

**Climate Change and Tourism:
Responding to Global Challenges**

Advanced Summary

October 2007

Table of contents

	Page
1. Introduction	1
2. The New Realities of Tourism in an Era of Global Climate Change	2
3. Impacts and Adaptation at Tourism Destinations	5
4. Implications of Climate Change for Tourism Demand Patterns	11
5. Emissions from Global Tourism: Status and Trends	12
6. Mitigation Policies and Measures	14
7. The Way Forward to Adaptation and Mitigation in Tourism	18

1. Introduction

This advanced summary is based on an extensive report commissioned to an international team of experts by the World Tourism Organization (UNWTO), the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO), in order to provide background information for the Second International Conference on Climate Change and Tourism (Davos, Switzerland, 1-3 October 2007).

The full report will be released after the Davos Conference, and it will include the Conference's key conclusions and recommendations as well. The report provides a synthesis of the state of knowledge about current and future likely impacts of climate change on tourism destinations around the world, possible implications for tourist demand, current levels and trends in GHG emissions from the tourism sector, and an overview of policy and management responses adopted by the key stakeholder groups (international organizations, public administrations, the tourism industry) with respect to adaptation to and mitigation of climate change.

This advanced summary and the full report to be released are principally aimed at the tourism industry and government organizations at the different levels, who will have the primary responsibility of developing mitigation and adaptation strategies to respond to the challenges that global climate change will bring to the tourism sector. The report will also constitute an important tool for international agencies, non-governmental organizations (NGOs) and financial institutions.

UNWTO, UNEP and WMO wish to thank the expert team involved in the preparation of this report:

Dr. Daniel Scott (Lead Author) - University of Waterloo, Canada

Dr. Bas Amelung - University of Maastricht, Netherlands

Dr. Susanne Becken - Lincoln University, New Zealand

Dr. Jean-Paul Ceron - Limoges University, France

Ghislain Dubois - TEC Conseil, France

Dr. Stefan Gossling - Lund University (Sweden), Western Norway Research Institute

Paul Peeters - Breda University, Netherlands

Dr. Murray C. Simpson - University of Oxford, England

2. The New Realities of Tourism in an Era of Global Climate Change

Compelling evidence indicates that global climate has changed compared to the pre-industrial era and is anticipated to continue to change over the 21st century and beyond. The Inter-governmental Panel on Climate Change (IPCC)¹ declared that 'warming of the climate system is unequivocal.' The global mean temperature has increased approximately 0.76°C between 1850–1899 and 2001–2005 and the IPCC¹ concluded that most of the observed increase in global average temperatures since the mid-20th century is 'very likely' (> 90% probability) the result of human activities that are increasing greenhouse gas concentrations in the atmosphere. Discernible human influences now also extend to other aspects of climate, including ocean warming, continental-average temperatures, temperature extremes and wind patterns.¹ Widespread decreases in glaciers and ice caps and warming ocean surface temperature have contributed to sea level rise of 1.8 mm per year from 1961 to 2003, and approximately 3.1 mm per year from 1993 to 2003. The biological response of ecosystems and individual species has been recorded on every continent.²

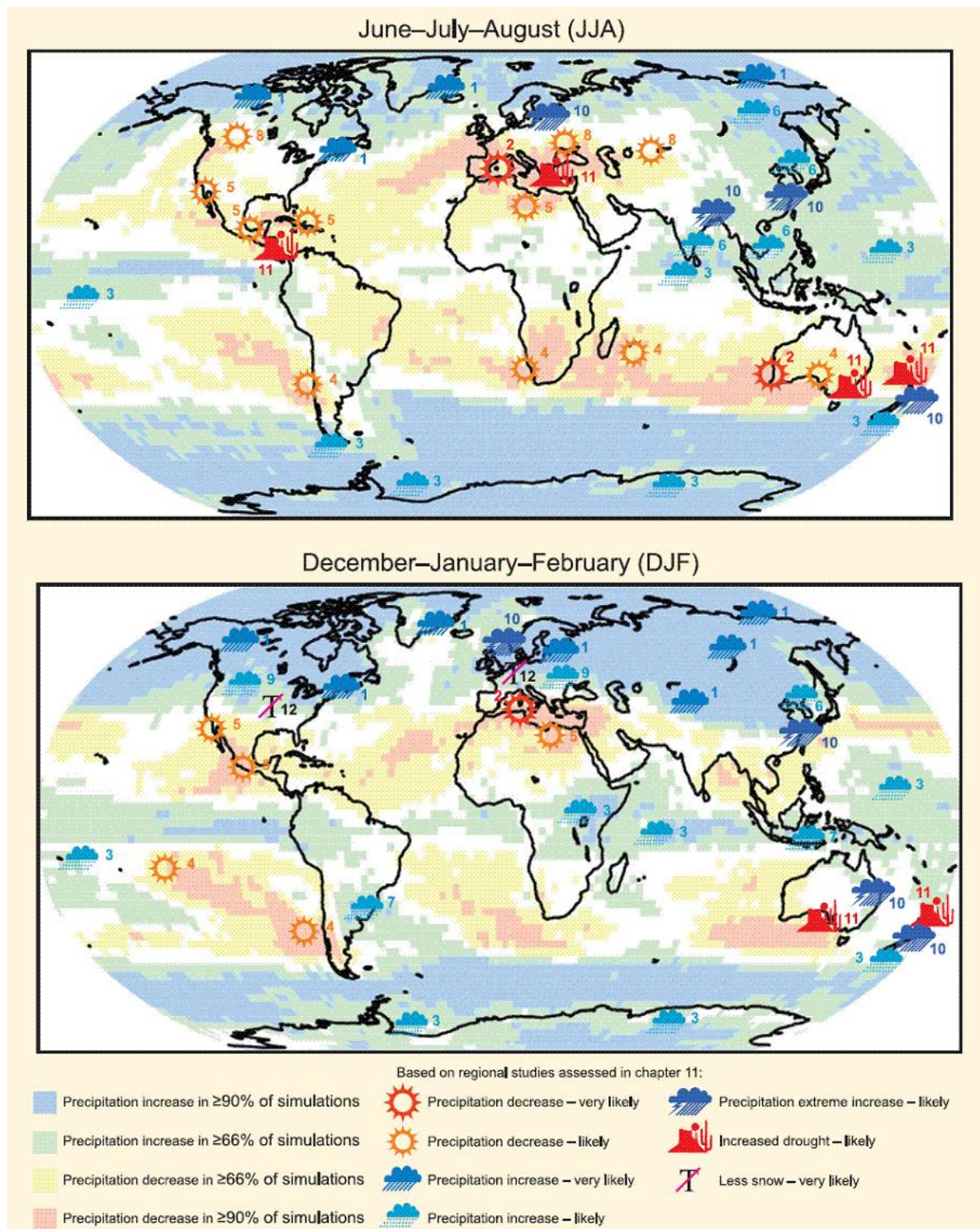
The IPCC has projected that the pace of climate change is 'very likely' (> 90% probability) to accelerate with continued greenhouse gas (GHG) emissions at or above current rates, with the best estimate that globally averaged surface temperatures will rise by 1.8°C to 4.0°C by the end of the 21st century.¹ Even if atmospheric concentrations of GHGs were stabilized at current levels, the Earth would continue to warm as a result of past GHG emissions and the thermal inertia of the oceans. The biological response to this continued warming and sea level rise would continue for several centuries.^{1,2}

Future changes in temperatures and other important features of climate will manifest themselves differently across the regions of the world (Figure 1). According to the IPCC, it is very likely that hot extremes, heat waves and heavy precipitation events will continue to become more frequent. It is likely that future tropical cyclones (typhoons and hurricanes) will become more intense, with larger peak wind speeds and more heavy precipitation associated with ongoing increases of tropical sea surface temperatures. There is less confidence in projections of a global decrease in numbers of tropical cyclones. The extension of the regions that will be primarily affected by these extreme events with major tourism destinations highlights the need for awareness and preparedness for natural hazards at the local level through systematic capacity building and strategies for disaster risk management. Extra-tropical storm tracks are projected to shift poleward, with consequent changes in wind, precipitation and temperature patterns, continuing the broad pattern of observed trends over the last half-century. Observed decreases in snow cover are also projected to continue.

