

THE IMPORTANCE OF CLIMATE AND WEATHER FOR TOURISM

LITERATURE REVIEW

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INTRODUCTION

Climate and weather are important factors in tourists' decision making and also influence the successful operation of tourism businesses. More specifically, climate is defined as the prevailing condition observed as a long term average in a location. In contrast, weather is the manifestation of climate at a specific point in time and place. So, while tourists might expect certain climatic conditions when they travel to a place, they will experience the actual weather, which might deviate quite substantially from the average conditions. Hence, in the first place tourists and tourism businesses are likely to be affected by weather conditions, although in the long term these will follow systematic changes as projected under different climate change scenarios. For example, surface and sea temperatures are generally forecast to increase, rain patterns will change with some areas becoming wetter and others drier, and the occurrence of extreme events is likely to increase. For this reason, tourist destinations will benefit from understanding potential climatic changes in their area and how they might impact on their operations.

The following sections of this report review the international literature on how climate/weather and tourism interact. The existing literature provides an insight into global phenomena, for example destination choice, as well as very specific case studies of weather-recreation interactions such as the impact of warmer summers in Canada on the length of the golfing season. Both aspects are relevant to tourism in New Zealand, although findings need to be transferred to the New Zealand situation. In the following, tourism demand will be discussed first. This includes an analysis of the importance of climate and weather for international tourist flows and destination choice, tourist satisfaction and safety. This is then followed by a discussion of how climate change will change the conditions in which tourism destinations will operate and manage tourist flows and assets. The impact of warmer temperatures, sea level rise, changing alpine environments as well as other ecosystems will be considered.

To illustrate how weather events affect tourism, in some cases positively, but more often negatively, Scott and Lemieux (2009) compiled a world map with recent headlines of event relevant to tourism (Figure 1).

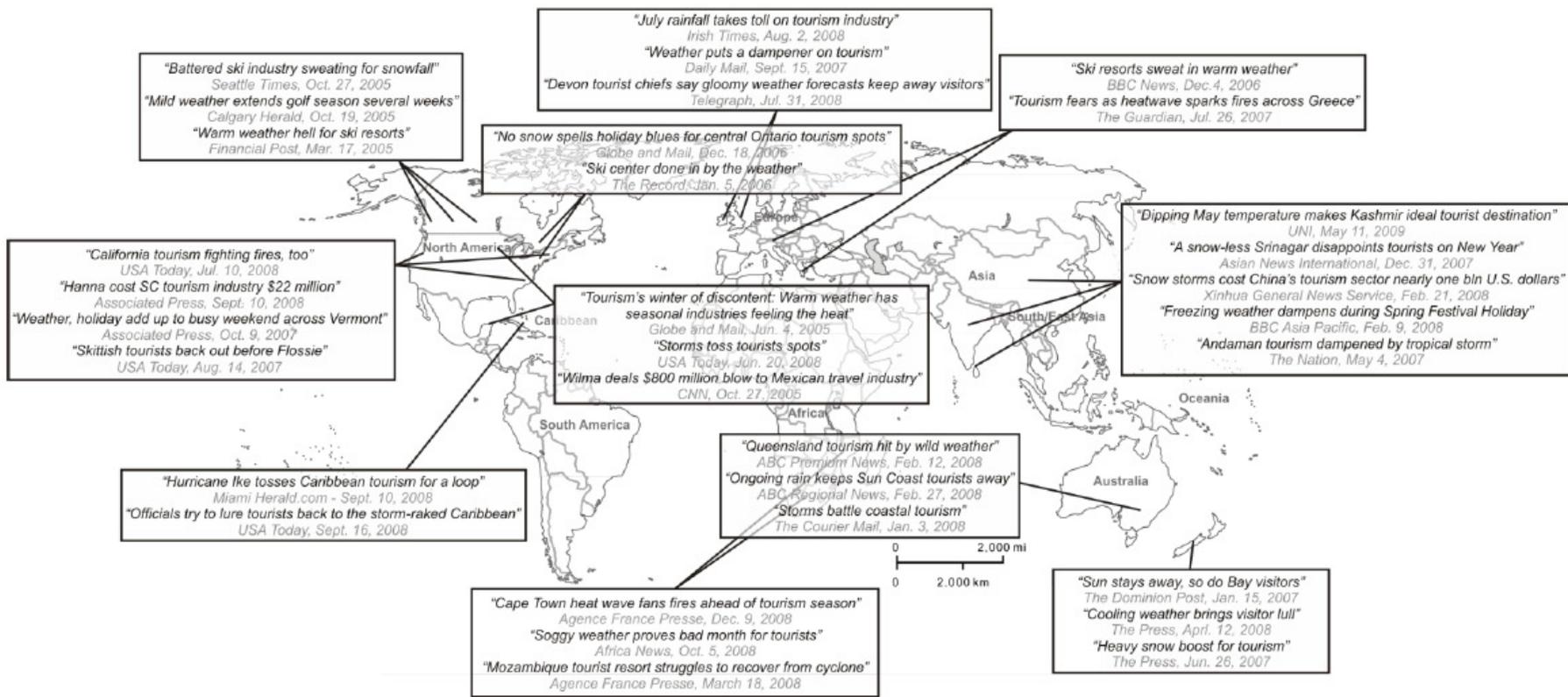


Figure 1 Recent media headlines of weather or climate impacts on tourism (Scott & Lemieux, 2009).

TOURISM DEMAND AND CLIMATE

This section provides a review of the international literature on the importance of climate and weather for tourism demand. First, climatic conditions influence destination choice and as a result national and global tourist flows. They also are important factors in tourists' satisfaction and activity participation, as well as safety. Finally, the role of weather/climate information for tourism is discussed briefly.

