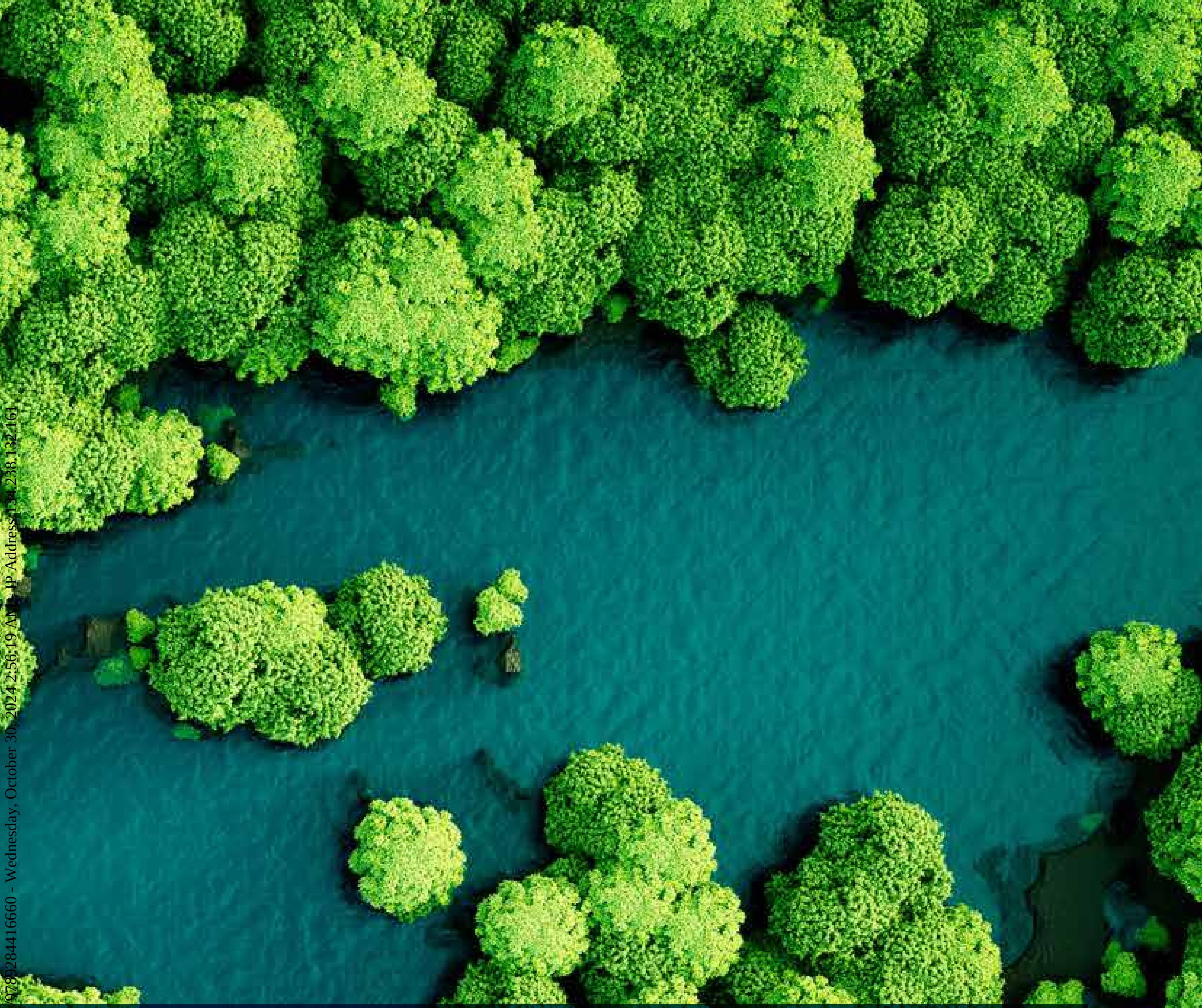

Transport-related CO_2 Emissions of the Tourism Sector

Modelling Results

UNWTO
World Tourism Organization

International Transport Forum

Transport-related CO_2 Emissions of the Tourism Sector

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At UNWTO, the preparation of this report was supervised by Dr. Dirk Glaesser, Director of Sustainable Development of Tourism, with lead contributions for the review of technical content from Virginia Fernández-Trapa, Marianna Stori and Birka Valentin. Sofía Gutiérrez coordinated several phases of the project and Lorna Hartantyo provided additional support; Julia Baunemann supported data collection and analysis. Comments on the overall draft were provided by Sandra Carvão and Javier Ruescas from the Tourism Market Intelligence and Competitiveness Department. The proofreading was carried out by Natalia Diaz.

Within ITF, the report was prepared under the supervision of Dr. Jari Kauppila, Head of Quantitative Policy Analysis and Foresight. The data modelling and drafting for the study has been led by Dimitris Papaioannou, with support from Elisabeth Windisch and building on previous work from Vincent Benezech.

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Foreword

by Mr. Zurab Pololikashvili

Secretary-General, World Tourism Organization (UNWTO)

Tourism has grown continuously over the past few decades and now represents 10% of global employment and 10% of global gross domestic product (GDP). With the number of domestic and international arrivals forecast to reach 15.6 billion and 1.8 billion by 2030 respectively, tourism is expected to continue generating significant benefits in terms of both socioeconomic development and job creation worldwide.

At the same time, this will have an environmental impact and one of the main challenges facing the tourism sector today is the need to decouple its projected growth from the use of resources and greenhouse gas (GHG) emissions.

In 2015, the international community defined a common vision for people, planet and prosperity through the adoption of the 2030 Agenda, which represented a landmark agreement to address climate change. By adopting the Paris Agreement, countries have committed to hold global average temperature increase well below 2 °C above pre-industrial levels, and to pursue efforts to limit the temperature increase even further to 1.5 °C.

Tourism is under significant threat from the effects of climate change, especially from extreme weather events that can lead to increasing insurance costs and safety concerns, as well as from water shortages, the loss of biodiversity and damage to assets and attractions at destinations. Continued climate-driven degradation and disruption to cultural and natural heritage will also negatively affect the tourism sector, harm the attractiveness of destinations and reduce economic opportunities for local communities.

As demonstrated by the UN Climate Action Summit held in September 2019, an ever-growing movement of the younger generation is demanding that global leaders take urgent climate action. Moreover, a growing number of actors, from governments to civil society organizations, as well as private businesses at the local, national and global level are engaging in discussions and committing to mitigating and adapting to the effects of climate change, first by 2030 and then by 2050.

I believe the tourism sector, with its diverse and cross-cutting nature, has the potential and responsibility to be a leading force in this movement.

In 2008, the first detailed assessment ever made of CO_2 emissions from tourism-related activities was carried out by UNWTO, the United Nations Environment Programme (UN Environment) and the World Meteorological Organization (WMO). The present report on *Transport-related CO_2 Emissions of the Tourism Sector – Modelling Results* by UNWTO and the International Transport Forum (ITF) has been prepared to update the estimate of the largest component of tourism GHG emissions, which are transport-related emissions. The report is a stepping stone towards a consultative process with Member States for the participatory formulation of actionable policy recommendations.

I trust that the valuable information, insights and analysis contained in this publication will improve the understanding of the role of different modes of transport in tourism and their CO_2 implications, and support national and subnational authorities and the private sector as they accelerate progress towards evidence-based low carbon tourism development.

Foreword

by Dr. Young Tae Kim

Secretary-General, International Transport Forum (ITF)

Tourism is an important driver of socioeconomic growth both in the developed and developing world. It generates over 10% of the global GDP and contributes to the creation of one in ten new jobs.

Transport connectivity is an important prerequisite for tourism. The benefits of better transport links often spill over to local communities, making goods, services and jobs more accessible.

Yet tourists also put a strain on resources and the transport network. Three quarters of CO_2 emissions from tourism are transport-related. Emissions from transporting tourists have grown steadily over the past decades, reaching almost 1,600 million tonnes of CO_2 in 2016, amounting to 5% of all energy-related CO_2 emissions.

Efficiency improvements have reduced emissions per passenger, but the growth in the number of tourists outweighs these improvements. The negative impacts of tourism increasingly concern governments around the world and many are striving to reduce tourism's carbon footprint. The decarbonisation of the transport sector will have to be an important part of the solution.

This report highlights the need for systematic data collection and analysis to support evidence-based decision making for the effective reduction of tourism's transport emissions. It also sheds light on future transport infrastructure needs resulting from tourism.

Tourism will only continue to deliver prosperity and well-being without threatening our climate and environment if governments take action now to steer it in the right direction. This report, a collaboration of ITF and UNWTO, makes the case that actions to reform transport policy are at the core of delivering that goal.

Chapter 1

Introduction

1.1 Climate change, tourism and transport

In 2015, the international community adopted the Paris Agreement with the objective to limit global temperature increase in this century to well below 2 °C compared to preindustrial levels, and given the serious risks, to strive for 1.5 °C. The Paris Agreement marked a historic turning point for global climate action connected to the urgent need to decouple economic growth from resource use and emissions in order to counteract the impacts of climate change. Moreover, climate action is included in the 2030 Agenda for Sustainable Development as a stand-alone Sustainable Development Goal (SDG), SDG 13, which provides a roadmap to reduce emissions and build climate resilience.

Affordable air travel, increased connectivity, new technological advances, new business models and greater visa facilitation around the world have fostered continuous growth of international and domestic tourism in the past decades. International tourist arrivals increased from 770 million in 2005 to 1.2 billion in 2016 and are forecast to reach 1.8 billion in 2030. Domestic tourist arrivals doubled from 4 billion in 2005 to 8 billion in 2016 and are projected to reach 15.6 billion in 2030. Today, tourism is one of the most important economic sectors driving growth and development. It represents 10% of global GDP and 10% of global employment and is forecast to continue growing steadily. While this evolution offers vast opportunities, it also comes with great responsibilities, notably with regards to environmental impacts and climate change.

