitution behaviours of visitors to the summer downhill ski centres in Norway – an underresearched country, despite its recognition as the cradle of skiing. For this purpose, a comprehensive survey was administered to a sample of 224 subjects. The results revealed high climate change awareness but limited climate friendliness, and a strong emphasis on the immediate climate impacts on summer skiing that create a tendency towards ski activity substitution within Norway. Individual profiles also played a significant role in the anticipated mitigation and substitution behaviours. The implications of the results involving demand attitude and behaviour are further discussed with regard to the suppliers.

KEYWORDS
Summer (glacier) ski tourism; climate change; mitigation; substitution; Norway

Introduction
Global warming has been occurring at an ever-increasing rate for the past few decades. This trend is physically evident in warming oceans, rising sea levels, retreating sea ice, melting glaciers, and diminishing snow cover. The essential playgrounds of ski tourism, namely snow cover and glacier surfaces, will continue shrinking in negative correlation with the rising surface temperatures during the twenty-first century (Intergovernmental Panel on Climate Change, 2013). As a matter of course, the ski industry is regarded as the type of tourism that is “the most directly and the most immediately affected” by climate change. Combined with the continuous stagnation on the ski tourism market in recent decades, and particularly the summer skiing market (Falk, 2016; Mayer, 2012;
Vanat, 2015, p. 24), the trouble is doubled. One may even see the trouble of ski tourism as tripled in the face of climate change, because of the increasing energy use and related greenhouse gas emissions embedded in ski tourism – thus making the sector vulnerable to the possibility of increased prices of energy and carbon due to future tougher climate policies (Aall, Klepp, Støa, Engeset, & Skuland, 2011). Therefore, ski resorts are currently competing in an environment in which there is not only a mature demand but also physical challenges that threaten their snow reliability – in addition to the possibility of facing additional economic threats due to soon-to-be-introduced climate policies based on the “polluter pays” principle. Such threats urge the supply side to carefully engage in certain adaptation measures, while demand side also undergoes some forced or voluntary alterations.

This paper attempts to reveal the acknowledgement of and responses to climate change among ski tourism consumers. It aims to analyse and discuss the climate change mitigation and adaptation of summer ski tourism demand in Norway: firstly, the traditional adaptation – to expected climatic changes – but we will also touch upon the issue of adapting to the tertiary effects (Aall & Høyer, 2005) of climate change arising from mitigation policies; the latter being an underresearched area to date. The major task of our paper is to gain a better understanding of the supportive and adaptive capacities of the consumption side by revealing the perceptions and the reactive behaviour of summer ski tourism consumers – thus also describing the consumer challenges to which the production side (the summer ski industry) must relate. For this purpose, an online survey seeking to reveal climate change awareness, summer skiing preferences, adaptation and substitution tendencies, and demographic and touristic profiles of visitors to the three existing Norwegian summer downhill ski centres was conducted during the summer of 2014. More inclusion of Norway and the related summer skier behaviour issues in research on climate change and ski tourism is seen as a good opportunity to fill in the gaps of this specific paradigm in terms of space and scope, as neither Norway, the cradle of ski sport, nor summer ski tourism has been adequately covered in the literature (Demiroglu, 2011), and the issue of touristic demand response to climate change still has a great deal to offer when it comes to elaboration by researchers (Gössling, Scott, Hall, Ceron, & Dubois, 2012).

**Literature review**

**Climate change and ski tourism demand**

The ski industry is “the first and the most studied aspect” of tourism embedded in a “geographically and methodologically diverse literature” (Scott, Hall, & Gössling, 2012, p. 202). A census on such literature (Demiroglu, 2011; Demiroglu, Dannevig, & Aall, 2013) displays more than 300 research works, a third of which appear as peer-reviewed articles. While the ski industries of 30 countries are covered within these works, the other 50 countries of the global ski tourism supply remain to be studied. Moreover, regarding the destinations covered, more research is needed in order to elaborate on the findings in terms of different scientific expertise, given the highly interdisciplinary characteristic of the topic which requires fair attention from both ends of the scientific spectrum, whether natural or social. Of the body of literature on climate change and ski tourism, 37%
entails natural science studies that mostly attempt impact assessments through climatological analyses. A further 44% is categorized as interdisciplinary, due to its blending of climatic and socioeconomic analyses. On the other hand, these works focusing solely on the human aspect are limited to only 19% of the body. Among this limited research concentration, while major efforts have been diverted to the issue of the climate change adaptation of ski tourism suppliers, “little research has been conducted to examine the influence of climate change on skier demand” (Dawson, Havitz, & Scott, 2011, p. 390). Such a small share has been comprised of certain country-specific studies, while a few others with a more general approach have also looked into the constraints on ski tourism demand, delimiting them beyond climate change but still finding “lack of snow” as one of the most vital barriers among the many intrapersonal, interpersonal, and structural factors (Andronikidis, Vassiliadis, Priporas, & Kamenidou, 2007; Gilbert & Hudson, 2000; Hudson & Gilbert, 2000).