Destination choice and global tourist flows

Even though most tourism demand studies focus on economic variables (Crouch, 1994; Lim et al., 2008), climate has been identified as a key driver for tourism and an important destination attribute (Hu & Ritchie, 1992). Climate is either the main tourism resource, for example in the case of beach destinations (Kozak et al., 2008), or it acts as a facilitator that makes tourism activities possible and enjoyable (Gómez Martín, 2005). The importance of climatic attributes for tourist destinations is reflected in advertising materials (Gómez Martín, 2005) as well as destination image construction (Pike, 2002). While Barbados sells 'good weather' with a money-back guarantee (Scott & Lemieux, 2009), other destinations have learned to turn potential disadvantages into successful niches. Tarifa in Spain has capitalised on its frequent and intense wind (unfavourable for beach tourism) to become a mecca for windsurfing (Gómez Martín, 2005).

Tourists' motivation of experiencing a certain climate has been confirmed in tourism demand studies, for example in Germany, the UK and Canada (Lohmann & Kaim, 1999; Scott & Lemieux, 2009). These studies show that besides destination choice, climate is also an important factor for the timing of travel (Lohmann and Kaim, 1999; Hamilton and Lau, 2005). Seasonality has been described as one of the main challenges of tourism's viability (see also the New Zealand Tourism Strategy, Ministry of Tourism, Tourism Industry Association and Tourism New Zealand, 2007). Tourism's seasonality is not only driven by climatic conditions at the destination and tourists' home countries, but also by institutional factors such as school holidays (Butler, 2001).

There has been a longstanding desire to capture or assess the climatic suitability of a potential or existing tourist destination. Factors that seem to be important include climatic elements such as temperature, wind chill effects, humidity and radiation. Other measures, such as wind speed or snow depth may also be important for specific recreational activities. The climatic parameters can be aggregated to a single index that gives some indication of a place's suitability for specific touristic activities. Mieczkowski (1985), for example, developed the Tourism Climate Index (TCI) which merged seven climatic parameters applicable to tourism sightseeing. The TCI has been further developed and applied in different settings, for example for beach environments (Morgan, 2000, in de Freitas et al., 2008), the impact of climate change on global tourism flows (Amelung et al., 2007) and the climatic ranking of 17 North American cities (Scott & McBoyle, 2001). More recently, de Freitas et al (2008) suggested a new Climate Index for Tourism (CTI) which considers thermal, aesthetic and physical aspects of weather in relation to beach tourism. The more recent studies confirm that climate elements explicitly important to tourism need to be given adequate consideration in the development of an index. Yu et al (2009) demonstrated

that elements such as visibility and precipitation, as well as a high temporal resolution (i.e. hourly weather data) are key to assess the tourism resources of a particular place.

Besides climatic conditions at tourist destinations, the climate in tourists' home countries was also found to be very important (Maddison, 2001). Unfavourable climate or poor weather conditions, either in the year of travel or the previous year (Agnew & Palutikof, 2006), act as a push factor for tourists to travel to warmer and drier locations (Lise & Tol, 2002). A warmer than average summer of 1°C was found to increase domestic tourism expenditure in Canada by 4% (Wilton & Wirjanto, 1998, in Scott et al., 2008). A recent study of European households found that a better climate in the region of residence is related to a higher probability of travelling domestically, whereas poor conditions increase the chance of international travel. Other socio-economic parameters included in this research were income, education, age, and the presence of an international airport, all of which had a positive effect on overseas travel. The number of adults in the household, the presence of a national airport and whether the household was located on the coast were all related to increased domestic travel (Eugenio-Martin & Campos-Soria, 2009).

Tourists' weather experience

Weather conditions experienced by tourists at the destination are important for many reasons. Foremost, weather allows for an activity to be undertaken, or likewise may act as an inhibitor to participation. For example, wind speeds over 15 km/h were found to be detrimental to fishing or water skiing, whereas motor boating could be undertaken up to wind speeds of 50 km/h (More, 1988). Weather will also influence how enjoyable an experience is and therefore tourists' satisfaction is likely to be at least partly weather dependent. Finally, tourists' safety can depend on the weather for example in relation to heatwaves, extreme wind events or avalanches.

De Freitas (2003) classified the different facets of tourism climate into aesthetic, physical, and thermal (Table 1). The thermal component describes how comfortable the tourist feels. The physical dimension relates to non-temperature climatic conditions such as wind and rain and is important to assess whether a certain activity is possible or not. The aesthetic aspect describes a psychological perspective as the tourist enjoys certain climatic conditions, for example the light or formation of clouds.

Table 1 Facets of climate and impact on tourists (Becken & Hay, 2007, after de Freitas, 2001)

Facet of climate	Impact on tourists
Aesthetic	
Sunshine/cloudiness	Enjoyment, attractiveness of site
Visibility	Enjoyment, attractiveness of site
Day length	Hours of daylight available
Physical	
Wind	Blown belongings, sand, dust etc.
Rain	Wetting, reduced visibility
Snow	Participation in activities
Ice	Personal injury, damage to property
Air quality	Health, physical well-being, allergies
Ultraviolet radiation	Health, suntan, sunburn
Thermal	
Integrated effects of air temperature, wind, solar radiation, humidity, long-wave radiation, metabolic rate	Environmental stress, heat stress Physiological strain, Hypothermia Potential for therapeutic recuperation

Weather conditions are not always ideal and there are different behaviours a tourist can display that indicate how comfortable they are and to what extent they are able or willing to adapt. The on-site behaviour by tourists can be categorised as follows (de Freitas, 2003, 50):

1. Avoid areas of unfavourable weather- or climate determined conditions (e.g., move from sun to shade)
2. Change activity to suit weather conditions (e.g. swim more/less)
3. Use structural or mechanical aids (e.g. umbrellas or wind breaks)
4. Adjust thermal insulation of body (clothing)
5. Adopt passive acceptance.

