

Research Probe

This Department has been specifically created to include findings of special significance and problem areas of subtle nuances in tourism research. Insightful contributions presenting the state-of-the-art, preferably from the developing societies, will be appreciated. It will also encourage scholars and authors to think against the grain, probing the consistency of theoretical notions and research trends whose heuristic value is all too often taken for granted. For details, contact Editor-in-Chief, Tourism Recreation Research, A-965/6 Indira Nagar, Lucknow, India. e-mail: tvsingh@sancharnet.in

Tourism and Climate Change: Knowledge Gaps and Issues

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Introduction

The role of climate on tourism has been the subject of considerable interest for many years. However, the relationship between tourism and climate change is a much more recent concern (Scott et al. 2005) which has witnessed a dramatic increase in the publication of articles, book chapters and monographs (e.g., Hall and Higham 2005; Becken and Hay 2007), including a valuable background report prepared for the UNWTO's second conference on climate change and tourism (Scott et al. 2007a). The reasons for such growth are several folds. First, because climate has a number of direct and indirect influences on tourist decision-making and destination attractiveness, tourism is a potentially sensitive economic sector with respect to climate change. Second, policy discussions with respect to mitigating climate change, e.g. through the imposition of 'green taxes' on aviation and/or tourists, but even including appeals to avoid forms of holidays that impact on the climate system, clearly have implications for tourism flows and tourist behaviour. Third, tourism has itself become a more significant component of the reporting of the Intergovernmental Panel on Climate Change (IPCC) that was formed in 1988 under UN auspices to inform policy-makers and society with respect to knowledge on the causes and impacts of climate change. For example, the first report IPCC assessment report did not even mention tourism, whereas the fourth assessment report published in 2007 has substantial reference to tourism and related subject areas. Finally, and connected to all the above, there is far greater public and media debate, and arguably concern with respect to the potential affects of climate change to which the academic community is responding to and contributing to, particularly those who are engaged within the environmental and impacts research tradition of tourism.

The purpose of this probe is to provide an overview of some of the key issues that emerge out of recent research on tourism and climate change as well as the policy context in which it is situated. The paper is divided into several sections. First, a brief account of the policy context for tourism and climate change research. Second, the place of tourism within IPCC assessments and the influential Stern (2006) review on the economics of climate change. Third, an overview of the major current research themes in tourism and climate change. Fourth, an account of research on a regional basis. Finally, the paper seeks to draw some conclusions with respect to the current state of knowledge on tourism and climate change.

The Policy Context

The results of academic research are not value free, perhaps nowhere more so in the case of such a politically charged area as climate change where research is an important element of policy determination. The reasons for the highly charged policy environment primarily relate to the implications of the costs of any mitigation and adaptation strategies (Monbiot 2006; Randerson 2006). For example, application of the 'polluter pays' principle to an area such as aviation would have significant impacts on costs of airline passenger and freight costs and therefore levels of demand. Furthermore, climate change is now part of wider political debates and appears to be a factor in electoral campaigns. For example, Australia's non-ratification of the Kyoto agreement under the conservative coalition government of Prime Minister John Howard was an issue that emerged a number of times during Australia's 2007 federal election (e.g., BBC News 2007). Similarly, political parties in the UK were seeking to position themselves with respect to climate change in the run-up to the next election, with the Labour government announcing an amended

climate change bill including adding emissions from the aviation and shipping industry in the UK's greenhouse gas (GHG) emissions targets (Ryan and Stewart 2007). The bill built on the British governments announcement in October 2007 that as from 2009 air taxes would be levied on the flight, rather than directly on the passenger, a measure that is regarded as better targeted at cutting carbon emissions (Wintour and Elliott 2007), and which was also a policy of the Conservative Opposition. The policy is supported by budget airline EasyJet who argued that air passenger duty should be dropped in favour of a scheme that grades aircraft according to their emissions and length of journey (Milmo 2007). However, given the potential lifespan of aircraft this may also have the effect of moving older aircraft with higher emissions to regions with weaker emissions rules such as Africa, Asia or Latin America.