The country-specific examples of climate change and ski tourism demand research have been carried out in various destinations such as Australia (König, 1998; Pickering, Castley, & Burtt, 2010), New Zealand (Hopkins, 2014; Hopkins, Higham, & Becken, 2013; Prince, 2010), the US (Dawson et al., 2011; Vivian, 2011), Austria (Landauer, Haider, & Pröbstl-Haider, 2014; Landauer, Pröbstl, & Haider, 2012; Unbehau, Pröbstl, & Haider, 2008), Switzerland (Behringer, Buerki, & Fuhrer, 2000), Germany (Dehnhardt & Kalisch, 2010), Slovenia (Vrtacnik-Garbas, 2007), and Finland (Falk & Vieru, 2017; Landauer, Haider, et al., 2014; Landauer, Pröbstl, et al., 2012; Landauer, Sievänen, & Neuvonen, 2009; Pouta, Neuvonen, & Sievänen, 2009).

Australia, termed the “canary in the coal mine” (Bicknell & McManus, 2006) that signals the initial warning of warming over ski tourism, has been one of the first destinations to be studied in terms of climate change and ski tourism demand. A part of the pioneering work by König (1998) for this region has set the stage for most of the demand-oriented studies worldwide by guiding them towards the exploration of the climate change perception and adaptation of snow sports tourists. A follow-up study (Pickering et al., 2010) to that of König (1998) for a large Australian ski resort revealed that awareness had been on the increase in recent years (from 78% to 87%) and found a tendency among skiers to ski less frequently. In other words, temporal substitution, in Australia’s warmer climate, had substantially increased from 75% to 90%.

In neighbouring New Zealand, a couple of recent studies (Hopkins, 2014; Prince, 2010) found very high awareness among visitors regarding climate change and likely behavioural alterations towards mitigative efforts; yet there were multiple opinions on snow-making as the leading supplier adaptation method, as some viewed it as a downfall in sustainability while others were satisfied with the extended seasons. Moreover, findings by Hopkins et al. (2013) underlined that the decisions of Australian tourists to travel to New Zealand (Queenstown) ski fields were shaped by not only snow reliability but also relative affordability and the diversity of non-snow activities and attractions.

In the US, on-premise skier surveys administered to 1158 subjects at six ski areas indicated that the likelihood of changing skiing behaviour parallel to poor snow conditions increased especially for the medium involvement segment, which made up 47% of the representative sample (Dawson et al., 2011). On the other hand, in a survey of 572 skiers/snowboarders in New England, Vivian (2011) found that the subjects, especially
those with high involvement, were highly loyal to their ski resort and region, minimizing the risk of spatial substitution for the New England ski tourism industry.

Looking at the Alpine cases: in Austria (Unbehaun et al., 2008), it was found that among the 540 respondents surveyed, most tended to choose to visit high-altitude areas perceived to be snow-reliable, with a tolerance for 10% additional cost and two hours’ additional driving. Above these thresholds, they would suspend skiing. In Switzerland (Behringer et al., 2000), surveys of skiers yielded the results that 83% of the demand perceived climate change as a threat, with half the demand expecting its impacts by 2000–2030. The adaptive capacity of demand was highly flexible, with almost half accepting of spatial substitution and 32% eager to ski less often. In Germany (Dehnhardt & Kalisch, 2010), ski visitors to the Ore Mountains placed snow reliability as their top priority for destination choice, with 69% stating that they would accept spatial substitution, mostly across the border to the Czech resorts, if the warming conditions remained. In Slovenia (Vrtacnik-Garbas, 2007), a 2004–2005 survey of 855 respondents, 92.5% of whom expressed their awareness regarding climate change, disclosed that a seasonal shift in the form of less snow in December and more in April could not ensure the same volume of business, as 38% of the subjects would have substituted skiing with other spring activities. However, more than half of those non-spring skiers would accept a temporal adaptation if such a climatic trend continued. Another detail was the convenient proximity of a spatial substitute. The fact that Slovenian ski resorts are quite remote from their competitors ensured domestic loyalty, as well as from the neighbouring Hungarian and Croatian markets.

Finally, the Finnish cases analyzed the behaviour of an often neglected but highly traditional Nordic segment of ski tourism, cross-country skiers, pointing out certain diverse behavioural dynamics among the participants. Those referring to cross-country skiing as a tradition, “the social type”, were the first to quit during warming trouble (Landauer et al., 2009), while demographic factors such as female gender, lower socioeconomic status, and urbanity increased skiers’ sensitivity to climate change (Pouta et al., 2009). Further studies by Landauer, Haider, et al. (2014; Landauer, Pröbstl, et al., 2012) also revealed that behavioural adaptation was strongly tied to national cultures, as in the case of a Finnish-Austrian comparison, in which it was clear that the Austrian cross-country skiers were more accepting of the costs of supplier adaptation with respect to their Finnish counterparts. Regarding alpine skiing, Falk and Vieru (2017) showed that the demand could decline by 5–23%, depending on the region, during low snowfall years.

**Climate change impacts on summer (glacier) ski tourism**

If one does not take into account the existence of opposite hemispheric seasons and dry or indoor slopes, few of the some 6000 ski resorts/areas worldwide offer summer skiing. Around 20 glacier ski areas operate during the summer months, although some cannot make it beyond late June or early July. These few centres are mostly concentrated to the major ski tourism cores of the world: the Alps, Nordic Europe, North America, and East Asia (Mayer, 2012; Vanat, 2015, p. 24).