Activity participation and satisfaction

There has been a long interest in the relationship between weather, climate and recreational activities, in particular outdoor activities such as skiing, swimming, golfing and the visitation of parks. As early as the 1970s, the Atmospheric Environment Service in Canada produced tourism and outdoor recreation handbooks that specified start and end dates for different kinds of activities and the climatic conditions that impact human comfort (Smith, 1990).

The ski industry is a prime example of a weather dependent tourist activity: snow reliability is one of the top requirements for activity participation. Broadly, ski areas can operate when the snow depth is more than 30 cm, when the temperature does not exceed 10°C for more than two consecutive days accompanied by rain, or when it does not rain for two days and over 20mm (Scott et al., 2006). During a snow-poor season, 49% of skiers in Switzerland would change to a more snow-reliable ski resort, and 32% would ski less often. Only 4% would not ski in such a season (Buerki *et al.*, 2003). Recent empirical research in North America confirmed that minimum and maximum temperature, snow depth and wind chill are statistically related to the ticket sales for downhill skiing (Shih et al., 2009). However, similar research in Austria showed that snow depth was only statistically related to visitation rates at low-elevation ski fields under 2000 metres. However, the Austrian study also demonstrated that income is a major driver of ski field visitation, in particular for high elevation ski fields where income elasticities reached a value of 1.63 (compared with 0.55 for low elevation ski fields) (Falk, 2009).

Seasonal declines in demand due to unfavourable conditions have severe economic implications for both ski fields and the associated resorts, including accommodation businesses and other supporting services (Elsasser & Buerki, 2002). A poor 2004/05 season in the State of Washington (Pacific West Region), where skier visits declined by 78% in 2004-05, meant that ski fields had to postpone infrastructure investments and were “in recovery mode for many years” (Goodman, 2005, in Scott & Lemieux, 2009). Research in Finland showed that high wind was the most common reason for ski field closure, while snowmobiling and cross country skiing were impeded most by frosty conditions (Tervo, 2008).

Similar to winter resorts, many beach tourist destinations also depend on favourable climatic conditions, for example ample of sunshine, no precipitation and no wind (Scott et al., 2008; Moscardo et al., 2001). Warm temperatures, clear waters and low

health risks were also found to be the most important environmental features influencing the choice of holiday destination for tourists of two Caribbean islands, Bonaire and Barbados (Uyarra *et al.*, 2005). Research at the Great Barrier Reef in Australia indicates that poor weather has a more pronounced effect on satisfaction than good weather: seasickness, cold or wet conditions, reduced visibility and difficult snorkelling conditions all led to reduced satisfaction levels (Coghlan & Prideaux., 2009). Poor weather as an important source of dissatisfaction was also identified in a survey of visitors to Scotland (Smith, 1993).

Tourist Safety

Tourists' safety can be linked to unfavourable weather conditions. Recently, a number of heat waves have been observed in Northern Europe with substantial impacts on tourism. Most directly, tourists experienced thermo-physiological discomfort which could be observed in increased hospital admissions and fatalities (e.g. for Florence, Italy, see Morabito *et al.*, 2004). The 2003 heatwave was responsible for 15,000 deaths in France and major shifts in traditional tourist flows for this year away from the traditional resorts in the Mediterranean and towards Northern or Western beach locations (UNWTO, UNEP & WMO, 2009).

Hot weather conditions increase the risk of forest fires. In Greece, after the devastating fires of summer 2000, more than half of all tourist bookings for 2001 were cancelled. Similarly, drought in the State of Colorado (USA) in 2002 created dangerous wildfire conditions and visitor numbers declined by 40% in some areas, largely as a result of media coverage and perceived risks by tourists (Scott & Lemieux, 2009).

Hurricanes can have a severe impact on tourism. Hurricane Ivan, for example, was a "category 4" hurricane system when it reached Grenada in September 2004. An official damage assessment reported 28 persons killed, 90% of hotel rooms damaged or destroyed, heavy damage to eco-tourism and cultural heritage sites, and damage to major infrastructure such as power lines and telecommunication (Organisation of Eastern Caribbean States, 2005, in Becken & Hay, 2007). Hurricane frequency and named storm days have increased in the Caribbean, although intensity has not increased substantially (Jackson, 2002)

Poor snow conditions have been linked to negative impacts on personal safety of tourists. During the poor snow conditions of the 1990/91 ski season in the Swiss and Austrian Alps, accident insurance claims by British skiers were almost double average levels, with approximately half listing accidents caused by exposed rocks and congestion on the slopes (Smith, 1993). Cold winters are also linked to higher road accident rates, whereas warmer than usual winters reduce the likelihood of accidents (Koetse & Rietveld, 2009).

Weather conditions can be linked to transportation delays, cancellations and accidents. For example wind and visibility are critically important for aviation. E.g. San Francisco where poor visibility in summer and rain storms in winter result in more than double cancellations and delays compared with normal conditions (Eads, 2000, in Koetse & Rietveld, 2009). Moreover weather was found to be a cause in 70% of aviation delays and 23% of accidents (Koetse & Rietveld, 2009).

Weather and Climate Information

Given the importance of climate to tourists in their decision making as well as holiday experience one would expect that tourists actively seek climatic information. Indeed, Hamilton and Lau's (2005) study found that 73% of interviewed German tourists had acquired information on the climate of their holiday destinations, usually on more than one aspect, but most often temperature. As Scott and Lemieux (2009) note climate information is available by many types of providers and media, for example travel agents, tourism marketing organisations, guide books, the internet, television, radio, newspapers, and hand-held devices.