The environmental and economic risks of the magnitude of climate change projected for the 21st century are considerable and have featured prominently in recent international policy debates.^{2,3,4} The IPCC concluded with very high confidence⁵ that climate change would impede the ability of many nations to achieve sustainable development by mid-century. The Stern Review⁴ on the Economics of Climate Change found that the costs of taking action to reduce GHG emissions now, are

much smaller than the costs of economic and social disruption from unmitigated climate change. Our lifestyles, economies, health and social well-being are all affected by climate change, and although the consequences of climate change will vary on a regional basis, all nations and economic sectors will have to contend with the challenges of climate change through adaptation and mitigation. Tourism is no exception and in the decades ahead, climate change will become an increasingly pivotal issue affecting tourism development and management.^{6,7,8,9,10,11}

Figure 1: IPCC Representation of Anticipated Regional Climate Change¹²



With its close connections to the environment and climate itself, tourism is considered to be a highly climate-sensitive economic sector similar to agriculture, insurance, energy, and transportation.¹³ The regional manifestations of climate change will be highly relevant for tourism destinations and tourists alike, requiring adaptation by all major tourism stakeholders. Indeed, climate change is not a remote future event for tourism, as the varied impacts of a changing climate are becoming evident at destinations around the world and climate change is already influencing decision-making in the tourism sector.

At the same time, the tourism sector is a non-negligible contributor to climate change through GHG emissions derived especially from the transport and accommodation of tourists.^{10,14} Tourism must seek to significantly reduce its GHG emissions in accordance with the international community, which at the 'Vienna Climate Change Talks 2007' recognized that global emissions of GHG need to peak in the next 10-15 years and then be reduced to very low levels, well below half of levels in 2000 by mid-century.¹⁵ The tourism sector cannot address the challenge of climate change in isolation, but must do so within the context of the broader international sustainable development agenda.^{2,16} The critical challenge before the global tourism sector is to develop a coherent policy strategy that decouples the projected massive growth in tourism in the decades ahead from increased energy use and GHG emissions, so as to allow tourism growth to simultaneously contribute to poverty alleviation and play a major role in achieving the United Nations Millennium Development Goals (MDG).

“Climate change as well as poverty alleviation will remain central issues for the world community. Tourism is an important element in both. Governments and the private sector must place increased importance on these factors in tourism development strategies and in climate and poverty strategies. They are interdependent and must be dealt with in a holistic fashion.”

UNWTO Secretary-General Francesco Frangialli - 2007

Tourism can play a significant role in addressing climate change if the innovativeness and resources of this vital global economic sector are fully mobilized and oriented towards this goal. The concern of the tourism community regarding the challenge of climate change has visibly increased over the last five years. The World Tourism Organization (UNWTO) and several partner organizations, including UNEP, convened the First International Conference on Climate Change and Tourism in Djerba, Tunisia in 2003. This event was a watershed in terms of raising awareness about the implications of climate change within the international tourism community. The Djerba Declaration recognized the complex inter-linkages between the tourism sector and climate change and established a framework for future research and policy making on adaptation and mitigation.⁶ A number of individual tourism industry associations and businesses have also shown leadership on climate change, voluntarily adopting GHG emission reduction targets, engaging in public education campaigns on climate change and supporting government climate change legislation.

"Far sighted action by the \$880 billion international tourism industry will send important signals to governments, industries and the public that mitigation and adaptation to the climate change challenge make economic and environmental sense. It is the kind of leadership that can encourage others to look not only to their exposure and to the risks posed by climate change, but also to the abundant opportunities and benefits of cost effective action".

Achim Steiner

UN Under-Secretary General and UNEP Executive Director

The scientific community has also responded, doubling the number of scientific publications that examine the interactions of tourism and climate change between 1996-2000 and 2001-2005¹⁷ and significantly advancing the place of tourism in the IPCC 4th Assessment Report (AR4) relative to previous assessments.¹⁸ In 2006, the World Meteorological Organization (WMO) established an Expert Team on Climate and Tourism in collaboration with the UNWTO, with the broad mandate to advance the application of weather and climate information in the tourism sector and understanding of the implications of climate change.

3. Impacts and Adaptation at Tourism Destinations

The tourism industry and destinations are clearly sensitive to climate variability and change.^{2,6,7,8,9} Climate defines the length and quality of tourism seasons and plays a major role in destination choice and tourist spending. In many destinations tourism is closely linked with the natural environment. Climate affects a wide range of the environmental resources that are critical attractions for tourism, such as snow conditions, wildlife productivity and biodiversity, water levels and quality. Climate also has an important influence on environmental conditions that can deter tourists, including infectious disease, wildfires, insect or water-borne pests (e.g., jellyfish, algae blooms), and extreme events such as tropical cyclones.

There are four broad categories of climate change impacts that will affect tourism destinations, their competitiveness and sustainability.

Direct climatic impacts: Climate is a principal resource for tourism, as it co-determines the suitability of locations for a wide range of tourist activities, is a principal driver of global seasonality in tourism demand, and has an important influence on operating costs, such as heating-cooling, snowmaking, irrigation, food and water supply, and insurance costs. Thus, changes in the length and quality of climate-dependent tourism seasons (i.e., sun-and-sea or winter sports holidays) could have considerable implications for competitive relationships between destinations and therefore the profitability of tourism enterprises. Studies indicate that a shift of attractive climatic conditions for tourism towards higher latitudes and altitudes is very likely.^{19,20,21} As a result, the competitive position of some popular holiday areas are anticipated to decline (e.g., the Mediterranean in summer), whereas other areas (e.g. southern England or southern Canada) are expected to

improve. Uncertainties related to tourist climate preference and destination loyalty require attention if the implications for the geographic and seasonal redistribution of visitor flows are to be projected. There are well established vulnerabilities among winter sports destinations to projected declines in natural snowfall. Even with increased snowmaking, contractions in the ski industry are very likely in the European Alps, Eastern and Western North America, Australia, and Japan, although projected impacts on destinations in these nations vary in magnitude and over different time horizons.^{22,23,24}

The IPCC¹ has concluded that changes in a number of weather extremes are probable as a result of projected climate change, including: higher maximum temperature and more hot days over nearly all land areas (very likely), greater tropical storm intensity and peak winds (likely), more intense precipitation events over many land areas (very likely), and longer and more severe droughts in many mid-latitude continental interiors (likely). Such changes will affect the tourism industry through increased infrastructure damage, additional emergency preparedness requirements, higher operating expenses (e.g., insurance, backup water and power systems, and evacuations), and business interruptions.