As Smiraglia et al. (2008) point out, “the use of glaciers for summer skiing is a relatively new phenomenon” (p. 207), just as the research on the interaction of summer skiing with climate change is also quite limited, even though there are numerous studies involving
winter skiing and other summer activities in mountain areas (Scott, 2006a). However, the debate is quite hot as summer skiing seems to have a relatively more vulnerable status than winter skiing concerning climate change. Deglaciation figures related to the European Alps from the mid-nineteenth century to the end of the twentieth century display that losses of 30–40% and 50% have occurred by surface area and volume, respectively (Haeberli & Beniston, 1998). Overall in the Alps, the number of operational summer ski areas has fallen from a maximum of 40 in the 1980s and 1990s to just a dozen in the 2000s (Mayer, 2012; Vanat, 2015, p. 24). The pioneering research by Abegg, König, and Maisch (1994) and König and Abegg (1997) pronounced an opportunity for glacier ski resorts in the Swiss Alps in terms of capturing the winter demand from the warming, and thus less snow-reliable, resorts at lower altitudes; but, at the same time, a threat was noted in the form of steadily declining summer skier figures in the last two decades of the twentieth century, attributed to the warming climate, as well as changing tastes towards other mountain sports for the summer, increasing costs and prices, and the competition pressure from the Southern Hemisphere ski resorts for the professional ski training market (Falk, 2016; Mayer, 2012). Recent developments regarding Swiss glacier resorts and summer skiing have verified this anticipation, as has recent research. Today, resort operators are more concerned over crevasses and rockfalls which risk safety, and permafrost melt which leads to the deterioration of the infrastructural foundations (Keyes, 2003; Steiger, Dawson, & Stötter, 2012). Abegg (2009) found that, out of the ten summer ski areas operating in Switzerland in the 1970s, only two remain. In the neighbouring Austrian Alps, four summer ski glaciers survive today, despite a loss of their vertical drops by more than half, from an average of 600 to 300 m (Steiger et al., 2012). Recent physical conditions at the one and only summer ski area in the US, on the other hand, have left the businesses there desperate and pessimistic about the future (UnofficialNet, 2015).

Regarding the Italian Alps, one of the four Italian summer ski areas recently announced the suspension of its operations (Vanat, 2014, p. 21). Furthermore, a study by Diolaiuti et al. (2006; Smiraglia et al., 2008), referring to a glacier claimed to be one of the oldest summer ski spots not only in the Italian Alps but in the world, voiced yet another pessimistic scenario for the future of Alpine summer skiing tourism. According to various observations, the glacier surface area decreased from 1.7 km² in 1888 to 0.6 km² in 2001, and the skiable surface area shrunk from 0.9 km² in 1965 to 0.38 km² in 2002. The overall reduction of summer skier visits to the glacier in the 1980s and 1990s is linked to warmer weather patterns which result in less snow and more open crevasses, but the socioeconomic reasons, such as high lift prices and changing preferences, are also underlined. In a run of 30 years, in line with the warming trends it is expected that the glacier will go extinct, putting the summer ski establishments out of business even before the anticipated period ends, as the desired snow reliability for skiing would be lost prior to the ultimate extinction.

**Adaptation of summer (glacier) ski tourism supply to climate change**

Many climate change adaptation measures have already been taken by ski industries worldwide. These include various technical, operational, and political alternatives such as snowmaking, supergrooming, snow farming, wind sheltering, shading, machine grading, salting, moving higher and polewards, cloud seeding, dry skiing, indoor skiing, snow insurance, weather derivatives, snow-guaranteed marketing, improved weather
forecasting and reporting, subsidies, cooperation and consolidation, winter product diversification, seasonal diversification, spatial diversification, and withdrawal; each carrying with it its own physical side effects and/or socioeconomic consequences (Abegg, Agrawala, Crick, & de Montfalcon, 2007, pp. 37–58; Elsasser & Bürki, 2002; Kaján, 2014; Landauer, Goodsite, & Juhola, 2017; Scott, 2006b; Scott & McBoyle, 2007).

Among the aforementioned adaptation measures, snowmaking is by far the most common implementation. Indeed, even one of the least exposed – owing to its high latitude and altitude – glacier ski areas today has serious plans to invest in this technology (Dahlby, 2015). However, the implementation of snowmaking usually results from different needs for the summer (glacier) ski areas as compared to the winter ones. While many winter ski resorts seek base layer or complete coverage and want to achieve early openings and extended seasons, snowmaking is usually significant for glaciers only because it can help compensate for negative accumulation/ablation balances, but usually through the aid of depot snowmaking and farming in winter (Mayer, 2012; Steiger & Mayer, 2008), as summer ski season wet bulb temperatures may generally not be sufficient to meet the minimum threshold of $-7^\circ C$ for good quality snow production according to the common technological requirements. Advanced but rare snowmaking technologies, on the other hand, can function at much higher temperatures and have already been installed at two Alpine glacier ski areas (Mayer, 2012).

However, snowmaking and many other adaptation measures may not be the priority for summer ski resorts, as certain customized forms of adaptation may suit them better. For instance, the aforementioned Italian case has been concentrating more on snow-transferring (from the accumulation basin to the ablation zone) than on snowmaking. This practice is criticized as well, however, as it is claimed to contribute to the reduction of glacier life (Smiraglia et al., 2008). Likewise, grooming and salting activities have also been deemed harmful to glacier survival (Andersen & Johnsen, 1996), whereas some recent studies have proven these practices to be neutral to the surrounding environment (Fischer, Olefs, & Abermann, 2011; Teichrob, 2010).