In a summary paper for the World Meteorological Organisation, Scott and Lemieux (2009) comment that tourism marketing materials and web sites provide limited climate information to potential travellers, with the most common practice being to provide only average monthly temperatures. Average conditions, however, are possibly of limited value to tourists who are more likely to be interested in the probability of experiencing certain (extreme) conditions such as hot temperatures or sunshine hours during specific periods of the year (de Freitas, 2005). Such kind of specific information would be particularly valuable in areas where weather could pose a real health or safety risk for tourists, for example in alpine areas, hot destinations or tropical zones.

Different types of information are required at different stages of the trip planning process. For example, climatic information (i.e. expected conditions) is useful in advance of the trip. German tourists reported that they would inform themselves about the climate of their destination before departing (73%) or even before booking (42%) (Hamilton & Lau, 2005). In contrast, once at the destinations tourists will find actual weather forecasts more important than climatic averages (Figure 3).

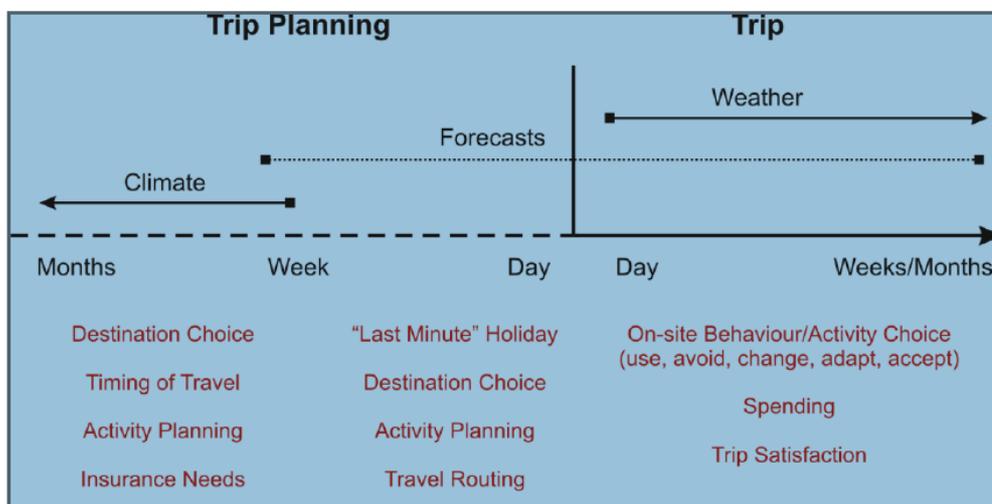


Figure 2 Weather-climate information for tourist decision-making (Scott & Lemieux, 2009)

It is important that climate information provided to tourists is representative of the actual locations that tourists are likely to visit. A recent study of tourist resorts in Phoenix, Arizona, showed that temperature and dew point measurements at seven resorts differed substantially from the official National Weather Service climate measurements at the airport. Thus, tourists would receive information that portrays less favourable conditions (i.e. hotter temperatures and higher dew points) than actually are.

DESTINATION MANAGEMENT AND CLIMATE CHANGE

The above discussion on tourism demand and weather impacts on tourist activities highlights that tourist destinations are exposed to natural climate variability and seasonality. This means that even under present-day conditions the profitability and viability of a business and destination is at least partly influenced by the climate. The exposure to climatic events will be exacerbated by climate change, although there are also opportunities due to potentially more favourable conditions in the future. It is therefore not surprising that increasing attention has been paid to how climate change might affect tourist destinations (Wall & Badke, 1994) and how these can adapt to minimise risks and maximise opportunities (Becken & Hay, 2007).

The range of impacts and their implications for tourism have been summarised in a comprehensive report by UNWTO, UNEP and WMO (2008) (Table 1). Climate change will impact on tourism in three ways: 1) as a result of gradual changes such as temperature or sea level rise; 2) due to increased numbers of extreme events such as high winds and 3) as a result of wider environmental changes that alter the resource base of tourism, for example limited water availability or changing ecosystems.

Table 2 Major climate change impacts and implications for tourism destinations (modified from UNWTO, UNEP & WMO, 2008)

Impact	Implications for tourism
Warmer temperatures	Altered seasonality, heat stress for tourists, cooling costs, changes in plant-wildlife-insect populations and distribution, infectious disease ranges
Sea surface temperatures rise	Increased coral bleaching and marine resource and aesthetics degradation in dive and snorkel destinations
Sea level rise	Coastal erosion, loss of beach area, higher costs to protect and maintain waterfronts
Reduced precipitation and increased evaporation in some regions	Water shortages, competition over water between tourism and other sectors, desertification, increased wildfires threatening infrastructure and affecting demand
Decreasing snow cover and shrinking glaciers	Lack of snow in winter sport destinations, increased snow-making costs, shorter winter sports seasons, aesthetics of landscape reduced
Increasing frequency and intensity of extreme storms	Risk for tourism facilities, increased insurance costs/loss of insurability, business interruption costs
Increased frequency of heavy precipitation in some regions	Flooding damage to historic architectural and cultural assets, damage to tourism infrastructure, altered seasonality
More frequent and larger forest fires.	Loss of natural attractions; increase of flooding risk; damage to tourism infrastructure.
Changes in terrestrial and marine biodiversity	Loss of natural attractions and species from destinations, higher risk of diseases in tropical-subtropical countries
Soil changes (e.g., moisture levels, erosion and acidity)	Loss of archaeological assets and other natural resources, with impacts on destination attractions

Warmer temperatures

Temperatures have been rising globally by about 0.74°C on average in the last 100 years (Intergovernmental Panel on Climate Change (IPCC), 2007). The scientific community is in general agreement that human activity such as the release of greenhouse gases into the atmosphere has and will continue to contribute to further warming. The expected temperatures depend on the atmospheric concentration of greenhouse gases, usually expressed in the form of carbon dioxide equivalent. A stabilised concentration of 500 parts per million would most likely result in a temperature increase of approximately between 2 and 4 degrees Celsius (Figure 3).

