TPCC

TOURISM PANEL ON CLIMATE CHANGE







Tourism and Climate Change Stocktake 2023

Foreword

We are pleased to present this first Tourism and Climate Change Stocktake, after a year of extensive international collaborations related to the state of tourism and the climate crisis. It follows the TPCC Foundation Report introduced during COP27 in November 2022.

This Stocktake was undertaken by over 60 global experts who assessed progress and gaps in critical dimensions of tourism climate action, including mitigation, adaptation, policy, and finance. The key findings, distilled and highlighted within each chapter, collectively indicate that the entire tourism sector needs to go further and faster to rapidly reduce tourism emissions, accelerate climate resilient tourism development, and advance inter-sectoral and international collaboration to support the transformative response needed to achieve the goals of the Paris Climate Agreement.

At present, no country, no destination, and no sub-sector have achieved meaningful reductions in tourism greenhouse gas emissions. The many signs of progress, good practice and innovation identified in the Stocktake need to be urgently scaled. Overall, observed action and incremental change is insufficient to achieve the climate goals articulated in the Glasgow Declaration on Tourism and Climate Action of halving emissions by 2030, and achieving net zero GHG emissions by 2050, or earlier. At the same time, the intensification of observable impacts of climate change on tourism destinations is unmistakeable. Few tourism authorities have focused adequately on the potentially massive impacts of climate hazards and the paradigm shift that will be required in the transition to climate resilient tourism development.

The findings raised many challenging questions about the future of tourism in a climate resilient and net-zero emissions world. To what extent does tourism need to be decoupled from difficult-to-mitigate air travel? What are the climate justice implications of such a decoupling and other proposed tourism mitigation policies, including the production and allocation of Sustainable Aviation Fuels? What is the reputational risk and consumer response of falling short of sector emission reduction goals? How do we keep tourists and tourism workers safe from worsening and more frequent climate hazards? Where compounding climate change impacts severely degrade current forms of tourism in communities and countries dependent on international tourism, what mechanisms could support a just transition for developing countries and those with lost tourism industry? How can co-benefits of tourism sector adaptation enhance climate resilient development in destinations around the world, but particularly in highly vulnerable low-income countries? What governance arrangements are needed to rapidly redirect climate finance to support climate resilient tourism development? How can climate compatible practice and tourism development be scaled up to become sector-wide standard?

Climate action in tourism is heavily influenced by other sectors, and tourism can do more to leverage its advocacy power within climate governance to accelerate solutions and avoid unintended consequences. The complexity of advancing climate action in tourism, whilst recognising tourism dependency in some countries and tourism contributions to biodiversity protection, requires an integrated approach involving multi-sector policy coordination and partnerships between public and private sectors. Tourism administrations must strengthen the collaboration with agencies leading the climate response in energy, transport and infrastructure systems, ecosystem management, and risk reduction and response. Partnerships will also be necessary to achieve adequate levels of climate finance for tourism climate action. Redirection of public sector funds towards investments that support low GHG, climate resilient tourism is imperative.

In 2023, the world witnessed an extraordinary succession of broken climate records, causing widespread and profound impacts on ecosystems and society. This moment compels a proportionate response from the tourism community, and we hope the new collaborations and foresight emerging from this Stocktake provide a stimulus toward a new era of climate resilient global tourism.

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TPCC Executive Board December 2023

The Tourism Panel on Climate Change (TPCC)

TPCC Vision

Our vision is a new era of climate resilient global tourism that is on track to achieve net zero emissions by 2050 and is successfully adapting to the accelerating impacts of climate change through actions that broadly advance the Sustainable Development Goals.

TPCC Mission

Our mission is to inform and rapidly advance science-based climate action across the global tourism system in support of the goals of the Paris Climate Agreement.

Experts

Connecting more than 60 leading experts from over 30 countries and from across academia, business and civil society to catalyse science-based tourism climate action in pursuit of the Paris Climate Agreement goals.

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TPCC

The TPCC is coordinated by the Green Growth and Travelism Institute, Belgium.

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Why a Tourism Stocktake?

Tourism is a vital component of the global economy, and one of the largest export sectors, directly and indirectly supporting one in 10 jobs.[1] The sector was hit hard by the COVID-19 pandemic but is now recovering rapidly. In 2022, domestic visitor spending reached 86% of 2019 levels. International expenditure reached US$1 trillion in 2022 (64% of pre-pandemic levels), and international arrivals recovered to 80% in the first quarter of 2023.[2]

In addition to economic impacts, travel and tourism contribute to individual and community wellbeing, and to nature conservation. For many countries, tourism presents an important pathway for development. At the same time, tourism is a major contributor to greenhouse gas (GHG) emissions, notably where international and longer-haul travel are involved. It is also vulnerable to various climate change impacts, including extreme weather events, sea level rise and ecosystem and species loss.[3] Some forms and large volumes of tourism can lead to significant negative social and cultural impacts on destinations.

1.1 About this Tourism Stocktake

1.1.1 Purpose and Audience

This Stocktake is intended to inform tourism policy-makers and actors in industry, civil society and science who operate within or in partnership with the tourism sector to achieve progress on climate action and provide strategic insight for planning and investment in climate resilient tourism (see Box 1). Climate change policy-makers will also benefit from sectoral information to better integrate tourism into national and global climate agendas.

The Stocktake provides indicators in the form of metrics that track key connections between climate change and tourism, including the sector's commitments in support of Paris Climate Agreement goals. The Paris Agreement Article 2 stipulates 'holding the increase in the global average temperature to well below 2˚C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5˚C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change'. The 40 metrics introduced in this Stocktake are not equally underpinned by robust or timeseries data, but they do provide a first comprehensive framework on which to base assessment of the tourism sector's progress on climate action. Criteria for metric selection included: (1) meaningful and policy-relevant; (2) scientifically accepted; (3) reliable and updatable; and (4) geographically representative globally or nationally, or for specific destination types.

Box 1 What is Climate Resilient Development?

The Intergovernmental Panel on Climate Change (IPCC) defines climate resilient development (CRD) as 'a process of implementing greenhouse gas mitigation (GHG) and adaptation options to support sustainable development for all'.[4] It emphasises the interdependence of climate action and sustainable development, the intersection between mitigation and adaptation, and the importance of agency and just societal transitions.

1.1.2 Process

A rigorous and open process was developed to ensure that the most authoritative and robust information was used to inform this Stocktake. Expert working groups were formed and multiple rounds of peer review ensured accuracy of data, interpretation of findings and key messages. The following steps formed part of the process:

- January 2023: Review of literature to create long list of potential indicators, grouped into five themes (emissions, mitigation, impacts, adaptation, policy).
- February 2023: Lead Expert agreement on Stocktake structure and approach, and evaluation of shortlist of indicators.
- April 2023: Formation of three Lead Expert working groups to finalise indicators and metrics, with input from Contributing Experts.
- July 2023: Expert workshop on metric analyses, key findings, gaps and new research priorities.
- September 2023: Draft report peer reviewed by Lead and Contributing Experts.

The Stocktake begins with an overview of tourism trends that are key drivers of climate outcomes (Chapter 1), followed by an assessment of progress on sector mitigation (Chapters 2 and 3) and adaptation (Chapter 4). Key enablers, including tourism climate policy (Chapter 5), climate finance (Chapter 6) and climate awareness and capacity-building (Chapter 7), are examined before a final chapter provides a synopsis of expert perspectives on the state of climate action as well as key challenges and recommendations for advancing climate resilient tourism. A total of 24 key findings are highlighted throughout the report.

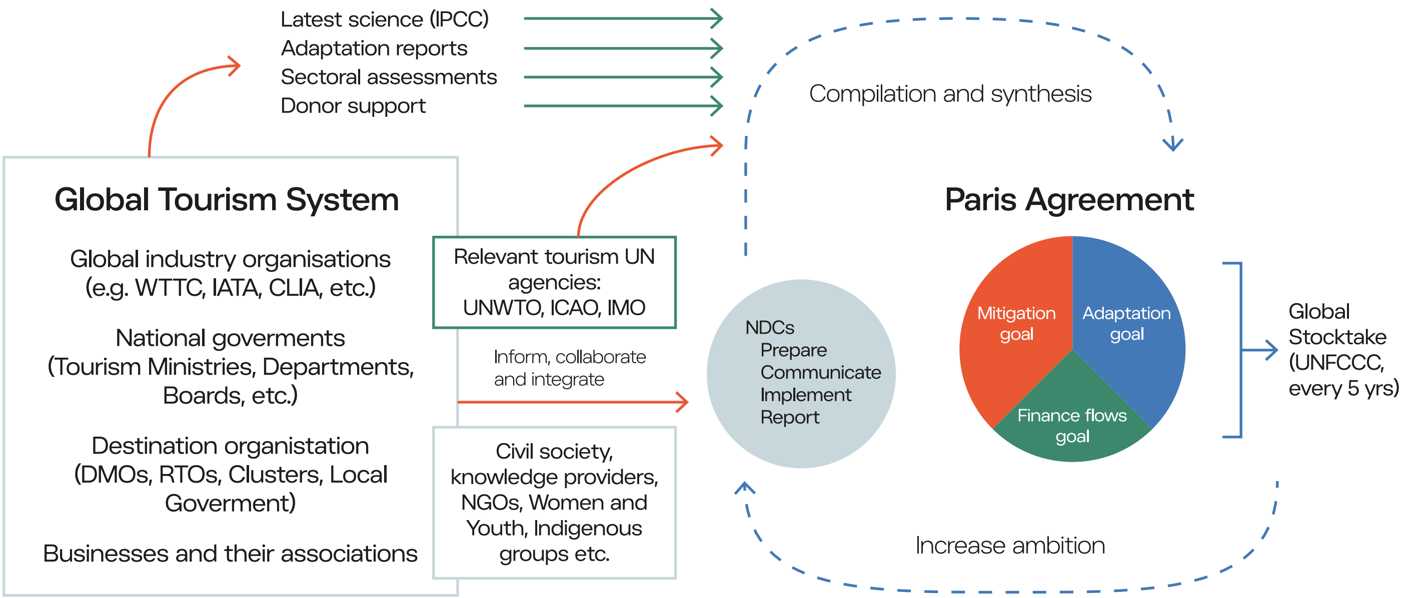
1.2 Tourism and Climate Change Framework

Tourism intersects with global climate policy frameworks (Figure 1), but systematic policy integration is lacking.[5] The United Nations Framework Convention on Climate Change (UNFCCC) Global Stocktake is a core element of the architecture under the Paris Agreement to report on progress and increase ambitions across three key areas. The Nationally Determined Contributions (NDCs) are the key mechanism for countries to report on their climate commitments. Low- and medium-income countries also report on adaptation plans and progress through their National Adaptation Plans (NAPs). Tourism representations in national governments can work with their respective climate agencies to improve tourism consideration in NDCs and NAPs.

While the tourism sector does not have a formal target linked to the UNFCCC, the Glasgow Declaration on Climate Action in Tourism [6]encourages the acceleration of climate action in tourism by securing commitments to reduce emissions in tourism by at least 50% over the next decade (2030) and achieve net zero as soon as possible before 2050. Signatories also commit to supporting affected and at-risk communities in climate adaptation and disaster response, align actions with the latest scientific recommendations and prioritize a just and inclusive transformation of tourism.

Figure 1

Overview of how the global tourism system connects to international climate change governance.[7]



1.3 Climate Resilient Tourism Growth?

Finding 1

Many countries support tourism because of its integral role in contributing to economic development. Tourism has seen significant growth and is continuing to grow faster globally than the rest of the economy, putting greater pressure on the need to decouple growth from emissions. Continued capital investments and trends toward longer average travel distances and more air travel are key barriers to emission reductions.

All tourism-related organisations, such as the United Nations World Tourism Organisation (UNWTO), International Civil Aviation Organisation (ICAO), International Air Transport Association (IATA) and World Travel and Tourism Council (WTTC), maintain a clear focus on growth. It is critically important to redefine 'growth' in a way that is compatible with climate goals (see Box 2).

The ambition to decouple tourism growth from emissions has yet to be realised.[8] The task for tourism is enormous: a recent report by the WTTC revealed that tourism emissions have grown (+2.5% per annum) between 2010 and 2019; this is faster than global emissions (1.3% during the same period).[9]

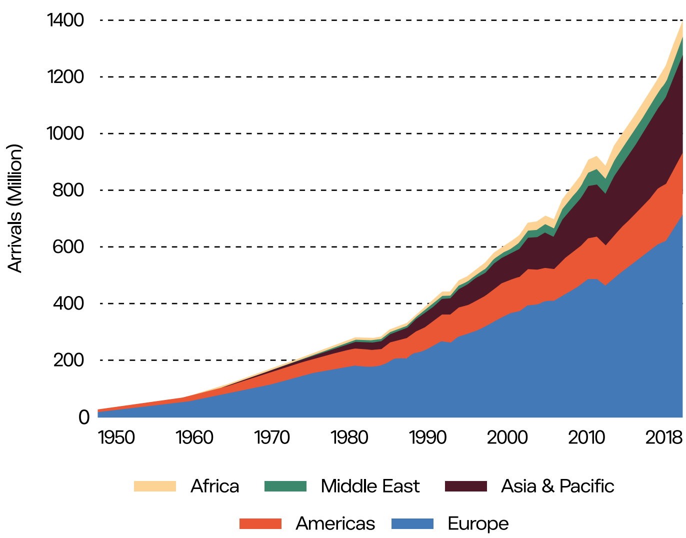
Global tourism is made up of both domestic and international tourism. While organisations, including many National Tourism Authorities, often focus on international tourism, only 26% of trips made in 2019 involved border-crossing.[10] The contribution of domestic tourism to the global visitor economy was estimated to be 72% in 2019.[11] A metric to monitor international arrivals is still informative given governments' interests in tourism's foreign exchange earning capability.

Metric: Annual International Tourist Arrivals

International tourism more than doubled from 2000 (Figure 2) reaching 1.4 billion in 2019. This number dropped to 407 million arrivals in 2020 due to COVID-19 restrictions and has since recovered to 963 million in 2022. Much tourism occurs in high-income countries (e.g. 50.8% of international arrivals are in Europe). Only 1.7% of international arrivals are to Least Developed Countries, despite these making up 12% of the global population.

Figure 2

Tourism growth (international overnight arrivals only) by UNWTO destination region[12]



Tourism is expected to grow faster than the rest of the economy (Table 1).

Table 1

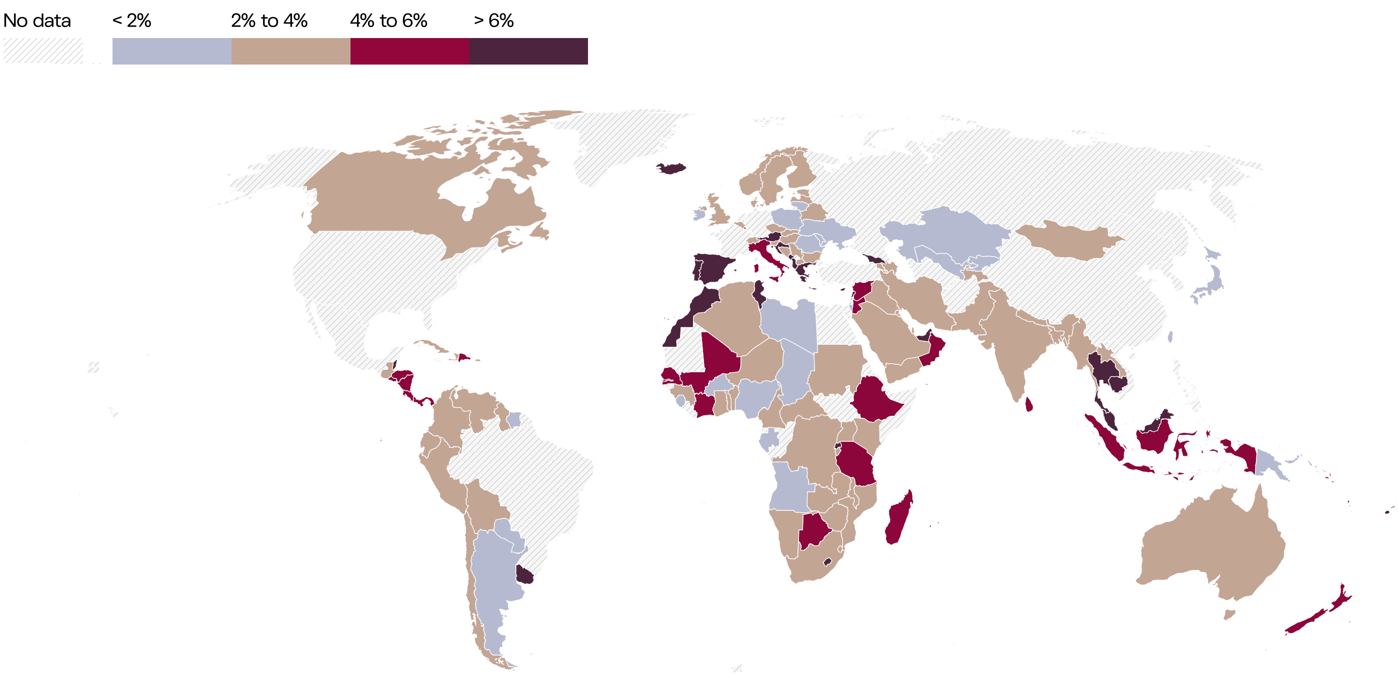
Estimated annual economic growth between 2022 and 2023 as reported by WTTC[13]

	2019 Tourism GDP (US$ billions)	Growth in Travel & Tourism GDP (%)	Regional Economic Growth (%)
Americas	855	3.9	2.0
Africa	85	6.8	3.3
Asia-Pacific	965	8.5	4.0
Europe	851	3.3	1.5
Middle East	95	7.7	2.5
Global	2849	5.8	2.7

The economic importance of tourism varies across regions and countries (Figure 3). Many Small Island Developing States (SIDS) have direct tourism contributions to Gross Domestic Product (GDP) of over 20% (e.g. Aruba, Cape Verde, Maldives, Seychelles). Path dependency, especially due to large infrastructure investments such as airports and cruise ship terminals, means some countries are locked into a conventional mode of tourism as a key economic sector. This could limit scope for adaptation and any shift in economic development strategy, including economic diversification. Over-reliance on a growing tourism industry, including hopes of realising economic benefits while reducing GHG emissions and other socio-environmental impacts, is increasingly scrutinised by academics and civil society, but policy development in this space is nascent (Box 2).[14] Managing carbon risk exposure and tourism assets at risk from climate impacts is becoming more challenging as the tourism sector grows.

Figure 3

International tourism direct contribution to GDP (2019)[15]



Box 2 Right-Sizing Strategies

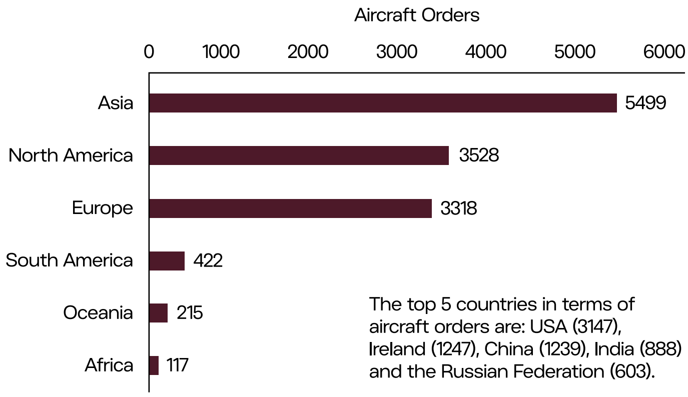
Most countries continue to pursue tourism growth strategies, but examples of 'demarketing' or 'capping' are emerging. France, the top country in terms of international arrivals (90 million in 2019), is now starting to proactively manage 'over-tourism' by capping numbers at popular destinations. The Balearic Islands have put a cap on the number of hotel beds and Airbnb properties; French Polynesia, Bali, Barcelona, Amsterdam and South Tyrol (Italy) are all exploring visitor caps. The West Sweden Tourist Board already focuses on domestic and proximate tourist markets to reduce the transport-related carbon footprint of its tourist market.

Metric: Number of Jet Engine Aircraft Ordered

Data on aircraft orders (Figure 4) show that airlines in Asia, North America and Europe continue to prepare for an expanding global travel and tourism market. Orders from the Southern Hemisphere are small either because of lower propensity to increase or replace existing fleets, or small populations (Oceania). Aircraft orders reflect an ongoing commitment to hydrocarbon combustion technology, even if these are propelled by lower carbon fuels (see section 2.3.2).

Figure 4

Aircraft orders by world region (commitments as of June 2023)[16]



1.4 Climate Relevant Tourism Trends

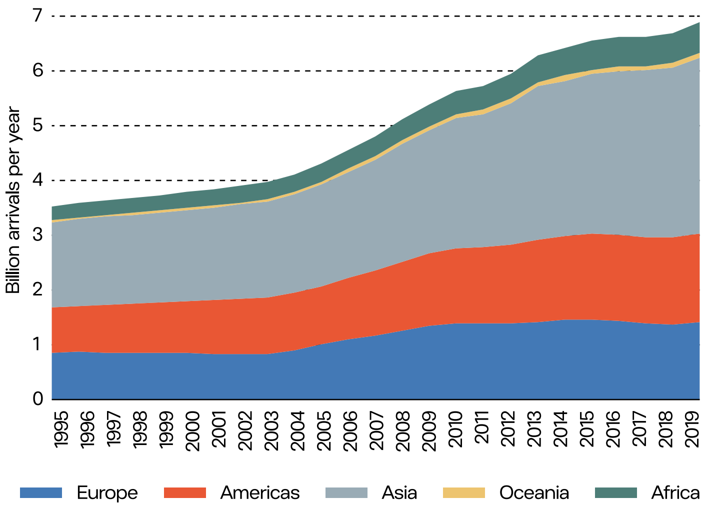
1.4.1 Domestic versus International Travel

Metric: Share of Domestic Trips of All Tourism

Over the last two decades, domestic travel increased slightly faster than international travel. Figure 5 shows the combined domestic and international overnight arrivals per continent. The visualisation can be contrasted with Figure 2, which is commonly communicated to indicate tourism growth but lacks the 5.6 billion domestic arrivals in 2019 in addition to the 1.4 billion international tourists. Providing the complete picture as shown in Figure 5 corrects this. The COVID-19 pandemic has shown that domestic tourism is more resilient to crises,[17] but shifts in demand can cause 'over-tourism' at other destinations and require infrastructure investment. In most countries, domestic travel typically has lower emissions due to shorter travel distances. Fostering domestic tourism can be an important climate strategy.[18]

Figure 5

Trips by international and domestic travellers[19]



1.4.2 Air Mobility

Metric: Share of International Arrivals by Air

Focusing on international tourist arrivals, the share of air travel as a form of transport has increased from 34% in 2000 to 47% in 2019. Land transport contributed 47% of international arrivals in 2019, with the remaining 6% coming from water transport (mainly cruise ships).[20] Given that aviation has evolved to be an integral part of tourism, it is surprising that the sectors often operate in silos – for example, in relation to policy frameworks (see also Box 11) and sector initiatives (e.g. airline support of the Glasgow Declaration is absent – see Table 5 further below).

1.4.3 Travel Distance

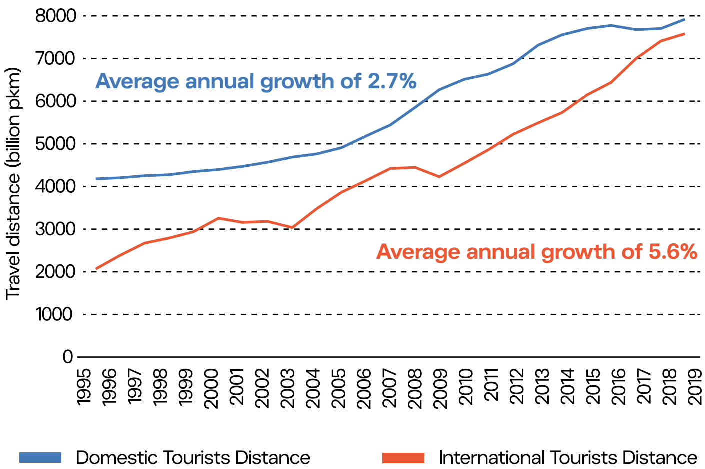
Tourist distance travelled over time was assessed to determine whether domestic and international travellers were visiting more distant destinations.

Metric: Total Tourist Distance Travelled

Total travel distance increased on average by 3.9% per year between 1995 and 2019, more than the 2.8% increase in the number of trips. The more pronounced average growth of international distance accelerated this trend (Figure 6).[21]

Figure 6

Tourist distance travelled (billion pkm)

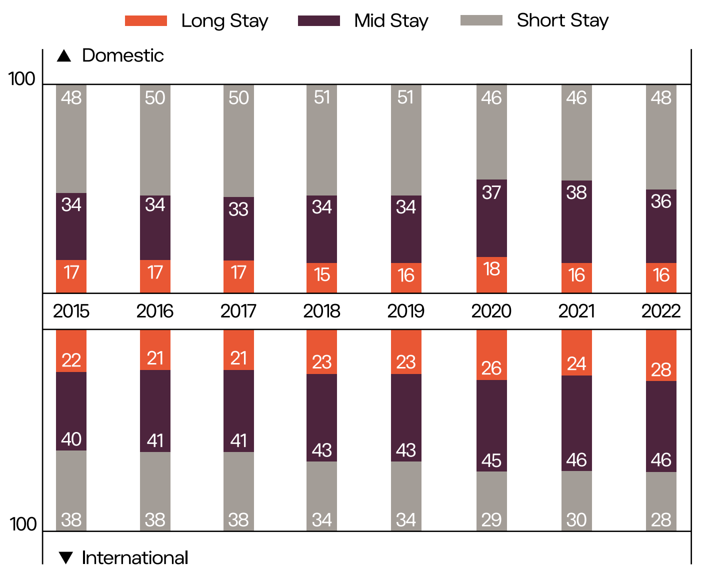


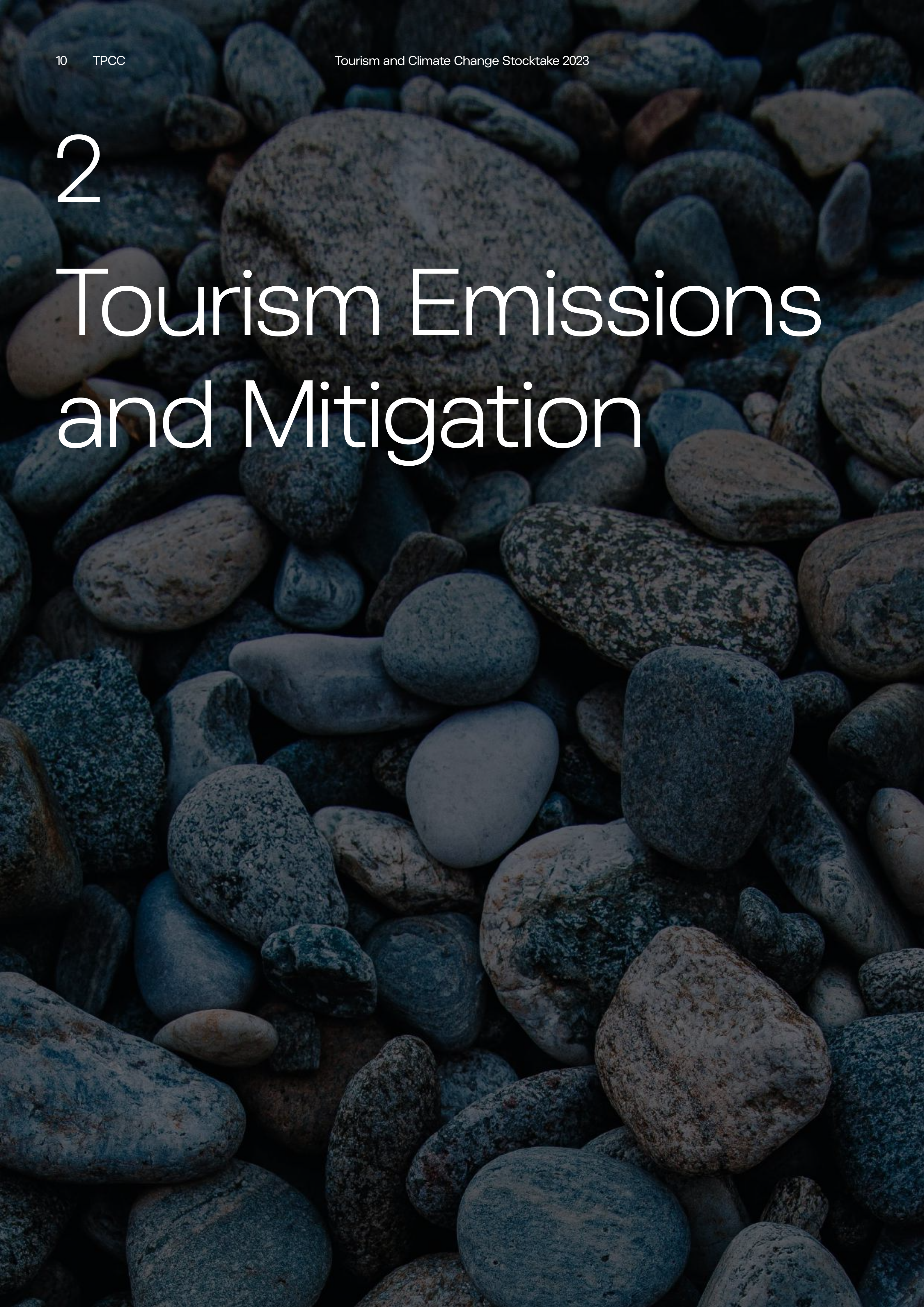
1.4.4 Length of Stay

Data on air travel from ForwardKeys indicate a weak trend towards longer stays for international trips before the pandemic, and the reverse for domestic travel (Figure 7). Ongoing monitoring is necessary to ascertain whether tourists are increasing their length of stay, an important climate strategy and one that aligns with most tourism plans to increase yield.

Figure 7

Length of stay categories for domestic and international air-based travel[22]





2

Tourism Emissions and Mitigation

Finding 2

Approximately 8-10% of global emissions are from tourism. Data show that tourism emissions have increased annually over the decade prior to Covid-19 disruptions, and tourism is not on track to achieve the Glasgow Declaration on Climate Action in Tourism interim target of reducing emissions by 50% by 2030. Urgent whole-of-sector leadership is required for tourism emissions to peak and decline substantially by the end of the decade.

2.1 Measuring Frameworks

The UNWTO's new Statistical Framework for Measuring Sustainability of Tourism (SF-MST) represents solid progress on the development of tourism standards for GHG accounting. The challenge is that it relies on Tourism Satellite Accounts and national environmental accounts, which not all countries have. The approach also requires significant resources and carbon accounting skills that remain limited throughout the global economy,[23] and it is even more challenging to apply at sub-national levels where Input-Output tables and tourism data are less available.[24]

There is an ongoing challenge to measure the emissions for tourism and sub-national destination scales, especially in relation to whether and how Scope 3 emissions (see Greenhouse Gas Protocol)[25] are to be included. GHG accounting standards that align with emerging national protocols are needed for destinations.

The Glasgow Declaration does not specify the baseline year for emission-reduction pledges. The lack of sectoral standards has implications for accountability progress and ambition. In addition, many organisations are not measuring emissions, but rather measuring the frequency of actions that may result in emissions reduction. A recent UNWTO[26] report found that of 428 leading companies, 34% reported measuring emissions, but few publicised what methodologies were used. Slightly more (37%) have set an interim target for Scopes 1 and 2, and 20% reported a Scope 3 target that was distinct from their Scopes 1 and 2 targets, but only 11.2% reported a long-term net zero target.

2.2 Global Tourism Emissions

2.2.1 Global Overview

The tourism carbon footprint encompasses direct emissions from tourism businesses as well as indirect emissions from the supply chain (Scope 3).

Metric: Global GHG emissions from tourism and share of all global anthropogenic emissions

A global analysis of 160 countries reveals that the tourism carbon footprint expanded from 3.9 Gigatonnes (Gt) in 2009 to 4.5 $GtCO_2$-e in 2013 (approximately 8% of global CO_2 emissions) (in the process of being updated to 2019). In 2021, analysis undertaken by WTTC estimated total tourism emissions to be 5.4 Gt in 2019, accounting for approximately 8–11% of global GHG emissions (WTTC-UNEP-UNFCCC, 2021). A 2023 analysis from the WTTC used a different methodology and parameters (undisclosed),[27] arriving at an estimate of 4.1 Gt (8.1% global emissions) in 2019.[28] This study found that annual tourism emissions increased 2.5% per year from 2010 to 2019, with international tourism transport increasing at 5.9% per year. Despite these differing estimates, the overall trend is clear: the carbon footprint of tourism continued to increase annually before the COVID-19 disruption.

GHG assessments sometimes include metrics to assess relative improvements in efficiency. The use of such carbon intensities is problematic in the context of achieving absolute emissions reductions, but it does enable a comparison between sectors. Tourism emerges as a relatively carbon-intensive sector. For every US dollar earned in tourism in 2013, the sector emitted about 1 $kgCO_2e$ (direct and indirect emissions). By comparison, the carbon intensities of manufacturing (0.8 $kgCO_2$-e per US$), construction (0.7 $kgCO_2$-e per US$) and the global average (0.75 $kgCO_2e$ per US$) are lower. Coupled with the strong growth of tourism in the decade prior to the COVID-19 pandemic, and as noted earlier, the surge in tourism-related emissions (3.3%/year from 2009–2013; 2.5% from 2010–2019) surpassed the growth rate of global CO_2-e emissions (IPCC, 2022).[29] Understanding the comparative GHG implications of sectoral growth is important for government decision-making in relation to the role of tourism in the national economy.