Also of great significance in policy terms has been the awarding of the Nobel Peace Prize to former US Vice-President Al Gore and to the IPCC in October 2007. In awarding the prize the Nobel committee signalled its view that climate change is now a global security issue which therefore means its policy importance is reinforced beyond an economic or environmental interpretation (Black 2007). However, it is important to recognise the extent to which such an award lends credibility to the science of climate change (see below) despite attempts by various interests to discredit scientific findings and recommendations (Monbiot 2006). Nevertheless, it is often the coincidence of weather related natural disasters combined with awareness of climate change that arguably leads to the most volatile policy environments such as in the case of the impacts of Hurricane Katrina in the United States; wildfires in Greece, the Iberian Peninsula and the United States; drought in Australia and the United States; and flooding in Africa and Mexico. In such cases, which involve major temporary and in the case of Hurricane Katrina and the Australian drought potentially permanent displacement of people, it is perhaps not surprising that the spectre of environmental refugees (Myers 2002) wrought by climate change is regarded as occurring in the present rather than just being in the future.

Tourism within Climate Change Reports

The global climate change political and public debate has been strongly influenced by the contents and media reporting of a number of climate change reports in which tourism is noted. In policy terms the 2006 review on the economics of climate change commissioned by the UK government from Sir Nicholas Stern, a former chief economist with the World Bank, was extremely important. In media terms, it generated substantial interest (e.g., Hinsliff 2006a, b; Randerson 2006). For example, the UK's Observer

newspaper ran a headline in covering the review: 'Ten years to save the planet from mankind' (Hinsliff 2006a).

The Stern review arguably did not bring anything new to the understanding of climate change in a scientific or environmental sense. But it did have the important function of 'independently' affirming scientific argument from the respectability of a conservative economic position rather than one that may be perceived as solely 'academic'. Just as significantly for economic thinking it placed a price on the cost of failing to act on climate change unless it is tackled immediately – a figure of £3.68 trillion. Stern (2006) forecast that the world needed to spend 1% of global GDP - equivalent to about £184bn per year – in dealing with climate change, or face a bill between five and twenty times higher for damage caused by letting it continue. According to Hinsliff (2006b) unchecked climate change could therefore cost as much as £566 for every man, woman and child on the planet – roughly 6.5 billion people – in 2006 terms.

The debate surrounding the review's release focussed on a number of areas of interest to tourism, particularly with respect to the potential imposition of green taxes on aviation (e.g., Hinsliff 2006b). Yet the review itself only gave minor consideration to tourism. Table 1 note that there were only 19 references to tourism, tourist and recreation and cognate terms in the review with most of these being brief mentions. The most substantive discussion of tourism was in relation to some of the positive effects that climate change will bring for a few developed countries for moderate amounts of warming, although it is also noted that they will become very damaging at the higher temperatures expected in the second half of this century. On page 126 it is stated that 'tourism may shift northwards, as cooler regions enjoy warmer summers, while warmer regions like southern Europe suffer increased heat wave frequency and reduce water availability. One study projected that Canada and Russia would both see a 30% increase in tourists with only 1°C of warming' (Stern 2006: 126; referring to Hamilton et al. 2005). Although the discussion then goes on to note the potentially harmful affects of climate change to alpine and winter tourism and to tourism resources such as the Great Barrier Reef. Tourism is thus only superficially considered in the Stern Review, and represented by a selective, non-comprehensive choice of references.

In contrast tourism is given much greater emphasis in the IPCC climate change reports. The IPCC's role is to 'assess on a comprehensive, objective, open and transparent basis the best available scientific, technical and socio-economic information on climate change from around the world. The assessments are based on information contained in peer-reviewed literature and, where appropriately documented,

Table 1. References to Tourism, Tourist and Recreation and Cognate Terms in Stern Review

Part	chapters	Focus	citations in text*
1	1-2, technical annex to 2	The nature of the scientific evidence for climate change, and the nature of the economic analysis required by the structure of the problem which follows from the science	0
2	3- 6	How climate change will affect people's lives, the environment and the prospects for growth and development in different parts of the world.	10
3	7-13	The economic challenges of achieving stabilisation of greenhouse gases in the atmosphere	4
4	14-17	Policy responses to mitigation	0
5	18-20	Policy responses for adaptation	5
6	21-27	International collective action	0

* does not include citations in references

in industry literature and traditional practices' (IPCC 2004: 1). The First Assessment Report was released in 1990 and outlined the scientific basis for concern about climate change. The Second Assessment Report was released in 1995. The Third Assessment Report, released in 2001 consisted of three working group reports on The Scientific Basis; Impacts, Adaptation and Vulnerability; and Mitigation, and a Synthesis Report primarily aimed at policy makers. The Fourth Assessment Report released in 2007 was released with a similar structure with three working group reports on The Physical Science Basis; Impacts, Adaptation and Vulnerability; Mitigation of Climate Change and a synthesis report.