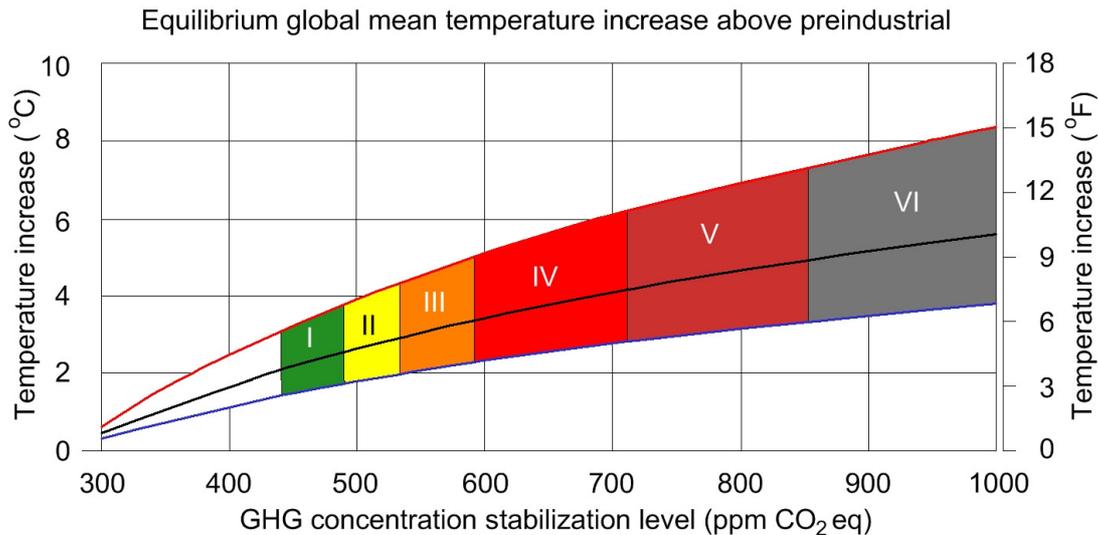


Figure 3 Stabilization scenario categories (coloured bands) and their relationship to equilibrium global mean temperature change above preindustrial, using (i) “best estimate” climate sensitivity of 3°C (black line in middle of shaded area), (ii) upper bound of likely range of climate sensitivity of 4.5°C (red line at top of shaded area) (iii) lower bound of likely range of climate sensitivity of 2°C (blue line at bottom of shaded area). (Figure redrawn from IPCC (2007) and commonly available on Wikipedia, http://en.wikipedia.org/wiki/IPCC_Fourth_Assessment_Report).

Under different warming scenarios, for example those developed by the IPCC (2000), some tourist destinations are likely to gain competitiveness while others will become less attractive or will have to shift their seasons, as for example suggested for the Mediterranean which might change from its current pattern of a summer peak season into a bimodal spring-autumn pattern (Amelung & Viner, 2006). While global or regional models on tourist flows have some important limitations (Gössling & Hall, 2006), they are useful in understanding potential ‘winners’ and ‘losers’ from climate change. The results generally show a shift in preferred destinations to higher latitudes (e.g. for a comparison of tourism in Alaska and Florida in 2050 see Yu et al, 2009) and to higher elevations in mountainous areas (e.g. Bigano et al., 2005 for Italy). Tourists from European nations that currently dominate international travel are expected to take more domestic holidays to take advantage of new climatic opportunities closer to home. More specifically, Hamilton *et al.* (2004) found that as a cool country warms it first attracts more tourists, but once the mean annual temperature exceeds 14°C, fewer tourists will visit. Similarly, the country will initially generate fewer tourists, but once the temperature reaches 18°C it will generate more tourists as people will seek opportunities to travel to cooler climates. Spain could see

a decrease between 5 to 14% in annual tourist flows, whereby most of the loss is expected in the summer months (18 to 26% depending on the climate scenario). Some northern areas of Spain were modelled to become net winners of tourist arrivals (Hein et al., 2009). The economic impacts of such changing patterns have been modelled by Berritella *et al.* (in press): Welfare loss will be unevenly spread across the globe, with changes in GDP between about -0.3% (e.g. Kiribati, Palau, Qatar, Cambodia and Sri Lanka) to around +0.4% in 2050 (e.g. Canada, Finland, Switzerland, and Belarus).

Experts use the experience from recent warm summers (so-called climate analogues) to better understand how changes towards warmer conditions might influence tourism in the future (Giles & Perry, 1998). The Deutsche Welle (2006) reported “Tourism Experts say hot summer means higher turnover” as German seaside resorts profit from warmer than normal temperatures. Other changes in consumption were observed during the 2003 heatwave in France, where camping sites with shade and swimming pools were most favoured and attractions such as caves benefited from higher visitation. Urban tourism experienced a decline in the 2003 summer and sales of soft drinks (+13%) and ice creams (+14%) went up (Létard et al., 2004 in UNWTO, UNEP & WMO, 2008).