Tourism emissions are concentrated mainly in high-income countries acting both as traveller residence and destinations. About half of all global tourism carbon emissions are caused by travel between countries with a per capita GDP of more than US$25,000.[30] Importantly, international tourism emissions represent a large portion of emissions in some destination countries. For example, in the Maldives, Mauritius, Cyprus and the Seychelles, international tourism represents between 30% and 80% of national emissions.[31]

2.2.2 Country-level Emission Trends

Very few countries formally report tourism GHG emissions or have been subject to an academic study that provides relevant data. Where they exist, analyses reveal that no destination has managed to reduce its tourism-related emissions while simultaneously experiencing tourism growth.

Metric: National Tourism GHG Emissions Growth Rates

Some countries, such as New Zealand and the Netherlands, saw only a minor increase in emissions, while China and Spain reported an expansion of more than 5% annually. This contrasts starkly with the 7.5% annual reduction needed to achieve net zero by 2050. The primary driver of the increasing emissions trend is rapid tourism expansion, which offsets improvements through technological efficiencies and renewable energies (see Box 3 and Figure 8).[32] Data show that the tourism sector typically sees efficiency gains (emissions per dollar) of around 2% annually.

Table 2

Annual growth rate of tourism emissions for selected countries (data refer to different combinations of inbound, outbound, and domestic tourism)[33]

Country	Year	Annual growth rate of tourism emissions
Australia	2004-2018	1.8%
China	1995-2009	9.9%
	2005-2016	15.7%
	2022-2015	7.7%
	1990-2012	9.8%
	2000-2015	6.7%
Netherlands	2022-2019	1.3%
New Zealand	2007-2013	0.8%
Norway	2007-2019	1.8%
Spain	1995-2007	5.2%

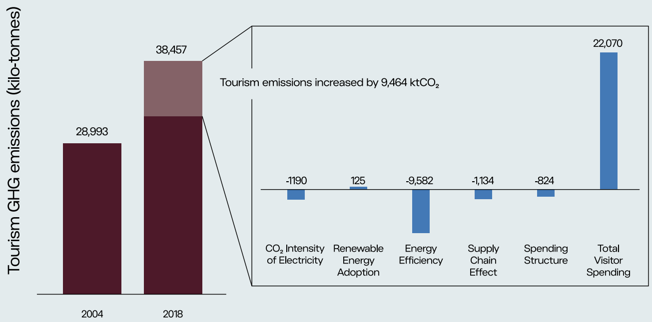
Consequently, any growth rate surpassing 2% results in increasing emissions (Table 2). The findings highlight that countries that do not measure tourism's GHG emissions may overlook a significant part of their economy emissions, missing important opportunities to implement effective decarbonisation policies.

Box 3 Tourism Emissions Trend in Australia

A decomposition analysis to assess progress on tourism decarbonisation in Australia revealed that some progress is evident, but it still falls far short of net zero requirements. The main driver of this is significant tourism growth, in particular leading to air transport emissions. The high carbon content of the electricity grid in Australia is also not assisting GHG reduction (Figure 8).

Figure 8

Decomposition analysis of Australia direct and indirect tourism GHG emissions, 2004–2018. The bars show improvements in energy efficiency, but these are more than compensated by growth.



2.3 Transport Emissions and Mitigation

2.3.1 Transport Emissions Growth

Mobility is an integral part of tourism. Tourism transport emitted 1,030 million tonnes (Mt) in 2019. Emissions more than doubled between 1995 and 2019.

Metric: Global Total Tourist Transport GHG Emissions

Figure 9 shows that the largest contributor to tourist transport emissions is air travel (74% in 2019). The second most important mode is the car, making up 21% of tourist transport emissions – mostly from domestic tourism, which contributes 62% of all tourist car travel emissions.

Figure 9

Tourist transport emissions by mode (from TTDM)

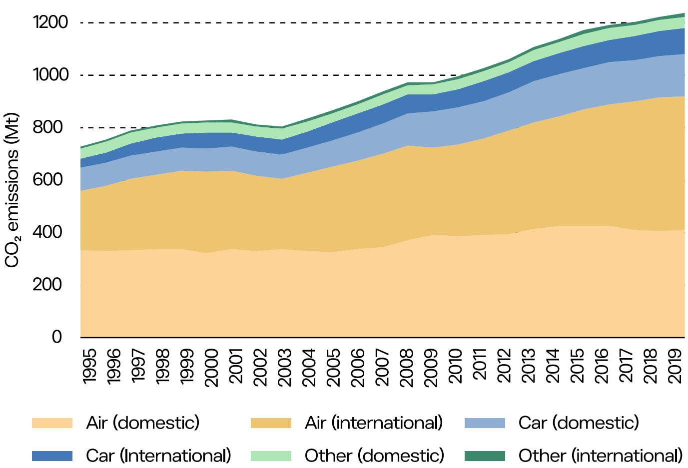


Table 3 draws on the Tourism Transport Distance Model (see note 10) to provide an overview of the role played by each transport mode in terms of share of trips, passenger kilometres (pkm) and GHG emissions. The table includes both international and domestic tourism. Air travel makes up only about a quarter of trips, but contributes three-quarters of emissions. Other transport, which includes rail, coach and water transport, represents 42% of trips, but only 5% of emissions.

Table 3

Overview of transport modes relative importance for 2019 (TTDM data)

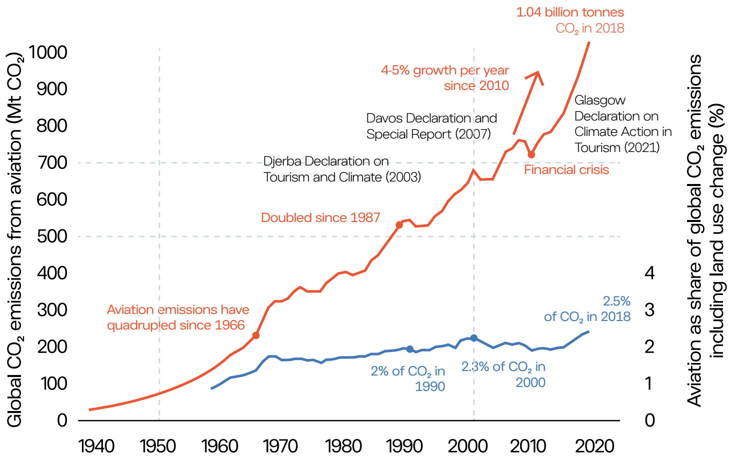
	Air	Automobile	Other
Trips	21.6%	31.5%	42.4%
Passenger km	64.4%	15.2%	20.4%
GHG Emissions	74.5%	21.0%	4.5%

Metric: Global Air Passenger GHG Emissions

According to IATA data, air travel emitted over 1 $GtCO_2$ in 2019, although when day trips and non-passenger emissions are excluded, the emissions are in the order of 745 $MtCO_2$.[34] The five years preceding the pandemic saw an increase in emissions of 27%, while passenger numbers increased by 38%.[35] Figure 10 shows the increase in aviation emissions and the industry's share of all human-made emissions. Emissions growth conflicts with 82 aviation-related net zero pledges made by the industry,[36] especially since claims that rely on carbon offsets are increasingly being questioned (see Box 7 further below)[37] – noting, however, the potential biodiversity benefits of restoring biological carbon sinks.

Figure 10

Aviation emissions in total and as proportion of all anthropogenic emissions[38]



The total climate impact of air travel is larger than CO_2 alone due to emissions of nitrogen oxides, water vapour and soot. The total impact can be quantified using the metric 'effective radiative forcing' (ERF), whereby aviation represents 3.5% of global ERF, or about 4% of the global temperature rise to date. Historical CO_2 aviation emissions represent about one-third and non-CO_2 emissions two-thirds of present-day ERF from aviation.[39]

Metric: Global GHG Emissions from Car and Rail Tourist Travel

Based on modelling using the TTDM, global car emissions increased by 112% between 1995 and 2019. This trend is due to an increase in distance (131%) and number of car trips (106%). 'Other transport' emissions from land and water modes (more than half are from rail), increased by 19% in the same timeframe. The emissions increase was due to both an increase in the travel distance (111%) and number of trips (69%). The fact that emissions increased much less than those drivers means that improvements in carbon efficiency were achieved. Electrification of rail transport (see below) is a key factor, highlighting the importance of directing investment away from fossil fuels and towards clean energy (see section 6.1).

Elsewhere, the International Energy Agency (IEA)[40] reports that rail transport emissions continue to remain under 100 $MtCO_2$ per annum; the target for 2030 is 63 $MtCO_2$. High-speed rail is seen as an alternative to replace some air travel in some countries, as long as energy comes from low- or zero-carbon sources.

Metric: Global GHG Emissions from Cruise Tourism

Based on data for Carnival, Royal Caribbean and Norwegian (making up 80% of passenger numbers globally), cruise tourism emissions (Scope 1–3, but excluding related air travel) were estimated at 45 $MtCO_2$ in 2019.[41] Per trip, when involving a flight, cruise tourism is among the most carbon-intense forms of tourism (1.6 t CO_2 per average trip of 7.2 days, nearly tripling when average flight emissions are included; up to eight times more than other international trips).[42] Even without flights, cruise tourism is highly energy intensive, as a result of the 'hotel function' of the vessels, which was found to consume 12 times more energy than a hotel based on land.[43]

Should the historic growth rate of 6.6% per year during the period 1990–2019 continue, cruise emissions would increase to 71 $MtCO_2$ by 2050, even with a projected 2% annual efficiency gain.[44] With large uncertainties over zero-carbon fuels and their availability,[45] a pathway to a cruise sector net zero 2050 remains highly uncertain.

2.3.2 Decarbonising Tourist Transport

Finding 3

Tourist transport emissions have increased by 65% between 1995 and 2019. Air travel was a key driver of this growth, now contributing 26% of all tourist trips (domestic and international), but 75% of tourist transport emissions. Existing aviation technologies are unlikely to fully mitigate emissions by 2050. Sustainable aviation fuels can contribute to mitigating aviation's climate impact, but their net GHG improvement, broader sustainability, scalability, and climate justice implications will constrain production. Emerging technologies will play an expanding role after 2040.

Finding 4

Rail travel is growing in some countries and can potentially gain a substantial share of short-haul tourism transport at low emissions where networks exist, or major new infrastructure investments are made. Rail represents the lowest emissions form of transport in tourism even with current use of fossil fuels. Further decarbonisation of rail relies on sufficient availability of low carbon electricity, which remains lacking in many countries.

Finding 5

Personal light duty vehicles (LDV) remain a key transport mode in tourism (32% of all tourist trips in 2019, and 15% of tourist transport emissions). Continuing improvement in global fuel efficiency and standards, as well as the increasing shift to low-emission electric vehicles is critical to reduce emissions from related tourism mobility. Important challenges remain in the electrification of LDV for tourism, including under-developed intercity, destination and accommodation charging networks, as well as availability of low-carbon electricity in many jurisdictions.

Aviation is difficult to decarbonise[46] because: (1) aircraft development and fleet renewal are slow processes that take decades to achieve; and (2) current zero-emission technology is still in its infancy. Most proposed interventions involve fleet renewal with more efficient aircraft types, maximising operational efficiency through air traffic management, pilot training and increasing load factors. Technological improvements for engine and airframe theoretically could deliver stepwise reductions, averaging 1.2% annually for single-aisle and 1.3% for twin-aisle aircraft.[47] However, this falls short of required reductions, especially considering ongoing growth rates.

More revolutionary technology involves battery electric aircraft, fuel cell electric aircraft and hydrogen jet aircraft. The gravimetric density (MJ/kg) of current batteries is about 2% of that for fossil kerosene, putting significant limitations on this technology.[48] If batteries improve their MJ/kg by a factor of four, the range could be up to 1,100 km.[49] This range could cover 43% of all air-borne trips but would only address up to 12% of emissions.[50] There is considerable potential for smaller, regional airlines, including through retrofit, to offer zero-emission aviation, potentially on quite differently constituted networks. ICAO provides updates on its Electric and Hybrid Aircraft Platform for Innovation (E-HAPI); however, mostly these are eVTOL (vertical take-off and landing) air taxis.[51]

The most promising fuel cell projects are from ZeroAvia, currently testing a Dornier 228 retrofitted aircraft with 19 seats and a range up to 600 km, and Universal Hydrogen, now testing on a De Havilland Canada Dash 8 retrofit with up to 70 seats. Airbus is developing fuel cells and direct hydrogen burning aircraft.[52] The combination of fuel cells – electric propulsion with hydrogen as an energy source – has much better prospects to serve ranges up to perhaps 6000 km.[53]

It is difficult to predict development times for revolutionary technology, but the assumption is that short-haul alternatives would have an entry into service date of 2035, medium-haul would follow in 2045 and long-haul would come online in 2055. It could take up to 2080 before these technologies reduce emissions to close to zero (assuming full decarbonisation of the supply chain).

Metric: Share of Sustainable Aviation Fuel of all Aviation Fuel Consumed

Therefore, an intermediate solution is needed for ranges where current (battery) technology is inadequate. SAF provides an option that may reduce emissions by 50% or more. SAF fall into one of three categories: (1) biologically derived; (2) waste-derived; and (3) synthetic (power-to-liquid). Significant challenges exist in producing the SAF volumes required by the aviation industry. These include financial capital, an ongoing need for research and development, global distribution and enabling policies. Sustainability associated with some types of SAF has been questioned (see Box 4), noting that synthetic fuels (e-fuels) are vastly superior to biofuel on sustainability grounds.[54]

Trips of over 4000 km make up 5% of all flights, but consume 40% of fuel, representing a key challenge for decarbonisation. For the near-term future, SAF are the only option for those long-haul flights. This explains the industry interest and support for this strategy. For example, the ICAO SAF Tracker[55] has been created to share progress (and presumably give confidence to investors and policy-makers) on different aspects of the SAF value chain.

Box 4 Limitations of SAF and Biofuel More Broadly

- Despite the potential for SAF to largely replace fossil kerosene, there are significant challenges and risks associated with the large-scale production of SAF.[56]
- Biofuel-based SAF relies on sufficient levels of sustainable feedstock supply. Global data show that there is not enough biomass to meet aviation's fuel requirements without diverting large volumes from other existing or future uses (including food production and other industries).
- The net GHG savings of bio-SAF are highly varied, and in some cases worse than fossil kerosene – especially when indirect land use change emissions or other displacements are considered.
- The energy requirements to produce synthetic SAF (or e-kerosene, made from water and captured CO_2) are extremely high and compete with other parts of the economy that rely on zero emission electricity for their decarbonisation. Therefore, the availability of sufficient low-carbon electricity is a prerequisite for synthetic SAF (as it is for green hydrogen) and allocation to aviation remains a major uncertainty.

The challenges that persist in decarbonising aviation with technology alone indicate a need for demand-management measures. These fall into two categories: fiscal measures (see section 6.1) and operations capping. A frequent flyer levy,[57] while appealing on equity grounds, may be difficult to implement. Demand management was also raised by the IPCC[58] as an option to reduce transport sector emissions, particularly in developed countries. The IEA Net Zero by 2050 report[59] proposed two demand measures (behaviour changes) for aviation: regional flights shifting to high-speed rail and long-haul air travel not exceeding 2019 levels. This may provide some tangible targets to begin with.

Operational capping might involve an environmental cap on airports, not simply in the form of the number of flights, but on the volume of their emissions to their first destination,[60] as decided for Amsterdam Schiphol Airport, which reduced its capacity from 500,000 flights in 2019 to 460,000 in 2024 and plans to further reduce to 440,000 in 2025.[61] The unintended consequences and international climate justice implications of aviation mitigation policies require much greater analysis and deliberation.

National climate policies focused on transport support the decarbonisation of car, coach, public transport, rail and non-international ferries. Electric rail transport shows the strongest development of decarbonisation. Almost 60% of all passenger rail transport is electric, and 59% of this electricity is from renewable sources.[62] Many European railway companies provide zero-emissions passenger transport. One challenge in Europe is that some rail networks are at capacity and expansions will take decades to implement.

Between 2010 and 2019, the global volume of high-speed rail increased from 245 billion pkm to 1072 billion pkm, a growth rate of 17.8% per year. The growth comes particularly from investment by China, which now operates the most expansive high-speed rail system. India's target is a 100% rail track electrification by 2030 to enable a road-to-rail shift as part of the 'Green Railway by 2030' plan. The Indian rail electrification share increased from 24% in 2000 to 65% in 2020. Morocco opened the first high-speed rail system in Africa in 2018; since 2022, it has been operating on renewable energy. In Saudi Arabia, one of the largest public transport projects in the world has seen the construction of the Riyadh metro system with a total length of 176 km and 85 stations. Egypt is investing in a 2000 km rail network. Many countries have neglected train as a transport option (e.g. New Zealand, Australia, Canada), although in places railway lines exist and could be revitalised. Along similar lines, night trains (Box 5) are experiencing renewed public sector support in Europe. The importance of rail travel for a low-carbon tourism transition highlights the need for policy integration between tourism administrations and transport ministries.

Box 5 Night Trains for Long Distance

There has been an expansion of night rail services, offering long distance travel with low carbon intensity and low marginal cost. Europe in particular saw the introduction of new routes and innovative providers (city tourism packages). In some countries, this shift is supported by public policy. In Austria, for example, the state-owned railway company ÖBB saved the long-distance night train network when it took over from the German DB. Furthermore, several private companies recently launched new services (e.g., GreenCityTrip, European Sleeper).

In relation to private light duty vehicle (LDV) transport, most developments depend on progress beyond tourism, including battery technology (noting concerns over the sustainability and availability of input minerals), government support for electric charging networks, policy incentives for the uptake of alternative technologies and customer demand. Electrification is a primary strategy to reduce passenger vehicle emissions, with policies in 55 countries restricting the sale of new internal combustion engine (ICE) vehicles between 2025 and 2040. From market sizes of electric car rentals (c. $10 billion in 2022) and the overall rental car market (some $100 billion), we deduce that between 5 and 10% of rental cars are electric.[63] In Europe, some bus companies are planning to introduce long-haul electric buses by 2027. Like rail, the capacity of electrification to reduce emissions from LDV transport depends on the availability of low carbon electricity.

The barriers to LDV electrification for drive tourism and the implications for tourism patterns remain under-researched.[64] Key challenges to the electrification of LDV tourism transport need to be overcome in countries leading the EV transition. Greater density and availability of rapid charging (level 3) is required for inter-city and regional tourism. Improved charging capacity is needed at virtually all destinations (including accommodation – see section 2.4). For example, an analysis of road trip itineraries near Canada's national parks found that 24% of multi-day routes were highly inconvenient or impossible due to large gaps between charging stations. Charging demand in these national parks is projected to exceed expected capacity in 75% of parks by 2030 and all parks by 2035.[65] Similar infrastructure gaps have been reported in several countries, indicating that EV drivers do not have equal access to tourism attractions and destinations. The emergence of fast-charge highway corridors in the European Union and United States, and 'EV tour routes' at some destinations are positive initiatives to support the shift to low emission LDV-based tourism. These developments remain limited and charging networks, particularly for high-speed charging, pose a barrier to low-emission tourism mobility. Tourism authorities and DMOs should prioritise collaboration with governments and the private sector to accelerate tourism-focused charging networks to incentivise EV travellers.

2.4 Accommodation Emissions and Mitigation

Finding 6

The GHG intensity of hotel operations is gradually improving among leading operators in some regional markets but, without acceleration and expansion globally, will fall short of reducing emissions by 50% by 2030. Energy demand per room remained steady, indicating that emission reductions are the result of decarbonisation of electricity rather than lower energy consumption in the hotel.

Tourist accommodation includes various types of establishments, including commercial, sharing economy and private properties. Data on both volumes and emissions are patchy, but are most readily available for hotels; thus hotel emissions were selected as indicative of progress. Due to their relatively higher carbon intensity, hotels contribute the most to tourist accommodation emissions.[66]

Metric: Global Hotel Industry GHG Emissions and Emission Intensity per Room

The analysis draws on data from Greenview and the Cornell Hotel Sustainability Benchmarking (CHSB) Index (including nearly 800,00 hotels) as well as analysis of data from 11 global hotel chains by Gössling et al. (2023).[67] The Greenview analysis found a 5% decrease in GHG emissions per hotel room between 2017 and 2019, which offset emissions from a larger number of hotels and rooms (Table 4). Over the same period, Gössling et al. (2023) found a 20% reduction per hotel room (and a larger reduction between 2015 and 2019), but an increase in total emissions related to acquisitions and sales of hotels and changes in reporting by some firms. Trends in emissions per room varied substantially between firms.

Decreasing CO_2-e emissions per room reflect a decarbonisation of electricity, the main source of energy in hotels.[68] Ongoing measurement and monitoring are vital to track reductions in GHG emissions in the accommodation sector, and to identify key areas for intervention – be they technological, managerial or behavioural.

Table 4

Hotel sector emission (2017–2019)

Year	Total Emissions Mt CO_2-e	Total Hotels	Total Rooms	Emissions per room kg CO_2-e
2017	243.6	759,568	26,414,580	9,223
2018	259	794,522	28,107,908	9,215
2019	242.1	782,807	27,372,769	845

Water consumption in hotels is relevant to both climate change mitigation (see on the water-energy nexus)[69] and adaptation (e.g. in water-scarce regions). Data by Greenview show that water consumption per room remained relatively unchanged at 178 kilolitres (kL) in 2017, 179 kL in 2018 and 178 kL in 2019. Due to an overall increase in room numbers, the total water use in 2019 was 3.8% higher than in 2017 (increase from 4,704 to 4,882 billion litres in 2019, globally).

The Green Lodging Trends Report (GLTR) provides insights into sustainability practices in hotels.[70] The most recent data from 2022 indicate that:

- 60.9% of all hotels globally plan and implement GHG reduction initiatives
- 43.1% of all hotels globally measure GHG emissions, and most measure at least on a quarterly basis
- 22.7% of all hotels globally generate some renewable energy onsite.

Across these data, there is a trend for higher uptake of mitigation measures among larger, full-service hotels than in limited-service and smaller hotels. Accommodation providers can support climate action beyond their own operations, including through supply chain management (Scope 3 emissions). Similarly, the hotel industry is increasingly asked to provide information on emissions for corporate customers in response to their reporting requirements. In addition, more can be achieved in collaboration with the guests. Co-creating low carbon experiences can provide a point of differentiation, reduce utility costs, and provide educational experiences for visitors. Governments can support sustainability-oriented innovation in tourism.[71]

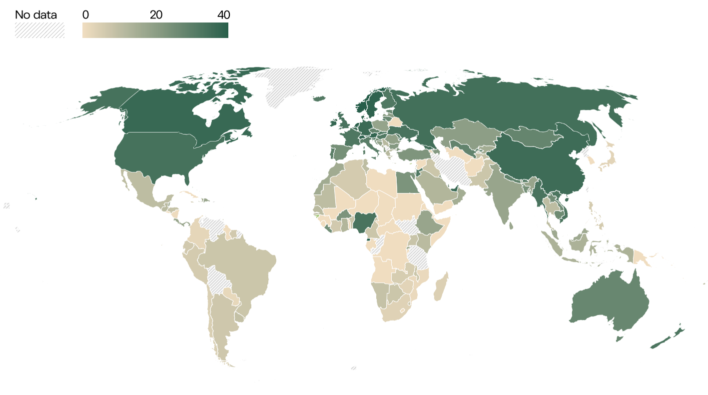
Another way to encourage tourism decarbonisation is to provide facilities for guests to support low-carbon transport. This could involve encouraging bicycle tourism (e.g. maps, discount for cycle tourists, repair tools) and providing public transport links (e.g. pick-up from train station, timetables, offering free local transport passes). The GLTR reports that 95.6% of all hotels in the survey report that they encourage the adoption of sustainable transportation by staff and guests.

Metric: Share of Hotels with EV Charging Facilities

Another way in which accommodation providers can support low-carbon transport is through the provision of EV charging facilities.[72] Yet an analysis of over 240,000 hotel properties worldwide found that only 10% reported onsite charging facilities.[73] Figure 11 shows that hotel charging capacity is highest in countries with the largest EV sales and supporting policies, led by Scandinavia and the European Union as a whole, followed by Canada, New Zealand, the United Arab Emirates and Equatorial Guinea. Charging facilities at all accommodation types was lower (5.7% of over 800,000 properties worldwide).

Figure 11

Global hotel properties with electric vehicle charging infrastructure



3

The Costs of the Tourism Mitigation Gap

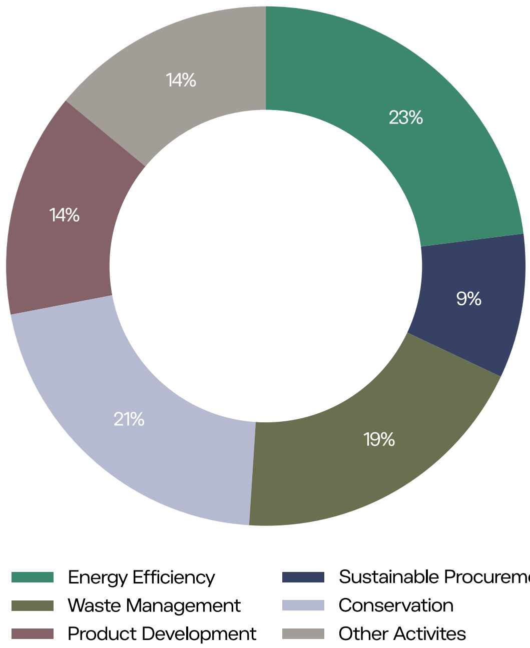
Finding 7

Shortfalls in mitigation from low-emission technologies and their implementation mean that demand management and shifts in consumer behaviour away from the highest-emitting tourism activities are a necessary part of measures to achieve GHG reduction targets.

3.1 Is Progress Sufficient?

Comprehensive data on sectoral mitigation are lacking, relying on self-report surveys or case study approaches that often focus on leaders and fail to capture sector-wide mitigation progress. A UNWTO survey showed that energy efficiency and nature conservation initiatives were the most reported climate-mitigation actions (Figure 12). The actual impact in terms of carbon reduction was not provided. Industry reports often use intensity carbon-reduction targets to avoid emissions penalties (i.e. evidence of increase) from tourism growth.[74]

Figure 12
Tourism stakeholder mitigation initiatives



The mitigation challenge appears stark. Integrated modelling and scenario analysis can inform pathways that align with climate goals, including those stipulated by the Glasgow Declaration for the tourism sector (Figure 13 and Box 6).

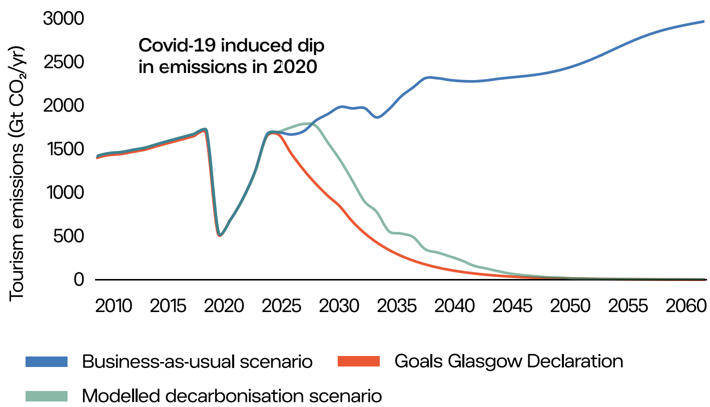
Box 6 Integrated Emissions Scenario

The Tourism Decarbonisation Scenario (TDS) (see also Figure 13) published by the Travel Foundation provides an insight into future pathways. The analysis showed that net zero emissions in 2050 would be possible if:

- the total number of trips and tourism revenues develop as in the business-as-usual scenario (BAU)
- total guest nights grow faster than in BAU
- the total mobility (pkm) grows only 19% between 2025 and 2050, after which it resumes its BAU development.

The scenario relies on SAF, particularly e-fuels, but notes that SAF production would consume up to 50% of all renewable energy by about 2040–2045 to cover BAU-aviation volumes. Further, rail travel has progressed to zero emissions, and accommodation, car, bus and water domestic transport emissions have reached zero due to national policies. Ocean cruising has been phased out.

Figure 13
Tourism emission trajectories[75]



In separate research, and focusing on the avoidance, reduction and substitution of emissions, researchers have estimated the mitigation potential by 2030, assuming no further growth in tourism.[76] Using a combination of interventions, the emissions from air travel could be reduced by 35% (assuming removal of all subsidies, a premium class duty and a blend-in mandate for SAF). Building emissions could be cut by 90% and those related to land transport by 60%. Water transport emissions could decrease by 40% and those related to food waste by 45%. Considerable financial investment, alongside drastic shifts in policy would be required to achieve these reductions, although between 10% and 25% could be achieved by means of avoidance alone – for example, remove subsidies (see section 6.1) or reduce food waste.[77]

Importantly, carbon offsets are not contributing to reduction within the tourism sector and represent an unreliable sector mitigation strategy (Box 7).[78] Moreover, a lack of genuine climate action and failure to achieve sector targets represent a reputational risk that is very likely to erode tourism social licence to operate in many destinations. Legal action against tourism companies may increase.[79]

Box 7 Offsetting and Climate Litigation

Carbon offsetting schemes have existed since the Kyoto Protocol. Many tourism operators acquire credits from Voluntary Carbon Markets, and the aviation industry has institutionalised offsetting in the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA). Offsetting has been criticized on several grounds. First, the integrity of many credits is questionable despite certification, including infringement of indigenous rights. Second, many of the credits issued fail to meet the criteria of additionality (especially commercially viable clean energy). Third, offsetting does not equate to physical emission reductions. Avoidance credits do not meet net zero criteria as no carbon is removed. Removal credits, on the other hand, are scarce.

Insufficient mitigation or claims that lack integrity can lead to court cases. Several airlines are facing a lawsuit or are being investigated due to misleading claims about the sustainability of flying, including 'carbon neutrality'. Regulators are concerned that consumers are given false impressions of low-carbon flying, for example due to extra charges for sustainable aviation fuels or offsets that do not deliver carbon reductions. Airlines are being sued in court in multiple countries in Europe, North America and Asia.[80]

3.1.1 Emissions Equity and Climate Justice

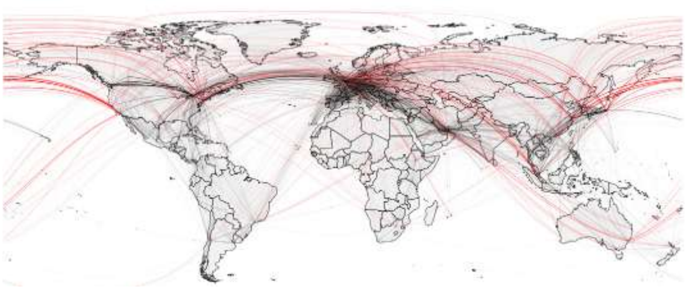
Finding 8

Global tourism emissions are heavily concentrated in a few high-income outbound markets and destinations. The unequal distribution of tourism emissions and potential mitigation strategies have important climate justice implications.

Climate justice has not been explored sufficiently in the tourism context.[81] Tourism – especially international long-haul travel – is a luxury good.[82] Research on aviation equality revealed that 90% of the world's population does not fly each year. Moreover, 10% of frequent flyers emit 50% of CO_2 from commercial aviation.[83]

A map of 2019 air flows between countries highlights where these flights mainly take place, namely over Europe, North America and the Asia-Pacific. In contrast, Africa and South America are contributing very little to air travel (Figure 14). Inequality also becomes apparent when looking at air travel emissions on a per capita basis. While the world average per capita aviation emissions are 103 $kgCO_2$, some countries exceed these significantly. Examples of high emissions of CO_2 for air travel include the United Arab Emirates (1,950 kg per person), Singapore (1,173 kg per person), Iceland (1,070 kg per person), Finland (1,000 kg per person), Australia (879 kg per person), the United Kingdom (841 kg per person) and Switzerland (761 kg per person).[84]

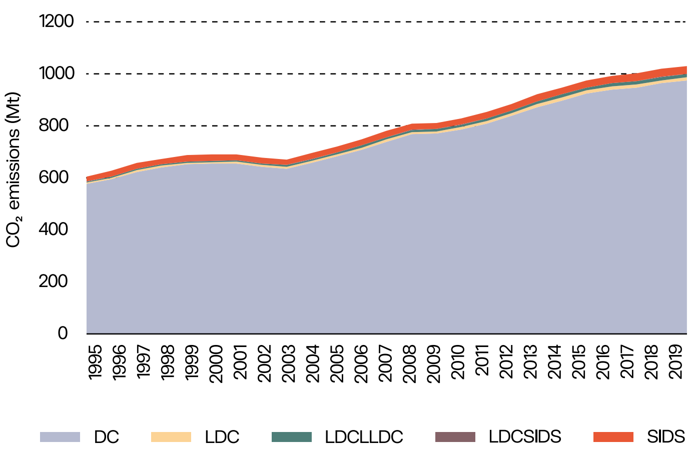
Figure 14
Highest per passenger emission aviation routes in 2019[85]



Metric: Share of Tourist Transport Emissions to and from Developing Country Destinations

When looking at all tourism transport, it becomes clear that most emissions are the result of travel to/from and between developed countries. Tourist transport emissions to developing countries represented only 7.5% of international arrivals and 5.4% of all emissions in 2019 (Figure 15). SIDS, in particular, are often identified as depending on air travel for connectivity and tourism; however, globally their share of tourism arrivals is only 1.2%, with emissions only contributing 3% in 2019. Any policy to address transport mitigation could apply differentiated responsibilities to SIDS and LDCs, without compromising overall reduction success to ensure that these are not negatively affected by mitigation policies.