Indirect environmental change impacts: Because environmental conditions are such a critical resource for tourism, a wide-range of climate-induced environmental changes will have profound effects on tourism at the destination and regional level. Changes in water availability, biodiversity loss, reduced landscape aesthetic, altered agricultural production (e.g., wine tourism), increased natural hazards, coastal erosion and inundation, damage to infrastructure and the increasing incidence of vector-borne diseases will all impact tourism to varying degrees. In contrast to the varied impacts of a changed climate on tourism, the indirect effects of climate induced environmental change are likely to be largely negative. Mountain, island, and coastal destinations are considered particularly sensitive to climate-induced environmental change, as are nature-based tourism market segments.^{2,6,7,8,9} UNESCO has also identified several World Heritage Sites that are critical tourist destinations, to be vulnerable to climate-induced environmental change (e.g., Venice, Italy - sea level rise, Great Barrier Reef, Australia - coral bleaching and mortality, Glacier-Waterton International Peace Park, USA and Canada - glacier retreat, Chan Chan Archaeological Zone, Peru - El Niño-Southern Oscillation (ENSO) caused flooding and eroding).²⁵ While our understanding of the impacts of climate change for various destination types has improved since the Djerba Conference, it is important to emphasize that there remain major regional gaps in our knowledge of how climate change will affect the natural and cultural resources critical for tourism in Africa, the Caribbean, South America, the Middle East and large parts of East Asia.¹⁸

Impacts of mitigation policies on tourist mobility: National or international mitigation policies – that is policies that seek to reduce GHG emissions – are likely to have an impact on tourist flows. They will lead to an increase in transport costs and may foster environmental attitudes that lead tourists to change their travel patterns (e.g., shift transport mode or destination choices). There has been substantial recent media coverage on this topic, specifically as it relates to air travel. Long-haul destinations can be particularly affected and officials in Southeast Asia, Australia-New Zealand, and the Caribbean have expressed concern that mitigation policies

could adversely impact their national tourism economy.^{26.27.28} On the other hand, emission scenario projections developed for this report indicate that opportunities may arise for low carbon emission transport modes like coach and rail. This may also help to re-vitalize destinations that are nearer to the main markets.

Indirect societal change impacts: Climate change is thought to pose a risk to future economic growth and to the political stability of some nations.^{2.4.29.30} The Stern Report on the Economics of Climate Change concluded that although a global warming of only 1°C might benefit global GDP, greater climate change would eventually damage economic growth at the global scale, including the stark conclusion that unmitigated climate change could cause a reduction in consumption per capita of 20% later in the 21st century or early 22nd century.⁴ Any such reduction of global GDP due to climate change would reduce the discretionary wealth available to consumers for tourism and have negative implications for anticipated future growth in tourism; however there has been no in-depth interpretation of the Stern Report⁴ for the tourism sector.

‘Our actions over the coming few decades could create risks of major disruption to economic and social activity, later in this century and in the next, on a scale similar to those associated with the great wars and the economic depression of the first half of the 20th century.’

The Stern Report (2006)

Climate change is considered a national and international security risk that will steadily intensify, particularly under greater warming scenarios.^{30.31.32} Climate change associated security risks have been identified in a number of regions where tourism is highly important to local-national economies.^{29.30.32} Tourists, particularly international tourists, are averse to political instability and social unrest.^{33.34} and the negative tourism demand repercussions for the climate change security hotspots⁶ are very evident. A security-related decline in tourism would exacerbate deteriorating economic performance in these destinations, potentially undermining development objectives in some LDCs.^{11.35.36.37} However, this study has shown that the main markets are short haul and domestic tourism and it is strongly advised to consider short-haul tourism as the main economic engine for poor areas in the world and not only count on long haul international tourism. Short haul tourism tends to be less vulnerable to the world social context.

Destination Vulnerability Hotspots: The integrated effects of climate change will have far-reaching consequences for tourism businesses and destinations. Importantly, climate change will generate both negative and positive impacts in the tourism sector and these impacts will vary substantially by market segment and geographic region. The implications of climate change for any tourism business or destination will also partially depend on the impacts on its competitors. A negative impact in one part of the tourism system may constitute an opportunity elsewhere. Consequently, there will be ‘winners and losers’ at the business, destination and nation level. Figure 2 provides a summary assessment of the most at-risk tourism destinations for the mid- to late-21st century. Due to the very limited information available on the potential impacts of climate change in some tourism regions, this qualitative assessment must also be considered with caution. Until systematic

regional level assessments are conducted a definitive statement on the net economic or social impacts in the tourism sector will not be possible. Furthermore, the outcome most likely will depend on the extent of climate change. The impact on the tourism sector may strongly parallel that of the global economy, where a 1° C temperature rise may result in a net benefit for the world economy, but greater increases increasingly show net declines.⁴

Destination Level Adaptation: It is now recognised that regardless of the emissions reduction efforts, there is an inevitable need for societies around the world to adapt to unavoidable changes in climate.² It is essential to emphasize that regardless of the nature and magnitude of climate change impacts, all tourism businesses and destinations will need to adapt to climate change in order to minimize associated risks and capitalize upon new opportunities, in an economically, socially and environmentally sustainable manner.

Tourists have the greatest adaptive capacity (depending on three key resources: money, knowledge and time) with relative freedom to avoid destinations impacted by climate change or shifting the timing of travel to avoid unfavourable climate conditions. Suppliers of tourism services and tourism operators at specific destinations have less adaptive capacity. Large tour operators, who do not own the infrastructure, are in a better position to adapt to changes at destinations because they can respond to clients demands and provide information to influence clients' travel choices. Destination communities and tourism operators with large investment in immobile capital assets (e.g., hotel, resort complex, marina or casino) have the least adaptive capacity.

The dynamic nature of the tourism industry and its ability to cope with a range of recent major shocks, including SARS, terrorism attacks in a number of nations, or the Asian tsunami, suggests a relatively high adaptive capacity within the tourism industry overall. The capacity to adapt to climate change is thought to vary substantially between sub-sectors, destinations, and individual businesses within the tourism industry.^{7,8,9,38,39}

“It is vital for tourism destinations [...] to anticipate the coming changes and to draw their consequences, starting now. [Adaptation] is a long-term project that must be anticipated and carefully prepared beforehand; it is not easy to see this through successfully, because it entails, all at the same time, modifying economic circuits, introducing new technologies, carrying out intensive training, investing in the creation of new products, [...] changing the minds of public authorities, entrepreneurs, host communities and tourists.”

UNWTO Secretary-General Francesco Frangialli - 2007

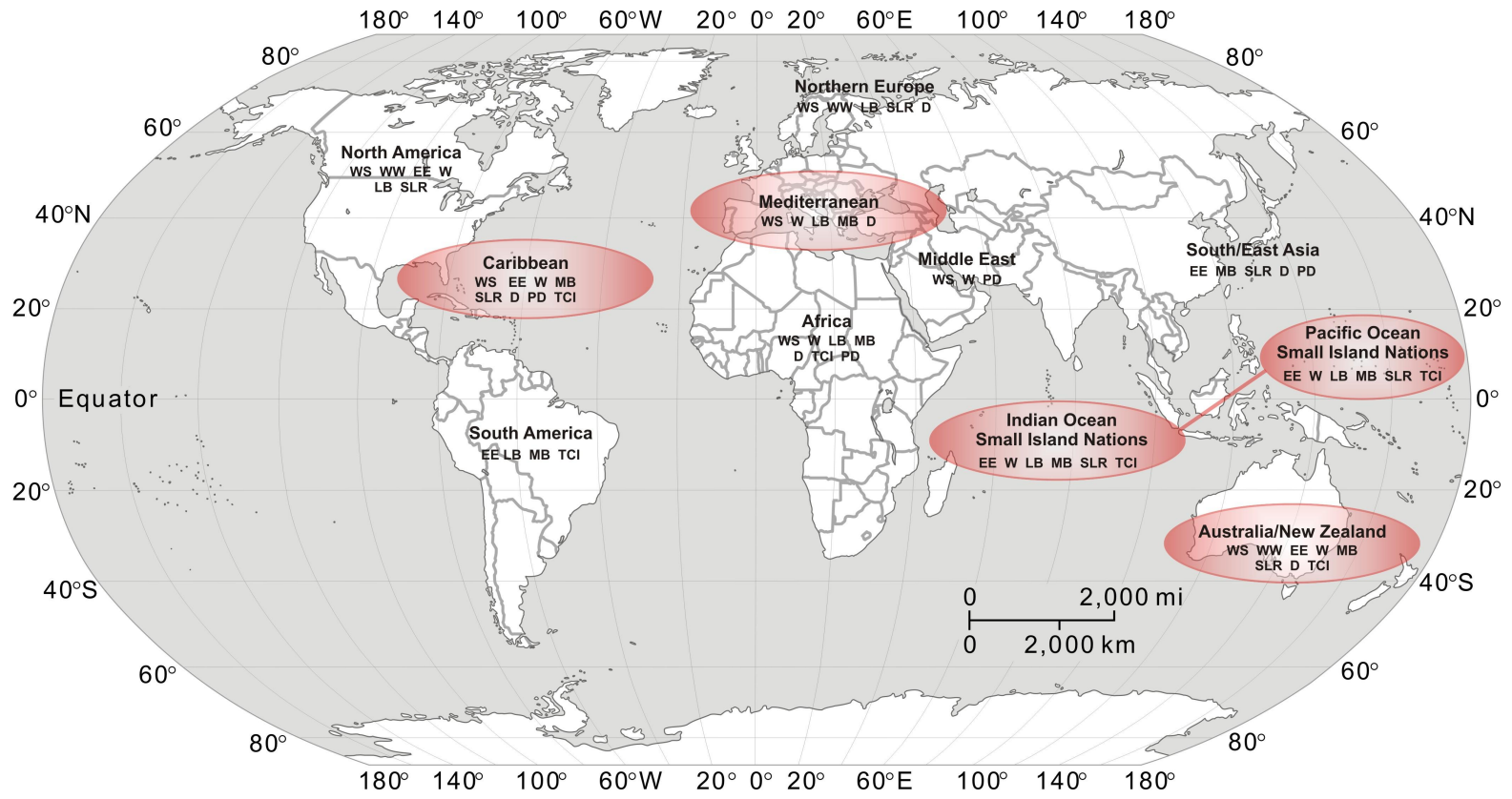
The tourism sector has been adapting its operations to climate zones world-wide, using a diverse range of technological, managerial, educational, policy and behavioural adaptations to deal with climate variability. However, adaptation has figured less prominently in climate change research on tourism than in some other economic sectors (e.g., agriculture). There has been a range of research activities