Although tourism has not been cited in reports on the scientific basis for climate change and only marginally with respect to mitigation, it has become increasingly recognised in the reports of the IPCC Working Group on Impacts, Adaptation and Vulnerability (Wall 1998; see also Amelung et al., forthcoming). Table 2 compares reference to tourism and cognate terms in comparable chapters of the 2001 (McCarthy et al. 2001) and 2007 (Parry et al. 2007) reports of the Working Group. It is noticeable that although there are similar total numbers of references to tourism, tourist, recreation and cognate terms in the regional chapters of the two reports, there is a substantial variation between chapters. In particular there are notable increases (greater than 10%) in citations in the chapters on Africa, Australia and New Zealand, Europe and Small Island States. There are decreases in citations with respect to Asia and the polar regions although these only have a small overall number of citations. The most significant decrease in citations of tourism related words occurring in the chapter on North America, down

Table 2. References to Tourism, Tourist and Recreation and Cognate Terms in Regional Chapters of IPCC Working Group II 2001 and 2007 Reports on Impacts, Adaptation and Vulnerability.

Regional Chapter	3 rd report (2001) citations	4 th report (2007) citations
Africa	3	28
Asia	9	7
Australia and New Zealand	22	31
Europe	34	40
Latin America	10	10
North America	86	27
Polar regions	11	7
Small island states	26	47
Regional chapter totals	201	197

Note: citations refer to references in text, figures, tables and headings with respect to tourism, tourist, recreation and cognate terms. References to terms in bibliographic information at the end of each chapter are not included in tallies of key words.

from 86 in 2001 to 27 in 2007.

Changes in word counts are important as it can be argued that they reflect aspects of the issue ecology of content in IPCC reports and are therefore a crude surrogate measure of importance and levels of knowledge on particular subjects. Of course, this is also partly a reflection of the authors of the various chapters as well with respect to their levels of knowledge of tourism and the selection of references they cite with the range of academic publications and approaches to tourism and climate change (Scott et al. 2005; Gössling and Hall 2006a; Scott et al. 2007a) being far greater than those actually utilised. Nevertheless, the relative emphasis of subjects covered by the report may broadly correspond to the relative research emphasis on tourism and climate change in general. Table 3 outlines the substantive comments on tourism issues (a sentence or more) in Parry et al. (2007). Although not the sole source, the identification of particular topics is used in the next section to provide an overview of the major current research foci on tourism and climate change.

Research Issues and Topics

The aim of this section is not to restate the IPCC's conclusions and forecasts with respect to the effects of climate change on the global environment and the role of anthropogenic warming (see Solomon et al. 2007). Instead, it seeks to identify some of the key topics and issues addressed by research on tourism and climate change.

Table 3. Dimensions of the Tourism and Climate Change Relationships Covered in the IPCC Working Group II 2007 Reports on Impacts, Adaptation and Vulnerability

Dimension	Specified locations	Chapter source
Sensitivity to climate change	Africa, Asia, Australia and New Zealand, Europe, North America, Tropical destinations, Small islands	Alcomo et al. 2007: 543-4; Boko et al. 2007: 450, 459; Cruz et al. 2007: 489; Hennessy et al. 2007: 523; Mimura et al. 2007: 689, 697; Schneider et al. 2007: 790; Wilbanks et al. 2007: 363, 368, 375, 380.
Issues in adaptation to climate change	Small islands	Alcomo et al. 2007: 561; Anisimov et al. 2007: 673, 676; Mimura et al. 2007: 705; Wilbanks et al. 2007: 380.
Effects on coastal tourism	Africa, Americas, Caribbean, Mediterranean, Florida, Thailand, Maldives, small islands	Alcomo et al. 2007: 543-4; Boko et al. 2007: 440, 449; Field et al. 2007: 634; Magrin et al. 2007: 584, 599, 600; Mimura et al. 2007: 689, 696, 698, 701, 703; Nicholls et al. 2007: 335-6, 337.
Degradation of coral reef, coral bleaching	Africa, Australia, small islands	Boko et al. 2007: 439; Fischlin et al. 2007: 235; Hennessy et al. 2007: 523; IPCC 2007b 13, 15; Mimura et al. 2007: 689, 696; Nicholls et al. 2007: 320.
Effects on summer tourism	Europe, especially Mediterranean	Alcomo et al. 2007: 565.
Effects on winter tourism	Asia, Europe, Bolivia	Adger et al. 2007: 721, 722, 734; Alcomo et al. 2007: 543-4, 561, 565; Cruz et al. 2007: 489; Field et al. 2007: 634; Hennessy et al. 2007: 523; IPCC 2007b 14, 18; Magrin et al. 2007: 589; Rosenzweig et al. 2007: 117; Wilbanks et al. 2007: 363.
Skiing	Asia, Australia and New Zealand, Europe	Adger et al. 2007: 721, 722, 734; Alcomo et al. 2007: 557, 561; Field et al. 2007: 634; Hennessy et al. 2007: 523; Magrin et al. 2007: 589; Rosenzweig et al. 2007: 89, 111.
Affects on mountain tourism	Europe	Fischlin et al. 2007: 223; Rosenzweig et al. 2007: 88, 89.
Affect on wild faunal diversity/nature-based tourism	Marine ecosystems, Mediterranean-type ecosystems, Small islands, Southern Africa, Tropical savanna systems	Boko et al. 2007: 435, 459; Field et al. 2007: 634; Fischlin et al. 2007: 225, 226, 234; Mimura et al. 2007: 696.
Reservation economies	North America	Field et al. 2007: 625.
Affect of extreme events	Mexico, North America, small islands	Field et al. 2007: 626; Magrin et al. 2007: 585; Mimura et al. 2007: 693, 702.