Figure 15
Annual emissions (CO_2) from tourist transport by destination development level (DC = Developed Country; LDC = Least Developed Country; LLDC = Landlocked Developing Country; SIDS = Small Island Developing State)



3.2 Social Cost of Tourism Carbon

Finding 9

The social cost of tourism carbon emissions is increasing and is likely to equal or exceed its direct contribution to the global economy by as much as US$2 trillion in 2030. The climate justice implications of travel emissions predominantly from high-income countries, and the disproportionate burden of the social costs of tourism emissions in highly vulnerable countries, compels greater consideration in tourism sector climate responses.

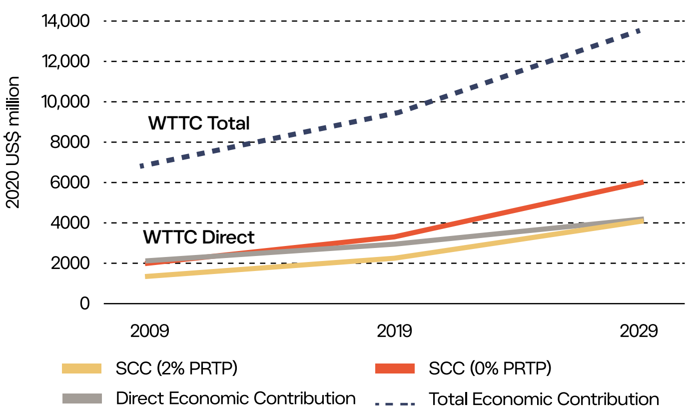
Metric: Global Social Cost of Tourism GHG Emissions

The social cost of carbon (SCC) is a measure of the monetary damage done by an additional tonne of CO_2 emissions and has been used in cost-benefit analyses for decades – but not in tourism. Using the range of recent SCC[86] in combination with estimated global emissions from the tourism sector,[87] the SCC of tourism emissions is compared with its global economic contribution (Figure 16).[88]

The SCC from tourism is increasing faster than its economic contribution. By 2029, the range of tourism SCC is equal to or much higher (US$4.1 to US$5.9 trillion) than the direct economic contribution (US$4.1 trillion).[89] When compared with the projected total economic contribution of tourism in 2029 (including indirect and induced contributions), tourism SCC damage represents as much as 44% of the total contribution. The implementation of a global SCC price would transform the cost-benefit economics of tourism policy and development and, like a carbon tax, incentivise the offer and choice of climate-friendly tourism products (see Box 8).

Figure 16

A comparison of the social cost of tourism carbon emissions and tourism economic contributions[90]



Box 8 Should Tourism Pay for Climate Change Losses and Damage?

Losses and damages have become an increasingly important topic in international climate policy negotiations and resulted in a historic decision at the Conference of Parties (COP) 27 in Egypt to establish a dedicated fund to compensate and support climate action in the most vulnerable countries. Climate finance sources for losses and damage remain unresolved, with few countries thus far pledging to be part of a donor base.

SIDS, despite their limited contributions to climate change, are the most vulnerable to its impacts. SIDS are trapped in a vicious circle of debt and climate emergencies. While SIDS received around US$1.5 billion in climate finance between 2016 and 2020, in the same period 22 SIDS paid almost 18 times more – over US$26.6 billion – to their external creditors.[91]

Tourism, specifically air travel, has been proposed as a possible funding mechanism. The International Air Passenger Adaptation Levy proposal was submitted to the 2008 COP to introduce a new charge on air travel tickets that would generate US$8–10 billion annually to support climate action in vulnerable countries.[92] In 2021, a similar proposal for a levy on international air travel to support finance for losses, damage and adaptation was brought by the UN Special Rapporteur on Human Rights and the Environment. The levy would generate between US$40–$300 billion annually if all countries participated,[93] far less than the damages related to the sector's current emissions (Figure 20). Tourism, like all sectors and countries, could be accountable for the estimated damage associated with its SCC through a proposed international price on carbon.[94]

4 Global Tourism Climate Impacts and Adaptation

The foundation for effective adaptation action is a robust understanding of exposure to climate hazards and observed as well as potential impacts on tourism operations, infrastructure, natural and cultural heritage assets, and demand patterns.

Finding 10

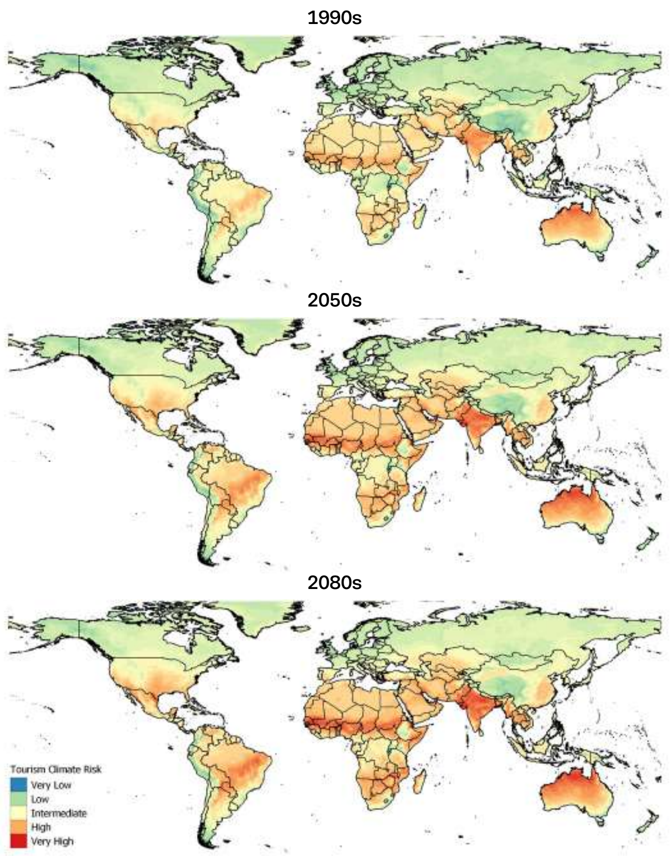
Climate change exposure and impacts are anticipated to be far-reaching for tourism. High sector vulnerability often coincides, both with regions where tourism contribution to GDP is high and those where tourism growth is anticipated to be the strongest through to the 2050s. Current forms of tourism will not be viable at some destinations.

Metric: Cumulative Climate Hazard Exposure

Tourism is a highly climate-sensitive sector that is strongly influenced by multiple climate hazards,[95] which are observed to be changing and will continue to evolve in the decades ahead.[96] Figure 17 illustrates the differential and changing global distribution of tourism exposure to multiple (19) climate hazards under a moderate (IPCC: RCP4.5) emission scenario.[97]

Figure 17

Tourism exposure to cumulative climate hazards



Exposure hotspots are found in South and South-East Asia, sub-Saharan Africa, the Amazon and central South America, small island developing states in the Caribbean and Indian and Pacific Oceans, Northern Australia and Southern USA and Mexico. Lowest exposures are found in Western and Northern Europe, Central Asia, and parts of China, Canada and New Zealand. High exposure in regions where tourism represents a large part of the economy (see Figure 3 earlier) or is considered a future development strategy demonstrates where climate change will pose a barrier to tourism contributions to the SDGs and where countries most need to incorporate tourism into National Adaptation Plans (see section 5.2). The implications of changing climate hazard exposure for tourism infrastructure, assets, operating costs and insurability remain important uncertainties. Links between tourism, disaster response and humanitarian aid may become increasingly relevant (see Box 9). This will require greater policy integration and collaboration at the destination level (see section 5.4).

Box 9 Tourism and Climate Disaster Response

The tourism sector is not only impacted by disasters, but often contributes to response and recovery, working on the ground to support visitors and communities. KAITHA, formed in Kerala (India), is an emerging platform that brings together stakeholders from tourism, development, and humanitarian sectors to develop more formal and planned links that increase the climate resilience of destinations. Hotel Resilient is a similar initiative that works with accommodation providers to increase climate and disaster preparedness and enable hotels to become islands of resilience for the wider community.

4.1 Extreme Heat

Metric: Heat Risk Exposure Days

The increased frequency and intensity of extreme heat events are aggravating heat-related illness (HRI) and mortality.[98] International travellers are particularly at risk of HRI because they are often not acclimatised to heat at destinations, they are physically active at the hottest time of day and they can have communication barriers to heat warnings.

HRI exposure for tourists and tourism workers is increasing in the world's leading city destinations.[99] The cumulative number of annual heat risk days (humidex exceeding 31°C)[100] at the 100 top city destinations increased 18% between the 1950s and current conditions (2015–2025) (Figure 18). By the 2050s, heat risk days are projected to further increase 13–18% above current conditions (RCP4.5 and 8.5 emission scenarios respectively). Late-century scenarios reveal more pronounced increases in tourist heat exposure (20-35%).

Figure 18

Cumulative annual heat risk days (>31°C) at the top 100 city destinations (relative to 2015–2025)

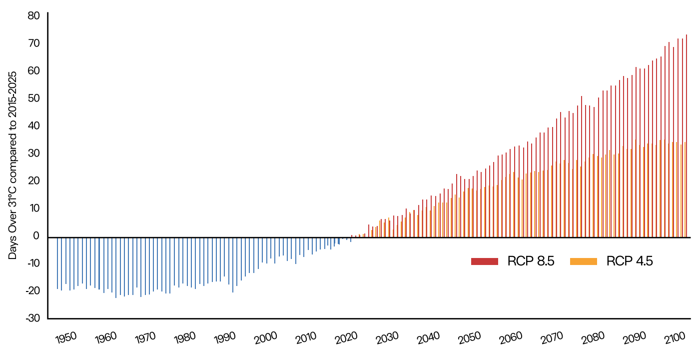
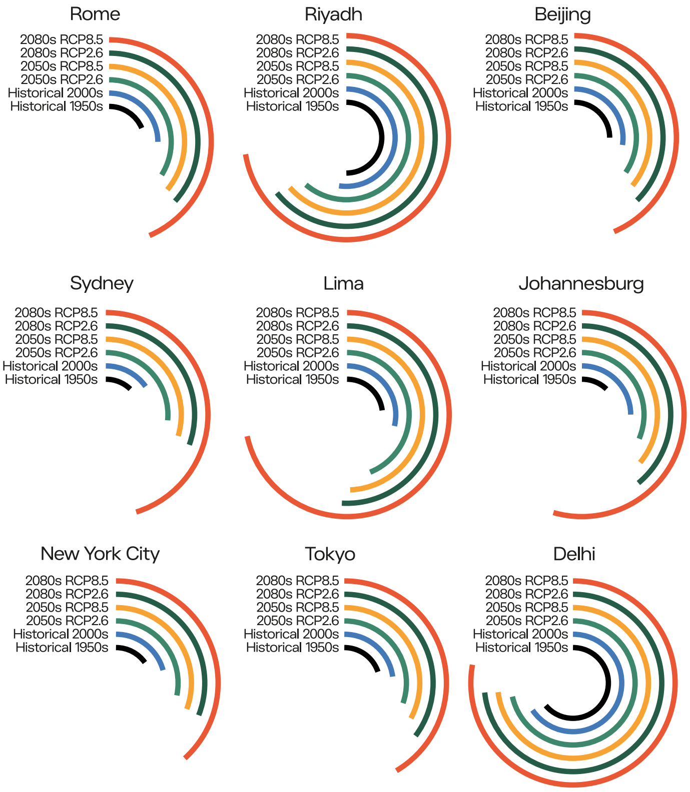


Figure 19 illustrates how the heat risk for tourists is projected to change in a sample of top 100 city destinations. Geographic and seasonal changes in heat risk have important implications for tourism demand patterns,[101] with heat-escape tourism becoming a national strategy in China.[102]

Figure 19
Evolving destination heat risk



Metric: Availability of Air-conditioned Accommodation

Air-conditioning is an important adaptation to tourism heat risk. Analysis of over 240,000 hotel properties worldwide found 76% have air-conditioning (Figure 20).[103] The availability of air-conditioning was lower (64%) for all accommodation types (800,000 properties). Regions with high frequency of HRI exposure and lower air-conditioning availability include countries in northern South America, parts of Central Africa, and some regions of France and Mexico. The growing need for air-conditioning in most of the top 100 city destinations represents an important increase in operating costs,[104] but also contributes to the sector emissions challenge where electricity emission intensity is high (maladaptation).

4.2 Fire Exposure

Metric: Wildfire Exposure of Destinations

Wildfires pose a significant threat to tourism infrastructure, assets and visitation in fire-prone regions (see section 7.1.1 for media coverage).[105] A multi-hazard analysis found wildfires were the second most detrimental type of disaster when measured in economic damage, with resident displacement and recovery major drivers of post-event accommodation demand that continues to disrupt tourism.[106] Wildfire activity and intensity are projected to increase in many regions under climate change,[107] including several major tourism regions. Some of the largest increases are in the European Mediterranean. Figure 21 shows the increase in high fire hazard days under a moderate emission scenario (RCP4.5) for the 2050s and 2080s.[108] The estimated annual cost of wildfires to Portuguese tourism alone is between €35.3 and €63.3 million in 2030, increasing at least fourfold in 2050.[109]

Figure 20
Global hotel properties with air-conditioning

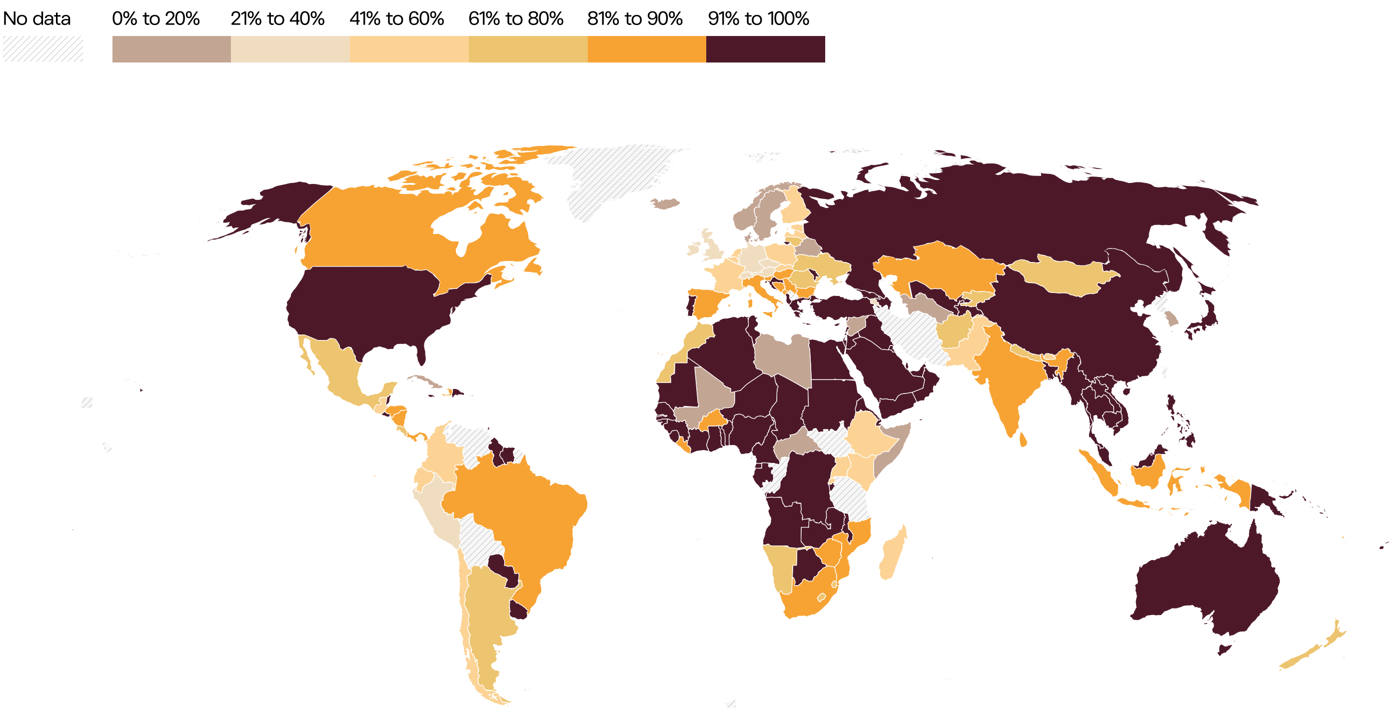
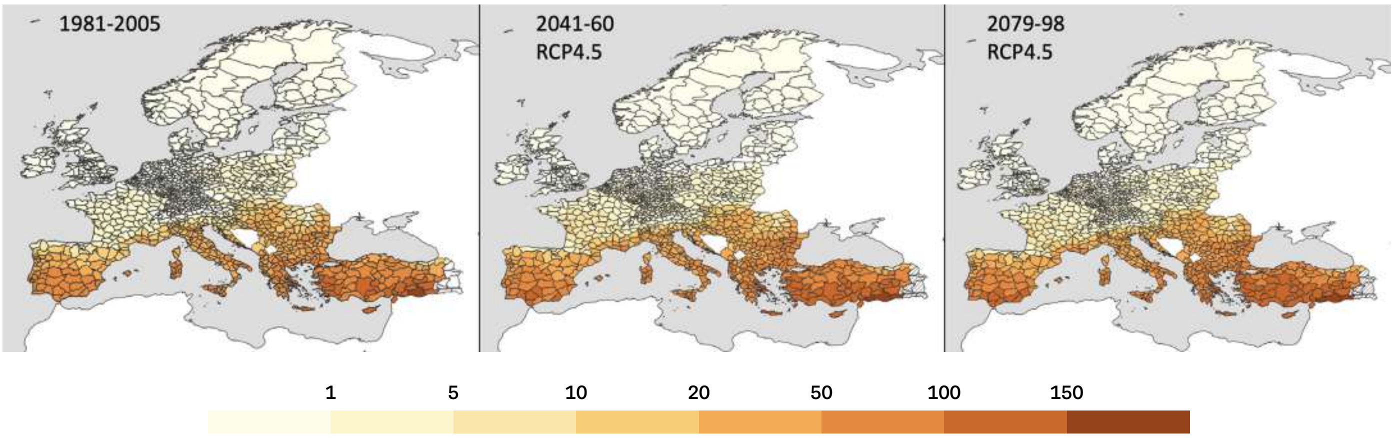


Figure 21
Wildfire hazard days in Europe



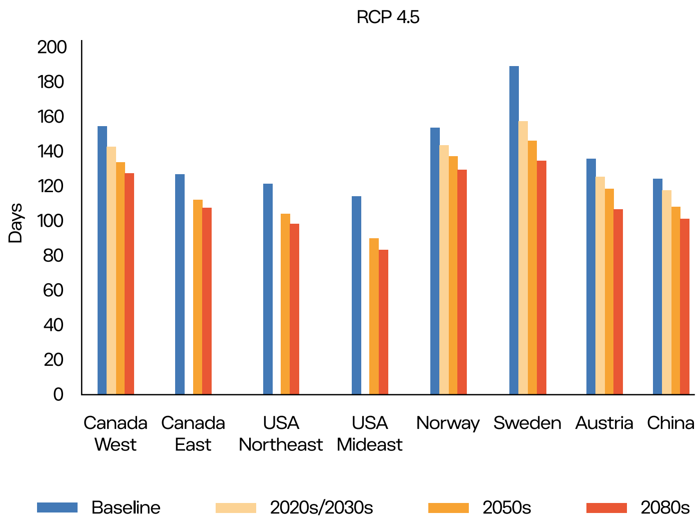
4.3 Slow Onset Climate Impacts

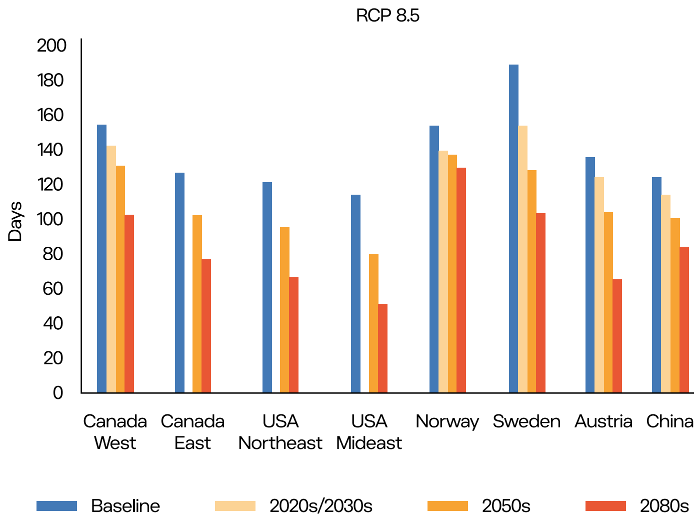
4.3.1 Snow-dependent Tourism Destinations

Metric: Ski Season Length

Warming and decreased snowfall in low-elevation and/or latitude regions[110] has impacted ski resort operations and tourism worldwide.[111] Figure 22 summarises the projected losses in ski seasons across regional markets even with advanced snowmaking in place.[112] Average season losses in the 2050s range from 15% to 22% (low and high emission scenarios) and are more pronounced in the 2080s (20–42%). To limit ski season losses requires substantial increases in snowmaking, with an average increase across all markets of 34–37% in the 2020s/30s, 96–127% in the 2050s and 115–158% in the 2080s.[113] Much higher increases are needed at many individual ski areas in all markets.

Figure 22
Losses in average ski season length for two climate scenarios

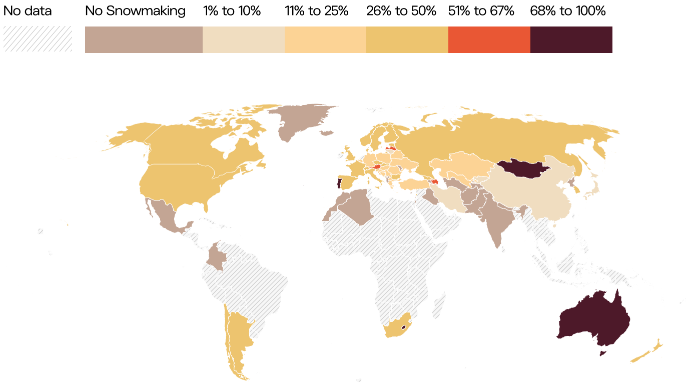




Metric: Snowmaking Adaptation Extent (Percentage of Ski Areas)

Snowmaking has been an integral climate adaptation of the global ski industry for decades and is widespread, with one-third of the 5682 alpine skiing areas globally utilizing snowmaking to some extent (Figure 23). Continued investment in expanding the adaptive capacity of snowmaking is expected.[114] Snowmaking has been criticised as maladaptive because of its substantial energy and water use.[115] However, snowmaking sustainability is highly place-context specific.[116] For example, snowmaking at all ski areas in Quebec (Canada) supports nearly six million skier days and causes the same emissions as only 65 skiers flying a round trip from Quebec to ski destinations in western Canada.[117]

Figure 23
Global snowmaking coverage



4.3.2 Sea Level Rise

Sea level rise (SLR) represents a transformative risk to coastal tourism worldwide, but research on destination level risk remains limited.[118]

Metric: Exposure of Tourism Assets (Resorts, Heritage Sites, Airports) to Sea Level Rise Inundation and Erosion

Coastal tourism assets and infrastructure around the world will increasingly at risk of SLR. Major airports face increased risk of flooding and operational disruptions. In a +2C scenario, 95 additional airports and 866 flight routes are projected to be impacted by SLR, increasing to 144 airports and 1062 flight routes in an RCP8.5 scenario.[119] Several airports are at risk in Europe, North American and Oceania, but risks are highest in South-East and East Asia.

High proportions of coastal resorts in the Caribbean[120] and Thailand[121] are at risk of flooding and erosion damage by late century, with major implications for destination revenue, competitiveness and sustainability. Importantly, while the 2050 or 2100 risk to coastal tourism depends on the rate of local SLR and associated erosion, the nature of long-term SLR means that the impacts of higher emission scenarios will only be delayed.

UNESCO World Heritage sites (WHS) represent outstanding cultural and natural heritage value across generations and are major tourism assets that increase arrivals to countries.[122] WHS are concentrated in coastal areas, making them at risk of SLR. Analysis of 340 WHS found that 51–55% of them would be at risk of partial to complete annual flooding by 2100.[123] Figure 24 displays the SLR risk posed to these sites under a 2100 high-emission scenario (RCP8.5). The losses and damages associated with such impacts on WHS are immeasurable.

Figure 25 shows the potentially devastating flooding risk of the historic city of Ayutthaya (Thailand). Analyses such as these indicate the importance of both horizontal and vertical collaboration between key organisations, including UNESCO, government agencies charged with cultural preservation and urban planning. Furthermore, WHS offer a unique opportunity to raise awareness of climate risk, including GHG emissions, in an integrated approach targeted at both stakeholders and visitors.[124]

Figure 24
2100 SLR Risk of World Heritage Sites

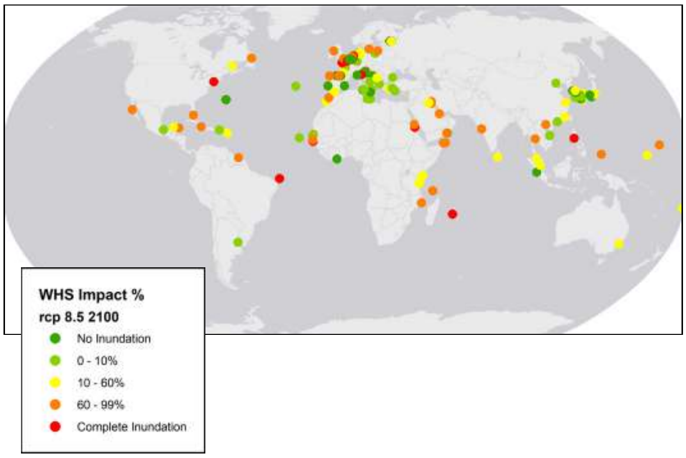
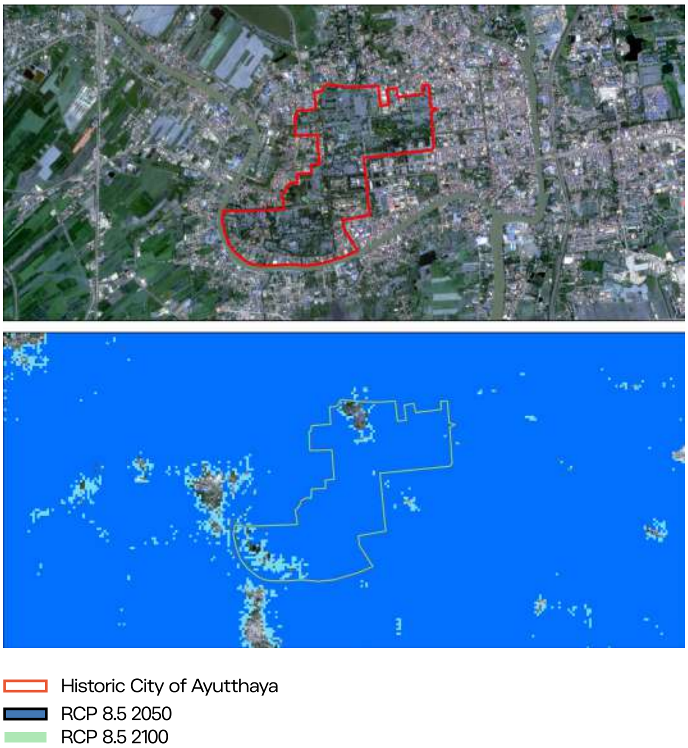


Figure 25
Sea level rise Impact at Ayutthaya, Thailand



4.4 Biodiversity and Tourism

Finding 11

Tourism can be a support mechanism for biodiversity and ecosystem management, although careful management of tourism impacts on biodiversity is required. The continued ability of tourism to support biodiversity conservation requires due consideration of associated GHG emissions from travel, sequestration potentials, and whether tourism to support adaptations such as ecosystem restoration or expanded protected areas are maladaptive.

Biodiversity and natural ecosystems are key attractors for tourism. A 2015 study[125] estimated that terrestrial protected areas alone attract about eight billion visits per year. Of these, 80% are in Europe and North America, but biodiversity hotspots in other parts of the world are also iconic attractions.

Metric: Income Generated from Protected Area Tourism

Protected area tourism generates significant income, of the order of US$600 billion per year in direct in-country expenditure,[126] which is distributed though value chains into local and national economies. Tourism is a vital source of revenue to protect ecosystems, including potential climate adaptation and mitigation measures.[127] In many cases, protected areas continue to exist thanks to tourism. If poorly managed, tourism imposes additional pressure on already stressed ecosystems (cumulative risk). In response, some countries actively restrict behaviour and distribution, and adjust management actions to achieve desired conditions (e.g. the rotation system of National Parks in Thailand).[128]

Climate change is posing a growing risk to biodiversity, and as a result to the attractiveness of some nature-based tourism destinations.[129] The IPCC[130] has reported that all biodiversity hotspots are already being impacted and will increase under all future climate scenarios (Figure 26). The risk of species extinction increases with warming in all climate change projections.[131]

The IPCC recognised the potential of tourism as a key support mechanism for enabling nature-based solutions that provide multiple benefits, including carbon sequestration, restored ecosystem resilience, cultural services and value for nature-based tourism.[132] Some realities of tourism as a mechanism for nature-based solutions remain uncertain. Questions such as whether tourism in the region might still be viable under future climate scenarios, whether emissions from travel to the destination outweigh sequestration benefits and the implications for Indigenous land rights have not been explored.[133] The recent interest in 'regenerative tourism'[134] provides an important opportunity to connect climate action, ecosystem restoration and community wellbeing.

Metric: Extent of Coral Reef Bleaching

Coral reefs are particularly vulnerable ecosystems. Already, about 25–50% of the world's coral reefs have been destroyed, with 60% of remaining reefs under threat. The occurrence of coral bleaching events will increase rapidly over the next decades (Figure 27),[135] which will not only affect tourism, but will impact a wide range of local livelihoods. Research has showed that global reef tourism has an economic value of US$36 billion per year.[136] In places, tourism can contribute positively to coral restoration projects.[137]

Figure 26

Projected loss of climatically suitable areas in terrestrial biodiversity hotspots for a global average of 1.5°C (upper row), 2°C (middle) and 3°C (lower)

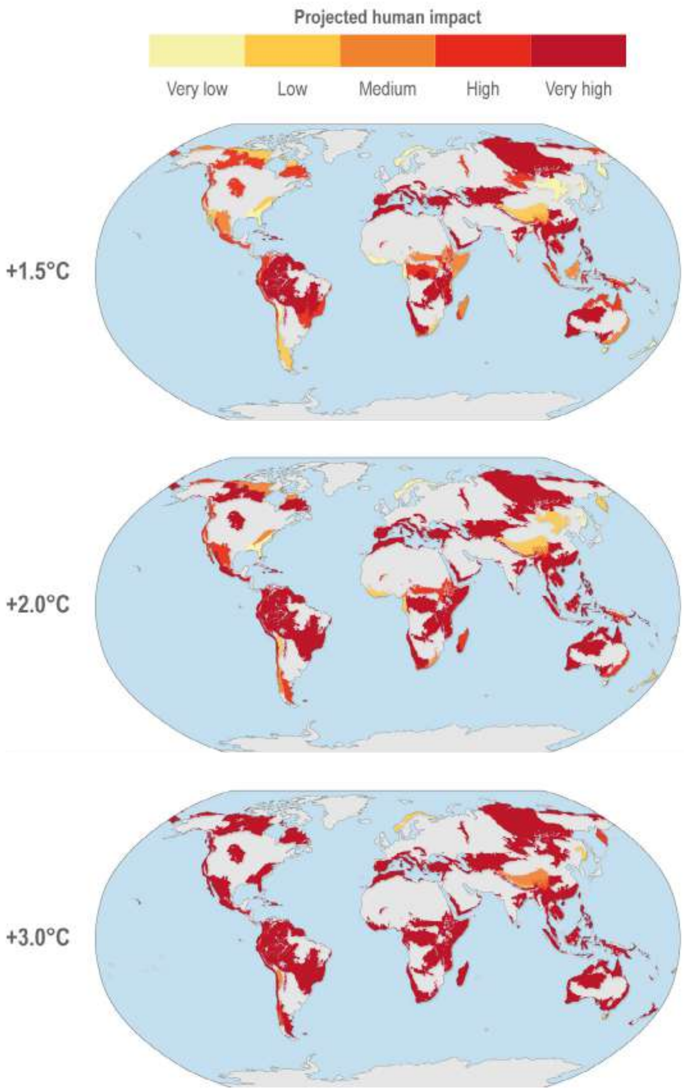
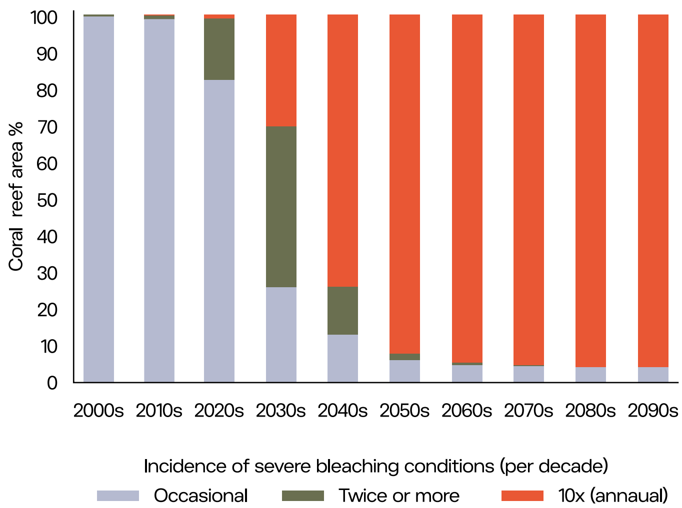


Figure 27

Coral bleaching incidence under future climate change (RCP8.5 emissions scenario)



4.5 Integrated Assessments of Climate Change Risks

Finding 12

Assessments of the integrated effects of climate hazards at the destination scale remain very limited, providing an incomplete and potentially under-estimate of risk. More comprehensive understanding of the interactions of multiple hazards as well as from climate change responses is needed to inform effective adaptation.