Periods of extreme heat pose other limitations on tourists and recreationists. During drought, as for example experienced in Australia over the last few years, there might be local restrictions on the use of water for irrigating green areas or filling swimming pools (UNWTO, UNEP & WMO, 2008). Forest areas may be denied to tourists due to the risk of fire, mountain streams might dry of for fishing and the water quality of lakes declines with possible algae blooms (International Institute for Sustainable Development, 1997; Smith, 1990). Already, under conditions of drought as experienced in Colorado (USA) in 2002 anglers were restricted from fishing in many rivers because fish populations were highly stressed by low water levels and high water temperatures. Low water levels also shortened the river-rafting season substantially with some companies losing 40% of their normal business (Scott & Lemieux, 2009).

Periods of hot temperatures increase the risk of fire by influencing ‘flammability’, but at the same time it is essential to monitor changes in visitation numbers. Tourists constitute a major ‘ignition source’ which in combination with drier conditions leads to an increased number of forest fires. Hence, McEvoy et al. (2006) concluded for the Peak District National Park in England’s Northwest, that human impact in combination with amenable weather conditions will be the key risk factors for more forest fires in the future. In some areas, fire risk might increase substantially. In the Blue Mountains, Australia, there are currently, on average, 13.3 days when the Forest Fire Danger Index is ‘very high’ or ‘extreme’. Climate projections by the CSIRO predict that this will increase to 13.8–16.3 days by 2020 and 14.5–23.6 days by 2050. It is also possible that the fire season will expand under climate change from currently early October to mid-January to late July to mid-February by 2050 (STCRC, 2009).

Hot temperatures also increase the need for cooling (and costs for air conditioning, e.g. in the tourist destination in and around Darwin, STCRC, 2009) and cause major damage to transportation systems, for example due to bleeding of asphalt or buckling of pavement (Mills & Andrey, 2002). Thus operational and maintenance costs are expected to increase substantially under different global warming scenarios. These need to be factored in as part of today’s decision making and investment, and adaptive measures such as heat proofed building designs will be beneficial.

There are also opportunities associated with warmer temperatures. Outdoor tourism in many of the Canadian and North American parks is constrained by cool conditions and warmer temperatures are likely to result in increased visitation (Richardson & Loomis, 2004). Assuming that other socio-economic factors that influence park visitation remain relatively constant, Canada's parks are anticipating higher visitation of 6 to 8% over the next thirty years (Jones & Scott, 2006). Similarly, the golf industry is projected to be positively affected by climate change because warmer temperatures will alter the length of the operating season and influence seasonal and total golf demand. Golf courses on Canada's East Coast could witness an increase in operating season by 25 to 45 days by 2020 (Scott & Jones, 2007). On the other hand, drier conditions will require increased turf management as a result of a greater need for irrigation, turf grass selection and turf disease and pest management (UNWTO, UNEP & WMO, 2008).

Potential growth opportunities for tourism in the Arctic have been explored in the light of melting sea ice in the Northern Hemisphere and a greater accessibility for Arctic cruise tourism. However, Stewart et al. (2007) note that this might be a double edge sword as while ships might be able to navigate to previously inaccessible areas, the environmental conditions might reduce the destinations' attractiveness as a result of changing landscapes and reduced wildlife viewing opportunities. There will also be areas (e.g. the North-west Passage) where warmer conditions will increase sea ice hazards that pose safety concerns for tourism.

As some destinations anticipate future opportunities for tourism development, McEvoy et al (2006) warn that regional visitor economies "cannot rely on climate change alone to boost the sector" (p. 13). Only forward planning and management will lead to sustainable outcomes; in particular McEvoy et al. suggest to explicitly build in resilience (to climate extremes but also other shocks) as a key element of planning for future growth.

Mountain destinations

Winter sport destinations around the world are now seriously considering the implications of climate change (Agrawala, 2008; Scott et al., 2006; STCRC, 2009). At present, a ski resort in Switzerland is considered "snow-reliable" if in seven out of ten winters there is a snow covering of at least 30 cm on at least 100 days between 1 December and 15 April. Currently 85% of Switzerland's ski resorts are considered to be snow-reliable. With the line of snow-reliability rising to 1500 m, as is projected to occur by 2030 to 2050, the number of snow-reliable ski resorts drops to 63%. A rise to 1800 m results in only 2% of small ski areas and 44% of larger ski resorts qualifying as snow reliable. For every 1°C rise in temperature there will be about 14 fewer skiing days (Schwarb & Kundewicz, 2004, in Becken & Hay, 2007). Winter tourism entrepreneurs in Finland reported that they require an average season length of 90-120 days to operate profitably (Tervo, 2008). It appears that a warming trend poses less of a risk to these operations than an increased number of extreme events.

In Australia, the ski season is already short with a length of 60-70 days being considered a minimum for viability (Galloway, 1988). Under a high emission scenario, temperatures in the Australian Alps are expected to increase by 1°C by 2020. This would result in a 60% reduction in the duration of the ski season (Hennessy et al., 2008) and a likely loss of customers. Already, 90% of skiers surveyed in 2007 would ski less often if the next five years experienced low natural snow; 69% would

ski less often, 5% would give up and 16% indicated that they would go overseas (Pickering et al., 2009). An assessment in Japan estimated that reduced snowfall at ski areas resulting from a potential 3°C warming scenario would reduce overall skier visits by 30% (Fukushima et al., 2002).