The relationship between GHG emissions and the nature of economic development is regarded as extremely important to climate change mitigation in the longer term

with a number of factors influencing the amount of emissions:

- Structural changes in the production system in relation to the role of high or low energy-intensive industries and services.
- Technological patterns in sectors such as energy, transportation, building, waste, agriculture and forestry.
- Geographical distribution of activities encompassing both human settlements and urban structures in a given territory, and its twofold impact on the evolution of land use, and on mobility needs and transportation requirements.
- Consumption patterns – for a given income per person, parameters such as housing patterns, leisure styles, or the durability and rate of obsolescence of consumption goods will have a critical influence on long-run emission profiles.
- Trade patterns – which may influence access to the best available technologies and to finance may limit the building of infrastructure (Fisher et al. 2007: 177).

Surprisingly, even though mobility, transport and leisure consumption were noted as long-term determinants of emissions there was very little discussion in the IPCC reports of the role of tourism in mitigation, even with respect to tourism transport. In contrast several studies (Gössling 2002; Gössling and Hall 2006b; Peeters et al. 2006) have noted the rapid growth of tourism as a contributor to emissions. Scott et al. (2007a) estimated that 5% of the global share of CO₂ emissions are attributable to tourism within a range of 4-6%. Measured in radiative forcing, a measure of the influence a factor has in altering the balance of incoming and outgoing energy in the Earth-atmosphere system that is an index of the importance of the factor as a potential climate change mechanism, the contribution of tourism to global warming may be up to 14%, even though there is great uncertainty with regard to the contribution of cirrus-related effects. The majority of tourist trips create only small amounts of emissions. However, air travel, and especially long-haul travel are major contributors. For example, long haul travel between the five world regions accounts for only 2.7% of all tourist trips, but contributes 23% to global tourist transport emissions. Furthermore, given current predictions for travel growth under a 'business as usual' scenario it is estimated that tourist attributable CO₂ emissions will grow by 152% and radiative forcing by 171% by 2035 (Scott et al. 2007a). Therefore, given such forecasts it is perhaps not surprising that reducing the effects of air travel through technological,

regulatory and/or behavioural mechanisms has become a significant focus for tourism and climate change research (e.g. Peeters et al. 2006, 2007; Peeters 2007; Gössling et al. 2007 a, b), although other parts of the tourism system are also of importance (e.g. Chan and Lam 2003; Gössling et al. 2005).

Wilbanks et al.'s (2007) chapter on industry, settlement and society probably provided the most substantial assessment of the impact of climate change on tourism within the IPCC context. Tourism was identified as a 'climate-sensitive human activity' with the chapter concluding that vulnerabilities of industries to climate change are 'generally greater in certain high-risk locations, particularly coastal and riverine areas, and areas whose economies are closely linked with climate sensitive resources, such as ... tourism; these vulnerabilities tend to be localized but are often large and growing' (Wilbanks et al. 2007: 359). However, one of the greatest problems with assessing the impacts of climate change on tourism is that both direct and indirect effects will vary greatly with location (Gössling and Hall 2006b). Direct affects include the role climate variables, such as temperature, sunshine hours, precipitation, humidity and storm frequency and intensity play with respect to tourist decision-making, including activity and destination choice (Scott et al. 2007d). Another effect is the extent to which particular environments, such as tropical or alpine resorts, gain some of their appeal from climatic variables. Finally, indirect effects of climate change such as heat waves, fires, disease outbreaks, landscape change, and biodiversity change can also have substantial affects on tourism activities, perceptions of a location, and the capacity of firms to do business. However, as Rosenzweig et al. (2007: 111) identified, 'as a result of the complex nature of the interactions that exist between tourism, the climate system, the environment and society, it is difficult to isolate the direct observed impacts of climate change upon tourism activity. There is sparse literature about this relationship at any scale'.