focusing on climate change impacts for destinations or specific tourism sectors (e.g., ski operations), but they generally have not identified properly the range of adaptation options available to tourism stakeholders. Due to a lack of integration of adaptation measures in impact analysis studies, the perspectives on projected impacts may be misleading.

Much more needs to be done to incorporate adaptation into future impact assessments in the tourism sector given its high adaptive capacity. Second, knowledge of the capability of current climate adaptations to cope successfully with future climate change remains rudimentary.⁴⁰ A important lesson learned from Hurricane Katrina and the extremely warm winter of 2006-2007 in the European Alps is that adaptations can be overwhelmed by events unexpected and beyond the range of experience of the tourism sector. Such events should be anticipated under climate change, and consequently there is a critical need for the tourism sector to evaluate the effectiveness of current adaptations under projected climate conditions. In an era of global climate change, it will no longer be sufficient to rely on past experience. The information requirements for effective, anticipatory climate change adaptation will be substantial and therefore adaptation is a critical area for future research.

Climate change is slowly entering into decision-making of a range of tourism stakeholders (e.g., investors, insurance companies, tourism enterprises, governments, and tourists); studies that have examined the climate change risk appraisal of local tourism officials and operators have consistently found relatively low levels of concern and little evidence of long-term strategic planning in anticipation of future changes in climate.^{35,37,39,41,42,43,44,45,46} There is also some evidence that local tourism operators may be overestimating their adaptive capacity (e.g., capacity to make snow under the warmest scenarios). The incorporation of adaptation to climate change into the collective minds of private and public sector tourism decision-makers ('mainstreaming') remains several steps away. Consequently, there is a real need for effective communication between the climate change science community and tourism operators at the regional and local scale, particularly with respect to the development of climate change scenarios and indicators catered toward local tourism decision-making.

Figure 2: Geographic Distribution of Major Climate Change Impacts Affecting Tourism Destinations ⁴⁶



WS = warmer summers	LB = land biodiversity loss	D = increase in disease outbreaks	
WW = warmer winters	MB = marine biodiversity loss	TCI = travel cost increase from mitigation policy	
EE = increase in extreme events	W = water scarcity		
SLR = sea level rise	PD = political destabilization		

4. Implications of Climate Change for Tourism Demand Patterns

Climate, the natural environment, and personal safety are three primary factors in destination choice, and global climate change is anticipated to have significant impacts on all three of these factors at the regional level. Tourists also have the greatest capacity to adapt to the impacts of climate change, with relative freedom to avoid destinations impacted by climate change or shifting the timing of travel to avoid unfavourable climate conditions. As such, the response of tourists to the complexity of destination impacts will reshape demand patterns and play a pivotal role in the eventual impacts of climate change on the tourism industry. Understanding and anticipating the potential geographic and seasonal shifts in tourist demand will remain critical areas of research in the future.

The evidence available from studies that have explored the potential impact of altered climate conditions for tourist demand suggests that the geographic and seasonal redistribution of tourist demand may be very large for individual destinations and countries by mid- to late-century.^{47,48} Anticipated impacts include a gradual shift in preferred destinations to higher latitudes and to higher elevations in mountainous areas. Tourists from temperate nations that currently dominate international travel (e.g., Northern Europe) are expected to spend more holidays in their home country or nearby, adapting their travel patterns to take advantage of new climatic opportunities closer to home. Tourism seasons will be altered with possibly more tourists travelling in shoulder seasons, or in winter seasons, as climate will be more appealing. This shift in travel patterns may have important implications, including proportionally more tourism spending in temperate nations and proportionally less spending in warmer nations now frequented by tourists from temperate regions. The direct effect of climate change might be significant enough to alter major intra-regional tourism flows where climate is of paramount importance, including Northern Europe to the Mediterranean and the Caribbean, North America to the Caribbean, and to a lesser extent North East Asia to Southeast Asia. However, the net effect of a change in climate on tourist demand at the global scale is expected to be limited, as there is no evidence to suggest that a change in climate will directly lead to a significant reduction of the global volume of tourism.

It is important to emphasize that it is the holistic impact of climate change on tourism environments that tourists will respond to, not just changes in climatic conditions.^{7,8} Tourism demand at the regional scale will also be affected by the range of indirect environmental and social impacts brought about by global climate change. The indirect impacts of global climate change are anticipated to influence tourist demand for specific destinations and perhaps at the regional level where political destabilization may occur, but not affect tourism demand at the global level, unless, as some economic analyses indicate,⁴ global economic growth were to be adversely affected by climatic change.

The perceptions of future impacts of climate change are likely to play the central role in the decision-making of tourists and tourism investors alike, as perceptions of climate conditions or environmental changes are just as important to consumer choices as the actual conditions. Perceptions of climate change impacts in a region are often heavily influenced by the nature of media coverage. Speculation and misinformation about the impacts of climate change on tourism destinations already abounds in the media, particularly with regard to the demise of the ski industry and extreme summer temperatures in the Mediterranean region.

The combination of increased awareness of the potential environmental impacts of air travel, as reflected in a number of recent public opinion polls^{48,49,50}, and national or international mitigation policies that increase the costs of travel, will also have important implications for shaping tourist demand. Current understanding of how price increases for travel may alter tourist mobility remains low. Past studies that have analysed the price sensitivity of air passengers, for example, show moderate⁵² inelasticity (-0.7).⁵³ Recent market surveys have also identified highly varied willingness to pay to offset the environmental consequences of air travel.^{50,51} The perception of transport, and in particular air travel, in relation to its carbon footprint is also likely to be an important influence on tourists' responses to price changes.