Climate will also influence the attractiveness of landscapes. Research has been undertaken on the changing quality of the mountain environment (e.g. including glaciations) as a result of climate change. Disappearing glaciers and changing ecozones have been identified as potential negative effects (Wall, 1992, in UNWTO, UNEP & WMO, 2008; Elsasser & Buerki, 2002). A recent study on changing environmental conditions under high warming scenarios for 2080 in Canada's Rocky Mountain National Parks revealed that recreationists will be less inclined to visit the park as a result of changing ecosystems, for example less abundant salmon fishing. A related study which focused on changing temperatures found that visitor numbers would actually increase. The combination of both studies highlights the need to consider both direct climatic effects (e.g. temperature) and indirect changes when seeking to anticipate future use patterns (Scott et al., 2007, 2008)

Sea level rise, flooding and extreme wind events

As temperatures increase, the oceans will expand which – in combination with glacial melting – will lead to rising sea levels. Global average sea levels have risen since 1961 at an average rate of 1.8 mm/yr and since 1993 at 3.1 mm/yr (IPCC, 2007). There is uncertainty if the faster rate for 1993 to 2003 reflects decadal variation or an increase in the longer-term trend (IPCC, 2007). The IPCC (2007) further estimated that sea levels might rise between 18 and 59 cm, although these estimates have now been considered as very conservative by some commentators (e.g. Vermeer & Rahmstorf, 2009). Sea level rise will also depend to a large extent on how fast Arctic and Antarctic ice masses are melting. Rising sea levels mean that coastal areas are more exposed to erosion and flooding.

Sea level rise poses both gradual and immediate risks, as a combination of extreme winds, high tide and an increasing sea level will lead to more frequent extreme events of coastal inundation and flooding. The latter risk is potentially associated with loss of life and severe damage to human and natural systems. However, also insidious changes in sea level will impact on tourism infrastructure, in particular that related to transportation and accommodation. Ports and marinas are major assets at many destinations and sea level rise might compromise their functionality. A study of 136 large port cities around the world found that exposure to flooding in 2070 will increase substantially under a sea level rise scenario of 0.5 m (Nicholls et al, 2008).

Past events of storm or flooding highlight the economic impacts. The estimated infrastructure damage of Katrina and Rita hurricanes in 2004 based on reported costs alone amounted to US\$1.1 billion (Grenzeback & Lukmann (2007) in Kotse & Rietveld, 2009). Whether extreme wind events increase in frequency and intensity depends on the region. In Australia, tropical cyclone are not expected to change in frequency over the next 60 years, but the intensity of cyclone category 3-5 events may increase by 60% by 2030 and 140% by 2070. This has significant implications for tourism in tropical areas such as Queensland, as cyclones cause considerable structural damage to both the reef and infrastructure. Cyclones also lead to increased flooding which might affect tourist numbers negatively (STCRC, 2009).

Sea level rise and flooding not only affect natural areas but also cultural assets that are located in coastal areas. Venice, for example, has been subject to a wide range of studies on sea level rise and possible measures to prevent severe damage (Carbognin et al., 2009). The Venice Tourism Office operates an 'aqua alta' (high water) information service to inform visitors of water levels, in particular during winter time where natural conditions often lead to flooding of large parts of the town. The lowest point in Venice is 64 cm above sea level (in front of Saint Mark's Church). Most other parts of Venice are between 110 cm and 140 cm above sea level (Turismo Venezia, 2009).

At a smaller scale, Jackson (2002) discussed the risks of sea level rise for yachting destinations in the Caribbean. He found that those destinations are most vulnerable that operate on poorly designed and engineered infrastructure, show poor management of boat yard services and have poorly managed hurricane shelters. Jackson commented that cruise ship terminals should be better adapted to sea level rise and extreme events due to their scale and better quality of engineering. It has been noted that while sea level rise poses a major risk to coastal destination, reduced water levels in inland destinations are likely to impact negatively on tourism (Wall, 1998). Lake-based marinas and boating infrastructure may become less functional with lower lake levels, as for example expected for the Great Lakes in North America (Smith, 1990).

In an attempt to assess the vulnerability of beach tourism destinations to climate change, Perch-Nielsen (2009) developed indicators for 51 countries around the world. Those related to sea level rise were

- “Number of people additionally inundated once a year given a sea level rise of 50 cm”;
- “Length of low lying coastal zone with more than 10 persons per km²”; and
- “Beach length to be nourished in order to maintain important tourist resorts”.

A major limitation of Perch-Nielsen's global study is that the selected indicators are not tourism specific and are not able to capture micro-geographical parameters. However, the results provide a first indication of which countries are likely to suffer most from climate change in relation to coastal tourism. When assessing the vulnerability of the local tourism industry it is important to consider a range of potentially interacting effects. A study of beach visitation in East Anglia showed that sea level rise would impact on beaches by reducing the width of the beach. However, resulting potential reductions in visitation were found to be outweighed by increased visitation due to more favourable temperatures (Coombers et al., 2009). These in turn will increase pressure on local biodiversity, in particular vegetation cover and habitat for nesting birds such as the ringed plover (Coombers et al., 2008).

Environmental change

The IPCC (2007) stated that “Observational evidence from all continents and most oceans shows that many natural systems are being affected by regional climate changes, particularly temperature increases”. More specifically, there is very high confidence that:

- Changes in snow, ice and frozen ground have increased the number and size of glacial lakes, increased ground instability in mountain and other permafrost regions and led to ecosystem changes in the Arctic and Antarctic.
- Some hydrological systems have also been affected through increased runoff and earlier spring peak discharge in many glacier- and snow-fed rivers and through effects of warming rivers and lakes.
- Warming resulted in earlier timing of spring events and poleward and upward shifts in plant and animal ranges.
- Some marine and freshwater systems have seen shifts in ranges and changes in algal, plankton and fish abundance due to warmer water temperatures, as well as related changes in ice cover, salinity, oxygen levels and circulation.