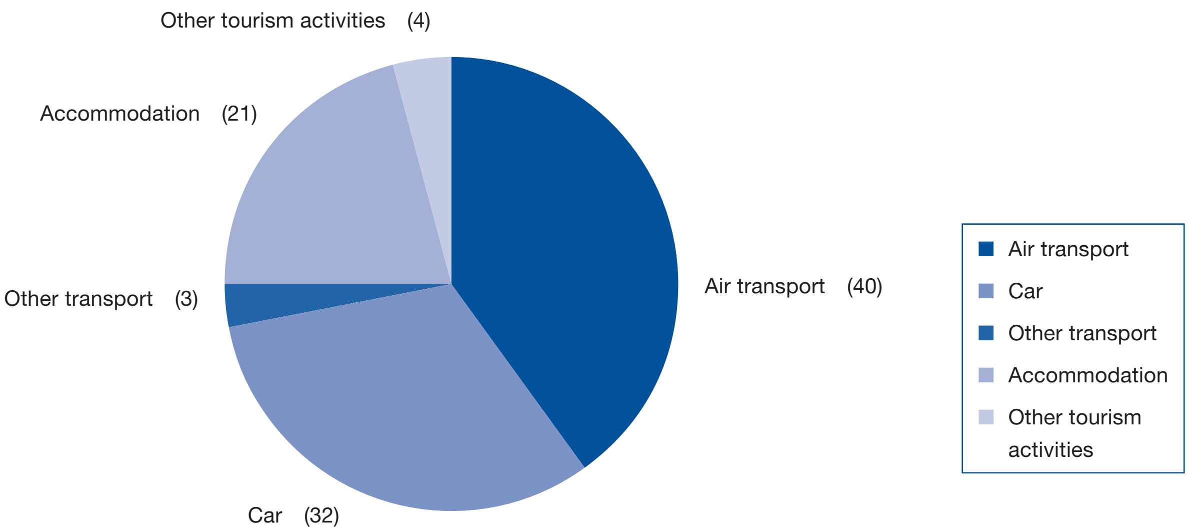
Alongside its impacts, tourism is also highly vulnerable to climate change. Threats for the sector are diverse, including direct and indirect impacts such as more extreme weather events, increasing insurance costs and safety concerns, water shortages, biodiversity loss and damage to assets and attractions at destinations, among others. As natural and cultural resources are the foundation for the tourism sector's competitiveness, continued climate-driven degradation and disruption to cultural and natural heritage are expected to negatively affect the tourism sector, reducing the attractiveness of destinations and lessening economic opportunities for local communities. Destinations such as small island developing states (SIDS) are among the most vulnerable.

At the same time, the tourism sector contributes to climate change. A first global assessment of the emissions from global tourism was commissioned within the framework of the Second International Conference on Climate Change and Tourism which took place in Switzerland in 2007. This gathering resulted in the adoption of the *Davos Declaration on Climate Change and Tourism Responding to Global Challenges*[1] acknowledging the urgency for the tourism sector to respond to climate change. According to the 2008 publication from UNWTO and UN Environment entitled

1 World Tourism Organization (2019a), 'Davos Declaration "Climate Change and Tourism: Responding to Global Challenges"', *Compilation of UNWTO Declarations, 1980 – 2018,* UNWTO, Madrid, DOI: https://doi.org/10.18111/9789284419326.

Climate Change and Tourism – Responding to Global Challenges, the tourism sector contributed approximately 5% of all man-made CO_2 emissions in 2005, with transport representing the largest component, i.e., 75% of the overall emissions of the sector (see figure 1.1).[2]

Figure 1.1 **Contribution of various sub-sectors to tourism CO_2 emissions, 2005 (%)**



Source: World Tourism Organization and United Nations Environment Programme (2008).

Since then, a variety of actions have been undertaken by tourism stakeholders worldwide but there is still limited public information on CO_2 emissions by tourism businesses and destinations[3] and the integration of climate strategies in tourism policies is low.[4] Therefore, furthering the engagement of the tourism sector in the adoption, implementation and monitoring of adaptation and mitigation measures and strategies has become essential to support addressing global warming and ensure the long-term sustainability of the sector.

1.2 About this report

With the objective of accelerating progress towards low carbon tourism development and the contribution of the sector to international climate goals, UNWTO and ITF joined efforts to:

– Advance the limited evidence available with regards to CO_2 emissions from tourism. Starting by generating an updated estimate of transport-related CO_2 emissions of the tourism sector as transport is the main sub-sector contributing to tourism's global emissions;

2 World Tourism Organization and United Nations Environment Programme (2008), *Climate Change and Tourism – Responding to Global Challenges,* UNWTO, Madrid, DOI: https://doi.org/10.18111/ 9789284412341.

3 Bobes, L. and Becken, S. (2016), *Proving the Case: Carbon Reporting in Travel and Tourism* (online), available at: https://amadeus.com/en/insights/research-report/proving-the-case-carbon-reporting-in-travel-and-tourism (11-11-2019).

4 World Tourism Organization and United Nations Environment Programme (2019), *Baseline Report on the Integration of Sustainable Consumption and Production Patterns into Tourism Policies,* UNWTO, Madrid, DOI: https://doi.org/10.18111/9789284420605.

– Improve the understanding of the role of the different modes of transport for tourism and their CO_2 implications. Especially by modelling against a *current ambition scenario,* which reflects the existing mitigation policies and announced mitigation commitments in the transport sector; and
– Set the basis to scale up climate action and ambition in the tourism sector through a consultative process with UNWTO Member States and the private sector in 2020 which will develop actionable policy recommendations to transform tourism development and operations.

For this study, the data structure of the model used in *Climate Change and Tourism – Responding to Global Challenges* has been taken into account and extended. As it was the case in the 2008 publication, in the present study all assumptions and estimates are therefore made only for CO_2 emissions. Yet, it must be acknowledged that in addition to CO_2, other GHG contribute to anthropogenic climate change[5] with the release of other GHG being particularly relevant for the emissions from aviation.[6] Air travel contributes to climate change through the emissions of CO_2, nitrogen oxides (NO_x), sulphur dioxide (SO_2), aerosols and their precursors (soot and sulphate) and water vapour.

1.3 Methodological note

This methodological note describes the main concepts, steps and assumptions taken to estimate current and future tourism demand, the share of different modes of transport and related CO_2 emissions, both for international and domestic tourism. As tourism always implies the movement of people to destinations for different purposes, the tourism sector is inherently connected to transport, notably with passenger transport services. The connection between transport and tourism is especially strong with regards to non-urban transport (transport outside of urban areas), as tourism always implies movement outside the usual environment of travellers. Keeping this context in mind, the following steps were taken in the modelling process:

First step: Analysing tourism-related transport demand

To be able to assess current and future tourism emissions generated from transport, tourism-related transport demand was analysed as a basis for further calculations. For this purpose, ITF in collaboration with UNWTO developed two tourism demand models:

1. One tourism demand model for international tourism; and
2. One tourism demand model for domestic tourism.

5 Sims, R. et al. (2014), 'Transport', in: Edenhofer, O. et al. (eds.), *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change,* Cambridge University Press, Cambridge and New York (online), available at: www.ipcc.ch/site/assets/uploads/2018/02/ipcc_wg3_ar5_chapter8.pdf (06-09-2019).

6 World Tourism Organization and United Nations Environment Programme (2008).

Overall, for both models, multiple data sources were used, including arrivals data from UNWTO and OECD, population data from the UN Department of Economic and Social Affairs[7] (UN DESA) and data on GDP growth from OECD[8]. These models are based on 2016 data as this was the most populated dataset available year when the study was initiated. The estimates refer to overnight stays only (i.e., international and domestic tourist arrivals) and therefore do not encompass same-day visitors.[9] Since persons arriving by cruise are accounted as same-day visitors,[10] they have not been integrated in the demand models. Nevertheless, further references to same-day visitors, as well as references to cruise tourism and its implications on tourism demand are discussed later in the study.

The data and modelling approach used for the demand model for international tourism (see annex 1) formed the basis of future projections as it allowed estimating tourism flows between countries by 2030. For the exercise, international tourism was divided into intraregional and interregional tourism: intraregional tourism referring to tourist movements from one country to another within the same region and interregional tourism referring to tourist movements from one country to another country in another region.

Overall, the model for international tourism uses socioeconomic indicators such as population and income to predict demand. The distance between countries is another variable that affects tourism demand. At the country of origin, population is considered to reflect the propensity to travel, i.e., the number of trips generated by that country. As disposable income has long been considered one of the driving factors of tourism demand,[11] each country's GDP per capita is used as the income variable for that country. Distance between countries works as a negative factor, as the model assumes it reduces the propensity to travel. In an effort to more accurately predict international travel within one region, an additional coefficient was identified through the calibration procedure. Coefficients related to the population at origin and at destination were also identified. The main assumption underlying the model is that model coefficients (defining the magnitude of impact that input variables, such as income or population, have on travel demand) will remain the same over the study period (2016–2030). As tourism origin and destination data are not available on a country-pair level for all countries (but destination data is available at subregional level and origin data is available at regional level), the model was calibrated on a region-pair (supra-national) level. The results of the model for international tourism were compared with UNWTO's forecast *Tourism Towards 2030 – Global Overview,*[12] (see section 2.1. for further details).

The data and modelling approach used for the domestic tourism model (see annex 2) is based on two main data sources, UNWTO and OECD, which combined provided data series covering

7 United Nations Department of Economic and Social Affairs and The World Bank (2017), *World Population Prospects: Key Findings & Advanced Tables,* UN, New York (online) available at: https://population.un.org/wpp/Publications/Files/WPP2017_KeyFindings.pdf (06-09-2019).

8 Organisation for Economic Co-operation and Development (2018), *OECD Economic Outlook,* Volume 2018, Issue 1, OECD Publishing, Paris, DOI: https://doi.org/10.1787/eco_outlook-v2018-1-en.