Perhaps the most interesting technical adaptation measure for summer ski areas is “swaddling”, in which the glaciers are covered with white sheets (Anonymous, 2005) which may increase albedo and reduce ablation up to 60% (Fischer et al., 2011). This practice helps strengthen the glacier and the permafrost, thus providing ski areas with snow reliability and the lift masts and facility foundations with more safety. Abegg et al. (2007, p. 41) report that swaddling is already in use in over 3% of the glacier ski area in Tyrol, 28 ha, and further diffusion is also observed for Switzerland. While the cost of 4 CHF/m$^2$ is perceived to be relatively economical, resulting in an annual cost of around CHF 110,000 for a proper glacier ski area (Zwingle, 2006), environmentalist groups express concern over the lack of regulation for this practice. Besides, no matter how much the method can prevent ablation, the ultimate end – total glacier extinction – would still be inevitable (Abegg et al., 2007, p. 41).

Last but not least, diversification of business is also an important option for summer ski centres facing adaptation challenges. Such attempts may occur operationally as well as temporally. Temporally speaking, many glacier resorts would always reserve their physical advantage over the winter resorts in terms of resilience concerning winter snow cover duration (König & Abegg, 1997). However, such a shift could require a reduced winter snowpack, which would ease road clearance, as well as a will to enter a market with many more
competitors than in the summer. Regarding new product development for the summer, on the other hand, glacier areas might enjoy warmer climatic conditions for the comfort of their potential non-ski visitors (Pröbstl, Greil, & Wirth, 2012; Wirth, Pröbstl, & Haider, 2009), while landscape scars remaining from slope development and glacier retreat might negatively affect the safety and aesthetics of the visit domain (Pröbstl, Haider, Hägeli, & Rupf, 2012). Glacier retreat, however, could also become an opportunity to set a new attraction for the emerging dark market of “climate change tourism” (Bauer, 2011).

One should note that the challenges of sectors, especially tourism, having to also adapt to climate change mitigation policies is an emerging topic in the climate change literature (Dannevig & Aall, 2012; Skarbø & Vinge, 2013). This new perspective on climate change adaptation relates to the wider debate on the links between adaptation and mitigation, but such debates tend to study how adaptation may affect greenhouse gas emissions and how mitigation may influence climate change vulnerability (see e.g. Klein et al., 2007; Wilbanks, Leiby, Perlack, Ensminger, & Wright, 2007). The point raised here is how sectors may have to adapt to climate change mitigation policies; in other words, for instance, how an increase in carbon tax or energy prices in general may affect a specific sector in economic or other ways – and how sectors can adapt to such challenges. In order to assess such vulnerabilities and thereby adaptation challenges, it is imperative to know the energy use and greenhouse gas emissions embedded in production and consumption in the sector in question. Such studies, in the case of tourism in general and ski tourism in particular, reveal that ski tourism may be highly vulnerable to a tougher climate policy regime manifesting itself through aspects such as increased energy prices and carbon taxes. The energy and greenhouse gas intensity in ski tourism is increasing in both a relative (per person) and total sense, due to increased tourism mobility, increased use of greenhouse gas-intensive means of transportation (primarily by airplane), increased use of personal equipment (number of skis per skier, specialized clothing etc.), and increased use of artificial snow production facilities with the potential dissemination of the aforementioned extremely energy-intensive all-weather snowmaking systems (Aall et al., 2011).

When ski tourism suppliers, whether summer- or winter-oriented, plan climate change adaptation, they should also realize that the demand will seek adaptation as well, with an even more flexible transition towards substitution spatially, temporally or activity-related. Some will abandon skiing, some will find another activity, some will look for another destination perceived to be snow-reliable, and so on (Unbehaun et al., 2008). Therefore, the total vulnerability of summer ski tourism cannot be fully comprehended unless the adaptive capacities of not only suppliers and but also consumers are well understood.

**The case of Norwegian summer (glacier) ski centres**

In Nordic Europe, while Sweden hosts a popular late spring resort on its northern Norwegian border and some Finnish resorts can have extended winter seasons, Norway constitutes most of the real summer downhill skiing tourism supply with three downhill ski centres on and around the glaciers Vesljuvbreen, Tystigbreen, and Botnabrea (Figure 1). The operational seasons vary from May-July to as late as October. However, one can still see how climate change has affected, and will continue to affect, glacier and snow
measures on and around these ski areas. Just as with the Alpine and North American cases, the future is not bright here either.

A retreat trend is in effect for the Norwegian glaciers (Norwegian Water Resources and Energy Directorate, 2010), even including the coastal ones that had advanced during the 1990s due to a positive phase of the North Atlantic Oscillation (Lemke et al., 2007, p. 359). Major shifts in the climate zones of the three summer ski centres are anticipated in the long term for the 2071–2100 period, such that: Vesljuvbreen would be confronted with an even colder, but drier, winter which could lead to a negative mass balance; Tystigbreen would be subject to an ever-increasing influence of maritime temperate climates; and Botnabrea would trade its cool summers with warmer ones. Moreover, 50–65 days of less snow cover for Vesljuvbreen and Tystigbreen, and even up to 80 days of reduction on the lower parts of Botnabrea, are also predicted for the same period. These reductions will naturally occur in the summer, jeopardizing the number of operational days (Demiroglu, Dannevig, & Aall, 2012).