Climate change is likely to have a long term effect on domestic and international tourist flows. Higher temperatures are potentially likely to change summer and winter destination preferences in the longer term, either through direct affects on a tourism resource such as snow availability, or in terms of making competing destinations more or less attractive climatically. However, the capacity of potential tourists to accurately judge the implications of changes in average temperatures or climate conditions for a destination is quite debatable (Gössling et al. 2006) with the exception of tourism resource loss, such as snow. Deterministic models such as the Tourism Comfort Index (Amelung and Viner 2006) indicated improved conditions

for tourism in northern Europe, while econometric modelling by Hamilton et al. (2005) indicated that an arbitrary climate change scenario of 1°C would also lead to a gradual shift of tourist destinations further north and up mountains thereby affecting the preferences of European summer tourists (Alcamo et al. 2007). Nevertheless, Gössling and Hall (2006b, c, d) have noted that there are a number of major weaknesses with respect to current models in predicting travel flows under conditions of climate change (Table 4) and have urged substantial caution in utilising the results of deterministic approaches to climate change adaptation given high levels of behavioural uncertainty.

Table 4. Major Weaknesses of Current Models in Predicting Travel Flows

• Validity and structure of statistical databases
• Temperature assumed to be the most important weather parameter
• Importance of other weather parameters largely unknown (rain, storms, humidity, hours of sunshine, air pollution)
• Role of weather extremes unknown
• Role of information in decision-making unclear
• Role of non-climatic parameters unclear (e.g., social unrest, political instability, risk perceptions, destination perception)
• Existence of fuzzy-variables problematic (terrorism, war, epidemics, natural disasters)
• Assumed linearity of change in behaviour unrealistic
• Future costs of transport and availability of tourism infrastructure uncertain
• Future levels of personal disposable income (economic budget) and availability of leisure time (time budget) that are allocated to travel uncertain

Source: Gössling and Hall, 2006b, c, d.

In light of concern with the role of higher temperatures on tourist flows it is perhaps not surprising that the environments that have attracted the most research attention are those of coastal, including those of small islands, and alpine areas. Arguably these are the same environments that have attracted tourism research on environmental impacts in general (Hall and Page 2006). Coasts and small islands are projected to be exposed to increasing risks, including coastal erosion, due to climate change and sea-level rise (IPCC 2007). In addition, the impact of climate change on tourism dependent coastal economies may be exacerbated because of the increased human-induced pressures tourism brings to coastal areas (Hall 2006a; Nicholls et al. 2007). Nicholls et al. (2007: 331) summary of climate-related impacts in relation to recreation and tourism in coastal areas argued that temperature rise (air and seawater), extreme events (storms, waves), erosion (sea level, storms, waves) and biological effects will have strong impacts; floods (sea level, runoff) will have a weak impact; and rising water tables (sea level) and saltwater intrusion (sea level, runoff) will have a

negligible impact or that an impact is not established. However, such relative impacts will not be the same in all locations (Uyarra et al. 2005).

Extreme events, such as cyclones and hurricanes, for example, are regarded as significant because of both their physical impact on environment and infrastructure (Nurse and Moore 2005) as well as the potential negative contribution to destination image. Under climatic change more frequent high-magnitude events may mean there is less time for physical and human systems to recover, meaning that recovery may never be complete and thereby resulting in long-term environmental deterioration. Such effects are already observed in coral reef ecosystems, even though the consequences for tourism remain unclear (Gössling et al. 2007b).

With respect to small islands Mimura et al. (2007) concluded that there was a high degree of confidence that the effects of climate change on tourism are likely to be direct and indirect, and largely negative.

Tourism is the major contributor to GDP and employment in many small islands. Sea-level rise and increased sea water temperature will cause accelerated beach erosion, degradation of coral reefs, and bleaching. In addition, a loss of cultural heritage from inundation and flooding reduces the amenity value for coastal users. Whereas a warmer climate could reduce the number of people visiting small islands in low latitudes, it could have the reverse effect in mid- and high-latitude islands. However, water shortages and increased incidence of vectorborne diseases may also deter tourists' (Mimura et al. 2007: 689).