9 Key Definitions and Terms can be found on page 61.

10 World Tourism Organization (2017), *UNWTO World Tourism Barometer,* Volume 15, UNWTO, Madrid, DOI: https://doi.org/10.18111/wtobarometereng.

11 Lim, C. (1997), 'Review of international tourism demand models', *Annals of tourism research,* Volume 24, Issue 4, pp. 835–849, DOI: https://doi.org/10.1016/S0160-7383(97)00049-2.

12 World Tourism Organization (2011), *Tourism Towards 2030 – Global Overview,* UNWTO, Madrid, DOI: https://doi.org/10.18111/9789284414024.

multiple years for a total of 70 countries. These two datasets were used to estimate domestic tourist arrivals data for the rest of countries and to form the basis of future projections. The estimations followed an approach in line with that used for the international tourism demand model. The annual number of domestic arrivals was calculated according to two main factors: the average income and the number of destinations within a country. Population is used as a proxy for destinations or attractions available in that country, as activities in general are connected with the presence of people.[13] There is a strong positive relation between income and the propensity to travel from the available data.[14] Nevertheless, data of observed domestic tourism show that the amount of tourism may increase even if the income remains at similar levels. An additional factor that complicates the modelling and forecasting exercise is that different income groups within the same country travel with different frequency to different destinations. However, the underlying input data provides average income levels per country only. It was therefore decided to group countries into three income categories and define respective tourism development pathways, reflecting that tourism increases with rising income for these country groups. Countries within these groups are not further distinguished (i.e., the same coefficient that defines the impact of income development on tourism growth is applied to all countries within the same group).[15]

Second step: Analysing the choice of modes of transport for tourism

Having created the basis for further modelling, the next step was to analyse how tourists reach the destinations. This analysis was done based on the non-urban passenger transport model developed by ITF in 2019 (see annex 3). The model is used to estimate all non-urban travel demand, the respective mode of transport shares and the related emissions for the entire world, covering the modes car, bus, rail and air. This model estimates both international inter-city flows, as well as subnational (regional) flows and is used to compute current and future mode of transport choices and travel distances for both domestic and international tourism.[16]

The ITF's non-urban passenger transport model encompasses two different scenarios, the *current ambition scenario and the high ambition scenario.*[17] The *current ambition scenario* extrapolates the *current* trajectory of technologies and policies in a business-as-usual approach. Technological advances, policy decisions and investments occur as foreseen today according to existing

13 As such, the more people living in a place, the higher the likelihood for more destinations. The alternative option for destinations would be the size of the country in km^2. However, empty areas are far less likely to be a tourism destination than populated areas. Therefore the number of inhabitants of a country serves as a better proxy and also builds on.

14 Organisation for Economic Co-operation and Development (2017a), 'Mobility in cities', *ITF Transport Outlook 2017,* OECD Publishing, Paris, DOI: https://doi.org/10.1787/9789282108000-8-en.

Organisation for Economic Co-operation and Development (2017b), *Linking People and Places. New ways of understanding spatial access in cities,* ITF, Corporate Partnership Board Report (online), available at: www.itf-oecd.org/linking-people-and-places (12-11-2019).

Organisation for Economic Co-operation and Development (2019), *Benchmarking Accessibility in Cities Measuring the Impact of Proximity and Transport Performance,* ITF (2019), available at: www.itf-oecd.org (06-09-2019).

15 Williams, A.M. and Shaw, G. (2009), 'Future play: tourism, recreation and land use', *Land Use Policy,* 26, pp. S326–S335, DOI: 10.1016/j.landusepol.2009.10.003.

16 The model is composed of 1,191 regions globally and it computes two factors: a) the activity within these regions (regional travel) and b) the activity between the regions (inter-city travel).

17 International Transport Forum (2019), *ITF Transport Outlook 2019,* OECD Publishing, Paris, DOI: https://doi.org/10.1787/transp_outlook-en-2019-en.

measures, as well as already-announced mitigation commitments.[18] The *high ambition scenario* reflects *more advanced* aspirations surrounding the deployment of technology and implementation of policies such as the rapid electrification of vehicles or increased carbon pricing[19] (see annex 4 for additional information on the current and high ambition scenario specifications).

For the purpose of this study, the *current ambition scenario* was used so as to set the baseline against the 2016 landscape and visualize its implications by 2030. For the estimation of air travel distances, transfer data provided by Amadeus was used, which allowed to strengthen the information within the ITF model (i.e., origin to destination distances) by capturing the distance implications of non-direct flights.

Third step: Calculating CO_2 emissions for international and domestic tourism

Knowing the number of trips done by each mode of transport and the average distance of each trip, it is possible to estimate current and future CO_2 emissions for both international and domestic tourism. To that end, carbon intensity coefficients by mode of transport and region/region pairs are used. These coefficients are obtained from ITF's non-urban model. They include inputs from the International Energy Agency's Mobility Model (IEA MoMo) for surface modes and from the International Civil Aviation Organization's (ICAO) carbon calculator for aviation. All CO_2 estimates developed are broken down by regions and subregions whenever possible.[20]

18 For instance, Open Skies policies follow current trends, while the share of seats offered by low-cost airlines remains stable. Overall aviation demand grows in line with GDP and population projections. Aircraft fuel efficiency improves and the relative cost of air travel falls over time following current trends and fuel costs. Such policies raise transport costs for all modes that rely on fossil fuels. Alternative energy sources remain too expensive to compete with fossil fuels and electric aviation only appears towards mid-century. Fuel efficiency standards are in place for car, bus and rail. Only currently planned high speed rail lines are built. The share of autonomous vehicles in non-urban travel remains marginal, while shared non-urban travel by private car see a marginal increase.

19 The carbon price for each scenario reflects a global average. In reality, the level of carbon pricing will vary between regions.

20 Regions and subregions used for this study are broken down according to UNWTO's geographical distribution of Member States.

Table 1.1 **Overview of models used for the study**

Model	Status	Main data sources	Purpose
International tourism demand model	New model created for this study by ITF and UNWTO	UNWTO, OECD, UN DESA	Estimates international tourism flows between countries using as variables the following: Population, income, distance between countries. It is based on existing international tourism data.
Domestic tourism demand model	New model created for this study by ITF and UNWTO	UNWTO, OECD	Estimates domestic tourism flows using socio-economic variables such as the income and number of destinations within a country. It is based on existing domestic tourism data.
Non-urban passenger model[a]	ITF model released early 2019	UNWTO, ITF, IEA, IATA, Amadeus	Estimates mode of transport shares for international and domestic tourism and travel distances. The model predicts international inter-city flows and subnational (regional) flows. It has two core components: – Inter-city passenger; – Regional non-urban passenger. CO_2 emissions for both components are then estimated using carbon intensity parameters by mode coming from IEA's Mobility Model (MoMo).

Notes: IATA: International Air Transport Association; IEA: International Energy Agency; ITF: International Transport Forum; OECD: Organisation for Economic Co-operation and Development; UN DESA: United Nations Department of Economic and Social Affairs; UNWTO: World Tourism Organization.

For more information on the details of the models used see annex 2: *International tourism demand model;* annex 3: *Domestic tourism demand model;* and annex 4: *Non-urban passenger model.*

a) The non-urban passenger model developed by ITF is an expanded version of the 2017 ITF International Air Model.

1.4 Same-day visitors

The models explained above cover only tourism activity for overnight stays, as complete datasets for same-day visitors are not available. In 2016, reported datasets for international same-day visitors were only identified for 109 countries. In view of the latter and taking into account that most same-day trips are by definition domestic, it was decided to build on the data used for the preparation of the *Climate Change and Tourism – Responding to Global Challenges* report. At that time, UNWTO estimated same-day visitors in 2005 at 5 billion – both domestic and international. These findings were therefore complemented with assumptions from the ITF non-urban passenger activity. In particular, international inter-city flows, subnational (regional) flows and daily trips by people living outside urban areas were the components taken into account. All in all, it was estimated that same-day trips (international and domestic) would have doubled from 2005, reaching 10 billion in 2016. The same approach was used to forecast the number of same-day trips in 2030. By that year, this number is expected to double again, reaching 20 billion trips.

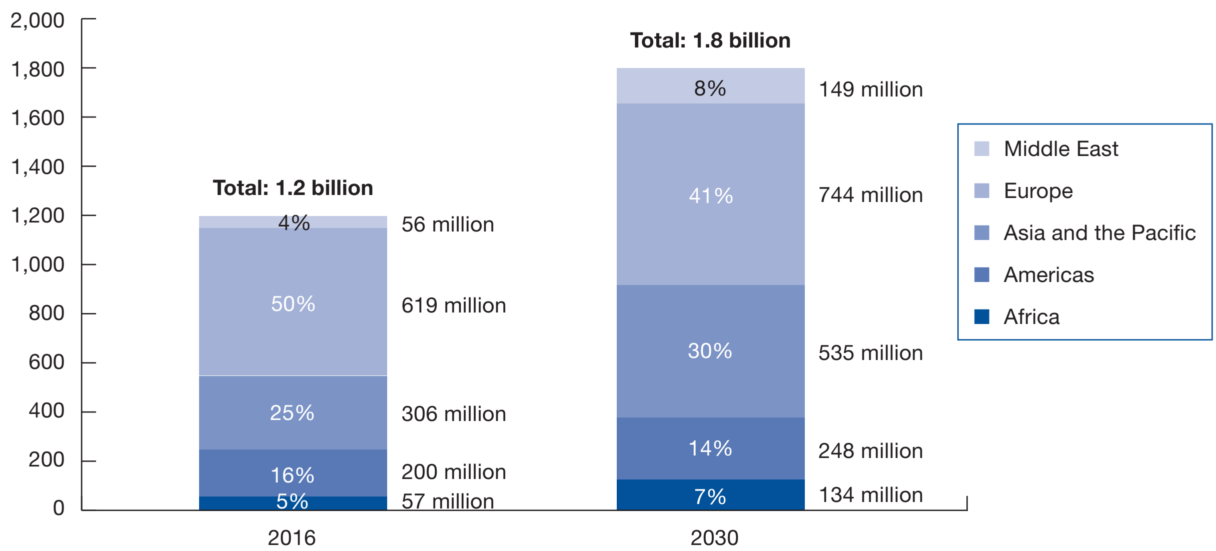
Chapter 2

Modelling tourism demand

2.1 International tourism

In 2016, the baseline year of this research, international tourist arrivals reached 1.2 billion. UNWTO's *Tourism Towards 2030 – Global Overview*[1] report updated international tourism projections from 2010 to 2030, indicating an expected growth of international tourist arrivals from 2010 to 2030 at an average of 3.3% annually. According to this forecast, international tourist arrivals would reach 1.8 billion international tourists by 2030. These estimations can be considered as conservative, taking into account that the forecast average annual growth rate of international tourist arrivals between 2010 and 2030 was predicted at 3.3% but has already been surpassed without exception every year from 2010 to 2016.