The investigation of stakeholder adaptation in terms of suppliers has revealed that technical strategies such as snowmaking, snow farming, and salt usage have already been put into effect at Vesljuvbreen, whilst the operator has acknowledged the ongoing climate change phenomenon as a “wavy” variability issue rather than a warming/retreating trend, and has even deemed it an opportunity, as the visible trouble with the Alpine glaciers has made his centre more competitive in terms of snow reliability. Despite these developments, the business has not adopted any mission on mitigation or stated any direct imposition by the Norwegian government, which is willing to reduce the country’s greenhouse gas emissions by 40% by 2030 with respect to the 1990 national level. On the other hand, the other two Norwegian summer ski centres have not been as lucky in terms of vulnerability and have recently undergone financial difficulties due to snow scarcity, but have ultimately

**Figure 1.** Locations of summer (glacier) downhill ski centres in Norway.
been saved by communal subsidies and private investors, who have even proposed extending the lifts to the higher terrains of their host glacier (Demiroglu et al., 2012).

There have been no studies on the consumer climate change adaptation with respect to summer ski tourism either in Norway – though some (Denstadli & Jacobsen, 2014; Denstadli, Jacobsen, & Lohmann, 2011; Forland et al., 2013; Rauken & Kelman, 2012; Rauken, Kelman, Jacobsen, & Hovelsrud, 2010) have studied non-ski summer tourism – or worldwide. However, recent work by Ferrari (2010) has made the initial step towards a disclosure of general knowledge on the attitudes and behaviours of Norwegian ski tourists towards climate change. The research was conducted through interviews with university students, and results showed that most respondents were aware of climate change but neither felt concerned or carried out specific climate-friendly acts, while good snow conditions, along with socialization, topped the list as the major factor for the travel decision. Regarding substitution tendencies, none of the respondents had enacted any climate-induced behavioural change concerning their ski habits, but some were likely to travel further to more snow-reliable resorts or even quit skiing if the climatic conditions were to worsen at their preferred ski area.

**Methodology**

In order to disclose the climate change awareness, perceptions, and behaviours of summer ski tourism consumers in Norway, we surveyed 224 subjects through convenience sampling during the summer ski season (May-October) of 2014. For administration, the survey was made available online and the summer ski centre operators were asked to share the related link through their official social media pages, which had approximately 30,000 followers in total, while the link was also shared in a news article in a popular Norwegian outdoor magazine (Meirik, 2014). Taking social media followers as the population base, the sample was representative with an error margin of +/−6.5% under a confidence interval of 95% and a significance level of 0.05. Seventy-four questions in Norwegian were posed, drawing on the best from the previous works reviewed in the literature for a comprehensive questionnaire under the three themes summer skier profiles and demographics, climate change mitigation, and climate change adaptation, with a final open comment box. Forty-three questions were based on a Likert scale, which displayed a relatively high consistency with an Alpha-Cronbach value of 0.736. Completed questionnaires were summarized into descriptives and, furthermore, return CO₂ footprints of the subjects were calculated based on the distances from their stated origins and destinations as well as modes of travel. Significant relationships were identified within a correlations matrix, for which dummies were created to include categorical variables in point-biserial analyses. Only those relationships with strong two-tailed significance (p < 0.01) and at least moderate Pearson product-moment correlation coefficients (r > 0.3) were highlighted, unless a specific aspect needed to be pointed out, especially regarding substitution behaviour.

**Results**

*Demographics & summer skier profiles*

Below is a summary of the respondents’ general demographics and skier characteristics, which make up most of the independent variables for further analyses. The general
features are characterized by a very high male gender share (86%) and domestic flow domination (86%) accompanied by Swedish interest (12%), middle age (mean: 34, median: 33), and an origin of households as families with two or more children and a middle-high income (Table 1).

Looking at the summer skiing profiles of the respondents (Table 2), we see that many (66%) practice Alpine skiing as their primary summer snow sports, while the rest prefer to ride snowboards (15%) or the nation’s very own free-heel skis, the Telemark (19%). When asked to count the multiple motives for their travel decision, many rank recreation – in the sense of sportive pleasure and socialization – as the top driver (67%), while the urge for training makes up the rest. Of the respondents (n = 25), 11% claim to be professional athletes on summer training. Along with the professionals, many of the summer snow sports enthusiasts perceive themselves as highly skilled in their primary sport, scoring an overall mean of 4 on a scale from 1 (beginner) to 5 (expert). In terms of frequencies, only three respondents view their skills as novice-level, a quarter as intermediate, and the remaining 74% as either advanced or expert. Moreover, other indicators also show that the sample is highly experienced in the sport, with an average ski tenure of 25 years and an annual ski frequency of as high as 52 days. Within such experience, summer skiing tenure is 11 years on average with an annual frequency of eight days, and most opt for daily (88%) rather than seasonal ski pass purchases. No change was expressed in general in terms of summer skiing visitation trends as the shares of respondents were distributed almost equally, with 34% noting an increase, 33% no change, and 31% a decrease (n = 220). Finally, the summer ski centre by Tystigbreen emerged as the most favourite destination (n = 172), especially in the higher age (r = 0.317; p < 0.01) and income (r = 0.323; p < 0.01) categories, followed by the centres on Botnabrea (n = 75) and Vesljuvbreen (n = 43), while Oslo was the most common origin (n = 52), according to this particular sample.