In the western Indian Ocean region, a 30% loss of corals resulted in reduced tourism in Mombasa and Zanzibar, and caused financial losses of about US\$12-18 million (Payet and Obura 2004). Australia's Great Barrier Reef has experienced eight mass bleaching events since 1979 (1980, 1982, 1987, 1992, 1994, 1998, 2002 and 2006). The most widespread and intense events occurred in 1998 and 2002, with about 42% and 54% of reefs affected, respectively (Berkelmans et al. 2004). Climate change related effects such as rising sea temperatures and ocean acidification being exacerbated by coral reefs exposure to local anthropogenic impacts, including sedimentation, pollution and reduction of fish stocks (Hoegh-Guldberg 1999, 2004). However, in addition to marine environments climate change related biodiversity loss is also significant for nature-based tourism in terrestrial environments (Hall 2006b; Scott et al. 2007a).

The potential impact of climate change on alpine and winter tourism has been a major focus of research in Europe (e.g. Burki et al. 2005; Harrison et al. 2005) and North America (e.g. Scott et al. 2003; Scott et al. 2006; Scott et al. 2007a, b, c).

Declines in mountain snowpack in western North America and in the Swiss Alps are largest at lower, warmer elevations with corresponding impacts on skiing, ice climbing and scenic activities in areas affected (Rosenzweig et al. 2007: 89). Over the past century snow cover has decreased in most regions, especially in Spring. Northern Hemisphere snow cover over the 1966 to 2005 period decreased in every month except November and December (Solomon et al. 2007).

The challenge for many alpine resorts is that mountain snow can be especially sensitive to only small changes in temperature, particularly in temperate regions where the transition from rain to snow is generally closely associated with the freezing level altitude. According to Agrawala (2007) under present climate conditions, 609 out of the 666 (or 91%) Alpine ski areas in Austria, France, Germany, Italy, and Switzerland can be considered as naturally snow-reliable with the remaining 9% already operating under marginal conditions. Agrawala (2007) estimated that the number of naturally snow-reliable areas would drop to 500 under a 1 °C increase, to 404 under 2 °C, and to 202 under a 4 °C warming of climate. Responses to climate change in alpine and winter tourism destinations include artificial snow-making and associated structures such as high altitude water reservoirs; grooming of ski slopes; moving ski areas to higher altitudes and glaciers; use of white plastic sheets as protection against glacier melt; market, economic and regional diversification; and the use of market-based instruments such as weather derivatives and insurance (Scott 2006, 2007 a, b, c; Agrawala 2007).

Ecotourism has been seen as a potential substitute for the ski industry in Asia (Fukushima et al. 2002; Cruz et al. 2007). However, as Scott et al. (2007c) point out climate and associated environmental change will also affect the viability of nature-based tourism in alpine areas. Similar concerns exist in the Arctic. For example, Anisimov et al. (2007) noted the potential significance of ecotourism as an opportunity for adaptation of indigenous peoples, even though the biodiversity and landscape of the region is experiencing some of the most rapid climate related environmental changes on the planet today, with average Arctic temperatures having increased at almost twice the rate of the rest of the world in the past 100 years (ACIA 2005; Solomon et al. 2007).

Even one of the most high-profile dimensions of climate change in 2007 – the opening of the Northwest Passage as the result of the loss of Summer ice – is seen as potentially beneficial for tourism. Anisimov et al. (2007: 676) state 'the Northern Sea Route will create new opportunities for cruise shipping. Projections suggest that by 2050, the Northern Sea Route will have 125 days/yr with less than 75% sea-ice cover,' Similarly, Instanes et al. (2005) noted that increased

possibilities for marine navigation and the extension of the warm-weather season will improve conditions for tourism.

The fact that there are potentially 'winners', at least in the short term, as well as 'losers' from climate change also reflects on the adaptation capacities of different regions, sectors, actors or firms. 'Adaptive capacity is the ability or potential of a system to respond successfully to climate variability and change, and includes adjustments in both behaviour and in resources and technologies' (Adger et al. 2007: 727). Because of their explicit focus on real-world behaviour, assessments of adaptation practices differ from the more theoretical assessments of potential response. However, at this stage an understanding of the adaptive capacities and practices of the various elements of tourism in relation to climate change are quite limited (Becken 2005; Gössling and Hall 2006a; Scott et al. 2007a). In one sense this situation reflects the large knowledge gaps that surround a number of areas of tourism and climate change research.