Assessing the complexity of climate change and tourism interactions is an important gap to inform climate action. Analysis of single climate hazards provides an incomplete and potentially misleading assessment,[138] yet that remains the dominant form of climate risk assessment in the tourism sector.[139] A comprehensive analysis of carbon and climate risks, including timing and potential compounding effects, has not been completed for any tourism destination (at any scale).[140]

Finding 13

Combinations of high levels of poverty, unsustainable tourism development and multiple climate hazards are undermining prospects of achieving sustainable development goals while exacerbating climate injustice in island and mountain destinations in low- and medium-income countries.

4.5.1 Tourism Climate Risk in SIDS

Small Island Developing States (SIDS) are among the most vulnerable countries to climate change and the most economically dependent on tourism.[141] The Caribbean region is illustrative of the range of climate change impacts that threaten the sustainability of tourism in SIDS (Figure 28).

Figure 29
Differential climate risk at Caribbean destinations

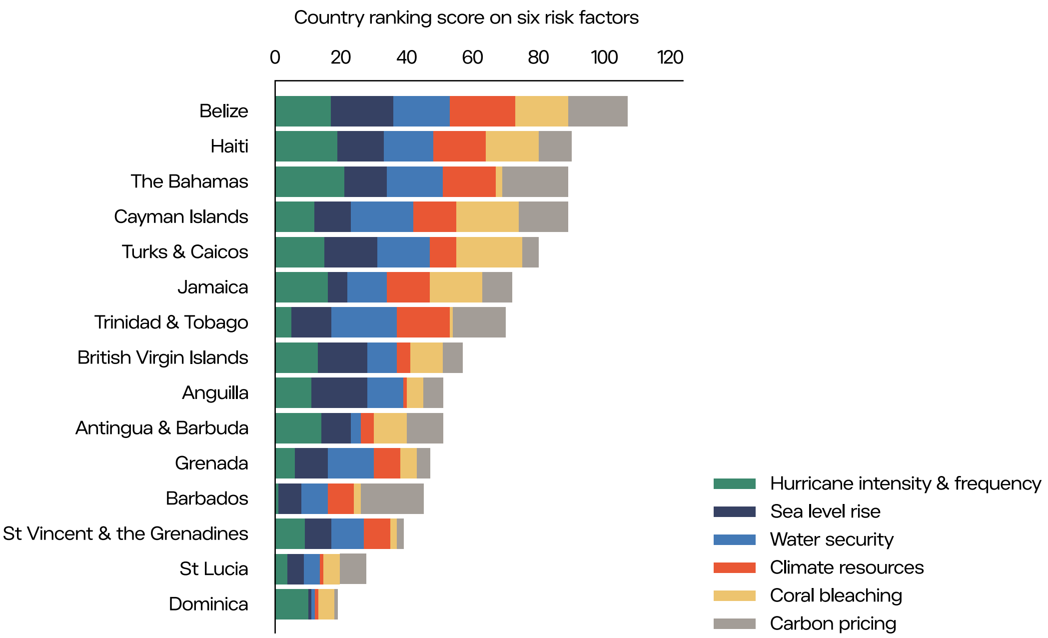


Figure 28
Dimensions of tourism climate risk in SIDS

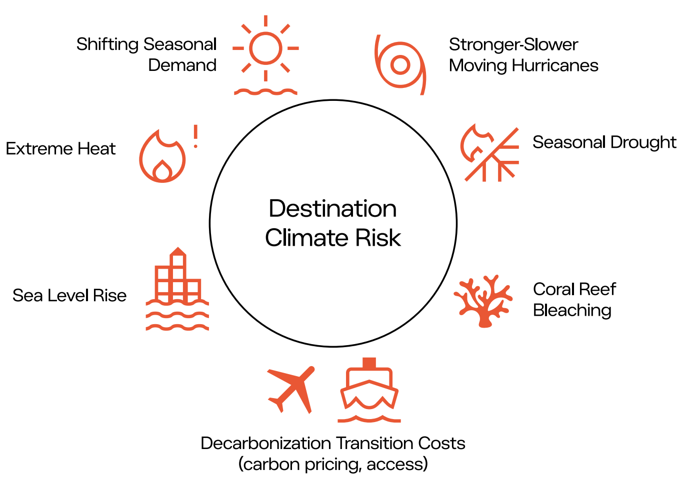


Figure 29 summarizes the combined threat of six priority climate change impacts identified by the Caribbean Tourism Organization across 22 countries.[142] The results underscore that not all Caribbean countries face the same level of climate change risk, with Belize, Haiti and the Bahamas at highest risk, and St Lucia and Dominica facing the lowest. Insight into the timing and potential interactions of climate hazards and supply- and demand-side responses (mitigations and adaptation) remains limited and a priority for future research. Integrated climate change risk assessments are needed to support policy-makers to develop country and destination-appropriate adaptation strategies.

In the South Pacific, the Pacific Sustainable Tourism Development Framework takes an integrated approach connecting the prosperity of communities, climate action and ecosystem resilience. Since the COVID-19 pandemic, considerable effort has been put into 'rethinking' tourism in the Pacific, empowering local voices and developing a grassroots approach with wellbeing at its core.[143]

4.5.2 Climate Risk Interactions in Mountain Destinations

Sustainable mountain development through tourism presents an important opportunity to address poverty alleviation, support economic development more broadly and generate much-needed investment. However, current mountain tourism development pathways combined with multiple cascading climate change impacts are increasing the vulnerability of local people and eroding tourism competitiveness.

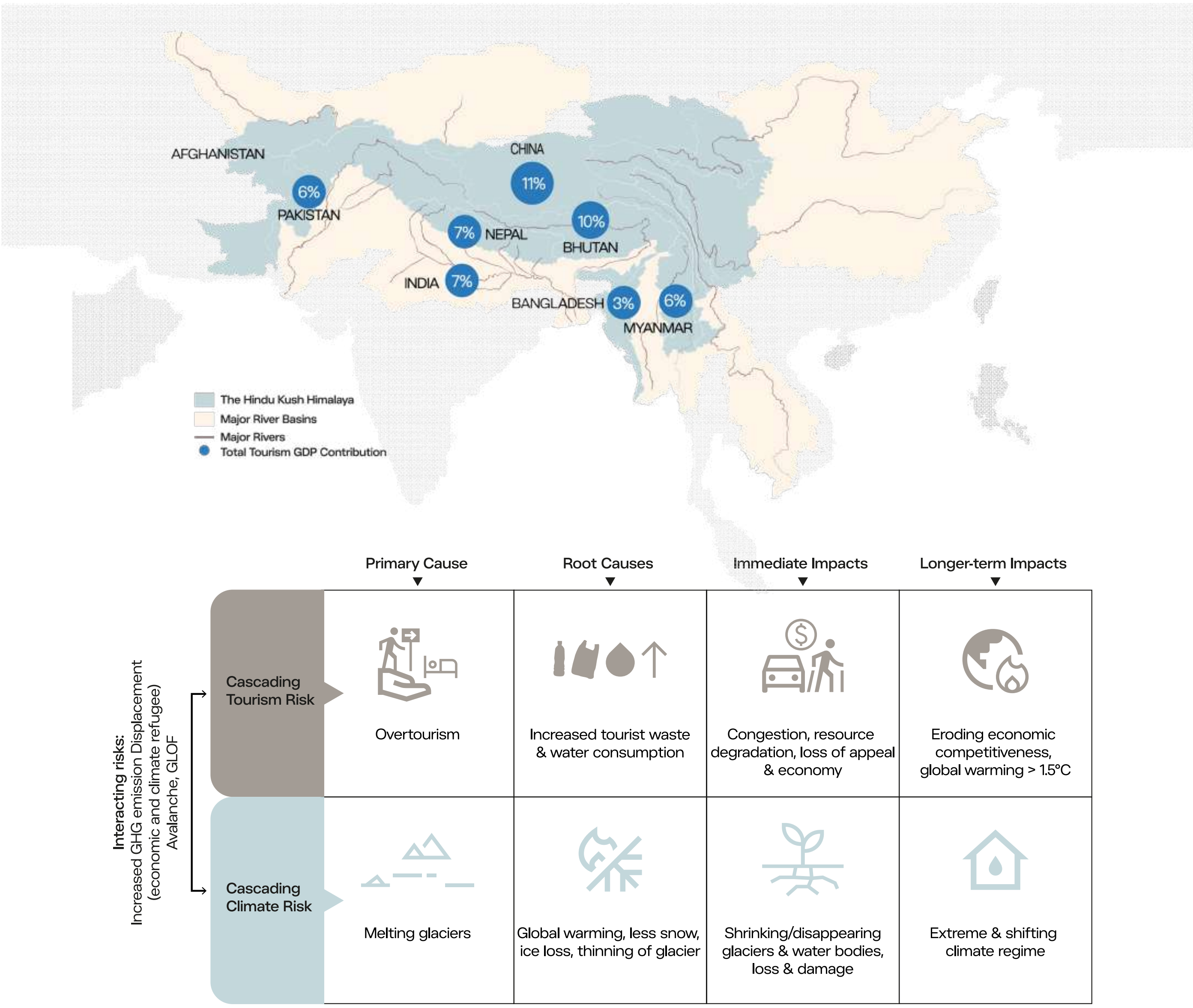
Warming in mountain regions has outpaced the global average and impacted the aesthetic, spiritual and other cultural aspects of mountain landscapes in many regions.[144] Figure 30 illustrates the multiple climate change impacts and complex interactions in the Hindu Kush Himalayan (HKH) region that influence tourism and sustainable development.

Figure 30
Cascading tourism and climate change risks in the Hindu Kush Himalayas[145]

The priority for countries and destinations in the HKH, formalised in the Moving Mountain 2030 strategy,[146] is to promote mountain tourism that advances climate change mitigation and adaptation in an integrated manner to advance sustainable development. Several policy responses have been developed:

- At the country level, Nepal's NAP, under Tourism Natural and Cultural Heritage, identified eight tourism-related projects with a required investment of US$1.8 billion.[147]
- Bhutan introduced a tourism levy (Tourism Levy Act of Bhutan 2020 and 2022), requiring international tourists to pay a Sustainable Development Fee of US$200/night. Regional tourists pay US$14.[148] At present, the levy has been halved to attract more visitors to assist COVID-19 recovery.

At a time when low-income countries are facing a widening deficit in required investment (from a wide range of sources, including development support or direct foreign investment), that will hamper countries' efforts to achieve the 2030 Sustainable Development Goals,[149] tourism development has important value. That value can only be realised if tourism helps to build climate resilience by channelling investment into energy, water, infrastructure, education, capacity-building and strengthened, inclusive governance.



The costs of climate change for mountain tourism are also evident in South America, due to glacier recession. Several types of mountain tourism are being affected: backpacking and adventure tourism; school trips; skiing and biking; canoeing and rafting; and climbing and trekking. For example, as the frequency of icefalls and avalanches is increasing, some climbing routes are becoming more dangerous. Conflicts are increasing among the actors involved, including the community, conservationists and park managers. In 2007, the Pastoruri glacier was the first Peruvian tourism destination closed due to 'adverse climatic conditions'. A quarter of the local community was economically impacted and protested. New policies were negotiated to partially reopen the area.[150]

4.6 Adaptation Planning and Reporting

Finding 14

Insight into the extent, effectiveness (current and future climate), co-benefits and equity of climate change adaptation in the tourism sector is very limited. Improved monitoring and evaluation are important to inform sizeable future investments in adaptation.

With exposure to climate hazards and potential impacts increasing throughout the tourism sector, the adaptation imperative is growing. Foundational to effective adaptation is an in-depth understanding of changing climate hazard exposure and potential impacts on tourism operations, infrastructure, assets and demand. A UNWTO 2021 survey of tourism businesses, destinations and organisations from 131 countries found that fewer than 10% had assessed existing and future climate change risks and vulnerabilities.[151]

Metrics: Tourism Organisations Assessing or Reporting Climate Change Impacts

Evidence of the extent of adaptation in the tourism sector is limited (see also section 5.2 on NAPs).[152] A 2011 study of tourism policy and planning in 44 countries by OECD found that only 12 considered adaptation strategies and that two regarded them as unnecessary.[153] A 2020 review of tourism plans in 12 Caribbean countries found only five mentions of climate change, with very limited information on climate impacts or potential adaptations and none indicating coordination with regional or national climate change lead departments.[154] One of the central barriers expressed by tourism planners in the region was the lack of tourism-specific information on climate change impacts or implications of policy responses at the country or destination scale. Box 10 describes initiatives by the governments of Mexico, Jamaica, and Chile to overcome this barrier and advance destination adaptation.

Box 10 Progress in Tourism Climate Change Impact and Adaptation Assessments

In Mexico, the Ministry of Tourism commissioned climate change vulnerability assessments at 20 priority destinations between 2012 and 2016. Climate hazard mapping, adaptation options and cost-benefit analysis, and evaluation of early warning systems were conducted to build resilience and inform future tourism developments (including where development should be avoided).[155] A lack of local technical capacity (see also section 7.2) to understand the impacts and financing to support prioritized adaptation responses were two key challenges (see also section 6.2).

New tourism strategies in development for Jamaica and Suriname, in collaboration with the Inter-American Development Bank, both include consideration of climate change. Building the resilience of the tourism industry to climate change and reducing the tourism industry contribution to climate change are two key elements of the new Jamaican tourism strategy.[156]

The climate change adaptation plan for the tourism sector in Chile is underway, and was a response to its 2015 NDC commitments. Impacts remain poorly defined due to a lack of sector-specific research. Regional workshops are planned to inform adaptation strategies by 2024 and to improve public–private sector coordination.

Metric: Tourism Organisations Engaged in or Monitoring Adaptation

The 2021 UNWTO survey found 4% of responding organisations of all types monitored and reported on climate adaptation progress.[157] Of the 17% of organisations that indicated they were engaged in adaptation, technical, policy, management and education were the most common actions. As disclosure requirements on physical climate risk and adaptation evolve for publicly traded companies, reporting is anticipated to increase rapidly in the mid-2020s.[158] Sectoral standards on climate risk disclosure that are aligned with financial market requirements are needed (e.g. tourism guidance on the International Sustainability Standards Board – IFRS S2 Climate-related Disclosures [IFRS S2] Standard). Understanding current and future physical climate risks at the destination and property levels will be increasingly important for maintaining insurability. Insurance coverage and cost trends for tourism operators, particularly post-climate disaster, remain an important adaptation uncertainty.

Finding 15

There is increasing consideration of adaptation and resilience building in tourism plans and strategies, but sector-specific actions remain fragmented, near-term focused and unequally distributed across regions and destination types.

Finding 16

Compounding climate hazards and limits to adaptation mean that current forms of tourism will not be viable in some destinations (e.g., ski tourism at low elevations, beach tourism in highly erodible coastlines, desert destinations). Where alternate tourism markets and destination rebranding are not successful, a just transition requires support for those with lost tourism-dependent livelihoods.

As in many sectors,[159] there is an urgent need for improved monitoring and evaluation of adaptation effectiveness (and its limits), scalability, potential and realized co-benefits, and maladaptation.[160] Because the potential adaptation pathways differ widely across destinations, there is also a need for insight into the distributional aspects of adaptation processes in which tourism is involved, including who participates, who makes decisions, who pays and who benefits.[161] Improving the capacity of those working in the tourism sector (e.g. at destination level) to plan and evaluate adaptation measures is essential (see section 7.2).

5

Tourism and Climate Policy

Finding 17

Tourism policy is not yet integrated with global and national climate change frameworks, despite an increase in sectoral climate pledges. Only 18% of Nationally Determined Contributions and 43% of National Adaptation Plans submitted over time address tourism, respectively. Tourism is omitted from climate change frameworks in many countries where tourism represents a high proportion of the economy. The separate treatment of domestic and international aviation and cruise liners at international and national levels is a governance challenge for effective tourism mitigation policy.

5.1 Sector Commitments

Metric: Number of Tourism Organisations and Companies Making Public Climate Commitments

The number of tourism organisations that publicly pledge climate action is growing. However, with 159 member states of the UNWTO, and close to 900,000 tourism businesses globally,[162] the numbers presented in Table 5 remain very small.

Table 5

Climate-related pledges for tourism[163]

	Glasgow Declaration	Future of Tourism	CDP	Science-Based Targets initiative
Government	11	9		
Subnational	75	34		
Hotels and Hotel groups	86	17	252	112 'Hotels, Restaurants and Leisure Services, and Tourism'
Other tourism businesses	283	479	63	
Airlines			134	26
Other transport	11			12 airports 43 railroad
Academia, NGOs, other	146	190		

5.2 Tourism in NDCs and NAPs

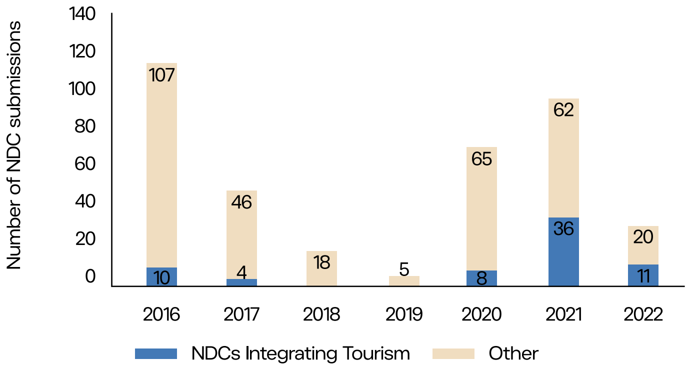
Metric: Share of NDCs and NAPs with Specific Tourism Considerations

A total of 392 NDCs were cumulatively submitted to the UNFCCC by the end of 2022. Of those, 17.6% addressed tourism in a significant way.[164] The highest share was in 2021, when 36.7% of newly submitted NDCs considered tourism (Figure 31). Most NDCs describe tourism as an 'at risk' sector rather than an area of decarbonisation. Only 13% of plans that address tourism define measurable indicators to monitor progress. Research indicates that measurement of tourism can foster dialog and learning, and incentivize stakeholder network for improved destination management.[165]

In countries where tourism is a major economic activity, it would be beneficial for tourism to be included in national climate policy. There are 64 countries where tourism's direct contribution to GDP is 5% or higher. Of these, fewer than half (45.3%) have active NDCs that address tourism in a significant way.[166] NDCs do not include emissions from international aviation or shipping (Box 11), despite some suggestions that they should.[167] Data from 2017 show that in 28 of 43 Annex I countries (industrialised plus transition countries in the Kyoto Protocol), the share of emissions from air bunker fuels exceeded 2% of annual GHG emissions.[168]

Figure 31

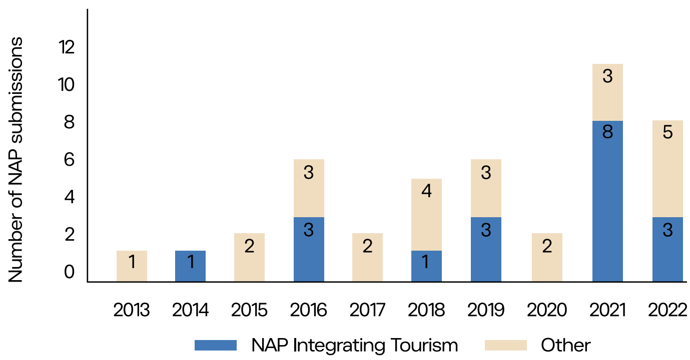
NDCs with specific tourism consideration (excluding INDCs)



NAPs are submitted by low- and medium-income countries. Of 44 NAPs in 2022, 43% considered tourism in a significant way (Figure 32). Of the 64 countries with a direct tourism contribution to GDP larger than 5%, only 11 submitted a NAP. Of these, 63.6% addressed tourism.

Figure 32

NAPS with specific tourism consideration



Box 11 International Aviation and Shipping

International air travel consumes about 60% of global aviation fuel, while domestic aviation makes up 40% (only domestic is covered under national climate policies). Legal analysis found that under the Paris Agreement, international aviation emissions are to be included in the NDCs. However, relatively few parties acknowledge this in their current NDC filings. One commitment in practice is by the EU and its member states (first NDC, 18/12/20), while New Zealand is currently considering whether to include international aviation in its 'net zero' commitments, as reportedly are the sub-jurisdictions of California and Scotland. The United Kingdom will include its share of international aviation emissions in its legally binding national climate targets, and this will come into effect with the sixth carbon budget in 2033. At the same time, countries are providing State Action Plans for aviation to ICAO. Of 136 SAPs submitted, only 88 states granted permission to make their SAP accessible. Most SAPs only address CO_2 (see section 2.3.1 on non-CO_2 emissions).

5.3 Climate in National Tourism Policy

Finding 18

Most national tourism policies or plans give limited consideration to climate change, although this is starting to improve. Tourism policies are currently not addressing mitigation in high emission forms of tourism, nor are they incentivising the development and choice of low-carbon tourism products.

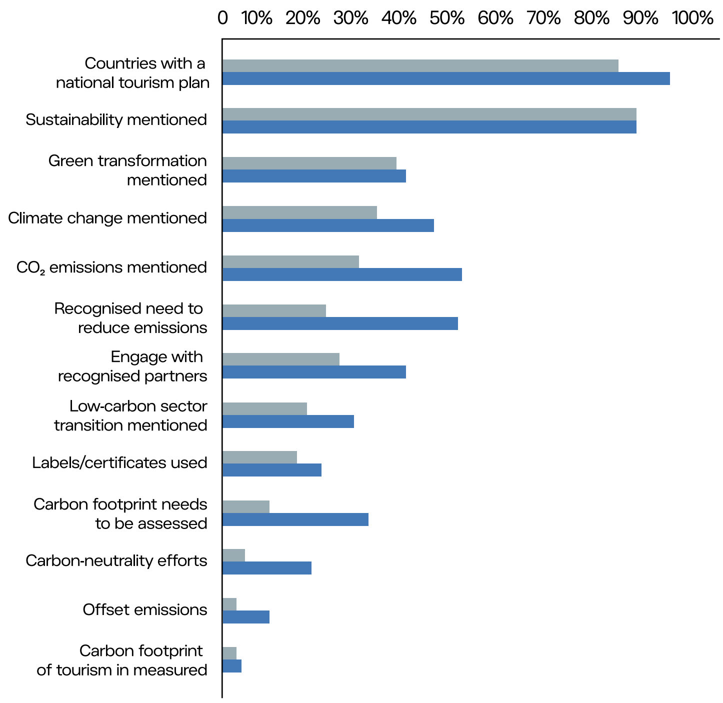
A global analysis of the role of climate change in tourism plans does not exist, although work undertaken in Europe provides a useful starting point (Figure 33).

Metric: Share of National Tourism Plans Supporting Climate Mitigation

review of 109 available national tourism plans over the timeframe October 2019 to July 2023 indicates increased inclusion of CO_2 emissions as a theme.[169] However, tangible activities such as GHG measurement or management remain limited, and the quality of plans varies. Future analysis should include a wider geography of tourism plans and actions related to adaptation and finance.

Figure 33

Changes of climate consideration within European national tourism plans between 2019 and 2023



A search of open access climate policy databases reveals that most tourism-relevant policy addressing climate change comes from non-tourism government agencies.[170] For example, In October 2023, the European Council adopted a new regulation relating to the 'ReFuelEU aviation' initiative, including sustainable aviation fuel mandates for suppliers, and environmental labelling for aircraft operators. In Norway, led by the Norwegian Maritime Authority, parliament supported a resolution to reduce cruise ships' and ferries' emissions in fjords in Norway (2018). The Royal Decree 635/2013 in Spain involved the Ministry of Agriculture, Food and the Environment, which effectively helped finance the Plan to Promote the Environment in the hotel sector PIMA SOL Spain (2013). Beneficiaries were hotels that implemented energy and water efficiency projects. The examples demonstrate that much climate action relevant to tourism is being developed outside tourism ministries or agencies. No evidence was found of policies targeted at influencing consumer decisions and lifestyles.

Box 12 Specific Tourism-Climate Strategies

Several countries have developed specific strategies to address climate change and tourism:

- Maldives Tourism Climate Action Plan: Strategic Pathways for Climate Resiliency In Tourism (2023)
- New Zealand (draft) Tourism Environment Action Plan (2023) as well as the Aotearoa Tourism Adaptation Roadmap (2023)
- South African Tourism Climate Change Communication Strategy (2021)
- Caribbean Sustainable Tourism Policy Framework (2020)
- Roadmap for Low-carbon and Resource-efficient Tourism in the Dominican Republic (2019)
- Action Plan for Low-carbon and Resource Efficient Accommodation in Mauritius (2019)
- Roadmap for Low-carbon and Resource-efficient Tourism in the Philippines (2019)
- Action Plan for Low-carbon and Resource Efficient Accommodation in Saint Lucia (2019)
- The Sustainable Island Project in Mauritius has developed a pro-handprint innovation project to improve comfort for customers while lowering emissions (2018).

In terms of tourism-climate governance, the UNWTO is now identifying climate focal points in each member state's tourism administration. This may trigger more investment in tourism-climate strategies (Box 12). At this point, no existing strategy clearly addresses high-emitting tourism sub-sectors.

5.4 Destination Leadership

Finding 19

Emerging good practice in destination governance falls far short of the need for sector-wide action to measure and mitigate tourism destination emissions and increase adaptive capacity and climate resilience. While increasing attention is given to the sustainability of tourism at the destination, travel to the destination often remains excluded.

Measuring destination carbon emissions is a critical step towards management actions to mitigate destination emissions. Some progress towards comprehensive destination carbon emissions measurement can be observed, but as noted by the UNWTO,[171] destinations face the greatest challenges when it comes to engaging in measurement, partly because scope and responsibilities are different.

Metric: Number of Destinations Measuring GHG Emissions

The One Planet Network was used to identify signatories of the Glasgow Declaration on Climate Action in Tourism in the Destination Management Organisation (DMO) subcategory (n = 37). Only four of the 37 signatories (11%), which self-identified as climate leaders, had conducted comprehensive emissions measurement; Visit SpaValencia (Spain), Destination Djerba (Tunisia), Tourism Vancouver Island (Canada) and GoSaimaa (Finland). The remaining 90% of DMOs either did not measure emissions or focused on providing mitigation advice and support for other tourism and non-tourism entities, including the visitors.

The lack of consistency in defining Glasgow Declaration signatories in the DMO category was clear, with signatories including local businesses, urban park authorities, and county/state and national tourism organisations. Some reported only their own organisational emissions rather than those of the wider tourism sector. The need to clarify system boundaries of a destination and the inclusion of Scope 3 emissions in accordance with GHG protocols is apparent.

The emissions baseline measurement, monitoring and mitigation efforts of DMOs is inadequate, possibly due to limited expertise and capacity, but also because of the lack of a clear mandate to do so. Several non-Glasgow Declaration signatories have collaborated with local authorities or draw on academic/scientific expertise to create emissions baselines (e.g. regional destinations in Australia, New Zealand and Germany). Several additional destination carbon footprint analyses have been published in isolation by academic researchers.

There is an urgent need to build collaborative networks of destinations. The Network of European Regions for Sustainable and Competitive Tourism (NECSTouR) provides an example of a network-wide approach to establish guidelines and requirements for destinations to measure and act upon carbon emissions (e.g. VisitFlanders). Good practice needs to be scaled up and connected horizontally and vertically to regional and national policy communities. Measurement is also important for determining the positive effects that tourism can have on destination carbon, such as 'impact travel' in the Hindu Kush Himalayan (HKH) region (Box 13).[172]

Box 13 Tourism can help reduce community emissions

Close to 16 million people in the HKH region lack primary access to electricity and modem sources for cooking. Global Himalayan Expedition (GHE) uses trekking expeditions to provide solar power and energy access to the remote communities of the Indian Himalayas. The objective is to contribute to an overall development of the community while empowering the local village population. The micro-grid infrastructure set up by GHE is owned and operated by the community. GHE trains the village members to maintain and troubleshoot the hardware. All equipment is transported by villagers and travellers on foot and emissions generated in the process of delivering solar panels are measured, as are the savings from removing emissions (eg. kerosene). So far, 231 villages have been electrified and 15,120 tonnes of CO have been saved.

6

Financial Flows

6.1 Public Sector Financial Support

Finding 20

Governments continue to invest in tourism infrastructure linked to high GHG emission intensity – for example, by providing 68% of US$601 billion for airport projects globally. Fossil fuel subsidies of US$732 billion globally are hindering the reallocation of investment into the low-carbon transition.

Pre-COVID-19, governments invested about US$553 billion globally into tourism support systems (e.g. marketing, borders, national parks, museums).[173] For context, the total direct GDP contribution in 2018 was $2751 billion. Tourism is a key beneficiary of this investment. Little is known about how much of government funding or tailored finance mechanisms support climate action (e.g. for the South Africa and Fiji cases, see Box 14),[174] although the evidence suggests these are dwarfed by subsidies for fossil fuels and infrastructure. Data on government spending on airport constructions and expansions, for example, show how the public sector globally continues to invest in high-carbon systems.

Box 14 Funding Tourism Climate Action

South Africa: In 2017, South Africa launched the Green Tourism Incentive Programme (GTIP) to incentivise resource efficiency for small tourism businesses. Through grant funding, businesses are encouraged to invest in energy and water efficient solutions, while also improving competitiveness and profitability. Qualifying businesses receive funding towards the total cost of implementing the interventions, to a maximum of ZAR 1 million (around US$50,000).

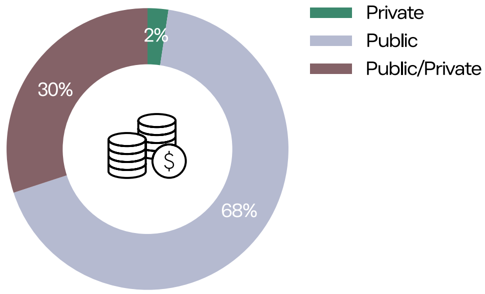
Fiji: The Environment and Climate Adaptation Levy (ECAL) helped to fund critical work across Fiji to protect the natural environment, reduce GHG emissions and adapt to the worsening impacts of climate change. According to the Environmental Levy Act 2017, ECAL includes 10% tax on importation of luxury vehicles; miscellaneous – inclusive of 10% charge on super yacht charters and docking fees; 10% income tax on individual earnings of more than FJ $270,000; 10 cents levy on plastic bags; and 10% ECAL on prescribed services (these include most tourism providers). In 2018, the levy raised US$50 million and funded 46 projects, including one specifically for tourism. The ECAL was reduced during COVID-19 and removed in 2022, when tax incentives (not directed at climate action) to restart tourism were increased.

Metric: Public Sector Investment into Airport Infrastructure

Current and pipeline (to 2026) airport projects amount to $601 billion worldwide,[175] of which $407 billion is government-financed. The United States alone is investing $132 billion into new airport infrastructure, followed by China ($66 billion) and India ($32 billion).

Figure 34 illustrates that public sector investment in airports far outweighs the private sector contribution. Expansion of aviation infrastructure, which has limited short-term prospects of decarbonisation (see section 2.3.2), effectively locks countries into high-carbon pathways.

Figure 34
Financial flows for airport projects



As the public sector has responsibility for a wide array of policy portfolios, including climate change, such investments are likely to be increasingly challenged. Commercial analysis of the global railway industry indicates growth (data vary, but broadly put the market at a worth of around US$50–60 billion in 2022). Much of the rail investment comes from the private sector.[176]

Another form of public sector finance is through global fossil fuel subsidies, which are considerable, exacerbating climate change and impeding progress toward international climate goals. Data from the IISD and OECD reveal subsidies and other support for fossil fuels globally more than doubled in 2021 to US$732 billion.[177] However, if associated externalities such as air pollution, GHG emissions and foregone revenue are considered, global fossil fuel subsidies were almost nine (8.85) times more at US$6.5 trillion in 2021.[178] This was about 7% of worldwide GDP in 2021 (US$97 trillion).[179]

Tourism businesses and activities directly and indirectly benefit from government energy and fuel subsidies, especially those relating to the aviation sector, where fuels are not taxed for international flights and can be exempt for domestic flights, alongside significant additional subsidies for manufacturing, infrastructure and airlines.[180]

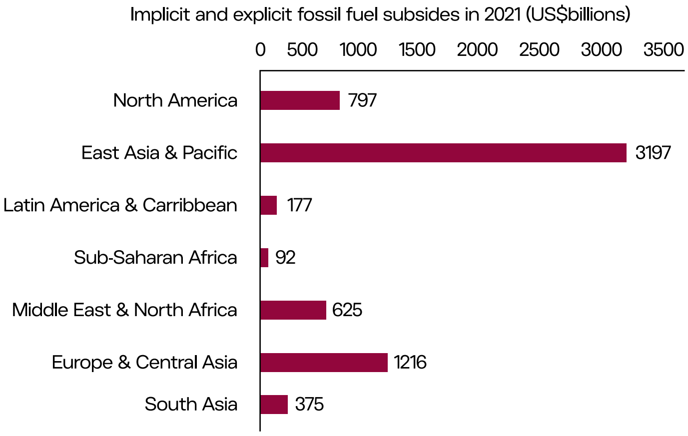
Metric: Fossil Fuel Subsidies (Implicit and Explicit)

Figure 35 illustrates the IMF fossil fuel subsidies data by region for 2021, showing East Asia and the Pacific region alone are responsible for 49% (US$3197 billion).[181] The same data by country income level indicate that 87% of global fossil fuel subsidies are the responsibility of high-income and upper middle-income countries, with only 0.1% associated with low-income countries. China stands out as the major contributor (US$2476 billion), followed by the United States (US$711 billion).