As with many ski tourists, snow aspects are the most important factor influencing the travel decisions of the summer ski centre visitors in our sample, as the mean scores for decision-making factors such as financial status, leisure time availability, company of friends/family, road conditions, ski pass prices, and resort snow conditions are 2.84, 3.84, 3.67, 2.53, 2.74, and 3.99, respectively, on a scale from 1 (very little) to 5 (very much). The respondents rely mostly on the Norwegian state meteorological service website (www.yr.no) to make their travel decisions, while sunny weather conditions at their home origin appear as the major “backyard” factor in driving their will to take part in summer skiing (Table 3). The “ideal summer ski day” is mostly described as a weekend/holiday in May-June with no wind, a clear sky, a temperature of 10–20°C, and

### Table 1. Demographic features of the respondents.

| Feature     | Category          | N   | %  | Feature     | Category          | n   | %  |
|-------------|-------------------|-----|----|-------------|-------------------|-----|----|
| Gender      | Female            | 32  | 14 | Household size | 1    | 49 | 22 |
|             | Male              | 192 | 86 |             | 2                | 58 | 26 |
|             |                   | 3   | 16 |             | 3                | 34 | 16 |
| Age category | 13–24             | 48  | 22 |             | 3+               | 80 | 36 |
|             | 25–40             | 121 | 54 |             |                   |    |    |
|             | 40+               | 54  | 24 | Income level | Less than 250,000 NOK | 54 | 25 |
|             |                   |     |    |             | 250,000–500,000 NOK | 60 | 27 |
|             |                   |     |    |             | 500,000–750,000 NOK | 75 | 34 |
|             |                   |     |    |             | More than 750,000 NOK | 31 | 14 |
| Nationality | Norwegian         | 190 | 86 |             |                   |    |    |
|             | Swedish           | 26  | 12 |             |                   |    |    |
a wet/corn snow cover with a depth of over 1 m (Table 4). The influence of the news media and official/scientific report findings on negative climate change impacts on the centres was neutral for present travel decisions, scoring 2.56 and 2.71, respectively.

**Climate change awareness & mitigation behaviour**

The respondents’ mean agreement score for the statement that “the Earth’s climate is changing in a global warming trend” was 4.2 on a scale from 1 (totally disagree) to 5 (totally agree) (n = 220). The share for the question on the cause of such change, however, was 37% for “mostly human” and 43% for “both (human and natural)”, yet still signalled an acknowledgement of the dominant anthropogenic cause of the phenomenon (Intergovernmental Panel on Climate Change, 2013). Accordingly, when the respondents were asked if they performed any specific climate-friendly behaviour (n = 224) – in other words, any attempts to reduce their carbon footprint such as by avoiding air travel – 41% said yes, while an equal percentage were negative and a further 18% were unsure if their behaviour was specifically meant for climate friendliness. Lastly, recognition of the global ski industry’s climate change activist body, Protect Our Winters – POW (Demiroglu & Sahin, 2015), remained at 37% (n = 224).

Furthermore, the survey had two other criteria to delve into the degrees of the respondents’ climate friendliness, related to the destination choice and the travel distances and means. Firstly, it seems that environment- and climate friendliness of a ski resort only slightly affected the respondents’ travel decision, as the mean scores appear as 2.2 and 2.3, respectively, on a scale from 1 (none) to 5 (a lot). Looking at the travel distances, on the other hand, a mapping of the distances among the respondents’ origins and destinations (Figure 2) yields an average return travel distance of 655 km. Such distance covered translates into a contribution to CO₂ emissions worth 117.5 kg per respondent.

### Table 2. Summer skiing profiles of the respondents.

| Summer skiing motives | Primary summer ski sports | Skill level in primary summer ski sports | Summer ski tenure |
|-----------------------|---------------------------|------------------------------------------|------------------|
| Motive                | Sports                    | Level                                    |                  |
| Training              | Alpine                    | Beginner                                 | Total years      |
| 110                   | 143                       | 0                                        | 11               |
| Health                | Snowboard                 | Novice                                   | Days/year        |
| 85                    | 33                        | 3                                        | 8                |
| Professional          | Telemark                  | Intermediate                             | Total years      |
| 25                    | 40                        | 56                                       | 25               |
| Recreation            | Total                     | Advanced                                 | Days/year        |
| 226                   | 216                       | 101                                      | 52               |
| Total                 | 336                       | Total                                    |                  |

### Table 3. Factors affecting summer ski travel decision.

| General factors                  | Mean | Top information sources for snow conditions*           | %   |
|----------------------------------|------|--------------------------------------------------------|-----|
| Snow conditions                  | 3.99 | State meteorological Service website                   | 33  |
| Leisure time availability        | 3.85 | Ski centre social media                                | 26  |
| Companionship                   | 3.67 | Ski centre webcams                                     | 19  |
| Financial situation              | 2.84 | Ski centre website                                     | 16  |
| Ski pass prices                  | 2.74 | Snow portals                                            | 6   |
| Road conditions                  | 2.53 | *Multiple responses considered                          |     |
| Backyard effect – sunny          | 4.00 |                                                        |     |
| Backyard effect – cold           | 3.30 |                                                        |     |
| Backyard effect – rainy          | 2.44 |                                                        |     |
taking into account the relevant CO₂ emissions reference for each type of travel means (Table 5).