Figure 2.1 **International tourist arrivals by region, 2016 and 2030 (million, share %)**



Sources: World Tourism Organization (2011); and World Tourism Organization (2019b).

To analyse tourism emissions from transport and calculate CO_2 emissions for international tourism, a demand model for international tourism was designed with arrival data from UNWTO and OECD, as well as other data provided by OECD and UN DESA (see methodological note – step 1).

1 World Tourism Organization (2011).

The new model created for this study is aligned with the world total of 1.8 billion international tourist arrivals forecast by UNWTO for 2030 (see table 2.1).[2] Regional differences are explained by the fact that the model used for the *Tourism Towards 2030* research was applying GDP and the cost of transport as key modelling factors, while the model used for this study encompasses population, GDP and distance between countries. In the new model, GDP has been allocated a stronger influence on the propensity to travel. Moreover, distances are more accurately represented in the new model allowing for a good understanding of the behaviour of the different modes of transport. As the latter is particularly relevant given the subject of the study, the new model has been used for all projections in the study henceforth.

Table 2.1 **Comparison of UNWTO *Tourism Towards 2030* forecast of international tourist arrivals and results of the new tourism demand model used in this study**

Regions	**2030 forecast**			
	***Tourism Towards 2030* estimates**[a]		**Model for this study**[b]	
	(million)	(%)	(million)	(%)
Africa	134	7	88	5
Americas	248	14	265	15
Asia and the Pacific	535	30	439	24
Europe	744	41	941	52
Middle East	149	8	69	4
Total	**1,809**	**100**	**1,803**	**100**

Note: New tourism-related transport demand model developed for this study.

Sources: a) World Tourism Organization (2011).

b) Based on UNWTO, OECD and UN DESA data.

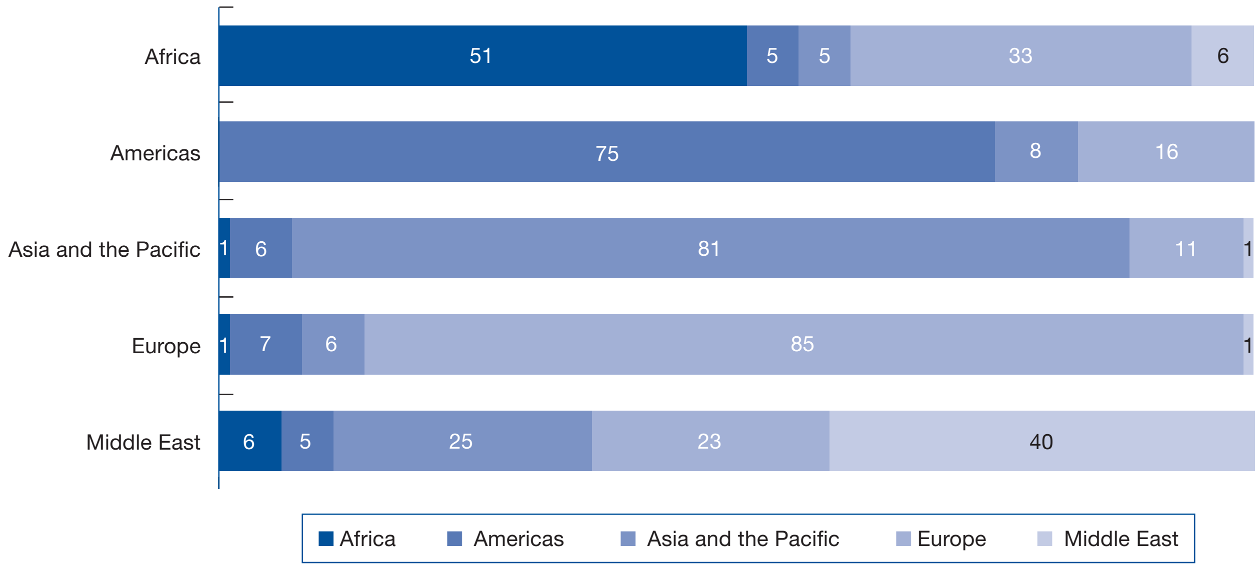
2.1.1 Intraregional and interregional travel[3]

In 2016, intraregional tourist arrivals represented 79% of all international arrivals, while 21% was generated interregionally. The results of the model show that the majority of international tourist arrivals will continue to be produced within the same region, as intraregional travel represents the largest share of all travel for the Americas, Europe and Asia and the Pacific both in 2016 and 2030 (see figures 2.2. and 2.3. and table 2.2.). Only the Middle East received more interregional tourists than tourists from the region itself in 2016 and this is expected to continue through 2030. The latter trend is expected to also apply to Africa in 2030. While in 2016 international arrivals to Africa from Africa (i.e., intraregional) surpassed those arriving from outside the region (i.e., interregional), in 2030 this will be inversed.

2 World Tourism Organization (2011).

3 In this analysis, international tourism is divided in a) **intraregional tourism** (referring to tourist movements from one country to another within the same region) and b) **interregional tourism** (referring to tourist movements from one country in one region to another country in another region).

Figure 2.2 **Regional market shares of international tourist arrivals per source market, 2016 (%)**

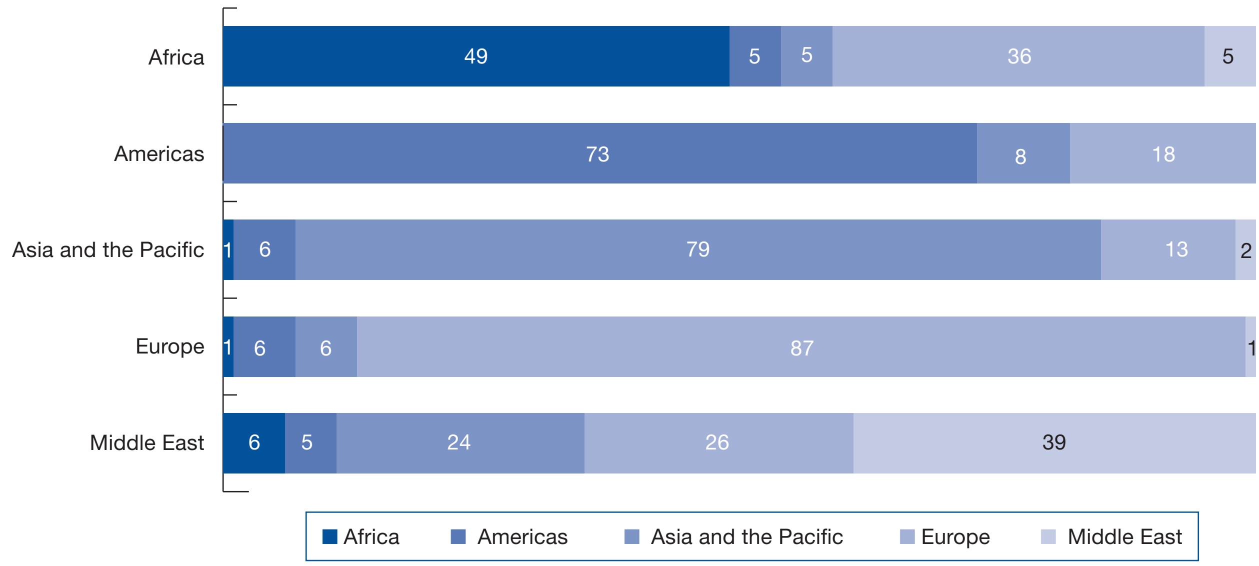


Notes: New tourism-related transport demand model developed for this study.

Due to rounding, aggregates do not necessarily add to 100.

Sources: Based on UNWTO, OECD and UN DESA data.

Figure 2.3 **Regional market shares of international tourist arrivals per source market, 2030 (%)**



Notes: New tourism-related transport demand model developed for this study.

Due to rounding, aggregates do not necessarily add to 100.

Sources: Based on UNWTO, OECD and UN DESA data.

Table 2.2 **International tourist arrivals per source market and by region, 2016 and 2030 (million)**

To \ From	Africa		Americas		Asia and the Pacific		Europe		Middle East	
	2016	**2030**	2016	**2030**	2016	**2030**	2016	**2030**	2016	**2030**
Africa	30	**43**	3	**5**	3	**4**	19	**31**	3	**5**
Americas	1	**1**	149	**194**	17	**21**	32	**48**	1	**1**
Asia and the Pacific	2	**2**	17	**25**	249	**348**	34	**57**	5	**7**
Europe	7	**8**	43	**56**	40	**53**	529	**814**	7	**10**
Middle East	3	**4**	3	**3**	13	**17**	12	**18**	21	**27**

Note: New tourism-related transport demand model developed for this study.

Source: Based on UNWTO, OECD and UN DESA data.