Information on tourist climate preferences and key thresholds (i.e., 'what is too hot for a beach holiday'), tourist perceptions of the environmental impacts of global climate change at destinations (i.e., perceptions of coral bleaching, diminished or lost glaciers, degraded coastlines, reduced biodiversity or wildlife prevalence), and tourist perceptions of the environmental impacts of tourism related travel and their willingness to pay to reduce this impact, remain important knowledge gaps that need to be addressed if potential long-range shifts in tourist demand are to be more accurately projected. There is also limited understanding of how climate change impacts will interact with other longer term social and market trends influencing tourism demand (e.g., globalization and economic fluctuations, fuel prices, aging populations in industrialized countries, increasing travel safety and health concerns, increased environmental and cultural awareness, advances in information and transportation technology).⁸

5. Emissions from Global Tourism: Status and Trends

The contribution of tourism to human-induced climate change has never been comprehensively assessed. This report represents the first attempt to calculate emissions of CO₂ from three main tourism sub-sectors – transportation, accommodations, and activities - as well as the contribution to radiative forcing (i.e. including all greenhouses gases) for the year 2005. 'Tourism' in this report refers to "the activities of persons traveling to and staying in places outside their usual environment for not more than one consecutive year for leisure, business and other purposes not related to the exercise of an activity remunerated from

within the place visited.”⁵⁴ Existing databases on tourism are not directly suitable for emission inventories, so the UNWTO Department of Statistics and Economic Measurement of Tourism prepared a specific database for this project with data provided for the baseline year of 2005.⁵⁵ In order to refine calculations of GHG emissions from the tourism sector and effectively monitor progress on GHG emission reductions in the future, a strategic reassessment of the current system of tourism statistics will be required so that appropriate data are collected at the necessary spatial and temporal resolutions.

While CO₂ is the most important greenhouse gas from human activities, other greenhouse gases also make significant contributions to global warming. In the tourism sector, this is particularly relevant for emissions from aviation, which, at flight altitude, has an enhanced impact on global warming. Radiative forcing is thus used to calculate the entire contribution of tourist (air) travel to global warming. Radiative forcing measures the extent to which emissions of greenhouse gases raise global average temperatures now or at a specified year in the future (estimates of tourism contribution to radiative forcing will be analyzed in the full report).

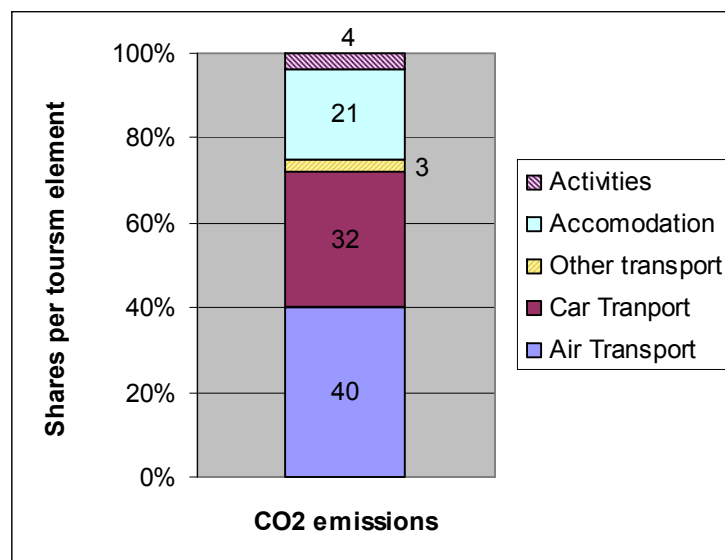
International and domestic tourism emissions from three main sub-sectors are estimated to represent between 4.0% and 6.0% of global emissions in 2005, with a best estimate of 5.0%.

Table 1: Emissions from Global Tourism in 2005 (including same-day visitors)⁵⁶

	CO ₂ (Mt)
Air transport	517
Other transport	468
Accommodation	274
Activities	45
TOTAL	1,307
Total world ¹	26,400
Share (%)	4.95

Table 1 shows the results of the emissions for world tourism in 2005. Figure 3 shows that in 2005 transport generated the largest proportion of CO₂ emissions (75%) from global tourism, with approximately 40% of the total being caused by air transport alone. Emissions from accommodation and activities were estimated to be substantially lower than transport emissions, but emissions from the accommodation sub-sector are also not negligible.

Figure 3: Contribution of Various Tourism Sub-sectors to CO₂ Emissions



The analysis also showed that emissions can vary greatly per tourist trip, between a few kilograms of CO₂ up to 9 t CO₂ for long-distance, cruise-based journeys. A globally averaged tourist journey is estimated to generate 0.25 t of CO₂ emissions. A small share of tourism trips was found to cause the main share of emissions: 17% of the aviation based trips cause 40% of all CO₂ emissions from tourism. Long haul travel by air between the five UNWTO world tourism regions represents only 2.7% of all tourist trips, but contributes 17% to global tourism-related CO₂ emissions. In contrast, trips by coach and rail account for 34% of all trips, but contribute only 13% of all CO₂ emissions. These results show that mitigation initiatives in the tourism sector will need to strategically focus on the impact of some particular forms of tourism (i.e. particularly those connected with air travel) if substantial reductions in CO₂ emissions are to be achieved. This also implies that climate change mitigation should primarily focus on a minor proportion of tourist trips.

6. Mitigation Policies and Measures

Climate change mitigation relates to technological, economic and socio-cultural changes that can lead to reductions in greenhouse gas emissions. Tourism-related emissions are projected to continue to grow rapidly under 'business as usual' conditions in contrast to the substantial emission reduction targets the international community agreed was required in the latest round of UNFCCC negotiations ('Vienna Climate Change Talks 2007'), where it was recognized that global emissions of GHG need to be reduced to well below half of the levels in 2000 by mid-century.¹⁵ Mitigation is thus of particular importance in tourism; however, mitigation policies need to consider a number of dimensions, such as

the need to stabilize the global climate, the right of people to rest and recover and leisure⁵⁷, and attaining the United Nations Millennium Development Goals. As the emission reductions required for tourism to contribute meaningfully to the broader emission reduction targets of the international community are substantial, mitigation should ideally combine various strategies, such as voluntary, economic, and regulatory instruments. These can be targeted at different stakeholder groups, including tourists, tour operators, accommodation managers, airlines, manufacturers of cars and aircraft, as well as destination managers. Instruments could also be applied with different emphasis in different countries, so as not to jeopardize the development and poverty reduction opportunity offered by tourism to countries in the South. It is clear that for those actors being pro-active in addressing climate change, mitigation offers a range of business opportunities. Given current societal trends, it seems that there will be new, permanent and growing markets for environmentally oriented tourists and many opportunities to develop new low-carbon tourism products.

Four major mitigation strategies for addressing greenhouse gas emissions from tourism can be distinguished: i) reducing energy use, ii) improving energy efficiency, iii) increasing the use of renewable energy, and iv) sequestering carbon through sinks. This report has systematically investigated the various options with regard to technological improvements, environmental management, economic and policy measures, and behavioural change, arriving at a number of conclusions:

1) Reducing energy use is the most essential aspect of mitigation, which can be achieved by altering destination development and marketing (tour operators), destination choices (tourists) as well as shifts in transport use from car and aircraft to rail and coach. Changing management practices can be of importance for business tourism (videoconferencing). Tour operators play a key role in this process, as they bundle products into packages that are advertised to and purchased by tourists. Tour operators can also increase length of stay, which would very effectively reduce the carbon footprint per tourist day and increase economic opportunities for destinations. It has to be considered however that current tourism trends show an increase of short stays. Overall, tour operators have a considerable influence on creating demand for less carbon intensive journeys by creating attractive products that meet tourists' needs and desires.

Regarding the most important sector, aviation, the industry favours emission trading over the taxation of fuel or emissions.⁵⁸ Aviation is likely to soon enter the European Union Emission Trading Scheme, which will increase the speed at which new technologies are introduced. An even better alternative might be to create an emissions trading scheme entirely for aviation. More efficient technology would be introduced faster, while the profitability of the aviation sector could grow rapidly, as prices for tickets can be increased despite stable costs for operating aircraft.