**Climate change perceptions & substitution behaviour**

Of the respondents, 68% perceive that the negative impacts of climate change are already visible at the Norwegian summer ski centres, and this share increases to 87% when

![Figure 2. CO₂ emissions from summer ski trips in Norway.](image)
expectations for the next decade are included. The centres are perceived as the most vulnerable, compared to other ski resorts in the world and in Norway specifically (Table 6). The top physical changes threatening ski centre attractivity are listed as decreasing snow depth (4.10), shortened season (4.09), increasing crevasses (3.40), increasing domination of artificial snow (2.90), and increasing avalanche risk (2.60). Regarding adaptation from the supply side, the respondents were neutral regarding the help of increased fencing and signage for crevasse openings (3.24) and avalanche risks (2.84), yet some were willing to directly contribute in order to compensate for increased costs due to supplier adaptation in general (48%); though more were willing to do so indirectly (64%). Skill level in primary summer ski sports had moderately negative correlations with increasing avalanche threat ($r = -0.305; p < 0.01$) and the possible help of enhanced fencing and signage adaptation ($r = -0.302; p < 0.01$). Moreover, media influence displayed a positive correlation with perceived avalanche threat ($r = 0.313; p < 0.01$).

When the respondents were asked how they would react, taking realistic account of their time and budget limits, if these negative perceptions held, activity substitution in the form of top-touring emerged as the most favoured alternative (3.84), followed by temporal substitution of the same ski centre in the summer (3.67), and a medium tendency towards spatial substitution of the other two centres in Norway (2.98). The least favoured alternatives were spatial substitution of the summer centres in the Alps (2.45), North America (1.89), and Japan (1.66), the winter resorts in South America (2.44), Australia and New Zealand (2.21), and South Africa (1.72), and activity substitution in the forms of skiing at dry (1.52) and indoor slopes (1.57) and replacing summer skiing for good with other leisure activities (2.23).

Regarding spatial substitution, older age was an important aspect in preventing substitution of North American ($r = -0.21; p < 0.01$), and Australian-New Zealand resorts ($r = -0.209; p < 0.01$), and dry ($r = -0.224; p < 0.01$) and indoor ski areas ($r = -0.227; p < 0.01$). Botnabrea visitors showed a tendency towards the other Norwegian centres ($r = 0.208; p < 0.01$) as well as long-haul destinations in North America ($r = 0.272; p < 0.01$), Japan ($r = 0.195; p < 0.01$), and Australia and New Zealand ($r = 0.181; p < 0.01$), whereas Vesljuvbreen

| Table 5. Summer ski travel-related CO2 emissions of the survey sample. |
| --- | --- | --- | --- | --- | --- | --- |
| Travel means | Quantity of return flows* | CO2 emissions reference (kg/km) | Total distance (km) | Total CO2 emissions (kg) | Average distance per flow (km) | CO2 emissions per flow (kg) |
| Car | 191 | 0.18 | 126,127 | 22,703 | 660.35 | 118.86 |
| Bus | 5 | 0.09 | 984 | 89 | 196.8 | 17.8 |
| Train | 2 | 0.06 | 549 | 33 | 274.5 | 16.5 |
| Flight | 1 | 0.30 | 688 | 206 | 688 | 206 |
| Total | $n = 196$ | | 128,348 | 23,031 | 654.84 | 117.51 |

*Two bus return trips are coupled with train rides, and one return bus trip is coupled with an interconnecting return flight.

| Table 6. Perceptions and expectations regarding negative climate change impacts. |
| --- | --- | --- | --- |
| Negative climate change impacts | Global ski resorts | Norwegian winter ski resorts | Norwegian summer ski centres |
| Already | 66% | 55% | 68% |
| Before 2025 | 21% | 25% | 19% |
| 2025–2050 | 9% | 15% | 9% |
| After 2050 | 4% | 5% | 4% |

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visitors showed a tendency towards the Alps ($r = 0.199; p < 0.01$), again Australia and New Zealand ($r = 0.21; p < 0.01$), and indoor ski areas ($r = 0.221; p < 0.01$). The choice of the Alps was also the case for those with the most number of annual ski days ($r = 0.206; p < 0.01$). The tendency towards South American winter resorts was correlated with those who favour ideal cold summer ski weather of $-10$–$0^\circ\text{C}$ ($r = 0.177; p < 0.01$). “Cold-weather likers” also matched up with powder chasers ($r = 0.361; p < 0.01$). Tystigbreen visitors, on the other hand, had a positive correlation with a substitution of top-tour skiing ($r = 0.194; p < 0.01$), which was also positively correlated with daily ski pass usage behaviour ($r = 0.289; p < 0.01$) and concerns over lost attractivity due to decreasing snow depth ($r = 0.211; p < 0.01$), and negatively correlated with packed snow preference ($r = -0.304; p < 0.01$) and being male ($r = -0.227; p < 0.01$). Concerns over decreasing snow depth ($r = 0.276; p < 0.01$), coupled with shortening season ($r = 0.257; p < 0.01$), were also correlated with temporal substitution tendency. The decision to quit was negatively correlated with annual ski days ($r = -0.272; p < 0.01$) and the willingness to directly contribute to supplier adaptation ($r = -0.211; p < 0.01$), and positively with the influence of snow conditions ($r = 0.238; p < 0.01$) and price ($r = 0.24; p < 0.01$) on the summer ski travel decision. Last but not least, 19% of the respondents were eager to visit their favourite destination and a further 32% were willing to visit it less frequently, if winter ski were offered. Such a tendency was positively correlated with the preference for ice/supportable crust snow quality ($r = 0.188; p < 0.01$), willingness to directly contribute to supplier adaptation ($r = 0.184; p < 0.01$), and trust in increased avalanche adaptation ($r = 0.206; p < 0.01$).