Overall, intraregional travel will increase by an estimated 450 million travellers between 2016 and 2030, representing 80% of the total growth of international tourism arrivals for the same period (total growth: 563 million international tourists). The highest increases come from Europe.

Out of the total increase of international tourist arrivals, interregional travel to all regions of the world is expected to increase with a total of 113 million international tourism arrivals between 2016 and 2030, representing 20% of the total growth in international arrivals between 2016 and 2030 (total growth: 563 million international tourists).

2.1.2 Mode of transport shares for international tourism

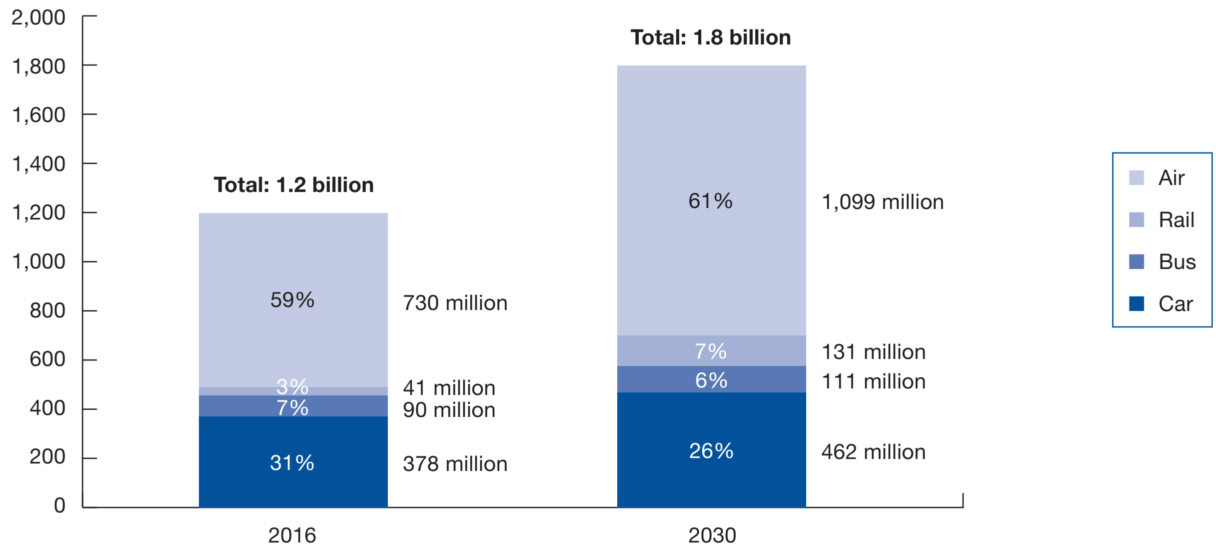
ITF's non-urban passenger transport model provides mode of transport shares for international tourism for 2016 and projects their evolution to 2030. While in absolute terms, travel by all modes of transport is increasing from 2016 to 2030, there are variations in the overall shares for the different modes (see figure 2.4).

In 2030, aviation is expected to continue playing a key role in international tourism, given the large distances involved. The share of travel by rail is expected to double for international tourism compared to 2016, with this growth coming mostly from Europe. The shares of car and bus will register reductions.

Interregional travel is almost always done by air. In 2016, 96.3% of all interregional arrivals were by air. In 2030, it is expected that 96.5% of interregional arrivals will be by air. Intraregional travel (see figure 2.5) is also mostly done by air in all regions, except Europe which is the region where arrivals by rail are growing the most (from 26 million in 2016 to 95 million in 2030). The share of intraregional travel by air is also expected to grow in all regions, except in the Middle East.

The shares of travel by surface are higher in intraregional travel than in interregional travel. Surface modes such as bus and car increase only slightly in absolute numbers across the regions, which decreases their overall share. The same is true for travel by rail, except for Europe where arrivals by rail will more than double.

Figure 2.4 **International tourist arrivals by mode of transport, 2016 and 2030 (million, share %)**



Note: New tourism-related transport demand model developed for this study.

Sources: Based on UNWTO, ITF, IATA and Amadeus data.

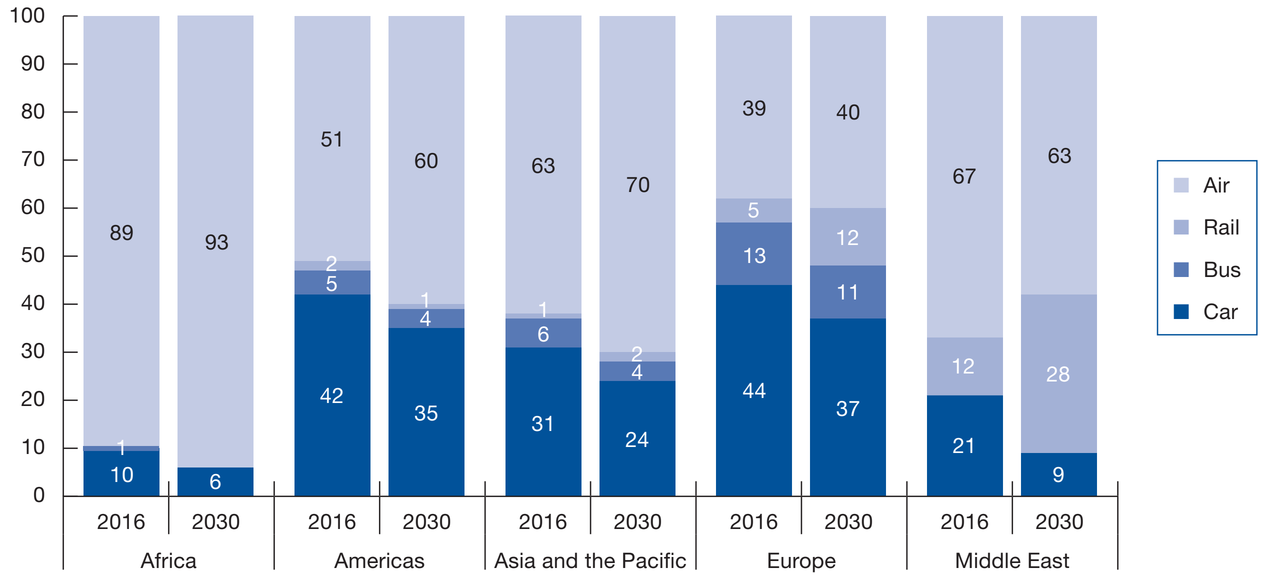
Table 2.3 **Intraregional tourist arrivals by mode of transport, 2016 and 2030 (million)**

Region	Year	Car	Bus	Rail	Air
Africa	**2016**	3.0	0.2	0	26.3
	2030	**2.7**	**0.2**	**0**	**40.4**
Americas	**2016**	63.0	7.0	2.7	76.3
	2030	**68.7**	**7.4**	**1.4**	**116.0**
Asia and the Pacific	**2016**	76.2	14.6	1.4	156.2
	2030	**82.5**	**13.8**	**6.5**	**245.3**
Europe	**2016**	230.5	67.6	26.3	204.1
	2030	**304.3**	**89.1**	**94.7**	**326.2**
Middle East	**2016**	4.2	2.5	0	13.8
	2030	**2.3**	**7.5**	**0**	**17.0**

Note: New tourism-related transport demand model developed for this study. This figure includes international arrivals only.

Source: Based on UNWTO, ITF, IATA and Amadeus data.

Figure 2.5 **Intraregional tourist arrivals by mode of transport, 2016 and 2030 (%)**



Notes: New tourism-related transport demand model developed for this study. This figure includes international arrivals only.

Due to rounding, aggregates do not necessarily add to 100.

Sources Based on UNWTO, ITF, IATA and Amadeus data.

Given the high share of intraregional arrivals in Europe, a more detailed breakdown from a subregional perspective of modes of transport is provided (table 2.4). Data for Europe's subregions underline the overall decrease of transport shares for car and bus by 2030 and the increase of the share of arrivals by air and rail.

Data also confirms the very high dependency of Northern Europe on air transport. The subregion shows the highest dependency on air transport when looking at travel from Northern Europe to Southern and Mediterranean Europe, with 93% of all travel being already conducted by air in 2016 and 93% of travel expected to be conducted by air in 2030.

Other subregions between which air travel is also growing strongly from 2016 to 2030 include travel from Southern and Mediterranean Europe to Central and Eastern Europe (39% to 46%), as well as travel from Central and Eastern Europe to Southern and Mediterranean Europe (40% to 46%).

Table 2.4 **Intraregional tourist arrivals in Europe by mode of transport, 2016 and 2030 (%)**

Origin	Destination	Car	Bus	Rail	Air	Car	Bus	Rail	Air
		2016				2030			
Central and Eastern Europe	Central and Eastern Europe	58	24	0	18	58	21	0	21
	Northern Europe	38	12	3	48	25	9	9	58
	Southern and Mediterranean Europe	49	11	0	40	44	10	0	46
	Western Europe	37	14	2	47	33	13	4	49
Northern Europe	Central and Eastern Europe	38	10	3	49	25	7	9	59
	Northern Europe	22	7	3	68	16	5	5	75
	Southern and Mediterranean Europe	7	0	0	93	6	0	0	93
	Western Europe	15	3	10	72	11	2	14	73
Southern and Mediterranean Europe	Central and Eastern Europe	51	10	0	39	45	9	0	46
	Northern Europe	7	0	0	93	6	0	0	93
	Southern and Mediterranean Europe	56	13	1	30	47	10	12	30
	Western Europe	36	8	4	52	31	7	7	54
Western Europe	Central and Eastern Europe	36	13	2	49	33	13	4	50
	Northern Europe	17	3	12	69	12	2	18	69
	Southern and Mediterranean Europe	34	8	5	54	30	8	8	55
	Western Europe	43	14	23	21	41	10	31	17

Note: New tourism-related transport demand model developed for this study.