2) Improving energy efficiency can be another mechanism to decrease energy demand. New technology will significantly reduce the emissions of aviation in a 'business-as-usual' scenario, simply because it saves fuel-costs and improves aircraft performance. Reductions in emissions per pkm are likely to be in the order of 32% between 2005 and 2035.⁵⁹ Additional efforts to bring aviation technology to the theoretical limit (50% reduction of emission factors between 2005 and 2035), would contribute to an overall reduction of total emissions from tourist travel (excluding same-day, including all transport modes) by 14% with respect to the business-as-usual scenario. The same overall emissions reduction (14%) may be achieved with strong reductions in the accommodations sub-sector. New technology within car transport has a potential of reducing 7% of all tourist emissions. Note however, that the introduction of new air transport technology takes decades as the market introduction of new technologies is slow, because fleet renewal stretches over several decades due to the long operational life of aircraft. The more rapid introduction of new technologies is thus dependent on environmentally pro-active management decisions that need to be aided by government policy, such as emission trading.

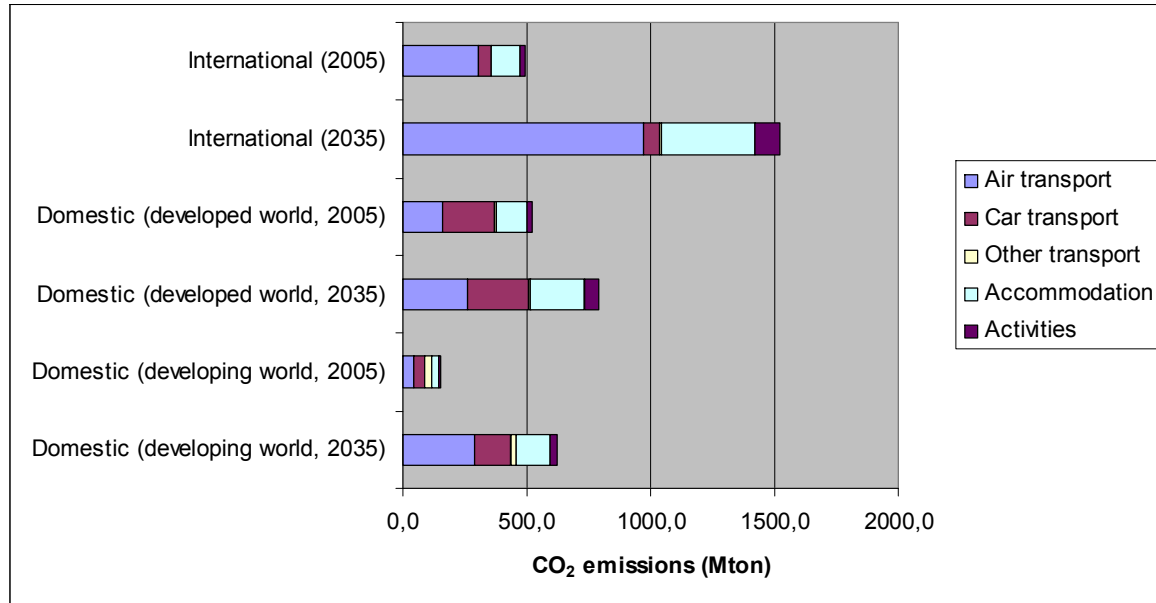
3) This study found that virtually all sources of renewable energy are relevant for tourism, including wind, photovoltaic, solar thermal, geothermal, biomass and energy regeneration from waste. Several studies have explored the extent to which renewable energy sources can be used for tourism, in particular in island destinations where energy supply based on fossil fuels is expensive and at risk of supply interruptions. These studies come to the conclusion that the use of renewable energy sources is generally economical and technically feasible.^{60,61} For example, in a vast number of destinations in the tropics, investments in solar energy can pay off in as little as two years. Biofuels are another option to contribute to more sustainable transport systems, even though it should be noted that several problems remain unsolved, particularly relating to the sustainability and efficiency of biofuel production and increasing competition over land, especially arable land area. Also the maximum share of biofuels for use in (all) transport is estimated at less than 10%.⁶²

4) CO₂ can also be stored in biomass (e.g. through afforestation and avoided deforestation), in aquifers or oceans, and in geological sinks (e.g. depleted gas fields). Within the tourism industry, this is currently practiced through carbon compensation or carbon offsetting, which means that an amount of greenhouse gas emissions equal to that caused by a certain activity (i.e. a flight), will be reduced elsewhere (i.e., through the planting of additional trees). There is still a lot of confusion among tourists about what carbon offsetting is⁶³ and there is also evidence that particularly hyper-mobile travellers, who account for the major share of the distances travelled and emissions caused, are not ready to support voluntary carbon offsets.^{64,65} There is also a risk that carbon offsetting, which has been initiated as a voluntary form of carbon reductions, is now becoming the means used by the industry to "reduce" emissions. This effectively means that producer responsibility is turned into customer responsibility, which may be problematic if no action to reduce fuel use is taken. As such, carbon offsetting

can be seen as a controversial solution to climate protection, because it potentially diverts from the real causes of the problems and therefore bypasses the structural and technological changes that need to be made to achieve long-term greenhouse gas reductions in the tourism sector. Nevertheless, carbon offsetting does have a role to play in future mitigation efforts in tourism.

In the framework of this report, the expert team developed several scenarios considering different mitigation options, in order to estimate how emission pathways in the global tourism sector might develop in the future. In case of the 'business as usual' scenario (which takes into account the UNWTO forecast of a 4% annual growth of international tourist arrivals) it was estimated that CO₂ emissions in the global tourism sector may experience a growth of 152% by 2035 (see Figure 4).

Figure 4: Projected CO₂ Emissions Under a 'Business as Usual' Scenario (excluding same-day visitors).



For example, the analysis estimated that emissions may be reduced through the following combination of changed assumptions with respect to a business-as-usual scenario for 2035:

- If maximum assumed technological efficiencies were achieved for all transport modes, accommodations and activities, this may result in 36% lower emissions.
- Reducing energy use by a combination of transport modal shifts, shifts to shorter haul destinations and increasing average length of stay may result in emission reductions by 43%.

Considering the projected dynamic growth of tourism activities, there is a large task ahead if tourism is to reduce its emissions to the same extent as other economic sectors. For an effective reduction of emissions, the tourism sector needs to apply a combination of mitigation measures. Under the most effective mitigation projection, using a combination of both above measures, the business-as-usual scenario emissions in 2035 could be reduced by 68%⁶⁶, thus achieving a 16% reduction of emissions with respect to the emissions in 2005.

7. The Way Forward to Adaptation and Mitigation in Tourism

Concern about climate change is increasing world-wide and the IPCC has made it clear that global climate change is only just beginning. The impacts of climate change on the tourism sector will steadily intensify, particularly under higher emission scenarios. Climate change would redistribute climate resources for tourism geographically and seasonally and poses a risk to ecosystems around the world. The nature and intensity of climate change impacts will differ for tourism destinations around the world. The most vulnerable regions are in developing countries, which generally also have less adaptive capacity², and this will be a particular challenge for their tourist destinations and their host communities. Climate change impacts on the tourism sector could influence other economic sectors, such as agriculture and local business networks supplying tourism. Conversely, the tourism sector must also be cognizant of the implications of climate change adaptation in other economic sectors, which could have significant impacts on tourism. As the financial sector incorporates a company's climate change strategy, or lack of one, into its investment criteria, it will influence credit rating and insurance rates. Climate change mitigation requires the transformation of energy and transportation systems worldwide, with implications for the cost of travel and tourist mobility. Climate change also has the potential to have an adverse effect on the global economy and poses a security risk in some regions. Consequently, climate change is anticipated to have profound implications that could fundamentally transform aspects of the global tourism sector.