**Discussion**

As glaciers are among the most warming exposed systems, summer skiers in Norway generally turn out to be direct witnesses to the impacts of climate change, which in return contributes to their literacy and sensitivity regarding the issue. As exemplified by the Australian cases (König, 1998; Pickering et al., 2010), awareness increases with time as the impacts become more visible. It could also be argued that moving beyond awareness to friendliness, found in Norway but not in the sample of university students in Ferrari (2010), could also be a matter of age. Unlike the relatively unconcerned university students, and although a ski resort’s climate friendliness did not matter much for the travel decision, a substantial number of summer skiers claim to be pursuing specific climate-friendly practices, such as avoiding flying or joining car pools. Such consumer types should be provided with the best implementations, such as more frequent shuttles, so that their potential climate friendliness can be converted into practice more. A lack of reinforcement for such an attitude could lead the way to reverse practices, as exemplified by an outlier in the sample, whose agreement level for climate friendliness is 1 out of 5 and CO$_2$ footprint from annual summer ski travel is 629 kg, compared to the sample average of 117.5 kg.

Despite the higher flexibility of the demand side in climate change adaptation, summer ski visitors in Norway are relatively connected to their favourite centres, unlike previous examples from Central Europe (Behringer et al., 2000; Dehnhardt & Kalisch, 2010; Unbehaun et al., 2008), opting initially for temporal substitution before going into spatial alternatives. This could be explained by the fact that these respondents represent high-involvement categories who are highly loyal to their ski areas, as empirically demonstrated.
in North America (Dawson et al., 2011; Vivian, 2011), and also the lack of a strong spatial substitute in close proximity, as was the case with Slovenia (Vrtacnik-Garbas, 2007). Moreover, the fact that the early season, May-June when the snow cover is the most reliable, is the most popular ski period liberates the ski centres from the threat of temporal substitution. However, it is also probable that a spatial concentration of summer ski demand would occur towards the high altitude and continental Vesljuvbreen, if the favourite May-June period could not be sustained at the other two centres, allowing for no more temporal substitution. In such a case, especially these two centres should consider positioning themselves as bases for summer top-tour skiing, e.g. through providing “corn buses”, capitalizing on the top substitution direction reflected by the summer skiers in this survey. Alternatively, converting into winter ski resorts would also be an option, given the likely improvement of the currently notorious road conditions and a partial persistent loyalty combined with a willingness to visit, albeit less frequently. In this case, the centres should adapt to the competition that will arise from the country’s other 215 ski areas.

Last but not least, we should note the positive outcome that options involving the spatial substitution of summer ski centres abroad and Southern Hemisphere winter resorts have not been greatly favoured, which otherwise would have implied a drastic increase in greenhouse gas emissions. Yet, some tour operators may capitalize on the emerging niche market seeking cold-weather and exotic destinations in the Southern Hemisphere. Nonetheless, we suggest the promotion of top-tour summer skiing as a tourism product not only in the two centres but for many concerned regions in Norway, as it seems to be the most climate-friendly and flexibly resilient remedy for sustaining summer skiing tourism. Going the other way around and insisting on artificial snowmaking, and even considering extremely high energy-intensive all-weather snow production technologies, as applied at some glaciers in the Alps, could severely conflict with building resilience through a sustainable adaptive capacity and, as already observed, require additional subsidies and/or exits. As one respondent suggests, “a summer ski centre that’s only open one month and is entirely dependent on financial transfers is uninteresting and won’t survive.” Such an objection has already been expressed in law cases in other parts of the world, where the public finance authorities have been accused of subsidizing unsustainable adaptation methods such as snowmaking and ski area extensions (Commission Internationale pour la Protection des Alpes, 2014).

Conclusion

This study was one of the pioneering works in exploring and elaborating on the issue of climate change and ski tourism, with particular attention to the situation of demand for the Norwegian summer ski centres. The results highlight a relatively high resilience of Norwegian summer ski tourism at the national level, but the destination-level vulnerabilities differed greatly according to the individual exposure extents and the adaptive capacities of the summer ski businesses.

A solution to the problem, mostly within the national boundaries, thanks to the nature of the visitor substitution responses, in a way helped mitigate great increases in greenhouse gas emissions. Moreover, the visitors did not greatly favour artificially produced snow – which is something the ski centre operators should consider when investing in
such facilities, as such improvements might not only reduce the attractiveness of their centres but also increase their financial burden through direct costs and carbon fees to be imposed by the emerging climate policies.

Further research should look into how highly literate and sensitive segments, like summer skiers, could become role models to promote climate friendliness. As an ultimate step, ways of transforming such potential friendliness into activism should also be sought in order to get the attention of the top decision-makers for the good of the atmosphere, which cannot be divided by either state borders or economic sectors. Hereby, we conclude with one respondent’s comment: “If everyone contributes, then change can come. But not without help from the whole world, as the whole world is in danger.”

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ORCID

O. Cenk Demiroglu http://orcid.org/0000-0001-7012-4111
Halvor Dannevig http://orcid.org/0000-0002-7648-4166
Carlo Aall http://orcid.org/0000-0002-4798-4612

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