Source: Based on UNWTO, ITF, IATA and Amadeus data.

2.1.3 Travel distances for international tourism

Another output of the ITF non-urban passenger transport model relevant for this research is the average travel distance. Travel by different modes of transport has different average lengths for each region as these depend on the available infrastructure and the size of the countries in each region. The ITF non-urban passenger model estimates average distances by mode of transport for each city pair. These are aggregated to the country-pair level, weighted by the number of arrivals for each. Distances are then aggregated to the subregional level and average travel distances for surface modes are grouped by subregion of origin. These average distances are used to estimate the CO_2 emissions at a later stage.

In contrast with surface modes of transport, travel distance between two regions by air can vary significantly. The additional distance travelled compared to the straight-line distance is called *travel displacement.* For surface modes, the displacement is comparatively small. For air travel, displacement can be very significant depending on the number and the location of flight transfers.

A common airline business model, the so-called *spoke-and-hub model,*[4] encourages and increases transfers and therefore travelled distance. Other airlines favour a model with more direct flights (point-to-point system) and fewer connections. Both business models have advantages and disadvantages, but these choices affect the distance travelled and the type of aircraft used, both of which in turn affect fuel consumption and emissions.

The speed of travel by air means that these displacements do not significantly increase travel time. To quantify aviation emissions, the actual distance travelled matters. A direct flight between South America and Europe for example is on average 10,000 km. However, if the same trip is done with a transfer in North America, the total distance travelled would be 15,000 km. Assuming an average emission factor per kilometre travelled, the projected emissions for this trip would be 50% higher.

For the modelling of air distances, UNWTO and ITF collaborated with Amadeus, which provided the paths of actual itineraries for air travel between all regions in 2016. Data was aggregated by origin, destination and transfer regions. For example, for travel between Europe and Africa, 42% of trips were direct, 36% included a transfer in Europe, 13% a transfer in the Middle East and 9% a transfer in Africa. With this information, a more realistic representation of air travel can be drawn which focuses on trip leg analysis rather than origin to destination analysis. In a theoretical scenario where all flights were considered direct, global passenger kilometres (PKM) for tourism in 2016 would be 10% lower (3,470 vs. 3,815 billion PKM). However, in such a scenario, other factors such as load factors and flight frequencies would still need to be considered.

Table 2.5 **Average international travel distances by mode of transport, 2016 and 2030 (km)**

Region	Year	Car	Bus	Rail	Air
Global	2016	655	791	278	4,104
	2030	651	492	288	5,713
Africa	2016	441	393	247	5,508
	2030	433	300	295	7,795
Americas	2016	676	777	212	5,295
	2030	681	416	223	7,463
Asia and the Pacific	2016	686	1,046	238	4,018
	2030	715	755	186	5,777
Europe	2016	639	739	309	3,332
	2030	629	458	334	4,475
Middle East	2016	795	551	202	4,697
	2030	701	547	149	6,524

Note: New tourism-related transport demand model developed for this study.

Source: Based on UNWTO, ITF, IATA and Amadeus data.

4 In the *hub-and-spoke* system, all passengers except those whose origin or destination is the hub, transfer at the hub for a second flight to their destination. Airlines use hub-and-spoke networks to connect origins and destinations between which demand is not sufficiently dense to allow profitable direct service. This implies that hub-and-spoke networks become less competitive when the density of demand increases and when the costs of providing service decline.

2.2 Domestic tourism

Estimating domestic tourism globally has proven a difficult exercise due to the existence of different measurement approaches. In fact, the variations in the operational definitions of the usual environment across countries can produce statistically significant differences in the size of estimates hindering the international comparability of domestic tourism activity. The concept of *usual environment* is specific to tourism statistics and plays a major role, as a tourism trip must take a traveller outside his/her usual environment. For instance, staying at paid accommodation within the usual environment will also not be considered as tourism activity whereas vacation homes – although frequently and routinely visited – are generally considered outside the usual environment.

In view of the above, and because there are no international borders to cross, the observation of the flows of domestic tourism remains highly complex and requires the use of different statistical procedures. Traditionally, as far as overnight domestic tourism is concerned, official accommodation statistics are a key information source to identify domestic and international tourists. Measurement challenges nonetheless arise with these statistics in terms of separating tourists from other types of travellers. Another challenge is to identify same-day domestic visitors and those not staying in officially registered accommodation establishments. Besides accommodations statistics, basic data and indicators for domestic tourism are further collected from different sources such as household surveys, statistical business register, structural business survey, population census, as well as increasingly from other, non-traditional (big data) sources such as mobile phone, credit card and social media, among others.[5]

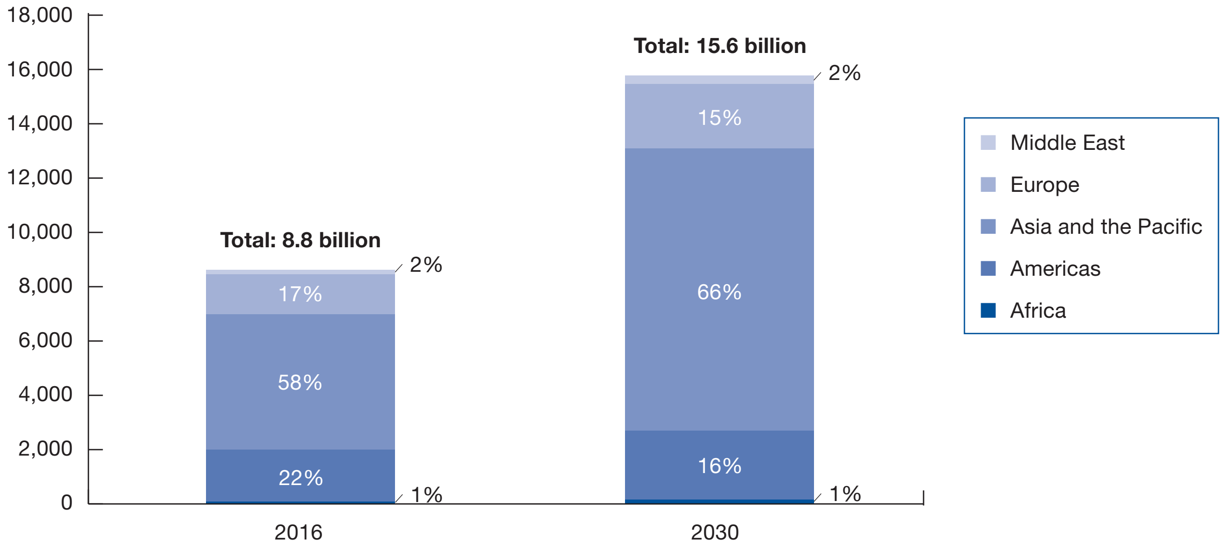
For this study, a model was built on existing domestic data series from UNWTO and OECD for a total of 70 countries. Results were then used to estimate domestic tourist arrivals and their projections for other countries.[6]

The model estimates domestic tourist arrivals to increase from 8.8 billion in 2016 to 15.6 billion in the period from 2016 to 2030 (see figure 2.6). This represents an average growth rate of 4.2% from 2016 to 2030, which is higher than the growth rate forecast for international arrivals (i.e., 3.3.% as described in section 2.1). The global projected growth of domestic tourist arrivals is especially coming from the Asia and the Pacific region (see figure 2.7).

5 For more details on the definition of domestic tourism and traditional data sources, see: United Nations (2010), *International Recommendations for Tourism Statistics 2008,* UN, New York, DOI: https://doi.org/10.18111//9789211615210.

6 While there is no definitive way to confirm the accuracy of domestic arrival estimates, their alignment with some key trends was confirmed during the study. For instance, seat capacity for domestic flights in China grew in parallel with the estimated growth of domestic tourist arrivals obtained when running the model. This relation is expected to continue during the study period (2016–2030). Similar fact-checking exercises were done for other modes, countries and regions (e.g., air movements in North America, air and rail movements in India as well as air and rail in Europe).

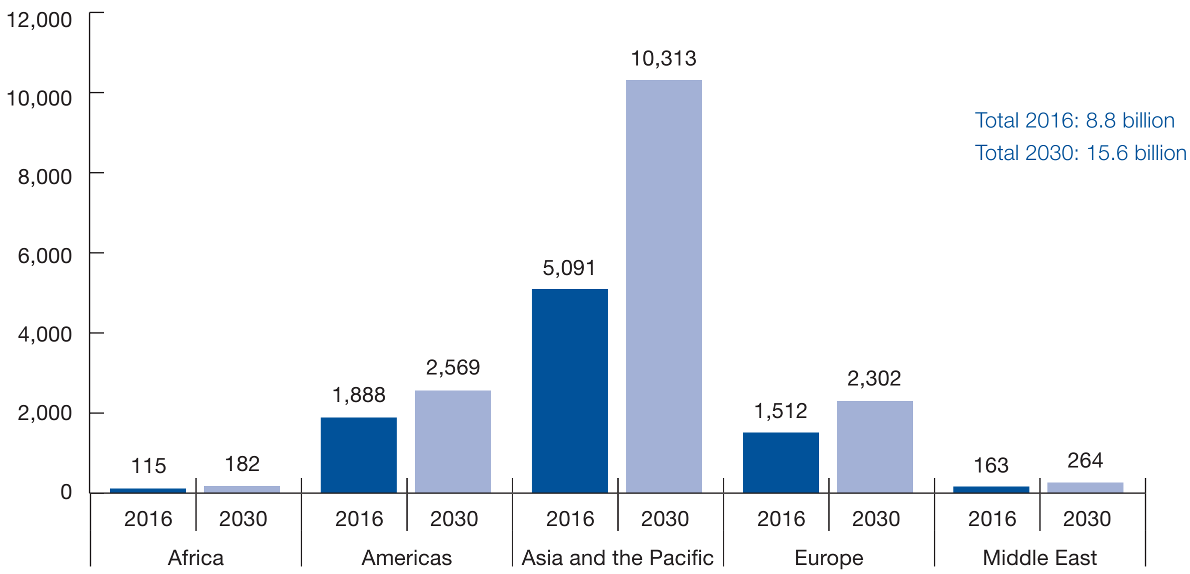
Figure 2.6 **Domestic tourist arrivals by region, 2016 and 2030 (million, share %)**



Note: New tourism-related transport demand model developed for this study.