Fossil fuel subsidies are in stark contrast to the need to phase out all unabated fossil fuels as concluded in the Synthesis Report by the co-facilitators on the technical dialogue as part of the UNFCCC Stocktake (released in September 2023).[182]

Figure 35

Fossil fuel subsidies by region



6.2 International Development Flows

Finding 21

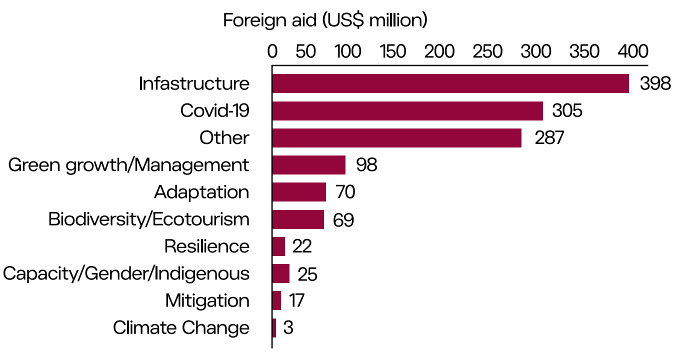
International development for tourism tends to support large infrastructure projects. The share of global projects that address climate change and tourism represents 8% of US$7198 million invested between 2000 and 2022.

The 2023 United Nations Conference on Least Developed Countries highlighted the potential of tourism as a vehicle for sustainable development. Tourism is a cross-cutting sector that provides opportunities for employment, often in remote regions. Tourism has contributed to the graduation of LDCs that are also SIDS, namely Cabo Verde, Samoa, the Maldives and Vanuatu.[183]

Tourism development is supported by development banks, UN agencies, national programs and NGOs. Based on data from the d-portal,[184] a total of US$7198 million has been spent since 2000 on projects with a significant tourism component. The largest type of investment (US$1684 million) was made into infrastructure projects (e.g. roads, airports, cruise terminals, corridors, water), typically by regional development banks (Figure 36).

Figure 36

Foreign aid tourism project categories in 2022



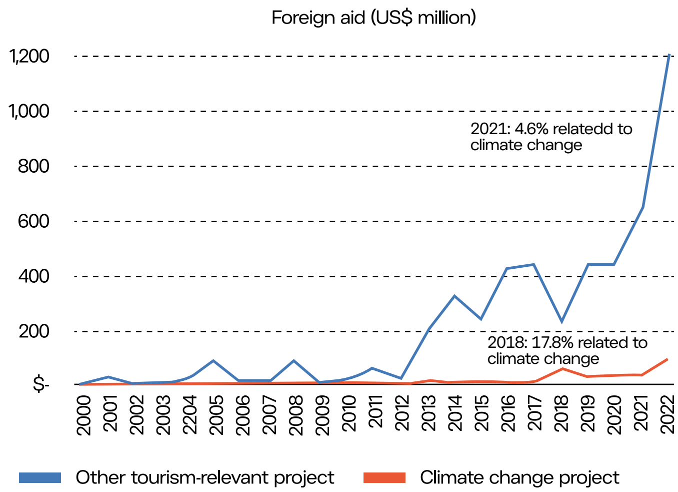
The single largest investor was the World Bank, with US$2576 million; 43% of this was for biodiversity or protected areas projects with tourism being a sub-component. Nature-based solutions projects[185] have great potential for tourism, but they are in their infancy.

Metric: Share of Donor Money for Tourism Projects That Support Climate Action

Three types of projects were considered to support climate action: those related to adaptation (US$451 million in total since 2000), mitigation (e.g. renewable electricity) (US$51 million); and integrated projects focused on climate change (US$77 million). The share of climate projects with a tourism component increased from zero to 7% in 2022. The sharp increase in overall funding is due to COVID-19 recovery support (US$380 million) (Figure 37).

Figure 37

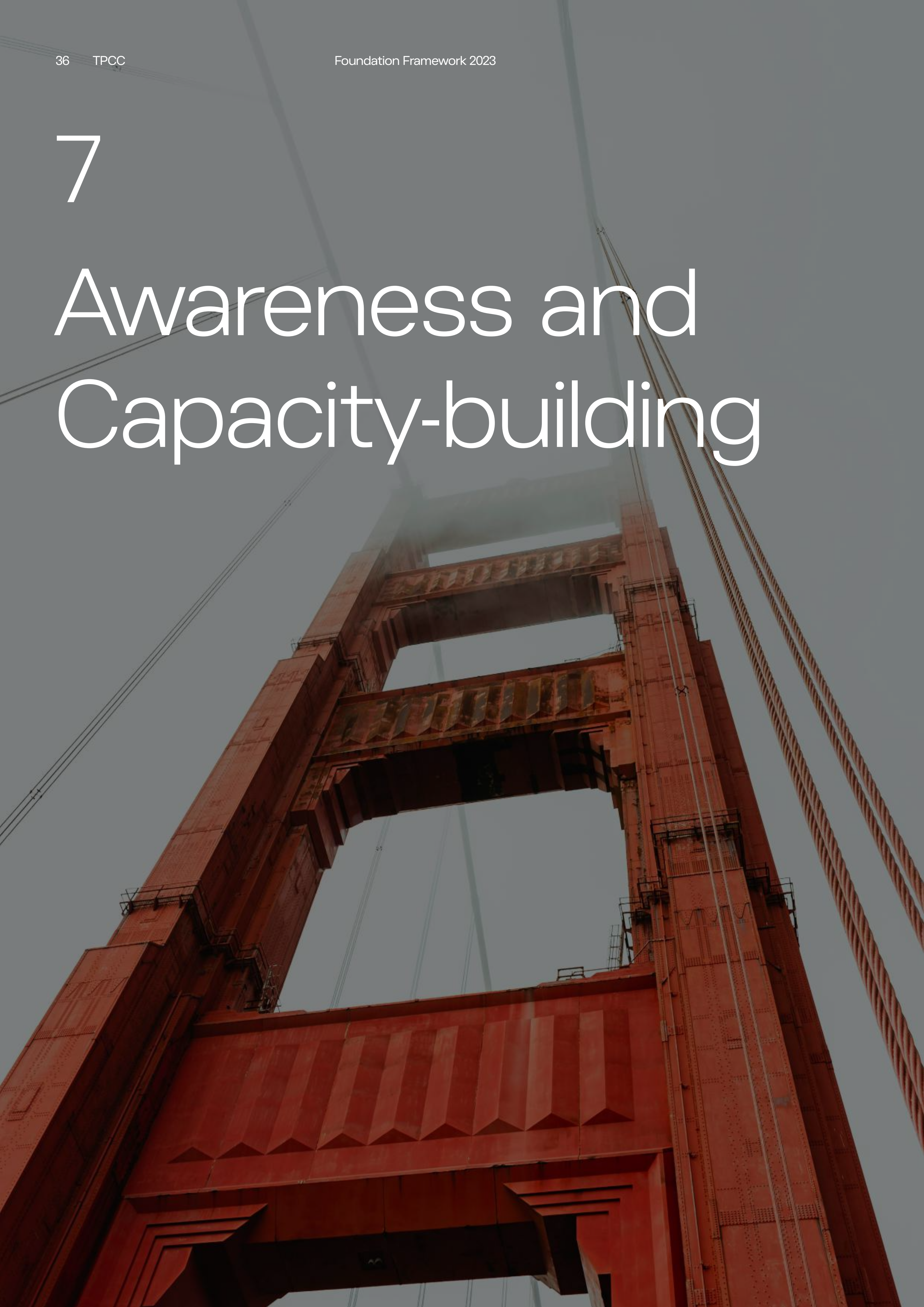
Climate-related projects among all tourism-relevant development projects



Adaptation projects are larger in size (US$10.3 million on average), but none focuses specifically on tourism. Mitigation projects are typically in the order of US$1°2 million. Debt-for-nature or debt-for-adaptation swaps are gaining traction. In 2021, for example, Belize re-purchased a quarter of its total public debt (US$553 million) in exchange for protecting 30% of its ocean and the Mesoamerican Reef. The Seychelles Conservation and Climate Adaptation Trust (SeyCCAT)[186] was established as an independent trust to manage the proceeds of debt restructuring. One of its objectives is to nurture business models to secure the sustainable development of the Seychelles' blue economy, including through tourism.

7

Awareness and Capacity-building



7.1 Public Discourse

Finding 22

While media coverage and consumer awareness of climate change and tourism have increased, there is limited evidence of behavioural change towards lower carbon tourism. The reputational risk for tourism remains uncertain. Provision of carbon labelling or relevant information and 'visitor pledges' may contribute positively to change.

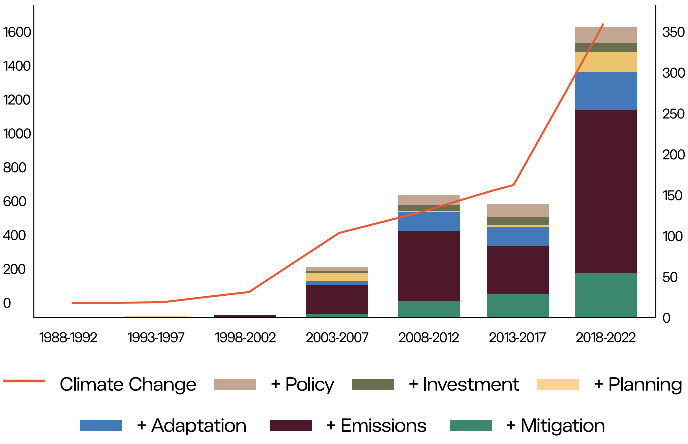
7.1.1 Media Coverage

Metric: Number of Media Articles that Focus on Climate Change and Tourism

International print media coverage of tourism and climate change has increased substantially, particularly over the last five years, and focuses mainly on tourism emissions (Figure 38).[187] The first media publication was in 1975, and since then 3379 articles have been identified. The last five years alone have seen 1631 media articles on this topic. The role of media in setting the agenda and influencing public discourse and awareness is well understood. It is assumed that it increases the pressure on tourism to respond to the climate crisis.

Figure 38

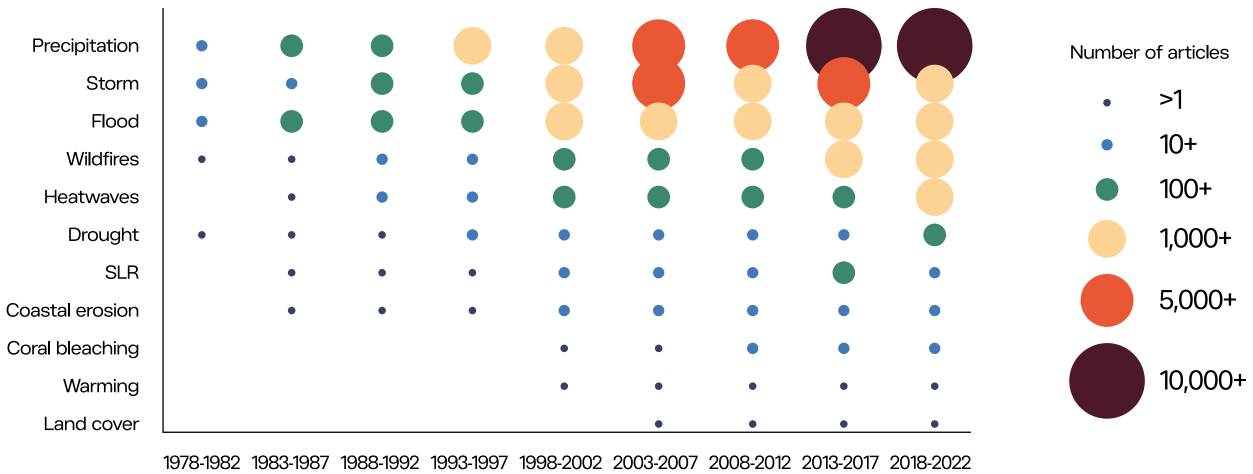
Media coverage of various tourism and climate change sub-themes



In terms of climate hazards, the analysis revealed that precipitation events are most frequently covered, alongside storms and floods, with a marked growth in wildfire and heatwave coverage. Over time, more diverse climate impacts have been captured in the media (Figure 39).

Figure 39

Impacts of climate hazards on tourism as reported in the media over time



7.1.2 Consumer Perceptions

Metric: Share of Travellers who Report High Levels of Climate Consciousness

According to Booking.com's Sustainable Travel Report 2023,[188] a survey of more than 33,000 respondents across 35 countries, 76% of travellers say they want to travel more sustainably over the coming 12 months. This is up from 71% in the Sustainable Travel Report 2022, and 61% in 2021. This is supported by Expedia Group Media Solutions' Sustainable Travel Study, a survey of 11,000 people from 11 countries, which found that 65% of consumers want to opt for environmentally friendly transportation or lodging on their next trip. Yet Expedia Group's study also found 74% who said it costs too much to travel more sustainably. In the context of rising global inflation, these reports point to travellers who feel forced to decide between sustainability and cost concerns. Providing information is important to enable behavioural change (see Box 15). Information could be accompanied with 'visitor pledges' (e.g. Palau Pledge, New Zealand Tiaki Promise), although research has shown that these are more effective when accompanied by other instruments (e.g. regulation, economic levers).[189]

Considering ongoing growth in carbon-intensive travel demand, these industry reports reflect a long-recognised attitude–behaviour gap in sustainable tourism and transport.[190] Although two-thirds of consumers express a positive attitude, few engage in sustainable travel behaviours. Exceptions are, for example, the rise of sustainable niche products such as night trains (see Box 5), a form of slow tourism, with national rail operators in Austria, France, Finland and Norway ordering or refurbishing sleeper trains to meet rising demand. Outside such climate-motivated action in Northern Europe, a globally widespread attitude–behaviour gap in sustainable travel remains dominant, but is not unique to tourism; elsewhere, many consumers have a positive attitude towards sustainable products more generally, but commonly end up not purchasing them.

Box 15 Emission Reporting and Consumer Awareness

Through the Travalyst platform, progress has been made in terms of consistently estimating and communicating the emissions of travel choices to the consumer. Prominently, the Travel Impact Model (TIM) developed by Google and now implemented by other Travalyst coalition partners, provides CO_2 emissions for each flight at the point of decision-making. Emissions are also compared with the average emissions on the selected route to highlight those flights that are less carbon intensive.

7.2 Building Capacity

Finding 23

Although there is a large and recognised need to build climate change capacity in tourism, training in industry and tourism education programs remains very limited. Including climate change in university tourism curricula, as well as building climate literacy among tourism professionals, are key paths for enhanced climate action.

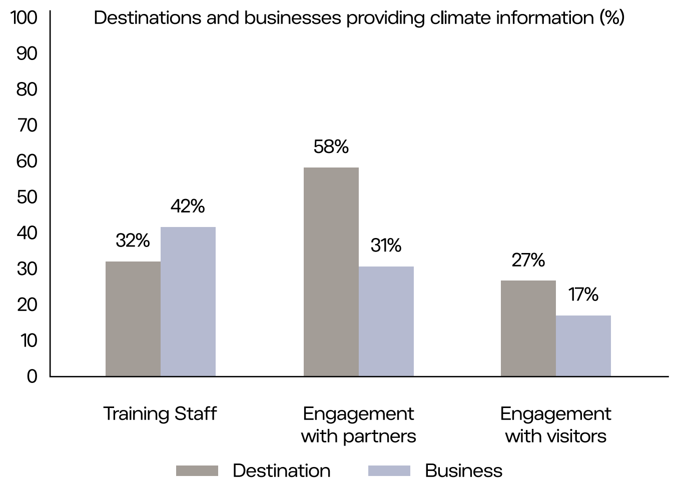
Capacity-building can occur in multiple parts of the tourism system and through different mechanisms.

7.2.1 Industry Programs

Metric: Climate Change Training for Tourism Staff

In a recent UNWTO survey, most of the destination and business respondents reported that they did not provide any guidance or training to operational staff related to climate actions. While destinations are more likely to share climate change resources with partner organisations, the engagement with visitors is quite low, especially for businesses (Figure 40).

Figure 40
Percentages of destination and business respondents to UNWTO survey who train or engage in climate action information exchange



Some countries are implementing specific programs to lift climate literacy. The climate change adaptation plan for tourism in Chile,[191] for example, emphasises the need to build capacity, enhance collaboration and improve information flows. Portugal's national tourism plan, for example, aimed to train 50000 professionals in areas of sustainability by 2023. Colombia built an online training platform for tourism businesses, providing practical interactive content to build skills related to sustainable tourism. An online course on sustainable gastronomy was launched in October 2020 in partnership with World Wildlife Fund Colombia and the UNEP. The Ministry of Tourism in Malta is working with SUNx (Strong Universal Network) to increase climate action through offering a diploma in climate-friendly travel for young tourism-climate ambassadors. In New Zealand, Tourism Industry Aotearoa is working with regional tourism organisations to build carbon literacy with hundreds of businesses through a 12-week sustainable tourism mentoring program. Business carbon audits form part of the course, along with a tailored action plan for each company.

It is critically important that any form of capacity-building and knowledge-generation/sharing also considers non-Western knowledge and practices (Box 16).

Box 16 Indigenous Knowledge to Support Effective Tourism Climate Action

The climate crisis presents another layer of complexity for most Indigenous peoples of the world, who still contend with the intergenerational impacts of colonisation and its associated historical injustices. Most Indigenous peoples are affected by colonial-era legislation and governance structures that perpetuate the loss of sovereignty over natural resources and disenfranchisement of indigenous knowledge systems and values. Traditional practices and their role in global adaptation and mitigation conversations are therefore under-represented. Most climate adaptation frameworks are anchored in Western framings, which often overlook the important aspects of Indigenous suffering linked to loss of spirituality and 'mana'[192] that strongly dovetail the regenerative nature of Indigenous practices. More Indigenous peoples are now getting organised and becoming empowered, offering novel solutions that can help human societies to adapt and further open pathways to mitigate the impacts of climate change. Indigenous voices, knowledge systems and people must be part of the broader process of knowledge generation, consensus-building and climate policy at a global level. Indigenous peoples must not be subjected to new forms of colonisation through current climate discourse; instead, a balanced, inclusive and integrated approach is essential.

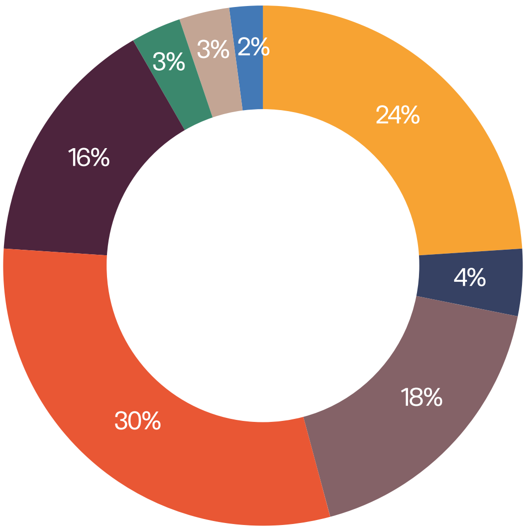
7.2.2 University Tourism Curricula

Metric: Climate Change in Tourism Education Programs

Educating the next generation of tourism professionals and leaders to enable them to meet the complex challenges of climate change is critical. Tourism professionals need to learn how to integrate sustainable practices to accelerate climate action. The integration of climate-related topics in tourism curricula remains limited (Figure 41). No comprehensive global survey has been conducted, but a recent analysis of 97 sustainable tourism-related courses in 83 hospitality programs found almost a quarter (24%) made no mention of climate change in their syllabus.[193] Only 5% of programs included climate change in multiple courses.[194]

Figure 41

Climate change integration into academic tourism courses with a broad focus on sustainability



7.2.3 Research Capacity

Finding 24

Research and scientific capacity to inform evidence-based climate action in tourism has increased substantially, but major thematic and geographic gaps remain, particularly in many highly vulnerable countries and regions in the Global South. This raises the risk of short-term and maladaptive responses to climate-related risks, and of limited identification and consideration of adverse side-effects of adaptation and mitigation strategies.

The proportion of climate change-focused papers published in top tourism journals provides an indication of the salience of climate change as a theme and the research capacity in the academy.

Metric: Published Tourism Research Focused on Climate Change

Substantive growth in climate change and tourism research began toward the end of the 2000s, increasing by a factor of five between 2010 and 2020.[195] Between 2000 and 2009, climate change-related papers represented only 1.5% of the papers published in the five tourism journals, increasing to 3.4% between 2010 and 2019.

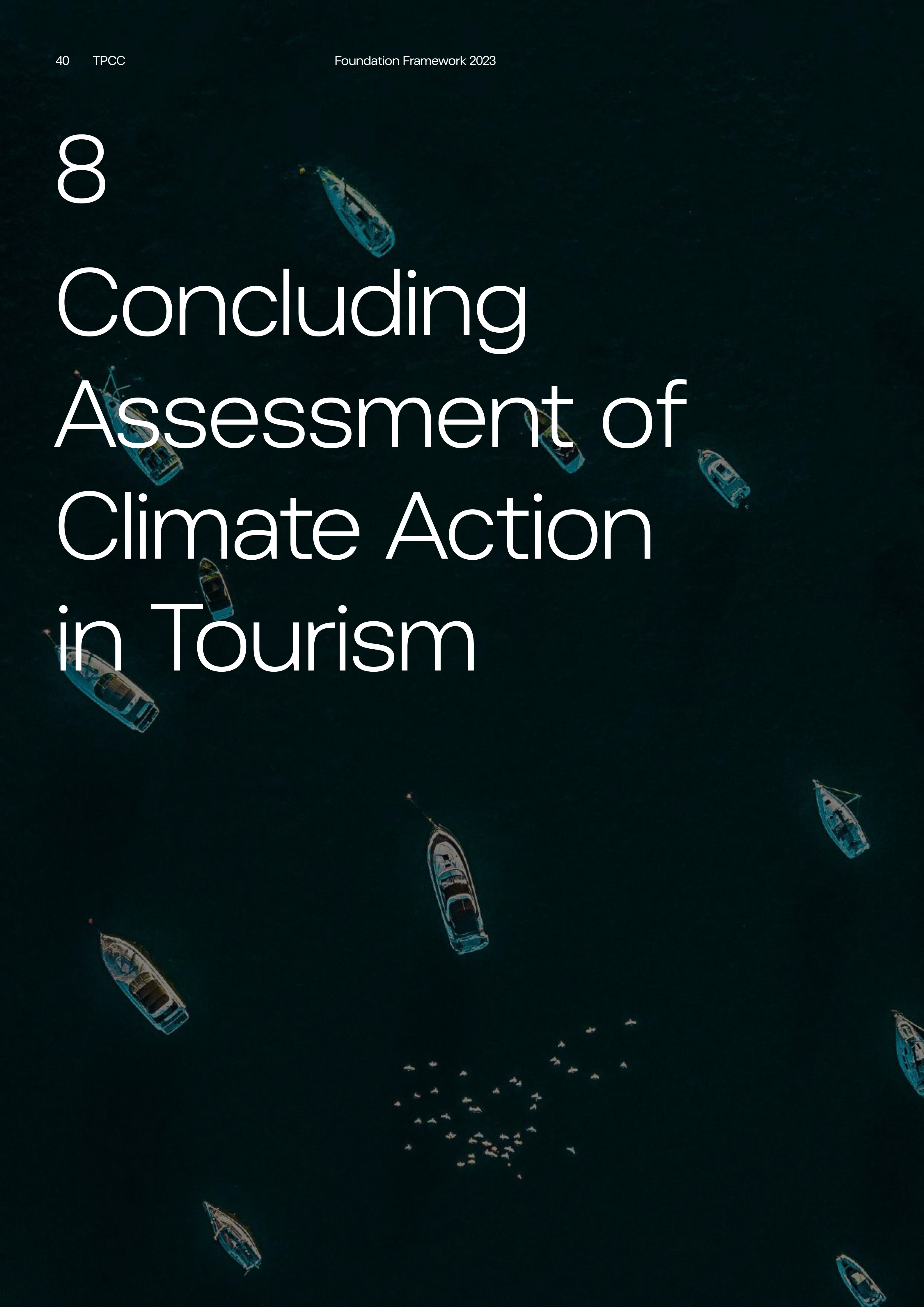
The availability, access and transferability of scientific information are important enablers for business and government decision-makers. Synthesizing key findings relevant to countries, destinations or specific market segments and policy decisions is valuable to better mobilise existing information. The fact that a tourism sector-focused science assessment, updating and building on the 2007 Climate Change and Tourism Responding to Global Challenges report by UNWTO, UNEP and WMO, has not been completed in 15 years continues to be a missed opportunity to translate new science for tourism decision-makers.[196]

Metric: Number and Regional Representation of Research Contributors

An important indicator of capacity to inform tourism climate action is growth in the number of scientists and their regional representation. An approximately fourfold growth in contributing authors occurred between 2010 and 2020.[197] Research capacity is highly concentrated in Europe, followed by Australasia and North America, with strong recent activity in China and Southern Africa in the 2010s. The limited representation of authors from key tourism regions, including the Middle East, South and Central America, and small islands, is disconcerting considering the importance of tourism for economic development in these regions and their vulnerability to climate hazards (see Chapter 4). It is possible that research in these regions is published in languages other than English, and as a result may be harder to identify. Research expertise informs curriculum development, and the relatively limited contributions of scholars from tourism schools/departments to the climate change and tourism literature[198] is an important capacity challenge that needs to be addressed.

Elsewhere, research found that only one out of ten papers on tourism and climate change in Latin America had been written in English.[199] Two years later, in 2022, further investigation showed that just over half of the articles found on climate change and tourism in South and Central America were written in English. These numbers highlight the importance of considering non-English outputs.

8 Concluding Assessment of Climate Action in Tourism



This first tourism sector Stocktake has been based on the best available science and leading expertise, with extensive involvement of over 60 sectoral academia, business and civil society experts from over 31 countries.[200] Following the process of expert analysis and review (see section 1.1.2) that led to the development of this Stocktake report, all TPCC Lead Experts were invited to evaluate 26 statements related to tourism sector climate action and preparedness. Their responses to a short survey were informed by the evidence synthesised in the Stocktake, as well as their fulsome knowledge of the climate change and tourism scientific literature and their extensive professional experience with decision-makers in tourism industry, destinations, government and civil society from around the world.

The expert insights focused on five key themes. The first was the level of tourism and climate policy and planning integration. There was a strong consensus that national tourism policy was not aligned with climate change in most countries (93%), that national climate policy does not integrate tourism sufficiently so the sector can contribute to NDCs (86%) and that tourism policy does not support achieving national emission reduction targets (96%). There was similar strong agreement about insufficient integration of emission reduction (88%) and climate adaptation (88%) into destination management plans.

The second theme considered the likelihood that the tourism sector would achieve interim and longer-term emission reduction targets. Based on current emission trajectories and evidence of climate action, there was broad agreement that interim targets (tourism peaking in 2025, tourism – 50% by 2030, cruise emissions – 40% by 2030) would not be achieved (78%, 89%, 81% respectively, with an additional 11%, 11% and 18% unsure). It was stressed by experts that the tourism sector committed to decarbonise in the Davos Declaration on Climate Change and Tourism in 2007, yet sector emissions have continually increased over the following decade and a half (see section 2.2). There was slightly more optimism, but also greater uncertainty, regarding the potential to achieve longer-term targets, but experts agreed that the tourism, aviation and cruise industry would not achieve net zero targets by 2050 (70%, 81%, 70%). Experts raised important questions about the future of tourism in a climate resilient and net zero global economy.

Theme three asked experts for views on key factors to advance mitigation in tourism. Experts agreed that most international developments (78%) and public sector investments (80%) were not supporting the low carbon transition. They agreed that deep emission reductions would require some demand management to limit growth in emission-intensive types of tourism (78%). Some questioned the extent to which tourism needs to be decoupled from air travel if climate goals are to be achieved.

The experts were divided on whether consumer demand would be a key driver of emission reductions in tourism (32% agreed, 32% disagreed, 36% were unsure), reinforcing the need for further research on this important question. Finally, a critical perspective of the experts is that the climate justice implications of mitigation strategies in tourism have not been considered adequately (89%). Greater analysis and dialogue on proposed policies to alter outbound tourism from high-income countries was stressed. Experts emphasised that climate solutions can have unintended consequences and that this remains a very important area for policy development and research.

Theme four considered impacts of changes in climate and state of adaptation. The experts agreed that the impacts of climate change are already influencing tourism demand patterns (72%) and that future impacts will restrict tourism development in many destinations by 2050 as climate change accelerates (68%). They also agreed that limited information on physical climate risks continues to pose a barrier to adaptation action at many destinations (72%). With respect to climate change adaptation in the sector, there was unanimity that current adaptation was insufficient for projected changes in climate (100%) and consensus that neither official development assistance nor national public sector investments were supporting climate resilient tourism development (80% and 92% respectively).

The final theme assessed the state of climate change training and capacity-building in higher education (universities and college tourism programs). The experts concluded that higher education was not integrating training sufficiently to build the necessary climate change response capacity in the next generation of tourism professionals (72%, with 20% unsure). Capacity-building also needs to include ways to measure climate resilient tourism and to evaluate the effectiveness of interventions.

While this Stocktake has identified many critical areas where climate action is insufficient to achieve sectoral (and, as a result, global) goals, advancing climate resilient tourism development is the collective responsibility of the global tourism community and requires much greater collaboration between international tourism organisations, countries and tourism authorities, the tourism industry and operators, destination communities, civil society, the tourism academy, and tourists. Policy integration between tourism administrations and other parts of government will be essential for making meaningful progress, among others because many levers (including resources and legislative mandate) reside with non-tourism ministries where key decisions related to supporting a low-carbon transition are being made.

There is an imperative for tourism, like other major emitting and climate-vulnerable sectors, to accelerate its climate action, clarify and strengthen its pledges in the Glasgow Declaration on Climate Action in Tourism and catalyse new and stronger inter-sectoral and international climate policy and finance collaborations. In November 2007, tourism ministers from around the world gathered in London at the Summit on Tourism and Climate Change and declared that 'climate change is calling tourism world to a revolution'. As this Stocktake has clearly shown, the time for transformative change is urgently upon us.

In five years, the Tourism and Climate Change Stocktake 2028 must demonstrate progress on the many metrics identified in this 2023 Stocktake, including evidence of a sharp emission reduction trend, expanded adaptation and improved adaptive capacity, and a whole-of-sector roadmap to a just transition to climate resilient tourism.

Endnotes

1 TOURISM STATISTICS:
Provided by the United Nations World Tourism Organisation, including through their tourism dashboards and World Tourism Barometer, see https://www.unwto.org/ .

2 ACADEMIC REVIEW PAPERS:
Several recent academic review papers provide an overview of the tourism-climate change nexus, including the following:

- Gössling, S., & Higham, J. (2021). The low-carbon imperative: Destination management under urgent climate change. Journal of Travel Research, 60(6), 1167-1179.
- Loehr, J. & Becken, S. (2021). The Tourism Climate Change Knowledge System. Annals of Tourism Research, 86, 103073. https://doi.org/10.1016/j.annals.2020.103073
- Scott, D., Hall, C.M., & Gössling, S. (2019). A Global Climate Change Vulnerability Index for the Tourism Sector. Annals of Tourism Research, 77, 49-61.
- Scott, D., & Gössling, S. (2022). A review of research into tourism and climate change-Launching the annals of tourism research curated collection on tourism and climate change. Annals of Tourism Research, 95, 103409.

3 CLIMATE RESILIENT DEVELOPMENT:
The IPCC conceptualization and discussion of CRD is available in Chapter 18 (Climate Resilient Development Pathways) of Working Group 2 contribution to the 6th Assessment Report: https://www.ipcc.ch/report/ar6/wg2 chapter/chapter-18/

4 TOURISM ECONOMIC CONTRIBUTION:
Estimates of global economic contribution and employment are available from the World Travel and Tourism Council – Economic Research portal: https://wttc.org/research/economic-impact

5 TOURISM AND CLIMATE POLICY INTEGRATION:
For an analysis of how climate and tourism policies interlink see Becken, S., Whittlesea, C., Loehr, J. & Scott, D. (2020). Tourism and climate change: evaluating the extent of policy integration. Journal of Sustainable Tourism, 28(10), 1603-1624. https://doi.org/10.1080/09669582.2020.1745217

6 GLASGOW DECLARATION FOR CLIMATE ACTION IN TOURISM:
https://www.oneplanetnetwork.org/programmes/sustainable-tourism/glasgow-declaration#:~:text=The%20Glasgow%2Declaration%20is%20a,soon%20as%20possible%20before%202050

7 CLIMATE CHANGE FRAMEWORK:
Graphic developed based on Moosmann, L., Urrutia, C., Siemons, A., Cames, M., & Schneider, L. (2019). International Climate Negotiations. https://www.europarl.europa.eu/RegData/etudes/STUD/2019/642344/IPOL_STU(2019)642344_EN.pdf .