The unmistakable conclusion of this report is that the significance of climate change to tourism is not in some distant and remote future. Climate change is already influencing decision-making within the tourism sector, including tourists, forward looking tourism businesses and investors, and international tourism organizations. The next generation of tourism professionals will need to contend with virtually all of the broad range of impacts outlined in this report.

“Given that climate change is expected to pose an increasing threat to tourism operations in many destinations [...], WMO urges governments and the private sector to increasingly use climate information[...], and to take additional steps towards incorporating climate considerations in tourism policies, development and management plans.”

WMO Secretary-General M. Michel Jarraud - 2007

Tourism can and must play a significant role in addressing climate change as part of its broader commitment to sustainable development and the United Nations Millennium Development Goals. Tourism as a non-negligible contributor to climate change has the responsibility to reverse the growth trajectory of its GHG emissions over the next three decades to a more sustainable emissions pathway consistent with the actions of the international community. The climate change mitigation potential is thought to be relatively high in the tourism sector because efforts to lower energy consumption and GHG emissions in the sector are still largely in their infancy and thus far have been generally taken without any vision of a coordinated sector-wide strategic response.¹¹ Also in this study it is shown that several combinations of strong efforts, including decoupling of the growth of tourism from the growth of tourism transport volumes and technological innovation, may significantly reduce emissions in 2035, without jeopardizing the growth of world tourism in number of trips or guest-nights.

Regardless of the success to reduce GHG emissions by the international community, there will undoubtedly also be costs associated with climate change adaptation.⁴ These costs cannot be borne solely by those affected, especially as those most affected are likely to be those less able to take action to cope with the changes (e.g. LDCs, SIDS and local tourism SMMEs). The capacity of the tourism sector to adapt to climate change is thought to be relatively high due to its dynamic nature and therefore there will be important opportunities for tourism to reduce the vulnerability of communities to climate change.

The United Nations Secretary General Ban Ki-moon has called for action by the international community on climate change to be taken in close coordination with action on poverty alleviation and the Millennium Development Goals. The IPCC further contends that there are significant synergies that can be exploited in bringing climate change to the development community and critical development issues to the climate change community. There is an important opportunity for the tourism sector to show leadership in the development of a coherent policy agenda that integrates both development and climate change perspectives.

This is the time now for the tourism community to collectively formulate a strategy to address what must be considered the greatest challenge to the sustainability of tourism in the 21st century.

References

- (1) Intergovernmental Panel on Climate Change (2007a). Summary for Policymakers. In: S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor & H.L. Miller (Eds.), *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press.
- (2) Intergovernmental Panel on Climate Change (2007b). Summary for Policymakers. In: M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden & C.E. Hanson (Eds.), *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge, United Kingdom & New York, NY, USA: Cambridge University Press.
- (3) Intergovernmental Panel on Climate Change (2007c). *Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [B. Metz, O. R. Davidson, P.R. Bosch, R. Dave, L. A. Meyer (Eds.)]. Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press.
- (4) Stern, N. (2006). *The Economics of Climate Change: The Stern Review*. Cambridge, UK: Cambridge University Press.
- (5) Yohe, G.W., Lasco, R.D., Ahmad, Q.K., Arnell, N.W., Cohen, S.J., Hope, C., Janetos A.C. & Perez, R.T. (2007). Perspectives on climate change and sustainability. In: M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden & C.E. Hanson (Eds.), *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* (p.811-841). Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press.
- (6) United Nations World Tourism Organization (2003). *Climate Change and Tourism: Proceedings of the First International Conference on Climate Change and Tourism, Djerba, Tunisia, 9-11 April 2003*. Madrid: World Tourism Organization.
- (7) Gossling, S. & Hall, C.M. (2006). An introduction to tourism and global environmental change. In: S. Gossling & C.M. Hall (Eds.), *Tourism and Global Environmental Change* (p.1-34). London: Routledge.
- (8) Scott, D. (2006). Climate change and sustainable tourism in the 21st century. In: J. Cukier (Ed.), *Tourism Research: Policy, Planning, and Prospects* (p.175-248). Waterloo: Department of Geography Publication Series, University of Waterloo.
- (9) Becken, S. & Hay, J. (2007). *Tourism and climate change – risks and opportunities*. Cleveland: Channel View Publications.
- (10) Peeters, P. (2007). *Tourism and Climate Change Mitigation – Methods, Greenhouse Gas Reductions and Policies*. NHTV Academics Studies No. 6. NHTV. Breda, The Netherlands: Breda University.
- (11) United Nations World Tourism Organization (2007). *Tourism Development and Climate Change: Understanding, Anticipating, Adapting, Participating in the Common Effort*. <http://www.un.org/apps/sg/sgstats.asp?nid=2603>.
- (12) Christensen, J.H., B. Hewitson, A. Busuioc, A. Chen, X. Gao, I. Held, R. Jones, R.K. Kolli, W.-T. Kwon, R. Laprise, V. Magaña Rueda, L. Mearns, C.G. Menéndez, J. Räisänen, A. Rinke, A. Sarr and P. Whetton, 2007: Regional Climate Projections. In: *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
- (13) Wilbanks, T.J., Romero Lankao, P., Bao, M., Berkhout, F., Cairncross, S., Ceron, J-P., Kapshe, M., Muir-Wood, R. & Zapata-Marti, R. (2007). Industry, settlement and society. In: M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden & C.E. Hanson (Eds.), *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* (p.357-390). Cambridge, United Kingdom & New York, NY, USA: Cambridge University Press.
- (14) Gossling, S. (2002). Global environmental consequences of tourism. *Global Environmental Change*, 12 (4), 283-302.
- (15) The 'Vienna Climate Change Talks 2007' represent the latest international negotiations on GHG emission reductions under the auspices of the United Nations Framework Convention on Climate Change. www.unis.unvienna.org/unis/pressrels/2007/unisinf230.html
- (16) United Nations (2007b). Climate change and development must be tackled together –Ban Ki-moon. *UN News Centre*, 9 May 2007. <http://www.un.org/apps/news/story.asp?NewsID=22498&Cr=commission&Cr1=sustainable>.
- (17) Scott, D., Jones, B., & McBoyle, G. (2005). *Climate, Tourism and Recreation: A Bibliography -1936 to 2005*. Waterloo, Canada: University of Waterloo.