All of the above ecosystem changes are indirectly affecting tourism, especially in destinations where nature is a key attractor for tourists, as in the case of World Heritage Areas (e.g. Sagarmatha National Park in Nepal, Kilimanjaro National Park in Tanzania, the Wet Tropics of Queensland, Australia or Ichkeul National Park in Tunisia, UNESCO, 2007). Comparative research on tourists in Bonaire and Barbados in the Caribbean revealed that visitors to Bonaire were motivated by environmental attributes such as coral and fish diversity and abundance, whereas those to Barbados preferred beach features and other components of the terrestrial environment (Uyarra et al., 2005). The impacts of climate change will therefore likely be different in these two destinations.

Climate change is likely to have a significant influence on the tourism economies of island countries by way of degradation of environmental features important to tourists (Becken & Hay, 2007). For example, during the El Niño event of 1998 surface water temperatures in Palau, South Pacific, exceeded 30°C from June through November. This resulted in a massive coral-bleaching event that killed one-third of Palau's reefs. Some populations declined to as much as 99% below pre-bleaching levels. The associated economic loss was estimated at US\$91 million, partly because of a 9% drop in annual tourism revenues (Hay *et al.*, 2003). Bleached coral reefs are mostly affecting the segment of upper-end expert dive tourists and are less likely to affect budget tourists who may not be able to distinguish healthy from bleached coral (Cesar, 1998).

Small island destinations are also particularly exposed to water shortages due to climate change (IPCC, 2007) and rapid growth of tourism in many destinations is placing additional stress on local water supplies. Water availability has to be seen in the context of already occurring natural inter-annual and decadal-scale variability in precipitation, as well as the quality of water management systems. Periods of below-average precipitation may be exacerbated by inadequate rainwater catchment facilities, or the sandy nature of the soil allowing the limited rain that falls to infiltrate rapidly and become difficult to access (Hay *et al.*, 2002). A study of water supply in Mallorca, Spain, found that while climate change is likely to exacerbate existing problems around water, it is the natural variation that poses the more immediate pressure on tourism (Kent et al., 2002).

Apart from small island destinations, the IPCC (2007) projects that dry regions will get drier (e.g. large parts of Africa or Australia), and wet regions are projected to get wetter (e.g. the West Coast of New Zealand). More precipitation will impact on road maintenance, disaster management (e.g. landslides) and flood prevention. More

specific to tourism, more rain will increase the need for track maintenance in national parks. A recent study of tourism and climate change in Northern England noted that foot path erosion in the Lake District National Park is likely to increase as a result of more intense winter rainfall accompanied by the absence of snow cover. Footpaths were found to be particularly vulnerable when trampling by recreationists and rainfall alternate (McEvoy et al., 2006).

Changes in the hydrological schemes of glaciers will have severe impacts on the water supply of people that depend on seasonal glacial melting for their water supply. This has been observed in most alpine areas but is particularly concerning in the Himalayas as millions of people depend on water supply from the glacier fed rivers (Eriksson et al., 2009). In the case of India alone, the Ganges, Brahmaputra and Indus river systems all originate from the Himalayas and contribute more than 60% to the total annual runoff for all the rivers of India (UNESCO, 2009).

Climate change-related changes in ecosystems that are relevant for tourism have been observed in a range of situations, for example for forest-based recreation in North America (Loomis & Crespi, 1999, in Richardson & Loomis, 2004), tourism in wetland areas (Wall, 1998), or the implication of changing temperatures for a popular tulip festival in Canada (Jones et al., 2006). A wide range of literature discussed the relationships between climate change and biodiversity, more generally (Green et al., 2001; Taylor & Figgis, 2007) and specifically in relation to tourism (Christ et al., 2003; Tratalos et al., 2005). Changes to narrowly defined habitats are particularly concerning, for example in the case of wetlands in the Kakadu National Park, Australia, where sea level rise of up to 56 cm by 2070 will reduce the living space for alligators substantially (STCRC, 2009).

Wildlife tourism in Africa, for example, is based on the current network of parks and reserves which in turn reflect current climatic conditions and distributions of species. Changing ecological conditions, such as precipitation, evaporation and flowering time have the potential to threaten populations or induce a shift in distributions and migration patterns. Reserves that are closely connected to seasonality like Lake Manyara National Park in Kenya with its 380 (largely migrating) bird species or the Serengeti with the 'great migration' of wildebeest and zebras are particularly vulnerable (Viner & Agnew, 1999). At a smaller scale, McEvoy et al (2006) discussed the impacts of climate change on the very popular dune systems in Sefton, Northwest England. It is likely that the hydrological system will lead to more mobile dune systems and a loss in biodiversity. The authors recommended that in the light of increases in visitor numbers due to warmer temperatures the management of the dunes need to be adjusted to protect the habitat for example through biological monitoring and careful visitor management (McEvoy et al., 2006).

CONCLUSION

Both weather and climate are extremely important for tourism, and it is often the perception of climate that may be more important than the reality. Tourists make decisions based on what they believe the climatic conditions of a destination are. As a result tourists will learn over time and adjust their decision making (Ehmer & Heymann, 2008). This is not only relevant with respects to perceived temperature and precipitation (e.g. "too hot", Gossling & Hall, 2006) but also in relation to perceived

safety, for example in response to the (perceived) risk of hurricanes or other extreme events. As such there may well be “Winners and Losers” as suggested in a Deutsche Bank (2008) report. Actual impacts of climate change on tourist destinations are potentially much further reaching, as they affect the resource base of tourism, both directly and indirectly. Already, challenges such as water shortages or increased incidence of forest fires pose themselves to destinations. Environmental changes, for example the distribution of wildlife or coral bleaching, are also of fundamental importance for tourism. Understanding these changes is a first step towards managing them and adapting to new circumstances.

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