8 DECOUPLING:
Dwyer, L. (2023). Tourism Degrowth: Painful but Necessary, Sustainability, 15, 14676. https://doi.org/10.3390/su152014676.

9 EMISSIONS GROWTH:
For more detail on tourism versus global emissions:

- WTTC (2023). The Environmental impact of Global Tourism. https://researchhub.wttc.org/product/the-environmental-impact-of-global-tourism-2023
- IPCC (2022). Summary for Policymakers. In: Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [P.R. Shukla, J. Skea, R. Slade, A. Al Khourdajie, R. van Diemen, D. McCollum, M. Pathak, S. Some, P. Vyas, R. Fradera, M. Belkacemi, A. Hasija, G. Lisboa, S. Luz, J. Malley, (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA. doi: 10.1017/9781009157926.001.

10 TOURISM TRANSPORT DISTANCE MODEL (TTDM):
For the origins of the TTDMdyn model, see Peeters, P.M. (2017). Tourism's impact on climate change and its mitigation challenges. How can tourism become 'climatically sustainable'? Delft University of Technology]. Delft.

The TTDM builds on data from the UNWTO, as gathered by Prof Jaume Rosselló Nadal. The database contains 323,000 records for each origin-destination relationship from the theoretical 923,000 relationships for 233 countries over 27 years (1995-2021). For 15 large countries, domestic tourism was redistributed over distance classes, to avoid flawed shares of aviation at high average domestic distances, which added 6500 records to the database.

Initially, the intention was to use domestic numbers from the original UNWTO database. However, the data coverage of domestic numbers changed rather substantially between 1995 and 2021 (from only one country in 1995 to a maximum of 28.4% of all countries in 2019). Such an increase in datapoints causes a strong data-quality trend, rendering the data less useful for the trend analysis purpose of TTDM. Also, it appeared that several UNWTO data series behaved in an unexpected way, while rather dominant in the totals (particularly India). It is unclear whether some data included day visitors, who fall outside the definition of 'tourist' used here (namely a person who is outside their usual environment for more than 24 hours).

Because the total number of trips of a population depends highly on GDP/capita, total trips were calculated using GDP, income equity (Gini) and population data from the World Bank. (A detailed description is available from Prof Paul Peeters.) By subtracting the known international outbound trips based on the UNWTO international data, an estimate of the domestic trips was generated. With those data, Prof Peeters added the following additional variables to each record (OD-pair) of initial UNWTO data from Prof Rosselló-Nadal:

- Regional and development indicators per country (continent, subcontinent, LDC, SIDS, landlocked developing country (LLDC) and developing country (DC)) added for both origin and destination country.
- The arithmetic distance from Centre d'Etudes Prospectives et d'Informations Internationales (CEPII) for international distance, corrected for neighbouring countries (factored by 0.8).
- For domestic distances, the country-area method was used, as described by Peeters, P. M. & Landré, M. (2012). The emerging global tourism geography – an environmental sustainability perspective. Sustainability, 4(1), 42-71). For 15 countries, this was redistributed for 200 km distance classes.
- Share of three main transport modes:
  - o Air: Taken from distance class distribution as generated for each year by the GTTMdyn model
  - o Car: Taken from GTTMdyn, but corrected for origin car-ownership rates and road quality indicators
  - o Other (mainly rail, but also bus, ferry, etc.): The remaining share until 100% per record
- Emissions based on emission factors (kg CO_2/pkm):
  - o Air: Factor based on average for 2019 and corrected for distance and year
  - o Car: Calculated from GTTMdyn run by dividing total car emissions by total car distances for each year between 1995 and 2021
  - o Other: As car, but corrected for the trends given for rail

11 DOMESTIC TOURISM ECONOMIC CONTRIBUTION:
WTTC (2021). Travel and Tourism Economic impact 2020 World. World Tourism and Travel Council.

12 TOURISM ARRIVALS:
The data for this graph are drawn from the United Nations World Tourism Organization (UNWTO) in the Tourism Barometer. The idea for visualisation came from https://ourworldindata.org/tourism

13 TOURISM GROWTH AND ECONOMIC SIZE:
The 2019 direct GDP data were measured in 2018 real prices and exchange rates, see WTTC (2022.) Travel & Tourism Economic Impact – Global Trends. https://wttc.org/Portals/0/Documents/Reports/2022/EIR2022-Global%20Trends.pdf

14 STEADY GROWTH AND RIGHTSIZING:
For a recent paper on degrowth, see Dwyer, L. (2023). Tourism Degrowth: Painful but Necessary, Sustainability, 15, 14676. https://doi.org/10.3390/su152014676.

Further, an assessment of demarketing opportunities in tourism is discussed in Hall, C.M. & Wood, K.J. (2021). Demarketing Tourism for Sustainability: Degrowing Tourism or Moving the Deckchairs on the Titanic? Sustainability, 13, 1585. https://doi.org/10.3390/su13031585. Also refer to media articles such as France24 (2023). France to combat overtourism. https://www.france24.com/en/france/20230619-france-lays-out-strategy-to-combat-overtourism. For the cap on Balearic Island tourism, see Iolov, T.V. (2023). The Balearic Islands to put a cap on number of tourists per year. https://www.themayor.eu/en/a/view/the-balearic-islands-to-put-a-cap-on-number-of-tourists-per-year-11517 (accessed 23/07/2023).

15 CONTRIBUTION TO GDP:
The UNWTO Department of Statistics reports data on the Sustainable Development Goals indicators 8.9.1 and 12.b.1, included in the Global Indicator Framework (see: https://www.unwto.org/tourism-statistics/economic-contribution-SDG). Data collection started in 2019 and provides data from 2008 onwards, the latest update took place on 15 March 2023. Indicator 8.9.1 on Tourism Direct GDP helps to monitor Target 8.9 which calls on countries "to promote sustainable tourism" under Goal 8 on decent Work and Economic Growth. The data collection occurs in cooperation with the OECD, and a visualisation is provided at https://ourworldindata.org/tourism

16 AIRCRAFT ORDERS:
Both Boeing and Airbus release regular information on aircraft orders. At an aggregate level, Ch-aviation monitor all aircraft orders from across the globe. An overview as of June 2023 is available here: https://about.ch-aviation.com/blog/2023/06/19/ch-aviation-report-aircraft-on-order-worldwide/?utm_source=rss&utm_medium=rss&utm_campaign=ch-aviation-report-aircraft-on-order-worldwide

17 IMPACTS OF COVID-19 PANDEMIC ON DOMESTIC TOURISM:
Wu, D. C., Cao, C., Liu, W., & Chen, J. L. (2022). Impact of domestic tourism on economy under COVID-19: The perspective of tourism satellite accounts. Annals of Tourism Research Empirical Insights, 3(2), 100055.

18 DOMESTIC TOURISM AS A CLIMATE ACTION STRATEGY:
For a discussion of the potential benefits and trade-offs:

- Gössling, S., Balas, M., Mayer, M. & Sun, Y.Y. (2023). A review of tourism and climate change mitigation: The scales, scopes, stakeholders and strategies of carbon management, Tourism Management, 95. https://doi.org/10.1016/j.tourman.2022.104681.
- Seyfi, S., Hall, C.M. & Saarinen, J. (2022). Rethinking sustainable substitution between domestic and international tourism: a policy thought experiment, Journal of Policy Research in Tourism, Leisure and Events, DOI: 10.1080/19407963.2022.2100410
- Becken, S. (2019). Decarbonising tourism: Mission impossible? Tourism Recreation Research. 44(4), 419-433.

19 TOTAL TRIPS:
The data come from the UNWTO, whereby domestic arrivals were modelled using the TTDM (see endnote 5). Source: World Tourism Organization (2023). 145 Key Tourism Statistics, UNWTO, Madrid: https://www.unwto.org/tourism-statistics/key-tourism-statistics

20 TRANSPORT SHARE:
The share of air travel and other transport modes of all international arrivals is provided by UNWTO, for example in their International Tourism Highlights report (2020 edition).

21 TRAVEL DISTANCE:
Data for this indicator came from two different sources, put together by Dr Jaume Rosello (more detail on method on request).

First, the UNWTO collects data on tourist arrivals to a specific country of destination, discriminating tourists' origin. Data originally come from the different national statistical institutes. It is important to emphasise that countries usually provide information on the main countries of origin from where tourists are received. When the number of tourists from a certain origin is very low, a 0 appears in the specific cell, and the number of tourists is moved to a generic category titled "Others". Since the goal here was to obtain a distance measure, the "Other" row was discarded, so the least important destinations for each destination are neglected. Data matrixes from 1995 to 2019 were collected. The UNWTO dataset includes 210 destinations and 234 origins.

The second dataset determines the distances between country pairs. Data from the CEPII 2012 dataset were used. CEPII develops and maintains different databases relating to international trade, including different data to estimate gravitational data. With regards to the distance data, geographical distance was used, including distances that reflect the within-country spatial distribution of activity. CEPII collects different distance measures between countries, including distance between the most populated cities of each country, population-weighted distance between most populated cities, distance between capitals, measured in km, bilateral. For this report, the harmonic weighted (by population) bilateral distance between origin and destination in kilometre was used, which is probably the most widely used distance measure in both international trade applications and the modelling of international tourism with gravity models.

22 LENGTH OF STAY:
The data were provided by ForwardKeys and relate to air travel only. The LOSNIGHTS_CATEGORY refers to the traveller stay (number of nights) at the flight leg destination.

- SHORT STAY
- MID STAY
- LONG STAY

23 LOW CARBON TRANSITION SKILLS GAP:
Discussion of the types of skills and training gaps that pose a barrier to the low carbon transition are available from:

- Jagger, N., Foxon, T., & Gouldson, A. (2013). Skills constraints and the low carbon transition. Climate policy, 13(1), 43-57.
- HSBC Centre for Sustainable Finance (2021) Skills for the Low Carbon Transition. https://www.sustainablefinance.hsbc.com/-/media/gbm/sustainable/attachments/green-skills.pdf
- Sato, M., Cass L., Saussay, A., Vona, F. & Mercer, L. (2023). Skills and wage gaps in the low-carbon transition: comparing job vacancy data from the US and UK. London: Grantham Research Institute on Climate Change and the Environment and Centre for Climate Change Economics and Policy, London School of Economics and Political Science.

24 MACRO-ECONOMIC FRAMEWORKS:

- Sun, Y.Y., Cadarso, M.A., & Driml, S. (2020). Tourism carbon footprint inventories: A review of the environmentally extended input-output approach. Annals of tourism research, 82, 102928.
- Gössling, S., Balas, M., Mayer, M., & Sun, Y.Y. (2023). A review of tourism and climate change mitigation: The scales, scopes, stakeholders, and strategies of carbon management. Tourism Management, 95, 104681.
- Pham, T., Meng, X. & Becken, S. (2022). Measuring tourism emissions at destination level: Australia case. Annals of Tourism Research Empirical Insights, 3, 100062. https://doi.org/10.1016/j.annale.2022.100062

25 GREENHOUSE GAS PROTOCOL:
https://ghgprotocol.org/sites/default/files/standards/ghg-protocol-revised.pdf

26 The UNWTO report "Climate Action in the Tourism Sector – An overview of methodologies and tools to measure greenhouse gas emissions" released in March 2023 is available here: https://www.e-unwto.org/doi/10.18111/9789284423927

27 TRANSPARENCY AND PEER REVIEW OF EMISSIONS:
To assess the approximate 15% discrepancy in these two global estimates, which use similar input-output modelling approaches, requires greater transparency of methods and data for the WTTC (2023) study. The enhanced transparency framework under the Paris Agreement is an accountability mechanism for countries emissions tracking. It has also been widely argued that transparency in science-based targets is non-negotiable

for effective and accountable climate action, particularly for corporate carbon accounting and disclosures (see Bjørn et al., 2023). The UNDP (2023) considers transparency to include, "…the reliable measurement, accessible reporting, and expert review of the progress made by countries towards achieving their national climate goals and pledges."

- Bjørn, A., Matthews, H.D., Hadziosmanovic, M., Desmoitier, N., Addas, A., & Lloyd, S.M. (2023). Increased transparency is needed for corporate science-based targets to be effective. Nature Climate Change, 13(8), 756-759.
- UNDP (2023). What does transparency mean when it comes to climate change? https://climatepromise.undp.org/news-and-stories/what-does-transparency-mean-when-it-comes-climate-change
- WTTC (2023). The Environmental impact of Global Tourism. https://researchhub.wttc.org/product/the-environmental-impact-of-global-tourism-2023

28 GLOBAL CARBON FOOTPRINT:

Global tourism emission estimates based on:

- Lenzen, M., Sun, Y. Y., Faturay, F., Ting, Y. P., Geschke, A., & Malik, A. (2018). The carbon footprint of global tourism. Nature climate change, 8(6), 522-528. Note that this work published in 2018 is currently being updated and should be available in early 2024.
- WTTC (2023). The Environmental impact of Global Tourism. https://researchhub.wttc.org/product/the-environmental-impact-of-global-tourism-2023

29 GLOBAL EMISSIONS GROWTH:

For more detail, see IPCC (2022). Summary for Policymakers. In: Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [P.R. Shukla, J. Skea, R. Slade, A. Al Khourdajie, R. van Diemen, D. McCollum, M. Pathak, S. Some, P. Vyas, R. Fradera, M. Belkacemi, A. Hasija, G. Lisboa, S. Luz, J. Malley, (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA. doi: 10.1017/9781009157926.001.

30 CONTRIBUTION TO EMISSIONS BY COUNTRY:

Lenzen, M., Sun, Y. Y., Faturay, F., Ting, Y. P., Geschke, A., & Malik, A. (2018). The carbon footprint of global tourism. Nature climate change, 8(6), 522-528.

Note that this work is currently being updated and should be available in early 2024.

31 TOURISM EMISSIONS AS PROPORTION OF NATIONAL EMISSIONS:

Lenzen, M., Sun, Y. Y., Faturay, F., Ting, Y. P., Geschke, A., & Malik, A. (2018). The carbon footprint of global tourism. Nature climate change, 8(6), 522-528.

Note that this work published in 2018 is currently being updated and should be available in early 2024.

32 AUSTRALIA CASE STUDY:

Sun, Y. Y., Gössling, S., & Babakhani, N. (2023). Macro-scale decarbonisation of tourism: insights from Australia. Journal of Sustainable Tourism, 1-25.

33 CARBON EMISSIONS GROWTH RATE IN COUNTRIES:

- Cadarso, M. Á., Gómez, N., López, L. A., Tobarra, M. Á., & Zafrilla, J.E. (2015). Quantifying Spanish tourism's carbon footprint: the contributions of residents and visitors: a longitudinal study. Journal of Sustainable Tourism, 23(6), 922-946.
- Eijgelaar, E., Neelis, I., Peeters, P., de Bruijn, K., & Dirven, R.J.A.G. (2020). Travelling large in 2018: The carbon footprint of Dutch holidaymakers in 2018 and the development since 2002. BUas (Breda University of Applied Sciences).
- [Note that this study focuses on outbound and domestic tourism emissions, distinguishing it from the other studies].
- Meng, W., Xu, L., Hu, B., Zhou, J., & Wang, Z. (2017). Reprint of: Quantifying direct and indirect carbon dioxide emissions of the Chinese tourism industry. Journal of Cleaner Production, 163, S401-S409.
- Shi, Y., & Yu, M. (2021). Assessing the environmental impact and cost of the tourism-induced CO2, NOx, SOx emission in China. Sustainability, 13(2), 604.
- Sun, Y. Y., & Higham, J. (2021). Overcoming information asymmetry in tourism carbon management: The application of a new reporting architecture to Aotearoa New Zealand. Tourism Management, 83, 104231.
- Sun, Y. Y., Gössling, S., Hem, L. E., Iversen, N. M., Walnum, H. J., Scott, D., & Oklevik, O. (2022). Can Norway become a net zero economy under scenarios of tourism growth? Journal of Cleaner Production, 363, 132414.
- Sun, Y. Y., Gossling, S., & Babakhani, N. (2023). Macro-scale decarbonisation of tourism: insights from Australia. Journal of Sustainable Tourism, 1-25.
- Tang, Z., Shang, J., Shi, C., Liu, Z., & Bi, K. (2014). Decoupling indicators of CO2 emissions from the tourism industry in China: 1990–2012. Ecological indicators, 46, 390-397.
- Tang, M., & Ge, S. (2018). Accounting for carbon emissions associated with tourism-related consumption. Tourism Economics, 24(5), 510-525.
- Zha, J., Yuan, W., Dai, J., Tan, T., & He, L. (2020). Eco-efficiency, eco-productivity, and tourism growth in China: A non-convex metafrontier DEA-based decomposition model. Journal of Sustainable Tourism, 28(5), 663-685.

34 TRANSPORT EMISSIONS:

The 745 MtCO2 of overnight passenger aviation emissions reported here is derived from the TTDM. The data align with other publications, including overall aviation emissions reported byICCT and IATA:

- Mithal, S., & Rutherford, D. (2023). ICAO's 2050 net zero CO2 goal for international aviation. ICCT.
- IATA, 2021. IATA - Net zero Carbon Emissions by 2050. Available (02/08/22) https://www.iata.org/en/pressroom/pressroom-archive/2021-releases/2021-10-04-03/.)
- This section also supports earlier work on tourist transport emissions by the UNWTO, see World Tourism Organization and International Transport Forum (2019), Transport-related CO2 Emissions of the Tourism Sector – Modelling Results, UNWTO, Madrid, DOI: https://doi.org/10.18111/9789284416660.

35 EMISSIONS GROWTH:

These data come from the United Nations 2020 Gap report, which drew on IATA and IEA statistics. See Faber, J. et al. 2020. International Aviation and Shipping. United Nations Environment Programme. Emissions Gap Report 2020. Nairobi.

36 SUSTAINABLE AVIATION:

ICAO tracks a wide range of sustainability initiatives, including "Aviation net zero initiatives and commitments" on https://www.icao.int/environmental-protection/SAC/Pages/Aviation-net zero.aspx

37 CARBON OFFSETTING:

For more detail regarding offsetting aviation emissions:

- Becken, S. & Mackey, B. (2017). What role for offsetting aviation greenhouse gas emissions in a deep-cut carbon world? Journal of Air Transport Management, 63, 71-83.
- Faber, J. et al. (2020). International Aviation and Shipping. United Nations Environment Programme. Emissions Gap Report 2020. Nairobi.
- Schneider, L., La Hoz Theuer, S., Howard, A., Kizzier, K., & Cames, M. (2020). Outside in? Using international carbon markets for mitigation not covered by nationally determined contributions (NDCs) under the Paris Agreement. Climate Policy, 20(1), 18-29.

For consumer uptake and communication, see:

- Babakhani, N., Ritchie, B. W., & Dolnicar, S. (2019). Improving carbon offsetting appeals in online airplane ticket purchasing: Testing new messages, and using new test methods. In Marketing for Sustainable Tourism (pp. 87-101). Routledge.
- Guix, M., Ollé, C., & Font, X. (2022). Trustworthy or misleading communication of voluntary carbon offsets in the aviation industry. Tourism Management, 88, 104430.
- Ritchie, B. W., Kemperman, A., & Dolnicar, S. (2021). Which types of

product attributes lead to aviation voluntary carbon offsetting among air passengers? Tourism Management, 85, 104276.

38 AVIATION EMISSIONS:
This graph is inspired by a visualisation provided by Our World in Data. It forms part of an article written by aviation commentator Hannah Ritchie. For the full reference, see Ritchie, H. (2020). Climate change and flying: what share of global CO2 emissions come from aviation?". Retrieved from: 'https://ourworldindata.org/co2-emissions-from-aviation'.

Furthermore, for a detailed reflection on the aviation climate change context, see Lyle, C. (2022). Capacity for a Code Red Response – Sustainable Tourism's Achilles' Heel: Aviation Emissions. TPCC Horizon Paper.

39 NON-CO_2 EFFECTS FROM AVIATION:
For detail see:
- Lee, D.S., Fahey, D.W., Skowron, A., Allen, M.R., Burkhardt, U., Chen, Q., Doherty, S.J., Freeman, S., Forster, P.M., Fuglestvedt, J., Gettelman, A., De León, R.R., Lim, L.L., Lund, M.T., Millar, R.J., Owen, B., Penner, J.E., Pitari, G., Prather, M.J., Sausen, R., & Wilcox, L.J., (2020). The contribution of global aviation to anthropogenic climate forcing for 2000 to 2018. Atmospheric Environment, doi: https://doi.org/10.1016/j.atmosenv.2020.117834
- Klöwer, M., Allen, M.R., Lee, D.S., Proud, S.R., Gallagher, L. & Skowron, A. (2021). Quantifying aviation's contribution to global warming. Environmental Research Letters 16, 104027 https://doi.org/10.1088/1748-9326/ac286e

40 RAIL TRAVEL:
As part of the "Tracking Clean Energy Progress 2023" analysis, the IEA provides updates and data on rail travel emissions, see https://www.iea.org/energy-system/transport/rail

41 CRUISE SHIP EMISSIONS:
see Humpe, A., Sun, Y.-Y., & Gössling, S. (2023). Cruise emissions and economic feasibility of alternative fuels. Annals of Tourism Research, in press.

42 CRUISE TOURISM EMISSIONS:
- Humpe, Y.-Y. Sun, & S. Gössling (2023). Ocean-based tourism. In Hoegh-Gouldberg, O. and Northrop, E. (Lead authors): The Ocean as a Solution to Climate Change. World Resources Institute.
- Eijgelaar, E., Thaper, C., & Peeters, P. (2010). Antarctic cruise tourism: The paradoxes of ambassadorship, "last chance tourism" and greenhouse gas emissions. Journal of Sustainable Tourism, 18(3), 337-354.

43 ENERGY INTENSITY OF CRUISE TRIPS:
For the case of New Zealand, see Howitt, O. J., Revol, V. G., Smith, I. J., & Rodger, C. J. (2010). Carbon emissions from international cruise ship passengers' travel to and from New Zealand. Energy Policy, 38(5), 2552-2560.

44 CRUISE SHIP EMISSIONS:
Humpe, A., Sun, Y.-Y., & Gössling, S. (2023). Cruise emissions and economic feasibility of alternative fuels. Annals of Tourism Research, in press.

45 NET ZERO EMISSIONS:
International Energy Agency (2021). Net Zero by 2050: A Roadmap for the Global Energy Sector. https://www.iea.org/reports/net zero-by-2050

46 AVIATION AS HARD-TO-ABATE SECTOR:
See for instance: Energy Transitions Commission (ETC) (2018), Mission possible. Reaching net zero carbon emissions from harder-to-abate sectors by mid-century, London. https://www.energy-transitions.org/wp-content/uploads/2020/08/ETC_MissionPossible_FullReport.pdf.

47 AIRCRAFT EFFICIENCY:
The data are based on a review requested by ICAO using independent experts who estimated aircraft performance in 10 and 20 years (2027 and 2037). According to the review, improvements in the order of 21-22% were seen as possible by 2037. This translates into annual gains of 1.22 to 1.28 % for different aircraft types. Referenced from: Faber, J. et al. (2020). International Aviation and Shipping. United Nations Environment Programme. Emissions Gap Report 2020. Nairobi.

However, it is important to note that the efficiency improvements of aviation may slow down over time. As aerodynamic, thermodynamic and physics limits are reached, the effort to improve an aircraft becomes higher, while further increasing safety requirements add increasingly to the development time. See for instance: Peeters, P. M. (2017). Tourism's impact on climate change and its mitigation challenges. How can tourism become 'climatically sustainable'?. Delft University of Technology PhD dissertation.

48 BATTERY TECHNOLOGY:
An advantage of electric propulsion is that the propulsion efficiency is about two to three times better than for jet engines. Thus, electric planes need only a third to half of the energy, proportionally reducing battery weight. Traditional fossil fuel takes 10-30% of the take-off weight of a typical jet flight. Replacing that energy with a battery would increase the maximum take-off-weight requirement to five to ten times their current certified weights (including the propulsive efficiency advantage). Increasing the wing size five to ten times could accommodate the weight increase but would strongly increase the energy requirement for several items. This design spiral has no solution.

49 ELECTRIC AIRCRAFT:
Based on a paper by Schäfer, A.W., Barrett, S.R.H., Doyme, K., Dray, L.M., Gnadt, A.R., Self, R., et al. (2019). Technological, economic, and environmental prospects of all-electric aircraft, Nature Energy, 4(2), 160-166. https://doi.org/10.1038/s41560-018-0294-x.

An analysis of this paper would suggest that the legally required reserves of 200 nautical mile diversion and 30-60 minutes of keeping a holding pattern were not included. This would reduce the range of this aircraft by 40%. Others show that batteries would at best provide a 300 km range, and the improvement of the gravimetric density of batteries might be restricted by laws of physics to at most a factor three (not even the four assumed by Schäfer et al., 2019). See Epstein, A.H. & O'Flarity, S.M. (2019). Considerations for Reducing Aviation's CO_2 with Aircraft Electric Propulsion. Journal of Propulsion and Power, 35(3), 572-582. https://doi.org/10.2514/1.B37015.

50 DISTANCE OF FLIGHTS:
Useful information is provided by the EU-funded Clean Sky 2 project to illustrate the link between distance and fuel consumption. See Clean Sky 2 (2020). Technology Evaluator. First Global Assessment 2020. https://www.clean-aviation.eu/media/publications/technology-evaluator-first-global-assessment-2020-technical-report (accessed 22/09/23)

51 INNOVATION TRACKER:
for more information, see https://www.icao.int/environmental-protection/SAC/Pages/Technology.aspx

52 AIRBUS RESEARCH AND DEVELOPMENT:
For more information, see Flottau, J. (2023). Airbus targets both new conventional and hydrogen platforms for 2035 even as supply chain constraints will limit its growth for years. Aviation Week & Space Technology, 19 Jun-2 Jul, 34-37.

53 HYDROGEN:
NASA suggested this technology at the end of the 1990s and early 2000s already.
- Snyder, C. (1998). Zero-Emissions Aircraft? Scenarios for Aviation's Growth: Opportunities for Advanced Technology. Paper presented at the NASA Environmental Compatibility Research Workshop III, Monterey, CA.
- Snyder, C.A., Berton, J J., Brown, G.V., Dolce, J.L., Dravid, N.V., Eichenberg, D.J., et al. (2009). Propulsion Investigation for Zero and Near-Zero Emissions Aircraft. NASA TM-215487.

- Peeters, P.M. (2000). Annex I: Designing Aircraft for Low Emissions. Technical Basis for the Escape Project. (00.4404.17). Delft.
- These early attempts show that with moderate technological improvements, ranges of up to 10,000 km and payloads of up to 400 seats would become possible. While more recent overviews still show potential, they assume from a cost perspective that hydrogen-fuelled jets would provide the longest ranges.
- Also note that burning hydrogen in jets might further increase range but has the disadvantage that it will not solve all non-CO2 impacts at cruising altitudes of above 30,000 ft, where such aircraft become most efficient. Fuel cell aircraft likely fly at altitudes of 20,000 to 30,000 ft, which are much less prone to contrail forming. Furthermore, water vapour from fuel cells could be liquified before emitting into the atmosphere, which is impossible with a hydrogen-fuelled jet. Also, one could consider that all locations in the world could be connected with aircraft flying at a maximum range of some 5,000-6,000 km, which would accommodate current global air navigation networks, though with some more fuelling stop-overs for the 11% of tourism trips exceeding 6000 km (based on TTDM data).

54 SUSTAINABLE AVIATION FUELS:
- Becken, S., Mackey, B., & Lee, D. S. (2023). Implications of preferential access to land and clean energy for Sustainable Aviation Fuels. Science of the Total Environment, 886, 163883.
- Nakano, Y., Sano, F. & Akimoto, K. (2022). Impacts of decarbonization technologies in air transport on the global energy system. Transportation Research Part D: Transport and Environment, 110, 103417. https://doi.org/10.1016/j.trd.2022.103417.
- Ng, K. S., Farooq, D., & Yang, A. (2021). Global biorenewable development strategies for sustainable aviation fuel production. Renewable and Sustainable Energy Reviews, 150, 111502.

55 **ICAO SAF Tracker,** see https://www.icao.int/environmental-protection/Pages/SAF.aspx

56 CHALLENGES AND RISKS ASSOCIATED WITH SAF DEVELOPMENT, SCALABILITY, AND JUST ALLOCATION:
For a discussion of the technical, economic, and policy challenges of SAFs:
- Becken, S., Mackey, B. & Lee, D.S. (2023). Implications of preferential access to land and clean energy for sustainable aviation fuels. Science of the Total Environment, 886, 163883. https://doi.org/10.1016/j.scitotenv.2023.163883.
- Bergero, C., Gosnell, G., Gielen, D. et al. (2023). Pathways to net zero emissions from aviation. Nature Sustainability, 6, 404-414. https://doi.org/10.1038/s41893-022-01046-9.
- Gössling, S. & Lyle, C. (2021). Transition policies for climatically sustainable aviation. Transport Reviews, 41(5), 643-658, https://doi.org/10.1080/01441647.2021.1938284.
- International Transport Forum. (2023). Sustainable Aviation Fuels: Policy Status Report. https://www.itf-oecd.org/sustainable-aviation-fuels-policy-status.
- Pavlenko, N., & Searle, S. (2021). Assessing the sustainability implications of alternative aviation fuels. The International Council on Clean Transportation.
- The Royal Society (2023). Net zero aviation fuels: resource requirements and environmental impacts. https://royalsociety.org/topics-policy/projects/low-carbon-energy-programme/net zero-aviation-fuels/ (accessed 12/08/23)

57 FREQUENT FLYER LEVY:
For an analysis of what such a levy could look like, see Zheng, X.S. & Rutherford, D. (2022). Aviation climate finance using a global frequent flying levy. https://theicct.org/publication/global-aviation-frequent-flying-levy-sep22/ .

58 MITIGATION: IPCC WGIII SUMMARY FOR POLICYMAKERS:
IPCC (2022). Summary for Policymakers [P.R. Shukla, J. Skea, A. Reisinger, R. Slade, R. Fradera, M. Pathak, A. Al Khourdajie, M. Belkacemi, R. van Diemen, A. Hasija, G. Lisboa, S. Luz, J. Malley, D. McCollum, S. Some, P. Vyas, (eds.)]. In: Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [P.R. Shukla, J. Skea, R. Slade, A. Al Khourdajie, R. van Diemen, D. McCollum, M. Pathak, S. Some, P. Vyas, R. Fradera, M. Belkacemi, A. Hasija, G. Lisboa, S. Luz, J. Malley, (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA. doi: 10.1017/9781009157926.001.

59 IEA NET ZERO:
IEA (2021). Net Zero by 2050 - A Roadmap for the Global Energy Sector. International Energy Agency. https://www.iea.org/reports/net zero-by-2050.

60 AIRPORT BASED EMISSION CAPS:
A discussion of airport caps and other aviation mitigation strategies is available from: Lyle, C. (2023). Climate Change Policy of International Aviation – a Critical Assessment. Horizon paper. https://tpcc.info/wp-content/uploads/2023/Aviation-Climate-Policy.pdf

61 AIRPORT BASED EMISSION CAPS::
see Massy-Beresford, H. (2023). Flight cap debate highlights political pressure on airlines. Aviation Week & Space Technology, (Jun 19 - July 2, 2023), 38. https://aviationweek.com/aerospace/week-technology-june-20-24-2022

62 RAILWAY ELECTRIFICATION:
Data from UIC (2023). 2022 Global Rail Sustainability Report. International Union of Railways. https://uic.org/IMG/pdf/global-rail-sustainability-report-2022.pdf

63 ELECTRIV VEHICLES:
Data on the size of the electric car market were taken from https://www.mordorintelligence.com/industry-reports/electric-car-rental-market.

Data on the overall market were taken from https://www.mordorintelligence.com/industry-reports/electric-car-rental-market; overall market from https://www.statista.com/outlook/mmo/shared-mobility/shared-rides/car-rentals/worldwide.

64 EV TRANSITION CHALLENGES IN TOURISM:
Discussion of the barriers and implications of the EV transition in tourism are available from:
- Fitt, H. (2020). Boring and inadequate? A literature review considering the use of electric vehicles in drive tourism. Current Issues in Tourism DOI: 10.1080/13683500.2021.1937074
- Fjelstul, J. (2014). Vehicle electrification: on the "green" road to destination sustainability. Journal of Destination Marketing & Management, https://doi.org/10.1016/j.jdmm.2014.06.002
- Hopkins, D. (2020). Sustainable mobility at the interface of transport and tourism. Journal of Sustainable Tourism, 28(2), 129-143 DOI: 10.1080/09669582.2019.1691800
- Wang, Y., Lin, C. & Lee, T. (2018). Electric vehicle tour planning. Transportation Research Part D: Transport and Environment, (63) 121-136 https://doi.org/10.1016/j.trd.2018.04.016

65 EV READINESS OF CANADA'S NATIONAL PARKS:
Analysis of tourism transport emissions and reduction strategies for Canada's national park systems is available from: Scott, D. et al. (2023). National Parks Tourism Travel Emissions and Decarbonization Pathways. Report to Parks Canada.