Knowledge Gaps at a Regional Level

The level of knowledge with respect to tourism and climate change can be assessed regionally as well as thematically. Indeed, a number of knowledge gaps have been highlighted in the various IPCC reports. Table 5 provides a summary of the relative levels of knowledge for a region in relation to the estimated impact of climate change on tourism.

Table 5. Relative level of tourism specific climate change knowledge and estimated impact of climate change on tourism by region.

Region	Estimated impact of climate change on tourism	Relative level of tourism specific climate change knowledge
Africa	Moderately-strongly negative	Extremely poor
Asia	Weakly-moderately negative	Extremely poor
Australia and New Zealand	Moderately-strongly negative	Poor-Moderate (high in Great Barrier Reef)
Europe	Weakly-moderately negative	Moderate (high in alpine areas)
Latin America	Weakly-moderately negative	Poor
North America	Weakly negative	Moderate (high in coastal and ski areas)
Polar regions	Weakly negative – weakly positive	Poor
Small islands	Strongly negative	Moderate

Sources: derived from Gössling and Hall 2006a; Parry et al. 2007; see also Scott 2007a.

In the case of Africa, Boko et al. (2007: 450) stresses that 'very few assessments of projected impacts on tourism and climate change are available' and later notes:

There is a need to enhance practical research regarding the vulnerability and impacts of climate change on tourism, as tourism is one of the most important and highly promising economic activities in Africa. Large gaps appear to exist in research on the impacts of climate variability and change on tourism and related matters, such as the impacts of climate change on coral reefs and how these impacts might affect ecotourism (Boko et al. 2007: 459).

Tourism is similarly recognised by the IPCC as one of the most important industries in Asia, although the lack of research is bemoaned. 'Nature-based tourism is one of the booming industries in Asia, especially ski resorts, beach resorts and ecotourist destinations which are likely vulnerable to climate change; yet only a few assessment studies are on hand for this review' (Cruz et al. 2007: 489).

Even in North America, which is one of the better studied regions, substantial knowledge gaps exist. For example, Field et al. (2007: 634) note that, although 'coastal zones are among the most important recreation resources in North America, the vulnerability of key tourism areas to sea-level rise has not been comprehensively assessed.' Such assessment is extremely significant for policy makers and industry stakeholders as it can provide increased understanding of the relative vulnerabilities of destinations and attractions to climate change. For example, Scott et al. (2007b), highlights that early studies of climate change impact on the ski industry did not account for snowmaking capacity, which substantially lowers the vulnerability of some ski resorts to climate change.

In the case of Australia and New Zealand Henessy et al. (2007) note that few regional studies have assessed potential impacts of tourism, although it is still argued that 'Some tourist destinations may benefit from drier and warmer conditions, e.g., for beach activities, viewing wildlife and geothermal activity, trekking, camping, climbing, wine tasting and fishing' (Henessy et al. 2007: 523) but that there is likely to be greater risks to tourism as a result of increased hazards. Similarly, positive change with respect to summer and winter tourism is parts of Europe (Alcamo et al. 2007: 565), even though, as noted above, understanding of many of the behavioural and adaptive capacities with respect to tourism is currently relatively weak.

Conclusions

This review has sought to outline some of the key issues that have emerged in recent studies and debate on tourism and climate change. Although it has noted some of the

Table 6. Adequacy of tourism knowledge with respect to climate change adaptation, mitigation and impacts

Factor	Very inadequate	Inadequate	Adequate	Very adequate
Generic				
Understanding of tourism system at various scales		X		
Understanding of tourism within human, environmental and innovation systems at various scales		X		
Understanding of human behaviour with respect to destination and activity choice		X		
Impact of climate change on different environments in which tourism occurs				
Alpine environments			X	
Arid environments		X		
Coastal environments			X	
Coral reef environments				X
Polar environments	X			
Small islands (warm-water)			X	
Small islands (cold-water)		X		
Temperate forests		X		
Temperate grasslands		X		
Tropical forests	X			
Tundra	X			
Urban	X			
Impact of climate change on different tourism activities				
Adventure	X			
Cycling	X			
Eating out/restaurants	X			
Farm tourism	X			
Food and wine	X			
Fishing	X			
Garden tourism	X			
Health and spa	X			
Historic buildings	X			
Indigenous	X			
Museums and art galleries	X			
National parks		X		
Nightlife	X			
Scenic drives	X			
Shopping	X			
Sightseeing (urban and non-urban)	X			
Snow-based activities (e.g. skiing)				X
Sports tourism (e.g. golf)	X			
Theme Parks	X			
Water-based (lakes and rivers)	X			
Water-based (ocean)		X		
Wildlife viewing		X		
Adaptive capacities				
Airlines		X		
Attractions	X			
Coach and Bus		X		
Cruise ships	X			
Destination communities	X			
Hotels/resorts		X		