- (18) Amelung, B., Moreno, A., & Scott, D. (2008-in press). The place of tourism in the IPCC fourth assessment report: a review. *Tourism Review International*.
- (19) Scott, D., McBoyle, G., & Schwartztruber, M. (2004). Climate change and the distribution of climatic resources for tourism in North America. *Climate Research*, 27 (2), 105-117.
- (20) Amelung, B., & Viner, D. (2006). Mediterranean tourism: exploring the future with the tourism climatic index. *Journal of Sustainable Tourism*, 14 (4), 349-366.
- (21) Amelung, B., Nicholls, S. & Viner, D. (2007). Implications of global climate change for tourism flows and seasonality. *Journal of Travel Research*, 45 (3), 285-296.
- (22) Scott, D. (2006b). Global environmental change and mountain tourism. In: S. Gossling and C. M. Hall (Eds). *Tourism and Global Environmental Change* (p. 54-75). London: Routledge.
- (23) Abegg, B., Agrawala S., Crick F. & de Montfalcon, A. (2007). Climate change impacts and adaptation in winter tourism. In: S. Agrawala (Ed.), *Climate change in the European Alps: adapting winter tourism and natural hazards management* (p.25-60). Paris: Organization for Economic Co-operation and Development.
- (24) Scott, D., McBoyle, G., & Minogue, A. (2007). Climate change and Québec's ski industry. *Global Environmental Change*, 17 (2), 181-190.
- (25) UNESCO World Heritage Centre (WHC) (2007). *Case Studies on Climate Change and World Heritage*. Paris, France: UNESCO World Heritage Centre.
- (26) Lawrence Bartlett (2007) Australia Fears Jet Flight Guilt Could Hit Tourism, Agence France-Presse, 18 April 2007.
- (27) Boyd, A. (2007) Carbon tax threatens to ground Asia tourism. Asian Times Online. http://www.atimes.com/atimes/Asian_Economy/ID19Dk01.html.
- (28) Caribbean Hotel Association and Caribbean Tourism Organization (2007) CHA-CTO Position Paper of Global Climate Change and the Caribbean Tourism Industry. <http://www.caribbeanhotels.org/ClimateChangePosition0307.pdf>
- (29) Barnett, J. (2001). *Security and Climate Change*. Tyndall Centre Working Paper No. 7. http://www.tyndall.ac.uk/publications/working_papers/wp7.pdf
- (30) German Advisory Council on Global Change (2007). *World in transition: climate change as a security risk*. Berlin, Germany: German Advisory Council on Global Change.
- (31) Liotta, P., H. & Shearer, A.W. (2005). *The Use of Scenarios in Assessing Climate Change, Human Security, and Potential Outcomes*. Pell Center for International Relations and Public Policy. <http://www.cicero.uio.no/humsec/papers/Liotta-Shearer.pdf>
- (32) Feakin, T. (2005). *Climate change and the threat to global security*. Royal United services Institute for Defence and Security Studies. http://www.rusi.org/downloads/assets/HSM_05_p12-13_Climate.pdf.
- (33) Hall, C.M., Timothy, D., & Duval, D. (2004) Security and Tourism: Towards a New Understanding? *Journal of Travel & Tourism Marketing*, 15, (2/3), 1-18.
- (34) Sonmez, S. (1998) Tourism, terrorism, and political instability. *Annals of Tourism Research*, 25, (2), 416-456.
- (35) Becken, S. (2004). *Climate change and tourism in Fiji: Vulnerability, adaptation and mitigation*. Final Report. Suva, Fiji: University of the South Pacific.
- (36) Mitchell, T. & Tanner, T. (2006). *Adapting to Climate Change: Challenges and opportunities for the development community*. Tearfund Report. Institute of Development Studies. <http://www.ids.ac.uk/ids/pvty/climatechange/pdfs/adaptingtoclimatechange.pdf>.
- (37) Simpson, M.C. (2008-in press). Global Climate Change and the Implications for Tourism Resilience in Small Island Developing States (SIDS). In: *Building Tourism Resilience in SIDS: Maximising Economic Benefits and Sustaining Tourism Development*. The Bahamas: SIDS Tourism Organization.
- (38) Wall, G. (1992). Tourism alternatives in an era of global climate change. In V. Smith & W. Eadington (Eds.), *Tourism Alternatives* (194-236). Philadelphia: University of Pennsylvania.
- (39) Elsasser, H. & Bürki, R. (2002). Climate change as a threat to tourism in the Alps. *Climate Research*, 20, 253-257.
- (40) Scott, D., de Freitas, C., & Matzarakis, A. (2008-in press). Climate change adaptation in the recreation and tourism sector. In: K. Ebi and P. Hoeppe (Eds.), *Biometeorology For Adaptation*. New York: Springer.
- (41) Scott, D., Jones, B., Lemieux, C., et al (2002) The vulnerability of winter recreation to climate change in Ontario's Lakelands tourism region. Department of Geography Publication Series Occasional Paper 18, University of Waterloo, Waterloo, Ontario, Canada.
- (42) Raksakulthai, V. (2003). *Climate change impacts and adaptation for tourism in Phuket, Thailand*. Pathumthani, Thailand: Asian Disaster Preparedness Centre.
- (43) Scott, D., Jones, B. & Abi Khaled, H. (2005) *Climate change: a long-term strategic issue for the National Capital Commission (Tourism and Recreation Business Lines) – Executive Summary*. Report prepared for the National Capital Commission. Waterloo, Canada: University of Waterloo.

- (44) Sievanen, T., Tervo, K., Neuvonen, M., Pouta, E., Saarinen, J., Peltonen, A. (2005) Nature-based tourism, outdoor recreation and adaptation to climate change. FINADAPT Working Paper 11. Helsinki: Finnish Environment Institute.
- (45) Wolfsegger, C., Gossling, S., & Scott, D. (2008–in press). Climate change risk appraisal in the Austrian ski industry. *Tourism Review International*.
- (46) Key destination vulnerabilities are identified at the sub-regional scale in the full technical report.
- (47) Hamilton, J. M., Maddison, D., & Tol, R.S. (2005). Effects of climate change on international tourism. *Climate Research*, 29, 245–254.
- (48) Berritella, M., Bigano, A., Roson, R., & Tol, R. (2006). A general equilibrium analysis of climate change impacts on tourism. *Tourism Management*, 27, 913-924.
- (49) UK Department of Transport. <http://www.dft.gov.uk/pgr/statistics/datatablespublications/trsnstatsatt>
- (50) Conference Board of Canada (2007). Travellers Keen on Going Green. *Tourism Intelligence Bulletin*, 39, May 2007.
- (51) United Kingdom Department for Transport (2007). *Public attitudes towards climate change and the impact of transport*. <http://www.dft.gov.uk/pgr/statistics/datatablespublications/trsnstatsatt/publicexperiencesofandattitu1824?page=0null>.
- (52) Njegovan, N. (2006) Elasticities of demand for leisure air travel: A system modelling approach. *Journal of Air Transport Management*, 12, 33-39.
- (53) Gillen, A. (2004). *Air Travel Demand Elasticities: Concepts, Issues and Measurements*. Ottawa: Department of Finance Canada.
- (54) As defined by the the UNWTO/United Nations Recommendations on Tourism Statistics.
- (55) Note that this database contains estimates, as not all data needed for calculations are available. For instance, there are only estimates for domestic tourism, whose volume is several times larger than international tourism, particularly in large nations like the United States, Russia, China and Canada.
- (56) The colour of each grid cell in the table represent the degree of certainty with respect to the data and underlying assumptions. Green represents a degree of uncertainty of +/-10%, blue +/-25% and red +100%/-50%.
- (57) The universal right to tourism must be regarded as the corollary of the right to rest and leisure, including reasonable limitation of working hours and periodic holidays with pay, guaranteed by Article 24 of the Universal Declaration of Human Rights and Article 7.d of the International Covenant on Economic, Social and Cultural Rights; (<http://www.gdrc.org/uem/eco-tour/principles.html>)
- (58) <http://www.icao.int/env/>
- (59) Peeters, P. M. & Middel, J. (2006). Historical and future development of air transport fuel efficiency. *Transport and Climate Change (TAC) Conference*, 25-29 June 2006, Oxford.
- (60) Uemura, Y., Kai, T., Natori, R., Takahashi, T., Hatate, Y. & Yoshida, M. (2003). Potential of renewable energy sources and its applications in Yakushima Island. *Renewable Energy*, 29, 581-591.
- (61) Cavallaro, F. & Ciruolo, L. (2005). A multicriteria approach to evaluate wind energy plants on an Italian island. *Energy Policy*, 33, 235-244.
- (62) Bergsma G., Kampman, B., Croezen, H. & Sevenster, M. (2007). *Biofuels and their global influence on land availability for agriculture and nature: A first evaluation and a proposal for further fact finding*. Delft, The Netherlands: CE.
- (63) Becken, S. (2004). How tourists and tourism experts perceive climate change and forest carbon sinks. *Journal of Sustainable Tourism*, 12 (4), 332-345.
- (64) Becken, S. (2007). Climate change policies for international air travel – a tourist perspective. *Journal of Sustainable Tourism*, 15 (4), 351-368.
- (65) Gössling, S., Hultman, J., Haglund, L., Källgren, H. And Revahl, M. (2008-in press). Voluntary carbon offsetting by Swedish Air Travellers: Opportunities and Obstacles. *Current Issues in Tourism*.
- (66) This figure is less than the sum of the impact of both projections given in the two bullet points, because the different assumed changes interact with each other and sometimes reducing the mutual impact.