66 CARBON INTENSITY OF DIFFERENT ACCOMMODATION TYPES:
The following studies provide data on the energy or carbon intensity of different types of tourist accommodation.
- Becken, S., Frampton, C., & Simmons, D. (2001). Energy consumption patterns in the accommodation sector—the New Zealand case. Ecological economics, 39(3), 371-386.
- Becken, S., & McLennan, C. L. (2017). Evidence of the water-energy nexus in tourist accommodation. Journal of Cleaner Production, 144, 415-425.
- Cheng, M., Chen, G., Wiedmann, T., Hadjikakou, M., Xu, L., & Wang, Y. (2020). The sharing economy and sustainability–assessing Airbnb's direct, indirect and induced carbon footprint in Sydney. Journal of Sustainable Tourism, 28(8), 1083-1099.
- Filimonau, V., Dickinson, J., Robbins, D., & Huijbregts, M. A. (2011). Reviewing the carbon footprint analysis of hotels: Life

Cycle Energy Analysis (LCEA) as a holistic method for carbon impact appraisal of tourist accommodation. Journal of Cleaner Production, 19(17-18), 1917-1930.
- Puig, R., Kiliç, E., Navarro, A., Albertí, J., Chacón, L., & Fullana-i-Palmer, P. (2017). Inventory analysis and carbon footprint of coastland-hotel services: A Spanish case study. Science of the Total Environment, 595, 244-254.
- Warren, C., & Becken, S. (2017). Saving energy and water in tourist accommodation: A systematic literature review (1987–2015). International Journal of Tourism Research, 19(3), 289-303.

67 HOTEL EMISSIONS:

Two studies of different groups of hotel chains are included:
- A detailed methodology and results are provided in a separate TPCC Horizon Paper. The Greenview webpage at https://greenview.sg/services/chsb-index/ also contains useful information.
- Gössling, S., Humpe, A., & Sun, Y. Y. (2024). On track to net zero? Large tourism enterprises and climate change. Tourism Management, 100, 104842. https://www.sciencedirect.com/science/article/pii/S0261517723001243

68 ENERGY USE IN HOTELS:

For a review of the relevant literature, see Warren, C. & Becken, S. (2017). Saving energy and water in tourist accommodation: a systematic literature review. International Journal of Tourism Research, 19(3), 289-303.

69 WATER CONSUMPTION IN TOURISM:

Water use in hotels comes with a carbon footprint due to energy costs for providing the water and in many cases heating it (showers, laundry etc.). Improving water efficiency is also important for adaptation in areas where water is either temporarily or permanently a scarce resource. This is particularly important where there is a risk that tourism water use crowds out water availability for the local population.
- Becken, S. & McLennan, C. (2017). Evidence of the water-energy nexus in tourist accommodation. Journal of Cleaner Production, 144(15), 415-425.
- Becken, S. (2014). Water Equity – Contrasting Tourism Water Use with that of the Local Community. Water Resources and Industry, 7–8, 9–22.
- Gössling, S., Peeters, P., Hall, C. M., Ceron, J. P., Dubois, G., & Scott, D. (2012). Tourism and water use: Supply, demand, and security. An international review. Tourism Management, 33(1), 1-15.
- Hof, A., & Schmitt, T. (2011). Urban and tourist land use patterns and water consumption: Evidence from Mallorca, Balearic Islands. Land Use Policy, 28(4), 792-804.
- McLennan, C.L., Becken, S. & Stinson, K. (2017). A water use model for the tourism industry in the Asia-Pacific Region: The impact of water saving measures on water use. Journal of Hospitality and Tourism Research, 41(6), 746–767.

70 HOTEL PRACTICES:

https://greenview.sg/services/green-lodging-trends-report/

71 ENGAGING THE GUEST AND INNOVATION:
- Coghlan, A., Becken, S. & Warren, C. (2023). Modelling a smart tech user journey to decarbonise tourist accommodation. Journal of Sustainable Tourism, 31(3), 840-858, DOI: 10.1080/09669582.2022.2030344
- Dolnicar, S. (2020). Designing for more environmentally friendly tourism. Annals of Tourism Research, 84, 102933.
- Viglia, G., & Dolnicar, S. (2020). A review of experiments in tourism and hospitality. Annals of Tourism Research, 80, 102858.
- Warren, C., Becken, S. & Coghlan, A. (2016). Using persuasive communication to co-create behavioural change – engaging with guests to save resources at tourist accommodation facilities. Journal of Sustainable Tourism, 25(7), 935-954.
- Warren, C., Becken, S. & Coghlan, A. (2018). Sustainability-oriented Service Innovation: 14 year longitudinal case study of a tourist accommodation provider. Journal of Sustainable Tourism, 26(10), 1784-1803.

72 ELECTRIC VEHICLE CHARGING FACILITIES AT ACCOMMODATION ESTABLISHMENTS:

Analysis based on data from self-reported charging infrastructure at all accommodation types using the Booking.com platform. Data were collected in August 2023. Only the presence or absence of electric vehicle charging infrastructure could be determined; data on the number of chargers and capacity (level 1, 2, 3) were not available.

73 GLOBAL SURVEY:

UNWTO commissioned a survey of climate action in the tourism sector (July-Aug 2021). A total of 1 139 responses were collected, representing businesses, destinations and supporting organisations from 131 countries. UNWTO. (2023). Climate action in the tourism sector: An overview of methodologies and tools to measure greenhouse gas emissions. https://www.e-unwto.org/doi/epdf/10.18111/9789284423927

74 INDUSTRY CARBON MITIGATION REPORTS:

for a recent example see the roadmap released by WTTC. (2021). A net zero roadmap for travel & tourism. https://wttc.org/Portals/0/Documents/Reports/2021/WTTC_Net_Zero_Roadmap.pdf

75 SCENARIOS:

The Travel Foundation developed the tourism decarbonisation scenario using the dynamic Global Tourism and Transport Model (GTTMdyn). This long-term system dynamics model of the global tourism system allows the user to explore 45 measures in seven categories, ranging from technological development through taxes to several SAF types and offsetting.

See Travel Foundation. (2023). Envisioning tourism in 2030 and beyond. https://www.thetravelfoundation.org.uk/wp-content/uploads/2023/02/EnvisionTourism_Full_FINAL.pdf.

76 CARBON MANAGEMENT IN TOURISM:

Gössling, S., Balas, M., Mayer, M., & Sun, Y. Y. (2023). A review of tourism and climate change mitigation: The scales, scopes, stakeholders, and strategies of carbon management. Tourism Management, 95, 104681.

77 FOOD WASTE IN TOURISM:

Food services have great relevance for emissions in tourism. It is estimated that globally at least 75 billion meals are consumed annually in international tourism, some 200 million per day (Gössling et al., 2011). An estimated one-third of all the food in the world goes to waste (FAO, 2011). Depending on the type of business and hygiene standards, around 20–60% of all food purchased by holiday hotels ends up in the. Almost 80% of this amount of waste can be avoided either by producers or consumers (Filimonau & De Coteau, 2019). Food recovery programmes can play a big role to divert organic waste from landfill (e.g. https://www.tableedeschefs.org/en/programs/feed/food-recovery-program/)

Offering the right foods and making the right food choices in tourism can make a big difference in shaping emission pathways. GHG emissions depend mainly on the production methods used (outdoor vs. heated greenhouse cultivation, organic vs. conventional production), the mode and distance of transport (highest for air fright), and the food item itself. Meat and dairy products, fish and seafood are among the most carbon-intensive products while fruit, vegetables, and cereal products, on the other hand, cause low GHG emissions (Lund-Durlacher & Gössling, 2020).
- Babakhani, N., Lee, A., & Dolnicar, S. (2020). Carbon labels on restaurant menus: do people pay attention to them?. Journal of Sustainable Tourism, 28(1), 51-68.
- Dolnicar, S., Juvan, E., & Grün, B. (2020). Reducing the plate waste of families at hotel buffets–A quasi-experimental field study. Tourism Management, 80, 104103.
- FAO (2011). Global food losses and food waste – Extent, causes and prevention. Rome.
- Filimonau, V. & De Coteau, D.A. (2019). Food waste management in hospitality operations: a critical review. Tourism Manag. 71, 234–245. https://doi.org/10.1016/j. tourman.2018.10.009.
- Gössling, S., Garrod, B., Aall, C., Hille, J., & Peeters, P. (2011). Food

management in tourism. Reducing tourism's carbon 'foodprint'. Tourism Management, 32(3), 534–543. https://doi.org/10.1016/j.tourman.2010.04.006.
- Lund-Durlacher, D., & Gössling, S. (2020). An analysis of Austria's food service sector in the context of climate change. Journal of Outdoor Recreation and Tourism, DOI: https://doi.org/10.1016/j.jort.2020.100342

78 SECTOR MITIGATION OR EXTERNAL OFFSETTING:
Scott, D. Gössling, S., Hall, C.M. & Peeters, P. (2015) Can tourism be part of the decarbonized global economy?: The costs and risks of alternate carbon reduction policy pathways. Journal of Sustainable Tourism, 24 (1), 52-72. DOI: 10.1080/09669582.2015.1107080

79 LITIGATION:
See for instance Greenfield, P. (2023). Delta Air Lines faces lawsuit over $1bn carbon neutrality claim. https://www.theguardian.com/environment/2023/may/30/delta-air-lines-lawsuit-carbon-neutrality-aoe (accessed 02/08/23); Carroll, S.G. (2023). Airlines sued in Europe over greenwashing claims. https://www.euractiv.com/section/aviation/news/airlines-sued-in-europe-over-greenwashing-claims/

80 AIR TRAVEL EMISSIONS INTENSITY MAP:
Emission intensity of routes based on ICAO global airport-pairs data for 2019. ICAO data transformed to emissions (CO2e) using path distance, aircraft used, landing and take-off and climb-cruise-descent emissions, and passenger load factor.

81 GOVERNMENT LEGAL ACTION AGAINST AIRLINE CLIMATE CLAIMS:
For examples of, and the rationale behind, court cases by regulatory organisations against airlines' climate claims: Plucinska, J., Sterling, T. & Singh, R.K. (2023). Greenwashing cases against airlines in Europe, US. https://www.reuters.com/business/aerospace-defense/greenwashing-cases-against-airlines-europe-us-2023-09-13/. European Council for an Energy-Efficient Economy. (2023). Airlines sued in Europe over 'greenwashing' claims. https://www.eceee.org/all-news/news/news-2023/airlines-sued-in-europe-over-greenwashing-claims/. Maclaren, C. (2023). How a new wave of lawsuits is targeting airline "greenwashing". https://www.corporateknightscomtransportationlawsuits-airline-greenwashing-delta-klm/.

82 JUSTICE:
For some recent work on justice in the tourism context, see:
- Mika, J. P., & Scheyvens, R. A. (2022). Te Awa Tupua: peace, justice and sustainability through Indigenous tourism. Journal of Sustainable Tourism, 30(2-3), 637-657.
- Rastegar, R. (2022). Towards a just sustainability transition in tourism: A multispecies justice perspective. Journal of Hospitality and Tourism Management, 52, 113-122.
- Rastegar, R., & Ruhanen, L. (2023). Climate change and tourism transition: From cosmopolitan to local justice. Annals of Tourism Research, 100(C).

83 LUXURY GOODS:
Luxury goods are defined through income elasticities. A review by Peng et al. (2015) concluded: "The overall average income elasticity of international tourism demand is 2.526. This indicates that, on average, the majority of international travel is clearly in the "luxury" category (economists define luxury products as those with income elasticities greater than 1.0)." See Peng, B., Song, H., Crouch, G. I., & Witt, S. F. (2015). A meta-analysis of international tourism demand elasticities. Journal of Travel Research, 54(5), 611-633.

84 GLOBAL AIR TRAVEL:
Gössling, S., & Humpe, A. (2020). The global scale, distribution, and growth of aviation: Implications for climate change. Global Environmental Change, 65, 102194.

85 PER CAPITA AVIATION EMISSIONS:
The data were drawn from an article on Our World in Data, which in turn builds on methodology developed by the ICCT to estimate countries' per capital air travel emissions. See Ritchie, H. (2020). Where in the world do people have the highest CO2 emissions from flying? https://ourworldindata.org/carbon-footprint-flying#:~:text=In%20the%20United%20States%20the,and%20Canada%20(168%20kg).

86 SOCIAL COST OF CARBON:
Values in this analysis (US$426-624 per tonne of CO2 in 2019) are based on a meta-analysis of 207 studies published before 2022. See Tol, R.S.J. (2023). Social cost of carbon estimates have increased over time. Nature Climate Change, 13, 532–536. https://doi.org/10.1038/s41558-023-01680-x.

87 GLOBAL EMISSIONS FROM THE TOURISM SECTOR:
Estimates obtained from Lenzen, M., Sun, YY., Faturay, F. et al. (2018). The carbon footprint of global tourism. Nature Climate Change, 8, 522-528. https://doi.org/10.1038/s41558-018-0141-x.

88 THE TOURISM SECTOR'S ECONOMIC CONTRIBUTION:
Estimates of direct and total economic contributions obtained from WTTC (2019). Travel and Tourism Economic Impact 2019. https://wttc.org/research/economic-impact.

Direct and total contributions are defined as follows:
- Direct: GDP generated by industries that deal directly with tourists, including hotels, travel agents, airlines, and other passenger transport services, as well as the activities of restaurant and leisure industries that deal directly with tourists. It is equivalent to total internal travel and tourism spending in a country, less the purchases made by those industries (including imports). In terms of the United Nations' Tourism Satellite Account methodology, it is consistent with total GDP calculated in table 6 of the TSA:RMF 2008.
- Total: GDP generated directly by the travel and tourism sector, plus its indirect and induced impacts. 'Indirect' includes capital investment by all industries directly involved in travel and tourism, government spending in support of general tourism activity, and supply chain purchases of domestic goods and services directly by different industries in travel and tourism as inputs to their final tourism output.

89 METHOD NOTE:
All values were converted to 2020 US$. Social cost of carbon values for discount rate (or pure rate of time preference) of 0% and 2% were used in the analysis based on Tol's finding (2023) that 1.5% was the current standard discount rate in the literature. See Tol, R.S.J. (2023). Social cost of carbon estimates have increased over time. Nature Climate Change, 13, 532-536. https://doi.org/10.1038/s41558-023-01680-x.

90 DISCOUNT RATES IN CLIMATE CHANGE ECONOMICS:
The discount rate used in climate change economic studies matters significantly because of the long timescales. One of the key discount rates applied in most long-term economic analysis is the pure rate of time preference (PRTP). Some describe the PRTP as 'the rate at which analyses discriminate against future generations just because they exist in the future. A PRTP of 0% treats future generations as equal. The review of SCC studies by Tol (2022) found a shift to lower PRTP rates of less than 2% (recent average of 1.5%). See Tol, R.S.J. (2023). Social cost of carbon estimates have increased over time. Nat. Clim. Chang. 13, 532–536. https://doi.org/10.1038/s41558-023-01680-x

91 ANALYSIS OF CLIMATE FINANCE AND DEBT REPLAYMENT IN SMALL ISLAND DEVELOPING STATES:
European Network on Debt and Development (2022). Riders on the storm: How debt and climate change are threatening the future of small island developing states. https://assets.nationbuilder.com/eurodad/pages/3046/attachments/original/1678896856/Summary.pdf?1678896856

92 AIR TRAVEL AND ADAPTATION:
- Baker, A. (2011). How can air travel contribute to the costs of adapting to climate change? https://www.osti.gov/etdeweb/biblio/22073512.
- Müller, B., & Hepburn, C. (2006). IATAL—an outline proposal for an International Air Travel Adaptation Levy.

93 UN Special Rapporteur on Human Rights and the Environment. (2021). Tax air travel and sea shipping to help climate-vulnerable nations, UN expert tells COP-26 leaders. OHCHR. Retrieved December 2, 2022, from https://www.ohchr.org/en/press-releases/2021/11/tax-air-travel-and-sea-shipping-help-climate-vulnerable-nations-un-expert

94 CARBON PRICING:
IMF (2021). Proposal for an international carbon price floor among large emitters. https://www.imf.org/en/Publications/staff-climate-notes/Issues/2021/06/15/Proposal-for-an-International-Carbon-Price-Floor-Among-Large-Emitters-460468; Carbon Pricing Leadership Coalition. Report of the High-Level Commission on Carbon Prices. (2019).

And:

https://www.carbonpricingleadership.org/report-of-the-highlevel-commission-on-carbon-prices
Report of the high-level commission on carbon prices.

95 TOURISM SECTOR CLIMATE SENSTITVITY:
Reviews and discussions of the tourism and climate change literatures on multi-hazard sector sensitivity:

- Scott, D., Hall, C.M. & Gössling, S. (2019) Global Tourism Vulnerability to Climate Change. Annals of Tourism Research, 77, 49-61. DOI: 10.1016/j.annals.2019.05.007
- Mora, C., Spirandelli, D., Franklin, E. C., Lynham, J., Kantar, M. B., Miles, W., ... et al. (2018). Broad threat to humanity from cumulative climate hazards intensified by greenhouse gas emissions. Nature Climate Change, 8(12), 1062.

For detailed regional discussions of tourism sector climate sensitivity and impacts:

- Navarro-Drazich, D., Christel, L. G., Gerique, A., Grimm, I., Rendón, M. L., Schlemer Alcântara, L., ... & De Simón, C. (2023). Climate change and tourism in South and Central America. Journal of Sustainable Tourism, 1-17.
- Dube, K., Nhamo, G., Kilungu, H., Hambira, W. L., El-Masry, E. A., Chikodzi, D., ... & Molua, E. L. (2023). Tourism and climate change in Africa: informing sector responses. Journal of Sustainable Tourism, 1-21.
- Steiger, R., Demiroglu, O. C., Pons, M., & Salim, E. (2022). Climate and carbon risk of tourism in Europe. Journal of Sustainable Tourism, 1-31.
- Rutty, M., Hewer, M., Knowles, N., & Ma, S. (2022). Tourism & climate change in North America: Regional state of knowledge. Journal of Sustainable Tourism, 1-24.
- Steiger, R., Knowles, N., Pöll, K., & Rutty, M. (2022). Impacts of climate change on mountain tourism: A review. Journal of Sustainable Tourism, 1-34.
- Fang, Y., Trupp, A., Hess, J. S., & Ma, S. (2022). Tourism under climate crisis in Asia: impacts and implications. Journal of Sustainable Tourism, 1-17.
- Wolf, F., Moncada, S., Surroop, D., Shah, K. U., Raghoo, P., Scherle, N., ... & Nguyen, L. (2022). Small island developing states, tourism, and climate change. Journal of Sustainable Tourism, 1-19.
- Higham, J., Loehr, J., Hopkins, D., Becken, S., & Stovall, W. (2022). Climate science and tourism policy in Australasia: deficiencies in science-policy translation. Journal of Sustainable Tourism, 1-27.
- Hall, C.M. & Saarinen, J. (2021). 20 years of Nordic climate change crisis and tourism research: A review and future research agenda. Scandinavian Journal of Hospitality and Tourism, 21(1), 102-110.

96 PROJECTED CHANGES IN DIVERSE CLIMATE HAZARDS:
See IPCC AR6 for the most recent comprehensive review of how climate hazards are projected to evolve under varied emission scenarios. IPCC (2022). Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Pörtner, et al. (eds.)]. Cambridge University Press. Cambridge University Press, Cambridge, UK and New York, NY, USA, 3056 pp., doi:10.1017/9781009325844.

97 TOURISM CLIMATE HAZARD INDEX:
The methodology for this new subnational analysis is based on the climate vulnerability index approach of Scott, D., Hall, C.M. & Gössling, S. (2019). Global Tourism Vulnerability to Climate Change. Annals of Tourism Research, 77, 49-61. https://doi.org/10.1016/j.annals.2019.05.007.

Multiple climate hazards are combined in the index, with at least one indicator representing each of the ten main climate hazards (except landcover change) outlined by Mora, C., Spirandelli, D., Franklin, E. C., Lynham, J., Kantar, M. B., Miles, W., et al. (2018). Broad threat to humanity from cumulative climate hazards intensified by greenhouse gas emissions. Nature Climate Change, 8(12), 1062.

Data for 19 climate hazard variables (structured as the six sub-indices drought, wildfire, extreme precipitation, heatwaves/extremes, thermal comfort for tourists, and snow resources) were obtained from the Coupled Model Intercomparison Project Phase 6 for low, moderate, and high emission scenarios (RCP 2.6, 4.5 and 8.5 respectively). Only RCP4.5 is shown in the map. Other maps can be found at http://climate.risklayer.com/. Risklayer is a German-based company that specialises in providing data-driven insights and risk assessments for catastrophes and climate change.

98 CLIMATE CHANGE AND HEAT RELATED ILLNESS:

- IPCC (2022). Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Pörtner, et al. (eds.)]. Cambridge University Press. Cambridge University Press, Cambridge, UK and New York, NY, USA, 3056 pp., doi:10.1017/9781009325844.
- Vicedo-Cabrera et al. (2021). The burden of heat-related mortality attributable to recent human-induced climate change. Nature Climate Change, 11(6), 492-500. https://doi.org/10.1038/s41558-021-01058-x.

99 EUROMONITOR TOP 100 CITY DESTINATIONS:
Euromonitor International (2023). Euromonitor report reveals world's top 100 city destinations for 2022. https://www.euromonitor.com/press/press-releases/december-2022/euromonitor-report-reveals-worlds-top-100-city-destinations-for-2022.

100 HEAT THRESHOLD:
This is the threshold defined by tourists from several major outbound markets as unacceptably hot for city tourism (Scott et al., 2016), as the separator between deadly and non-deadly conditions in cities in 34 countries (Mora et al., 2017), and the point at which worker productivity is negatively affected (Levi et al., 2018).

- Scott, D., Rutty, M., Amelung, B. & Tang, M. (2016). An Inter-Comparison of the Holiday Climate Index (HCI) and the Tourism Climate Index (TCI) in Europe. Atmosphere, 7, 80. https://doi.org/10.3390/atmos7060080.
- Mora, C., Dousset, B., Caldwell, I., et al. (2017). Global risk of deadly heat. Nature Climate Change, 7, 501–506. https://doi.org/10.1038/nclimate3322.
- Levi, M., Kjellstrom, T. & Baldasseroni, A. (2018). Impact of climate change on occupational health and productivity: a systematic literature review focusing on workplace heat. La Medicina del Lavoro, 109(3), 163-179. https://doi.org/10.23749/mdl.v109i3.6851.

101 COMPARATIVE IMPACTS OF DISASTERS ON TOURISM:
For a comprehensive review of the macro-scale impacts of a range of climate and non-climate hazards on tourism, see Rosselló, J., Becken, S., & Santana-Gallego, M. (2020). The effects of natural disasters on international tourism: A global analysis. Tourism management, 79, 104080.

102 CLIMATE CHANGE IMPLICATIONS FOR WILDFIRE:
For details on projections of wildfire weather frequency and severity of fires under climate change scenarios:

- Senande-Rivera, M., Insua-Costa, D. & Miguez-Macho, G. (2022). Spatial and temporal expansion of global wildland fire activity in response to climate change. Nature Communications, 13, 1208.

https://doi.org/10.1038/s41467-022-28835-2.
- Bowman, D., Williamson, G., Abatzoglou, J., et al. (2017). Human exposure and sensitivity to globally extreme wildfire events. Nature Ecology & Evolution, 1, 0058. https://doi.org/10.1038/s41559-016-0058.

103 FIRE WEATHER INDEX:
The Fire Weather Index (FWI) is a meteorologically based index used worldwide to estimate fire danger. It consists of different components that account for the effects of fuel moisture and wind on fire behaviour and spread. The higher the FWI, the more favourable the meteorological conditions to trigger a wildfire. This indicator can help shape long-term tourist strategy and plan future investments under a changing climate. Multiple FWIs are estimated by CMIP-6 and projections for Europe can be found at: https://climate.copernicus.eu/fire-weather-index

104 WILDFIRE IMPACTS ON TOURISM IN PORTUGUAL:
For details on this economic analysis see Otrachshenko, V., & Nunes, L. (2022). Fire takes no vacation: Impact of fires on tourism. Environment and Development Economics, 27(1), 86-101. doi:10.1017/S1355770X21000012

105 CLIMATE AND TEMPERATURE IMPACTS ON TOURISM VISITATION PATTERNS:
The following key studies provide insights using economic and climate index-based methods:
- Bigano, A., Hamilton, J.M., Maddison, D.J., et al. (2006). Predicting tourism flows under climate change. Climatic Change, 79, 175-180. https://doi.org/10.1007/s10584-006-9190-7.
- Scott, D., Rutty, M., Amelung, B. & Tang, M. (2016). An Inter-Comparison of the Holiday Climate Index (HCI) and the Tourism Climate Index (TCI) in Europe. Atmosphere, 7, 80. https://doi.org/10.3390/atmos7060080.
- Scott, D. & Lemieux, C. (2010). Weather and climate information for tourism. Proceedia Environmental Sciences, 1, 146-183.
- Matei, N., Garcia Leon, D., Dosio, A., Batista E Silva, F., Ribeiro Barranco, R. & Ciscar Martinez, J.C. (2023). Regional impact of climate change on European tourism demand. Publications Office of the European Union, Luxembourg. https://doi.org/10.2760/899611

106 HEAT ESCAPE TOURISM IN CHINA:
Details on the Chinese government's 22 Degree Summer Destination Strategy are provided in a 2018 government report (available in Mandarin only) and outlined in Yu, D., Li, S., Chen, N.C., Hall, M. & Guo, Z. (2023). High Temperatures and Tourism: Enlightenment from China. https://doi.org/10.20944/preprints202308.1181.v1 .

107 AIR CONDITIONING (COOLING) AT ACCOMMODATIONS:
Analysis based on data from self-reported air conditioning at all accommodation types using the Booking.com platform. Data were collected in August 2023. Only the presence or absence of air conditioning at the accommodation establishment could be determined. It is uncertain whether every room has air conditioning.

108 HOTEL AIR-CONDITINING ERNERGY USE AND EMISSIONS:
- Torres, Y. D., Herrera, H. H., Plasencia, M. A. A. G., Novo, E. P., Cabrera, L. P., Haeseldonckx, D., & Silva-Ortega, J. I. (2020). Heating ventilation and air-conditioned configurations for hotels: an approach review for the design and exploitation. Energy Reports, 6, 487-497.
- Arenhart, R.S., Souza, A.M. & Zanini, R.R. (2022). Energy Use and Its Key Factors in Hotel Chains. Sustainability, 14, 8239. https://doi.org/10.3390/su14148239.

109 COASTAL TOURISM:
See Arabadzhyan, A., Figini, P., García, C., González, M. M., Lam-González, Y. E., & León, C. J. (2021). Climate change, coastal tourism, and impact chains–a literature review. Current Issues in Tourism, 24(16), 2233-2268.

110 OBSERVED CHANGES IN MOUNTAIN REGION TEMPERATURES AND SNOWPACK:
For a review of global evidence of observed changes in winter conditions in mountain regions, set: IPCC (2021). Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, et al. eds.]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, In press, doi:10.1017/9781009157896.

111 CLIMATE CHANGE IMPACTS ON SKI TOURISM OPERATIONS AND DESTINATIONS:
For a review of how climate change is and is projected to impact the ski industry and ski tourism see Steiger, R., Scott, D., Abegg, B., Pons, M., & Aall, C. (2019). A critical review of climate change risk for ski tourism. Current Issues in Tourism, 22(11), 1343-1379.

112 IMPACTS OF CLIMATE CHANGE ON SKI SEASONS:
Different studies of the observed and projected impact of climate change on the ski industry use different methods, making comparisons across regional markets difficult. Studies in different countries using a common methodology:
- Scott, D., Steiger, R., Knowles, N. & Fang, Y. (2019). Regional Ski Tourism Market Vulnerability to Climate Change: An Inter-comparison of Eastern Canada and the Northeast US. Journal of Sustainable Tourism, 568-586. https://doi.org/10.1080/09669582.2019.1684932.
- Scott, D., Steiger, R., Rutty, M., Knowles, N. & Rushton, B. (2021). Climate Change Risk in the US Midwestern Ski Industry. Tourism Management Perspectives. https://doi.org/10.1016/j.tmp.2021.100875.
- Rice, H., Scott, D., Steiger, R. & Cohen, S. (2021). Climate Change Risk in the Swedish Ski Industry. Current Issues in Tourism. https://doi.org/10.1080/13683500.2021.1995338.
- Scott, D., Steiger, R., Dannevig, H. & Aall, C. (2019). Climate Change and the Future of the Norwegian Alpine Ski Industry. Current Issues in Tourism, 2396-2409. https://doi.org/10.1080/13683500.2019.1608919.
- Steiger, R. & Scott, D. (2020). Ski Tourism in a Warmer World: Increased Adaptation and Regional Economic Impacts in Austria. Tourism Management, 77. https://doi.org/10.1016/j.tourman.2019.104032.
- Fang, Y., Steiger, R. & Scott, D. (2019). The impact of climate change on ski resorts in China. International Journal of Biometeorology. https://doi.org/10.1007/s00484-019-01822-x.
- Knowles, N., Scott, D. & Steiger, R. (2023). Climate Change and the Future of the Ski Industry in Canada's Western Mountains. Journal of Sport and Tourism.

113 SNOWMAKING REQUIREMENTS UNDER CLIMATE CHANGE.
See the studies in the previous endnote for details on projected changes in snowmaking requirements under a range of climate futures.

114 SNOWMAKING INVESTMENT:
Projections on the market size for snowmaking equipment is available from: Persistence Market Research (2018). Snowmaking System Market. Global Market Study on Snowmaking Systems: Developments in Theme Based Tourism Activities in Drive Growth Across Various Regional Markets, July. https://www.persistencemarketresearch.com/market-research/snow-making-system-market.asp

115 SNOWMAKING AS MALADAPTATION:
For a discussion of snowmaking sustainability and maladaptation:
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For a review of available literature, see Soontiens-Olsen, A., Genge, L., Medeiros, A. S., Klein, G., Lin, S., & Sheehan, L. (2023). Coastal Adaptation and Vulnerability Assessment in a Warming Future: A Systematic Review of the Tourism Sector. SAGE Open, 13(2). https://doi.org/10.1177/21582440231179215

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For details of the global analysis of airport impacts and adaptation costs, see Yesudian, A. N., & Dawson, R. J. (2021). Global analysis of sea level rise risk to airports. Climate Risk Management, 31, 100266.

120 SEA LEVEL RISE IMPACT ON CARIBBEAN COASTAL RESORTS:
- Spencer, N., Strobl, E. & Campbell, A. (2022). Sea level rise under climate change: Implications for beach tourism in the Caribbean, Ocean & Coastal Management, 225, 106207, https://doi.org/10.1016/j.ocecoaman.2022.106207.
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121 SEA LEVEL RISE IMPACT ON THAILAND COASTAL RESORTS:
Analysis of the sea level rise risk of resorts across Thailand using projections:
- Kopp, R.E., DeConto, R.M., Bader, D.A., Hay, C.C., Horton, R.M., Kulp, S., Oppenheimer, M., Pollard, D. & Strauss, B.H. (2017). Evolving Understanding of Antarctic Ice-Sheet Physics and Ambiguity in Probabilistic Sea-Level Projections. Earth's Future 5, 1217–1233. https://doi.org/10.1002/2017EF000663
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The importance of world heritage sites in driving international visitation is documented by Yu-Wen Su & Hui-Lin Lin (2014). Analysis of international tourist arrivals worldwide: The role of world heritage sites. Tourism Management, 40, 46-58.

123 SEA LEVEL RISE RISK TO GLOBAL WORLD HERITAGES SITES:
- Kopp, R.E., DeConto, R.M., Bader, D.A., Hay, C.C., Horton, R.M., Kulp, S., Oppenheimer, M., Pollard, D. & Strauss, B.H. (2017). Evolving Understanding of Antarctic Ice-Sheet Physics and Ambiguity in Probabilistic Sea-Level Projections. Earth's Future 5, 1217–1233. https://doi.org/10.1002/2017EF000663
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World heritage site maps on the UNESCO website were used to identify and digitise the location of nominated sites and buffer zones into a geographic information system with the sea-level projections from Kopp et al. (2017).

124 WORLD HERITAGE SITES AND CLIMATE CHANGE:
- Lafrenz Samuels, K., & Platts, E. J. (2020). An ecolabel for the world heritage brand? Developing a climate communication recognition scheme for heritage sites. Climate, 8(3), 38.
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TAT News. (2023). Opening/closed status of Thailand's national parks. https://www.tatnews.org/2023/07/the-latest-opening-and-closing-status-of-thailands-national-parks/.

126 BIODIVERSITY CHANGE IMPACTS ON TOURISM:
For further discussion of the potential impacts of biodiversity and landscape change on destination appeal:
- Scott, D., Jones, B. & Konopek, J. (2007). Implications of climate and environmental change for nature-based tourism in the Canadian Rocky Mountains: A case study of Waterton Lakes National Park. Tourism Management, 28(2), 570-579.
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127 IPCC BIODIVERSIY HOTSPOTS:
Costello, M.J., M.M. Vale, W. Kiessling, S. Maharaj, J. Price, and G.H. Talukdar, 2022: Cross-Chapter Paper 1: Biodiversity Hotspots. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 2123–2161, doi:10.1017/9781009325844.018.

128 EXTINCTION RISK IN BIODIVERSITY HOTSPOTS:
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- Manes, S., Costello, M. J., Beckett, H., Debnath, A., Devenish-Nelson, E., Grey, K. A., ... & Vale, M. M. (2021). Endemism increases species' climate change risk in areas of global biodiversity importance. Biological Conservation, 257, 109070.
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129 ECOSYSTEM SERVICES AND CULTURAL SIGNIFICANCE:
Bond, M.O., Anderson, B.J., Henare, T.H.A.,& Wehi., P.M. (2019). Effects of climatically shifting species distributions on biocultural relationships. People and Nature 1: 87–102.