Factor	Very inadequate	Inadequate	Adequate	Very adequate
Industry associations	X			
Intermediaries	X			
Railways			X	
Small operators	X			
Tourists	X			
Transnationals		X		
Mitigation capacities				
Airlines			X	
Attractions		X		
Coach and Bus				X
Cruise ships				X
Destination communities	X			
Hotels/resorts				X
Industry associations	X			
Intermediaries		X		
Railways				X
Small operators		X		
Tourists		X		
Transnationals			X	
Adaptation and Mitigation innovations and strategies				
Adoption of innovations and strategies	X			
Behavioural change	X			
Education and information		X		
Energy conservation (designed)				X
Energy conservation (behavioural)		X		
Energy-efficient building construction				X
Extreme event risk insurance				X
Demarketing	X			
Diversification of market (destination)	X			
Diversification of market (firm)	X			
Diversification of product (destination)		X		
Diversification of product (firm)	X			
Finance and insurance			X	
GHG emission offset programmes		X		
Government assistance programmes		X		
Health risk			X	
Impact management planning		X		
Monitoring and evaluation			X	
Policy formulation		X		
Pricing/'Green' taxes		X		
Recycling				X
Site location			X	
Snowmaking				X
Transport technology improvements			X	
Water conservation and recycling (designed)				X
Water conservation and recycling (behavioural)		X		

findings with respect to the potential impacts of climate change on tourism it has indicated that the lack of knowledge in many areas, including primary tourism processes and systems, is severely constraining capacity to better understand the relationship between tourism and climate change (Table 6). In particular, it reinforces the need to improve understanding 'as to how direct and indirect impacts of climate change affect human behaviour with respect to recreation patterns and holiday destination choice (Henessy et al. 2007: 530). Undoubtedly, tourism will see changes in travel flows and patterns in the short, e.g. reduction in ski season, and long term, e.g., changed competitiveness of destinations because of changes in climate and high-magnitude events (Hamilton et al., 2005; Schneider et al. 2007; Scott et al. 2007a). However, it is extremely important that the research based advice available to policy makers and stakeholders in tourism moves beyond deterministic modelling and is based on a deeper understanding of tourism behaviours and flows.

It is also important that a better understanding of the adaptive capacities of destinations, environments and firms is developed and, where possible, that adaptations are charted over time so as to better transfer innovations from one location or firm to another as well gain a more accurate account of such capacities. For example, research on small tourism firms by Hall (2006c) in New Zealand and Finland (Saarinen and Tervo 2006) indicates that although firms may be seeking to both adapt and mitigate with respect to climate change other immediate and more pressing business needs mean that climate change cannot be a primary focus of business activity. Thereby potentially hindering firm and destination innovation with respect to climate change (Hall 2007).

As well as being subject to climate change tourism is also seen as a non-climatic stress. For example, with respect

to Latin America the IPCC comments 'The rapidly expanding tourism industry is driving much of the transformation of natural coastal areas, paving the way for resorts, marinas and golf courses' (Magrin et al. 2007: 587). Similarly, tourism is also regarded as a competitor in a number of locations for potentially scarce water resources (Gössling et al. 2002; Mimura et al. 2007). Increasingly, demands for biofuels for transport, including for leisure travel, may also be placing pressure on food production leading to competition between mobility for the world's rich and food for the world's poor (Vidal 2007). Therefore, a better understanding of tourism and its role in sustainability also needs to be generated with respect to its place in wider human and physical systems (Hall 2008).

This review has identified a number of significant knowledge gaps with respect to understanding tourism and climate change relationships. These gaps are important not only in terms of the sustainability of the tourism industry but also with respect to destination communities and the physical environment. Stern (2006) noted that climate change adaptation policies and measures, if implemented in a timely and efficient manner, can generate valuable co-benefits such as enhanced energy security and environmental protection. It is to be hoped that if the present review was to be repeated following the next IPCC assessment report then not only would a greater range of research have been conducted and acknowledged in scientific and policy terms, but that concrete steps will have been taken to climate change and security concerns.

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