Sources: Based on UNWTO and OECD data.

Figure 2.7 **Domestic tourist arrivals by region, 2016 and 2030 (million)**



Notes: New tourism-related transport demand model developed for this study.

Sources: Based on UNWTO and OECD data.

The strong domestic arrival growth within Asia and the Pacific is predominantly driven by arrivals in South-East Asia, where domestic tourism is expected to grow from around 420 million in 2016 to 1.2 billion domestic arrivals in 2030. Despite experiencing the greatest growth, the subregion will only be the third one in terms of total domestic arrivals in 2030, with North-East Asia leading the way with a total of 6.3 billion domestic arrivals in 2030 (also experiencing strong growth with 119% between 2016 and 2030). South Asia will be experiencing the third strongest percent increase of domestic tourist arrivals in the region – a 54% growth – from 1.7 billion to 2.5 billion.

In the case of the Americas, it will be especially Central America showing a strong increase in domestic arrivals (137%). It is, at the same time, the subregion that received the lowest number of domestic arrivals in 2016 (7.3 million). In 2030, it will receive slightly more than the Caribbean (17.3 million vs. 17.1 million), which, by then, will be the subregion with the fewest domestic travellers in the Americas. With the few domestic arrivals, both regions will only represent 1% of all domestic travellers within the Americas in 2030.

In Europe, the subregion with the highest growth is expected to be Central and Eastern Europe, which will welcome 681 million domestic travellers in 2030, representing 30% of all domestic arrivals within Europe. This share will be the highest in 2030, followed by Southern and Mediterranean Europe, which is the subregion with the second biggest percentage growth (61% growth) and the second biggest total domestic arrival numbers (660 million). Although increasing in total domestic arrival numbers, Western Europe will be the only subregion that will experience a decrease in its share of domestic arrivals. While Western Europe received 35% of all domestic travellers within Europe in 2016, the subregion will receive 27% of all domestic arrivals by 2030.

Domestic arrivals within the Middle East are expected to grow by 61% by 2030, welcoming a total of 264 million domestic travellers in total.

In Africa, North Africa saw the highest number of domestic arrivals in 2016 and is expected to do so also in 2030. However, the biggest percentage growth between those two years is expected to happen in East Africa, with an 84% growth of domestic tourist arrivals happening in this subregion (growing from 16.7 million in 2016 to 30.6 million in 2030).

Table 2.6 **Domestic tourist arrivals by subregion and estimated growth, 2016 and 2030 (%)**

Region	Subregion	2016	2030	Growth
Africa	Central Africa	12%	13%	76%
	East Africa	14%	17%	84%
	North Africa	32%	29%	42%
	Southern Africa	26%	24%	46%
	West Africa	16%	18%	73%
	Total (million)	**115**	**182**	**58%**
Americas	Caribbean	1%	1%	74%
	Central America	0%	1%	137%
	North America	84%	80%	28%
	South America	15%	19%	78%
	Total (million)	**1,888**	**2,569**	**36%**
Asia and the Pacific	North-East Asia	57%	61%	119%
	Oceania	2%	1%	40%
	South Asia	33%	25%	54%
	South-East Asia	8%	12%	199%
	Total (million)	**5,091**	**10,314**	**103%**
Europe	Central and Eastern Europe	20%	30%	128%
	Northern Europe	18%	15%	26%
	Southern and Mediterranean Europe	27%	29%	62%
	Western Europe	35%	27%	16%
	Total (million)	**1,513**	**2,303**	**52%**
Middle East	**Total (million)**	**163**	**264**	**61%**

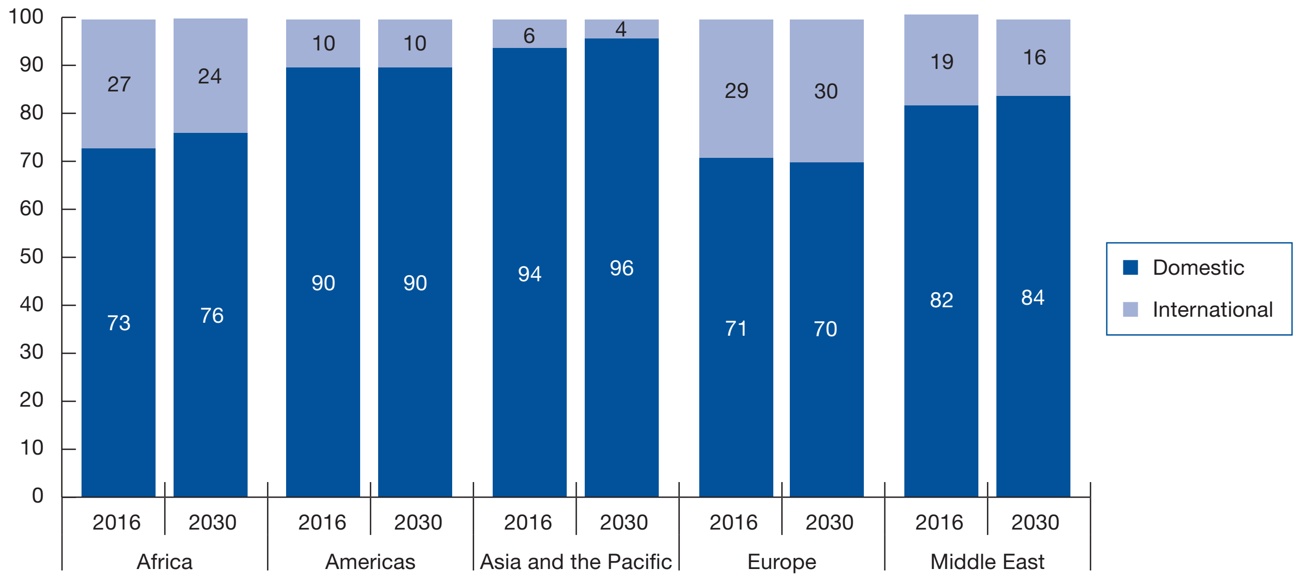
Note: New tourism-related transport demand model developed for this study. Shaded fields show highest numbers.

Source: Based on UNWTO and OECD data.

2.2.1 Comparison of international and domestic arrival shares

When comparing the arrival shares of domestic arrivals and the shares of international arrivals per region, it is in the Americas and Asia and the Pacific where domestic tourism represents respectively 90% and 94% of all tourist arrivals in 2016 (see figure 2.8). While this share does not change for the Americas in 2030, it is expected that by 2030, domestic tourism in Asia and the Pacific will represent 96% of all arrivals in the region.[7]

Figure 2.8 **Domestic and international arrivals, 2016 and 2030 (share, %)**



Notes: New tourism-related transport demand model developed for this study.

Due to rounding, aggregates do not necessarily add to 100.

Sources: Based on UNWTO and OECD data.

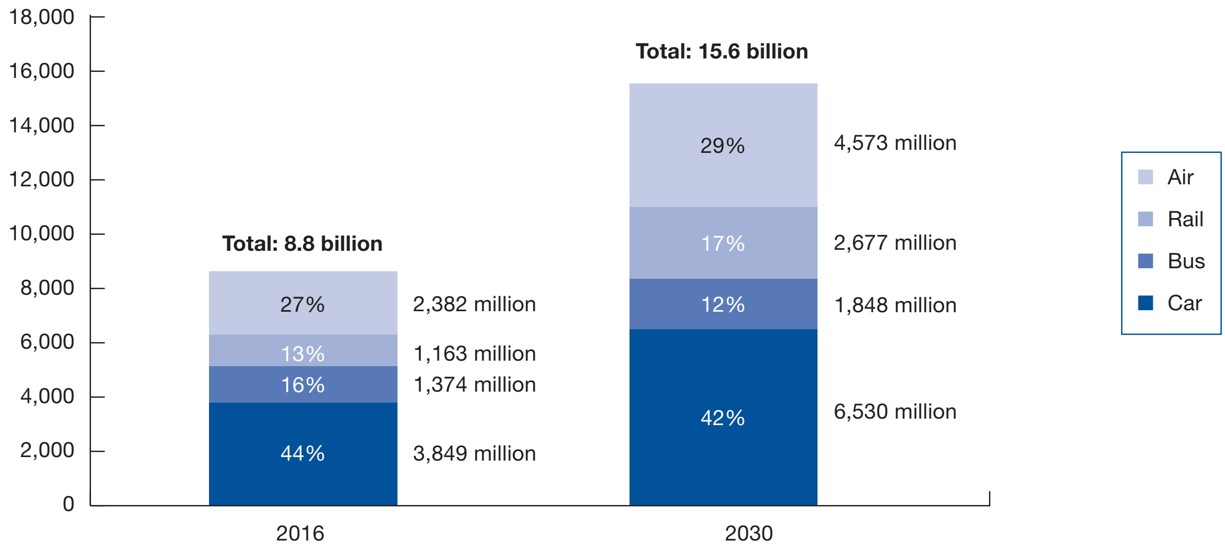
2.2.2 Mode of transport shares for domestic tourism

The non-urban passenger model developed by ITF in 2019 (see annex 3) predicts international inter-city flows and subnational (regional) flows. Notably its subnational (regional) component was used for this study to estimate the mode of transport shares for domestic tourism and the respective distances at a country level.