130 TOURISM AS A SUPPORTING MECHANISM FOR NATURE-BASED CLIMATE CHANGE SOLUTIONS:
For a discussion of the uncertainty relating to the capacity of tourism to support nature-based solutions, see Scott, D., Hall, C.M., Rushton, B. & Gössling, S. (2023). A Review of the IPCC Sixth Assessment and Implications for Tourism Development and Sectoral Climate Action. Journal of Sustainable Tourism. https://doi.org/10.1080/09669582.2023.2195597.

131 REGENERATIVE TOURISM:
- Becken, S., & Kaur, J. (2021). Anchoring "tourism value" within a regenerative tourism paradigm–a government perspective. Journal of Sustainable Tourism, 30(1), 52-68.
- Bellato, L., Frantzeskaki, N., & Nygaard, C. A. (2023). Regenerative tourism: a conceptual framework leveraging theory and practice. Tourism Geographies, 25(4), 1026-1046.
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- Matunga, H., Matunga, H. P., & Urlich, S. (2020). From exploitative to regenerative tourism: Tino Rangatiratanga and tourism in Aotearoa New Zealand.
- Pollack, A. (2019). Flourishing Beyond Sustainable Tourism. https://etc-corporate.org/uploads/06022019_Anna_Pollock_ETCKrakow_Keynote.pdf

132 CORAL REEFS AT RISK FROM CLIMATE CHANGE:
The graph shows an RCP8.5 emissions scenario. The dataset on coral reef extent used to calculate area statistics comes from Burke, L., Reytar, K., Spalding, M. & Perry, A. (2011). Reefs at Risk Revisited. http://pdf.wri.org/reefs_at_risk_revisited.pdf

133 CORAL REEF ECONOMIC VALUE:
Spalding, M., Burke, L., Wood, S. A., Ashpole, J., Hutchison, J., & Zu Ermgassen, P. (2017). Mapping the global value and distribution of coral reef tourism. Marine Policy, 82, 104-113.

134 CORAL RESTORATION:
- Blanco-Pimentel, M., Evensen, N. R., Cortés-Useche, C., Calle-Triviño, J., Barshis, D. J., Galván, V., ... & Morikawa, M.K. (2022). All-inclusive coral reef restoration: How the tourism sector can boost restoration efforts in the caribbean. Frontiers in Marine Science, 9.
- Le, D., Becken, S. & Curnock, M. (2022). Gaining Public Engagement to Restore Coral Reef Ecosystems in the Face of Acute Crisis. Global Environmental Change, 74, 102513.
- Westoby, R., Becken, S. & Laria, A.P. (2020). Perspectives on the human dimensions of coral restoration. Regional Environmental Change, 20, 109. DOI: 10.1007/s10113-020-01694-7.

135 TOURISM IN PROTECTED AREAS:
Balmford, A., Green, J.M.H., Anderson, M., Beresford, J., Huang, C., Naidoo, R., et al. (2015). Walk on the Wild Side: Estimating the Global Magnitude of Visits to Protected Areas. PLoS Biol, 13(2), e1002074. https://doi.org/10.1371/journal.pbio.1002074.
Note that biodiversity and ecosystems are also experienced by tourists outside protected areas, so the number of people benefitting from nature, and potentially contributing to its protection, is much higher than the eight billion estimated in the study above.

136 ECONOMIC CONTRIBUTION OF PROTECTED AREAS NATURE-BASED TOURISM:
Balmford, A., Green, J.M.H., Anderson, M., Beresford, J., Huang, C., Naidoo, R., et al. (2015). Walk on the Wild Side: Estimating the Global Magnitude of Visits to Protected Areas. PLoS Biol, 13(2), e1002074.

137 TOURISM AS A TOOL FOR CONSERVATION AND LINKS TO CLIMATE CHANGE:
There is a considerable amount of literature on this topic. Below are some key publications:
- Hoogendoorn, G. & Fitchett, J.M. (2018). Tourism and climate change: A review of threats and adaptation strategies for Africa. Current Issues in Tourism, 21, 742-759.
- Arbieu, U., Grünewald, C., Martín-López, B., Schleuning, M. & Böhning-Gaese, K. (2018). Large mammal diversity matters for wildlife tourism in Southern African protected areas: Insights for management. Ecosystem Services, 31, 481-490.

138 COMPLEXITY OF INTEGRATED CLIMATE RISK ASSESSMENTS:
The importance of a comprehensive understanding of multi-climate hazard risk is discussed by:
- Mora, C., Spirandelli, D., Franklin, E. C., Lynham, J., Kantar, M. B., Miles, W., ... & Hunter, C. L. (2018). Broad threat to humanity from cumulative climate hazards intensified by greenhouse gas emissions. Nature Climate Change, 8(12), 1062-1071.
- Simpson et al. (2021). A framework for complex climate change risk assessment, One Earth, 4(4), 489-501.

139 ASSESSMENT OF PHYSICAL CLIMATE RISK IN THE TOURISM SECTOR:
For a comprehensive review of climate change and tourism literature through to 2020 and a discussion of the limitations and gaps relating to understanding climate risk, see Scott, D. & Gössling, S. (2022). A review of research into tourism and climate change: Launching the Annals of Tourism Research curated collection on tourism and climate change. Annals of Tourism Research, 95, 103409.

140 ASSESSMENT OF PHYSICAL CLIMATE RISK AT THE DESTINATION SCALE:
A comprehensive review of the climate change and tourism literature through to 2020 and discussion of the limitations and gaps related to understanding of climate risk is available from: Scott, D., & Gössling, S. (2022). A review of research into tourism and climate change-Launching the annals of tourism research curated collection on tourism and climate change. Annals of Tourism Research, 95, 103409.

141 REGIONAL ECONOMIC DEPENDENCE ON TOURISM:
Discussion of relative economic dependence as measured by percentage of GDP and employment in tourism is discussed in the World Travel and Tourism Council annual reports on the economic contributions of tourism, see https://wttc.org/research/economic-impact.

142 COMPARATIVE TOURISM CLIMATE CHANGE RISK AMONG CARIBBEAN COUNTRIES:
Using the vulnerability index methods from Scott et al. (2019), Daniel Scott, Megan Sutton, Michelle Rutty combined data sources on the relative exposure of 22 Caribbean countries tourism sector to seven climate change risks identified as priorities to the Caribbean Tourism Organization.
- Scott, D., Hall, C.M., Gössling, S. (2019). Global Tourism Vulnerability to Climate Change. Annals of Tourism Research, 77, 49-61. DOI: 10.1016/j.annals.2019.05.007

143 SOUTH PACIFIC TOURISM:
- SPTO Sustainability Framework: https://southpacificislands.travel/pacific-sustainable-tourism-policy-framework/
- Movono, A., Scheyvens, R., & Ratuva, S. (2023). Beyond bouncing back: A framework for tourism resilience building in the Pacific.

Pacific Dynamics, 76(1). DOI : http://dx.doi.org/10.26021/14346.
- Scheyvens, R., & van der Watt, H. (2021). Tourism, empowerment and sustainable development: A new framework for analysis. Sustainability, 13(22), 12606.

144 IMPACTS OF CLIMATE CHANGE ON MOUNTAIN LANDSCAPES AND SOCIETIES:
The IPCC provides a synthesis of observed and projected impacts of climate change in mountain regions around the world:
- IPCC (2021). Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, et al. eds.]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, In press, doi:10.1017/9781009157896.
- IPCC (2022). Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Pörtner, et al. (eds.)]. Cambridge University Press. Cambridge University Press, Cambridge, UK and New York, NY, USA, 3056 pp., doi:10.1017/9781009325844.

145 CASCADING RISKS IN MOUNTAIN DESTINATIONS:
This figure was prepared by Dr Anu Kumari Lama, with support from the International Centre for Integrated Mountain Development (ICIMOD).

146 REGIONAL STRATEGY:
ICIMOD (2023b). ICIMOD Strategy 2030: Moving Mountains. International Centre for Integrated Mountain Development, Kathmandu Nepal. https://lib.icimod.org/record/36171#:~:text=This%20is%20a%20pivotal%20moment,and%20rising%20poverty%20and%20inequality.

147 NEPAL:
Ministry of Forest and Environment (2020). National Adaptation Plan (2021 – 2050), Nepal. Ministry of Forest and Environment, Kathmandu, Nepal. https://www.mofe.gov.np/uploads/uploads/notices/nap-full-repnoticepdf-3463-7921661679518.pdf

148 BHUTAN:
For more information on the tourism levy, see RGoB (2020). Tourism Levy Act of Bhutan 2020. https://www.mof.gov.bt/wp-content/uploads/2020/05/TOURISM_LEVY_ACT_OF_BHUTAN-2020.pdf and RGoB (2022). Tourism Levy Act of Bhutan 2022. https://www.tourism.gov.bt/uploads/attachment_files/tcb_eTgzl6X8_Tourism%20Levy%20Act%20of%20Bhutan%202022.pdf

149 WORLD INVESTMENT:
UNCTAD (2023). World investment report: Investing in sustainable energy for all. https://unctad.org/system/files/official-document/wir2023_overview_en.pdf

150 SOUTH AMERICA GLACIER TOURISM:
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- Bury, J., et al. (2011). Glacier recession and human vulnerability in the Yanamarey watershed of the Cordillera Blanca, Peru. Climatic Change, 105, 179-206. https://doi.org/10.1007/s10584-010-9870-1.

151 GLOBAL CLIMATE CHANGE AND TOURISM SURVEY:
UNWTO survey on climate action, see UNWTO. (2023). Climate action in the tourism sector – an overview of methodologies and tools to measure greenhouse gas emissions. https://www.e-unwto.org/doi/10.18111/9789284423927

152 ADAPTATION IN THE TOURISM SECTOR:
For an analysis of the state of knowledge on climate change adaptation in the tourism sector:
- Scott, D. & Gössling, S. (2022). A review of research into tourism and climate change: Launching the Annals of Tourism Research curated collection on tourism and climate change. Annals of Tourism Research. https://doi.org/10.1016/j.annals.2022.103409.
- Scott, D. (2021). Sustainable Tourism and the Grand Challenge of Climate Change. Sustainability, 13(4). https://doi.org/10.3390/su13041966.
- Jarratt, D. & Davies, N. (2020). Planning for climate change impacts: Coastal tourism destination resilience policies. Tourism Planning & Development, 17, 423-440.

153 POLICY FOR TOURISM AND CLIMATE CHANGE:
OECD (2011). Climate Change and Tourism Policy in OECD Countries, https://www1.oecd.org/industry/climate-change-and-tourism-policy-in-oecd-countries-9789264119598-en.htm

154 ADAPTATION IN CARIBBEAN TOURISM PLANS AND STRATEGIES:
For an evaluation of the status of climate change in Caribbean tourism plans, see Freeman-Prince, N. (2021). An Evaluation of National Tourism Plans in the Caribbean-SIDS Region in the Context of Climate Change. PhD dissertation. School of Planning, University of Waterloo, Ontario, Canada.

155 DESTINATION SCALE CLIMATE RISK AND ADAPATION PLANNING:
An example of good practice to support destinations to assess and respond to climate hazards in several Mexico destinations is summarized by: UNWTO (2018) Tourism for Development Volume II: Good Practices Retrieved. from UNTWO: https://www.e-unwto.org/doi/pdf/10.18111/9789284419746

156 INTEGRATING CLIMATE CHANGE RISK INTO TOURISM STRATEGIES:
A good example of integrating climate change into ongoing tourism planning is available from: JA-T1149: Tourism Strategy and Action Plan for Jamaica: Promoting Resilience, Sustainability, Innovation & Entrepreneurship
https://www.iadb.org/en/project/JA-T1149

157 GLOBAL CLIMATE CHANGE AND TOURISM SURVEY:
UNWTO survey on climate action, see https://www.unwto.org/news/new-report-to-support-climate-action-in-the-tourism-sector

158 PHYSICAL CLIMATE RISK DISCLOSURE REQUIREMENTS:
Trends in climate change disclosure requirements and guidelines are summarized by: The Imperative for Advancing Climate Risk Assessment in Tourism. https://tpcc.info/wp-content/uploads/2022/11/TPCC-Horizon-Paper-Climate-Resilience.pdf

International Sustainability Standards Board published its Climate-related Disclosures (IFRS S2) Standard in June 2023. The requirements of IFRS S2 include both (1) physical climate risks (including event-driven or acute risks, as well as longer-term shifts or chronic risks – including scenario-based analysis) and (2) transition risks associated with the shift to a lower-carbon economy (including consideration of financial and reputational risk, as well as speed and challenges of emission reduction aligned with regulatory requirements).

159 THE IMPERATIVE OF ADAPTATION MONITORING:
- IPCC (2022). Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Pörtner, et al. (eds.)]. Cambridge University Press. Cambridge University Press, Cambridge, UK and New York, NY, USA, 3056 pp., doi:10.1017/9781009325844.
- Berrang-Ford, L., Biesbroek, R., Ford, J. D., Lesnikowski, A., Tanabe, A., Wang, F. M., ... & Heymann, S. J. (2019). Tracking global climate change adaptation among governments. Nature Climate Change, 9(6), 440-449.
- IISD (2019). Monitoring and evaluation systems for adapting to climate change are only as good as they are usable. https://www.iisd.org/articles/measuring-evaluating-climate-change-adaptation

160 NEED FOR ADAPTATION MONITORING IN TOURISM SECTOR:
For a discussion of the state of knowledge on adaptation in tourism and the need to improve monitoring capabilities:

- Scott, D. & Gössling, S. (2022). A review of research into tourism and climate change: Launching the Annals of Tourism Research curated collection on tourism and climate change. Annals of Tourism Research. https://doi.org/10.1016/j.annals.2022.103409.
- Loehr, J. (2020). The Vanuatu Tourism Adaptation System: a holistic approach to reducing climate risk. Journal of Sustainable Tourism, 28(4), 515-534. https://doi.org/10.1080/09669582.2019.168 3185.

161 LIMITS OF KNOWLEDGE ON CLIMATE CHANGE ADAPTATION IN TOURISM:
For a detailed discussion of knowledge gaps and limits regarding adaptation in tourism, see Scott, D. & Gössling, S. (2022). A review of research into tourism and climate change: Launching the Annals of Tourism Research curated collection on tourism and climate change. Annals of Tourism Research. https://doi.org/10.1016/j.annals.2022.103409.

162 SIZE OF TOURISM SECTOR:
IBISWorld, an industry research company, put the number of Global Tourism Businesses in 2023 at 897,175, see https://www.ibisworld.com/global/number-of-businesses/global-tourism/2310/, for UNWTO membership, see https://www.unwto.org/member-states

163 TOURISM SECTOR COMMITMENTS:
The data from this table are from the One Planet website for the Glasgow Declaration (https://www.oneplanetnetwork.org/programmes/sustainable-tourism/glasgow-declaration/signatories), the CPD (organisations that responded to some or all questions regarding climate change programmes https://www.cdp.net/en/data) and companies who pledged to the Science Based Targets initiative (including non validated businesses https://sciencebasedtargets.org/companies-taking-action).

For a critical review of declarations, see Scott, D., & Gössling, S. (2021). From Djerba to Glasgow: have declarations on tourism and climate change brought us any closer to meaningful climate action? Journal of Sustainable Tourism, 30(1), 199-222.

164 UNFCCC DATABSES FOR NDC AND NAP SUBMISSIONS:
The data for NDC and NAP documents were retrieved from online databases. The Climate Watch (2022) NDC data base was used to search all submitted NDCs for the term 'tourism'. Excluding INDCs*, 214 documents were identified. All documents were reviewed to identify those where tourism is mentioned in a meaningful way. These were defined as documents identifying tourism as a priority sector for climate action, mitigation or adaptation, and those addressing tourism and climate change materiality, i.e. containing an objective, action and/or measure mentioning tourism (see also Becken et al., 2020). This excluded NDCs where tourism was mentioned simply as an important economic sector (without reference to climate change specifically), as part of a name of an agency, or in the section of consulted stakeholders. In total, 69 NDCs met the criteria.

To cross reference tourism focused NDCs with all submitted documents, a list of all submitted NDCs up to the end of December 2022 was downloaded from the UNFCCC NDC Registry (https://unfccc.int/NDCREG). This list contained 392 documents. Cross referencing both lists, those addressing tourism and climate change were highlighted. Note: INDCs were excluded, as these were often the same as the first NDC, and because they were not included in the UNFCCC NDC data base.

For the adaptation plans, the UNFCCC's NAP Central database was reviewed (https://napcentral.org/submitted-naps), which contains NAPs submitted by developing countries. All NAPS submitted to the UNFCCC by the end of 2022 were reviewed to identify those addressing tourism in a meaningful way (see above). Out of the 44 submitted NAPS, 19 met the criteria.

165 BENEFITS OF MEASUREMENT:
Crabolu, G., Font, X., & Miller, G. (2023). The Hidden Power of Sustainable Tourism Indicator Schemes: Have We Been Measuring Their Effectiveness All Wrong?. Journal of Travel Research, 00472875231195736.

166 ANALYSIS OF NDCs AND NAPs:
Addressing tourism in a 'significant' way means that the plan includes tourism in specific objectives, actions, or indicators, or identifies tourism as a priority sector for climate action. The countries with direct GDP from tourism higher than 5% were identified by using 2018 data from WTTC, crosschecked with GDP data provided by the UNWTO through their SDG reporting. Source: https://www.unwto.org/tourism-statistics/economic-contribution-SDG.

The 64 countries are (in order of tourism economic contribution): Macau, Maldives, Aruba, Seychelles, UK Virgin Islands, Former Netherland Antilles, US Virgin Islands, Samoa, Bahamas, Grenada, St Kitts and Nevis, Cape Verde, Vanuatu, Belize, St Lucia, Cambodia, Fiji, St Vincent and the Grenadines, Anguilla, Sao Tome and Principe, Philippines, Antigua and Barbuda, Barbados, Croatia, Dominica, Jamaica, Montenegro, Georgia, Thailand, Uruguay, Iceland, Albania, Greece, Morocco, Gambia, Cayman Islands, Tunisia, Mexico, Kiribati, Austria, Mauritius, Tonga, Portugal, Lesotho, Lebanon, Cyprus, Rwanda, Egypt, Bermuda, Viet Nam, Bahrain, New Zealand, Panama, Sri Lanka, Malta, Italy, United Arab Emirates, Spain, Dominican Republic, Honduras, Nicaragua, Syria, Jordan, Costa Rica.

It is worth noting that not all 64 countries are developing countries and there is a possibility that some countries have NAPs (or similar national plans) that integrate tourism but are not part of the UNFCCC NAP process/database.

167 LEGAL ANALYSIS:
Transport & Environment (2021). Don't sink Paris: Legal basis for inclusion of aviation and shipping emissions in Paris targets. Briefing paper. https://www.transportenvironment.org/wp-content/uploads/2021/10/Briefing-paper-NDCs-legal-advice-Aviation-Shipping-Final-2021-2.pdf

168 SHARE OF AVIATION EMISSION:
Analysis of country contributions to international air travel emissions based on aviation bunker fuels is available from: Gössling, S., & Humpe, A. (2020). The global scale, distribution and growth of aviation: Implications for climate change. Global Environmental Change, 65, 102194

169 CLIMATE POLICIES:
The examples here come from the Climate Policy Database, which is a collaborative effort to track policy adoption and identify global and national policy coverage gaps (https://climatepolicydatabase.org). The database is maintained by the NewClimate Institute; it covers national mitigation-related policies and is updated periodically. To find tourism samples, we applied a keyword search (the following yielded results): aviation, ferry, airport, public transport, hotel, travel, tourism, rail.
For the ReFuelEU initiatives, see https://www.consilium.europa.eu/fr/press/press-releases/2023/10/09/refueleu-aviation-initiative-council-adopts-new-law-to-decarbonise-the-aviation-sector/

170 The UNWTO report "Climate Action in the Tourism Sector – An overview of methodologies and tools to measure greenhouse gas emissions" released in March 2023 is available here: https://www.e-unwto.org/doi/10.18111/9789284423927 (accessed 04/08/23)

171 TOURISM STRATEGIES IN EUROPE:
Data presented here are from earlier research that was updated in 2023. The update is not formally published yet, but the initial approach is documented in: Conefrey, A. & Hanrahan, J. (2022a). Comparative analysis of national tourism decarbonisation plans. European Journal of Tourism Research, 31, 3105. https://doi.org/10.54055/ejtr.v31i.1979

172 IMPACT TOURISM:
for more information on this case study, see: https://unfccc.int/climate-action/momentum-for-change/financing-for-climate-

friendly-investment/global-himalayan-expedition and https://www.ghe.co.in/

173 GOVERNMENT INVESTMENT IN TOURISM:
Data stem from the WTTC 2019 economic impact assessment. Total Government spending is made up of two components: Government 'individual' spending on Travel & Tourism services directly linked to visitors, such as cultural (e.g. museums) or recreational (e.g. national parks). Government 'collective' spending supports wider Travel & Tourism activity tourism marketing and promotion, aviation, administration, security services, resort area security services, resort area sanitation services, etc. The individual component makes up 17.4% of Total Government spending globally. Thus, the majority of government spendings is 'collective'.

174 INVESTING IN TOURISM CLIMATE ACTION:
For more on the environmental levy in Fiji, see Fiji Revenue and Customs Service. (2019). Environment Climate Adaptation Levy (ECAL). https://www.frcs.org.fj/our-services/taxation/business/environmental-levy/.

For more on the South African example, consult the website of the South African Department of Tourism at www.tourism.gov.za, and Becken, S. & Scott, D. (2022). Promoting a Green Tourism Recovery. Chapter 3. OECD Tourism Trends and Policies 2022. https://www.oecd.org/cfe/tourism/oecd-tourism-trends-and-policies-20767773.html

175 AIRPORT PROJECTS:
A dataset on airport construction projects (new and extensions) was purchased from GlobalData. Projects >$25 million are included and the timeframe covers those 'up to and including execution' including those in the pipeline 2023 to 2026. A total of 134 countries are covered.

176 RAILWAY MARKET:
Data on the size of the market are available for purchase, and further analysis would be beneficial to fully explore tourism decarbonisation potential. An indication can be obtained from reports such as:
- Globe Newswire (2023). Global rail infrastructure market expected to reach USD 83.81 billion by 2032. https://www.globenewswire.com/en/news-release/2023/04/03/2639789/0/en/Global-Rail-Infrastructure-Market-Expected-to-Reach-USD-83-81-Billion-by-2032-Locomotive-Trains-Expected-to-Dominate-Market-with-Strong-Inflow-of-Government-Investments.html.
- Maximize Market Research (2023). Rail infrastructure market: Global industry analysis and forecast 2023-2029. https://www.maximizemarketresearch.com/market-report/global-rail-infrastructure-market/118017/.

177 FOSSIL FUELS:
Fossil Fuel Subsidies tracker, see www.fossilfuelsubsidytracker.org

Global Data estimated from OECD, IEA and IMF data. Note IEA fossil fuel subsidies database suggests 4,543 US$ million all countries for 2021. Methodology: https://www.iea.org/topics/energy-subsidies

178 IMPLICIT FUEL SUBSIDIES:
IMF Fuel Subsidy Template 2022. Subsidies are disaggregated into explicit and implicit subsidies, where explicit reflect subsidies due to supply costs being greater than the retail prices, whereas implicit reflect subsidies due to the efficient price being greater than the retail price, exclusive of any explicit subsidy. Combined total 2021 implicit and explicit subsidies (US% billions), for all fossil fuels. https://www.imf.org/-/media/Files/Topics/Environment/energy-subsidies/fuel-subsidies-template-2022.ashx

179 IMPLICIT FUEL SUBSIDIES:
IMF Fuel Subsidy Template 2022. Subsidies are disaggregated into explicit and implicit subsidies, where explicit reflect subsidies due to supply costs being greater than the retail prices, whereas implicit reflect subsidies due to the efficient price being greater than the retail price, exclusive of any explicit subsidy. Combined total 2021 implicit and explicit subsidies (US% billions), for all fossil fuels. https://www.imf.org/-/media/Files/Topics/Environment/energy-subsidies/fuel-subsidies-template-2022.ashx

180 AVIATION SUBSIDIES:
Gössling, S., Fichert, F. & Forsyth, P. (2017). Subsidies in Aviation. Sustainability, 9, 1295. https://doi.org/10.3390/su9081295.

181 FOSSIL FUEL SUBSIDIES:
IMF. (2022). Fuel Subsidies Template. https://www.imf.org/-/media/Files/Topics/Environment/energy-subsidies/fuel-subsidies-template-2022.ashx.

182 GLOBAL STOCKTAKE:
UNFCCC Secretariat. (2023). Technical dialogue of the first global stocktake. Synthesis report by the co-facilitators of the technical dialogue. https://unfccc.int/documents/631600.

183 TOURISM SUPPORTING LEAST DEVELOPED COUNTRIES:
UNWTO press release: https://www.unwto.org/news/un-conference-on-least-developed-countries (accessed 21/07/2023)

184 DEVELOPMENT AID FLOWS:
Data were extracted from the d-portal dataset, an open-source platform available at https://d-portal.org/ctrack.html#view=search. The platform provides stakeholders in developing countries with information that can help them plan and monitor development activities. It contains current data published to the International Aid Transparency Initiative (IATI) as well as the most recent year's data available on the OECD DAC Creditor Reporting System.

To identify relevant projects that funded tourism activities, several filtering steps were undertaken. First, 'Tourism' was selected under 'Sector Group' to identify 1 733 ended and active projects. Next, entries without an end date were deleted from the active list (repeated in subsequent steps for active projects; some are just in scoping phase). 'Tourism, Policy and Administrative Management' was selected under 'Sector', which revealed 1 688 projects. The project titles and descriptions were sifted through manually to separate tourism projects from other policy/management projects. In addition, the search terms 'climate' and 'tourism' were used to extract 446 ended and active projects. As a final step, the different spreadsheets were combined, and duplicates and irrelevant entries removed (e.g. auditing projects). The objective was to create a distinct tourism subcomponent. Projects were coded into categories for thematic analysis. Funds refer to 'spent' funds, not committed funds. Year refers to 'year ended' of project.

185 NATURE BASED SOLUTIONS:
More detail on ecosystem services and restoration activities is provided in Chapter 3 of the OECD Tourism Policies and Trends publication from 2022, see Becken, S. & Scott, D. (2022). Promoting a Green Tourism Recovery. Chapter 3. OECD Tourism Trends and ¬Policies 2022. https://www.oecd.org/cfe/tourism/oecd-tourism-trends-and-policies-20767773.htm

See also Padma, P., Ramakrishna, S., & Rasoolimanesh, S. M. (2022). Nature-based solutions in tourism: A review of the literature and conceptualization. Journal of Hospitality & Tourism Research, 46(3), 442-466.

186 SEYCHELLES:
For more on debt-for-nature swaps and blue bonds, see Pouponneau, A. (2023). Applicability of innovative finance for addressing loss and damage. https://unfccc.int/sites/default/files/resource/1_TC_Lessons%20from%20the%20Seychelles.pdf. For more on projects, see SeyCCAT. (2023). On-going SeyCCAT partnerships and projects. https://seyccat.org/projects/#database.

187 MEDIA ANALYSIS OF CLIMATE CHANGE AND TOURISM COVERAGE:
The analysis involved an advanced search in Nexis Uni (formerly LexisNexis) for global English-language news documents from

1975-2022. For example:

CC + T: hlead(recreation* or touris* or leisure* or holiday*)/5 and hlead(climat* change or global warming)

Note that all variations of a word are captured (e.g., tourism, tourist, tourists; climate, climatic) /5 = search terms must be within 5 words of each other (increasing relevancy).

Readers are referred to this paper for details on the method: Wright, K-A., Rutty, M. & Scott, D. (2023). News coverage of hurricane events and Caribbean tourism: A critical analysis of the last 40 years. Current Issues in Tourism, 1-18.

188 TRAVELLER DEMAND FOR SUSTAINABLE PRODUCTS:
Several large travel companies undertake regular consumer surveys to gauge trends of behaviour more broadly, and sustainability attitudes specifically. Unfortunately, despite multiple years of surveying (e.g. Booking.com), survey findings are presented slightly differently over the years. For those reasons it is not possible to present a clear trend for this metric at this point. For the original sources cited here, see:

- Booking.com (2023). Sustainable Travel Report. file:///C:/Users/sc0037/OneDrive%20-%20University%20of%20Surrey/Desktop/Cost%20vs%20Conscience_%20Booking.com%20Delves%20into%20the%20Dilemma%20Dividing%20Sustainable%20Travel%20in%202023.html, 8/11/23
- Expedia Group (2022). Sustainable Travel Study. https://go2.advertising.expedia.com/sustainability-study-2022, 8/11/23

189 BEHAVIOUR CHANGE:
for the impact of pledges, see Albrecht, J.N. & Raymond, E.M. (2022). National destination pledges as innovative visitor management tools – social marketing for behaviour change in tourism. Journal of Sustainable Tourism, DOI: 10.1080/09669582.2022.2037620 https://www.tandfonline.com/doi/abs/10.1080/09669582.2022.2037620

190 ATTITUDE-ACTION GAP:
The synopsis presented here draws on the following references:
- Cohen, S.A., Higham, J., & Reis, A. (2013). Sociological barriers to sustainable discretionary air travel behaviour. Journal of Sustainable Tourism, 21(7), 982-998.
- Georgiadis, P. (2023). 'We are full': the rebirth of Europe's sleeper trains. Accessed at https://www.ft.com/content/c9d92684-8c0a-480c-9b95-d568551fc42d.
- Park, H.J. & Lin, L.M. (2020). Exploring attitude-behavior gap in sustainable consumption: comparison of recycled and upcycled fashion products. Journal of Business Research, 117, 623-628.

191 CHILE:
Environment Ministry, Tourism Undersecretariat & National Tourism Service. (2019). Plan de Adaptación al Cambio Climático en el Sector Turismo. (2019). https://www.subturismo.gob.cl/wp-content/uploads/2023/02/plan-de-adaptacion-al-cambio-climatico-sector-turismo-2020-2024.pdf.

192 INDIGENOUS KNOWLEDGE:
For Māori, the indigenous people of New Zealand, mana refers to a supernatural force or power held by a person, place, or object.

193 CLIMATE CHANGE IN TOURISM CURRICULA:
The analysis was undertaken by Prof Harald Friedl and Dr Jonathon Day. In July 2023, educational databases such as masterstudies.com, bachelorstudies.com, educations.com, University Directory Worldwide, findamasters.com, bachelorsportal.com and additionally google.com were searched for academic curricula with a focus on sustainability using the search terms "tourism AND sustainable OR climate OR environment OR green" OR "ecotourism", each in English and German. The underlying assumption was that tourism education with this focus is far more likely to integrate aspects of climate change into the curriculum than traditional tourism curricula. The relevant hits were examined for mentions of the term "climate" in combination with "change", "warming" or "crisis" and broken down according to the intensity of their treatment in the respective curriculum. The results are limited by the exclusion of other tourism-related studies. The study itself also differentiated the results according to the categories type of study (Bachelor, Master, MSc etc.), study formats (off-line as well as on-line), duration of study in semesters or in ECTS, and amount of tuition fees. The survey was conducted by Leah-Isabell Heuer, BA.

For additional background, see Mínguez, C., Martínez-Hernández, C., & Yubero, C. (2021). Higher education and the sustainable tourism pedagogy: Are tourism students ready to lead change in the post pandemic era? The journal of hospitality, leisure, sport & tourism education, 29, 100329. https://doi.org/10.1016/j.jhlste.2021.100329

194 HOSPTIALITY TRAINING: HOSPITALITY TRAINING:
For more on sustainability in tourism food production, see Gössling, S. & Hall, C.M. (2022). The sustainable chef: The environment in culinary arts, restaurants, and hospitality. Routledge.

195 DEVELOPMENT OF SCIENTIFIC LITERATURE ON CLIMATE CHANGE AND TOURISM:
For a comprehensive review of climate change and tourism literature up to 2020, see Scott, D. & Gössling, S. (2022). A review of research into tourism and climate change: Launching the Annals of Tourism Research curated collection on tourism and climate change. Annals of Tourism Research, 95, 103409.

196 AVAILABILITY OF SCIENTIFIC INFORMATION AND KNOWLEDGE:
Loehr, J. & Becken, S. (2021). The tourism climate change knowledge system. Annals of Tourism Research, 86, 103073.

197 DEVELOPMENT OF SCIENTIFIC LITERATURE ON CLIMATE CHANGE AND TOURISM:
For a comprehensive review of climate change and tourism literature up to 2020, see Scott, D. & Gössling, S. (2022). A review of research into tourism and climate change: Launching the Annals of Tourism Research curated collection on tourism and climate change. Annals of Tourism Research, 95, 103409.

198 BUILDING CLIMATE CHANGE CAPACITY IN THE TOURISM ACADEMY:
Discussion of the limited climate change expertise in higher education tourism programs and the implications for training the next generation of tourism professionals is available from:
- Scott, D. (2021). Sustainable Tourism and the Grand Challenge of Climate Change. Sustainability.13(4), doi:10.3390/su13041966
- Scott, D., & Gössling, S. (2022). A review of research into tourism and climate change-Launching the annals of tourism research curated collection on tourism and climate change. Annals of Tourism Research, 95, 103409.

199 NON-ENGLIGH RESEARCH:
Navarro-Drazich, Diego (2020). Climate Change and Tourism in Latin America, in: Cristian Lorenzo (ed.), Latin America in Times of Global Environmental Change, Springer, 93-105. ISBN 2366-3421 · 2366-343X · 978-3-030-24253-4 · 978-3-030-24254-1 · doi.org/10.1007/978-3-030-24254-1

200 Tourism Panel on Climate Change (2022).
Foundation Framework. https://tpcc.info/