The model shows mode of transport shares for domestic tourism for 2016 and projects their evolution to 2030 (see figure 2.9). Overall, the total number of domestic tourist arrivals will grow for all modes of transport. In terms of shares, travel by car is expected to slightly decrease from 44% to 42%, representing in both years the main mode of transport, followed by air as the preferred mode of transport. Travel by air is expected to increase from 27% to 29%. Travel by bus is also expected to slightly decrease from 16% to 12%, while travel by rail is expected to increase from 13% to 17%, making it the third most preferred mode of transport in 2030.

7 Note: these figures exclude same-day visitors.

Figure 2.9 **Domestic tourist arrivals by mode of transport, 2016 and 2030 (million, share %)**



Note: New tourism-related transport demand model developed for this study.

Sources: Based on UNWTO, OECD, ITF, IATA and Amadeus data.

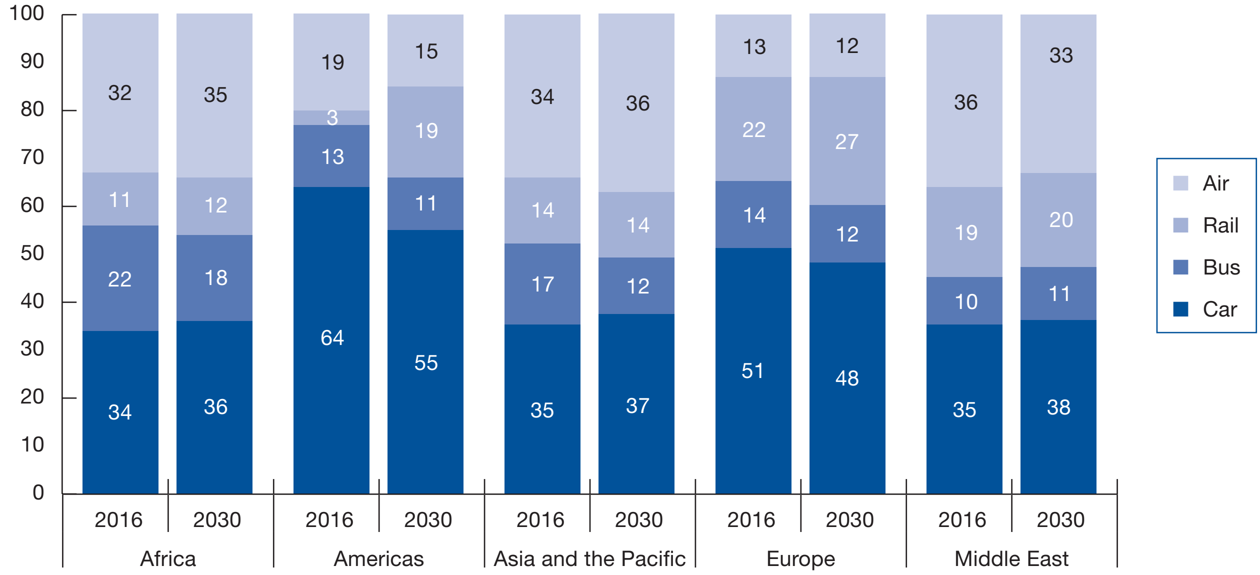
Table 2.7 **Domestic tourist arrivals by region and by mode of transport, 2016 and 2030 (million)**

Region	Year	Car	Bus	Rail	Air
Africa	**2016**	39.7	25.7	13.0	37.0
	2030	**65.2**	**32.7**	**21.5**	**63.0**
Americas	**2016**	1,214.3	244.6	63.2	365.7
	2030	**1,402.6**	**281.9**	**499.2**	**384.9**
Asia and the Pacific	**2016**	1,765.5	880.0	717.3	1,728.3
	2030	**3,851.1**	**1,220.6**	**1,490.8**	**3,750.9**
Europe	**2016**	772.6	208.3	337.8	193.5
	2030	**1,116.2**	**285.8**	**612.9**	**287.1**
Middle East	**2016**	57.2	16.1	31.8	58.4
	2030	**95.1**	**27.8**	**52.7**	**88.1**

Note: New tourism-related transport demand model developed for this study.

Source: Based on UNWTO, ITF, IATA and Amadeus data.

Figure 2.10 **Domestic tourist arrivals by region and by mode of transport, 2016 and 2030 (share, %)**



Note: New tourism-related transport demand model developed for this study.
Due to rounding, aggregates do not necessarily add to 100.

Sources: Based on UNWTO, OECD, ITF, IATA and Amadeus data.

When looking at the regional distribution of mode of transport shares (see figure 2.10), it can be observed that car is the preferred mode of transport in 2030 for domestic travel in all regions. The importance of rail is increasing, especially in Europe and the Americas (in particular North America). Bus is decreasing overall. Furthermore, air travel is expected to increase in all regions for domestic tourism with the exception of the Middle East. Africa is the region with most air travel also for its domestic tourism, relying primarily on car travel as an alternative mode of transport.

2.2.3 Travel distances for domestic tourism

Another output of the ITF non-urban passenger model used for this project is the average travel distance. Similar to estimates for international travel, the travel distance for domestic trips is calculated using the average distance between cities in a country, weighted by the relative travel demand for each city pair. Distance is dependent on the available infrastructure in each country (e.g., if domestic flights exist or if rail infrastructure is in place). The average travel distance within a region changes as demand on specific origin–destination pairs (OD pairs) within the same region change over time.

Table 2.8 **Average domestic travel distances by mode of transport, 2016 and 2030 (km)**

Region	Year	Car	Bus	Rail	Air
Global	2016	535	713	297	811
	2030	555	630	322	880
Africa	2016	385	328	46	540
	2030	417	353	166	465
Americas	2016	846	574	276	1108
	2030	673	536	327	997
Asia and the Pacific	2016	562	633	172	839
	2030	529	635	191	952
Europe	2016	342	379	292	734
	2030	421	421	319	1194
Middle East	2016	355	448	140	565
	2030	406	480	185	507

Note: New tourism-related transport demand model developed for this study.

Source: Based on UNWTO, ITF, IATA and Amadeus data.

Chapter 3

Analysing transport-related CO_2 emissions from tourism

In 2016, CO_2 emissions from transport, including both passenger (car, rail, air) and freight (maritime, air, surface) transport, are estimated to have totalled to 7,230 million tonnes globally, representing 23% of all man-made CO_2 emissions. Out of the total of transport emissions, 64% or 4,650 million tonnes of CO_2 were produced by passenger transport. Emissions from passenger transport are calculated to have split almost equally between non-urban and urban transport. In terms of transport volumes, the estimates show that a total of 44,000 billion PKM were travelled in 2016, 60% of which correspond to non-urban transport.[1]

According to forecasts from ITF for 2030, despite expected increases in fuel efficiency and the emergence of cleaner and greener modes of transport, growth in passenger and freight transport demand will lead to higher CO_2 emissions. By 2030, total passenger and freight transport-related CO_2 emissions are estimated to grow by 21% compared to 2016 and reach 8,772 million tonnes of CO_2, representing 23% of all man-made CO_2 emissions. Passenger transport-related demand is projected to increase by 69% by 2030, reaching 75,000 billion PKM, two thirds of which will be done in a non-urban setting.[2]

The non-urban passenger model developed by ITF in 2019 was used for this research to estimate transport-related CO_2 emissions for international and domestic tourism (see step 3 of the methodological note). The model estimates international inter-city flows, as well as subnational (regional) flows, estimating PKM by mode and route for each city pair. The resulting emissions for surface modes are computed using carbon intensity parameters which are based on the IEA's MoMo. Data from the IEA MoMo is also used to reflect fuel efficiency improvements for each mode in the period from 2016 to 2030.[3] The ICAO emissions calculator[4] is used to estimate CO_2 emissions for aviation. The parameters affecting emissions on the emission calculator are:

- Total fuel used for the flight;
- Passenger-to-freight factor;
- Number of economy seats;
- Passenger load factor; and
- Grams of CO_2 per litre of jet fuel burned.

1 International Transport Forum (2019).

2 Ibid.

3 International Energy Agency (2018a), *Global EV Outlook 2018: Towards cross-modal electrification,* IEA, Paris, DOI: https://doi.org/10.1787/9789264302365-en.

4 International Civil Aviation Organization (n.d./b), *Emissions Calculator* (online), available at: www.icao.int/environmental-protection/Carbonoffset/Pages/default.aspx (06-09-2019).

Using the ICAO calculator formula and the available seat capacity offered by different types of aircraft for each region pair obtained from the Innovata SRS flight database, the average CO_2 emissions per PKM are computed (see table 3.1).

It should be noted that this research uses tank-to-wheel (TTW) emissions as per the estimates of the IEA.[5] This corresponds to the CO_2 that is produced during the transport activity and does not include emissions that were generated for the production or distribution of energy, nor for the manufacturing and retirement of vehicles.

Table 3.1 **Global average CO_2 emissions per passenger kilometre (PKM) travelled, 2016 and 2030 (kg)**

Mode of transport	CO_2 per PKM	
	2016	2030
Car	0.1135	0.0752
Bus	0.0300	0.0244
Rail	0.0205	0.0188
Air	0.1042	0.0798
All modes	**0.0930**	**0.0680**

Notes: New tourism-related transport demand model developed for this study.

The resources required for maintenance and building of transport networks are not accounted for. Emission factors are obtained from ITF's non-urban model. In the ITF's non-urban model emission factors for surface modes are based on fuel economy and load factors from IEA's MoMo model, while emission factors for aviation are estimated using ICAO's emissions calculator.

Source: Based on UNWTO, ITF, IEA, IATA and Amadeus data.

The modes of transport of air and car are estimated to have CO_2 emissions per PKM of similar magnitude.[6] The same holds true for rail and bus, but at a lower level. Cars represent currently the most CO_2-intensive mode of transport, but this is expected to change by 2030 as the uptake of vehicle electrification and fuel efficiency improvements continue.[7]

Despite expected fuel efficiency improvements for aircrafts, the average CO_2 emission factor is expected to surpass that of cars by 2030. Aviation emissions depend heavily on the type of airplane and the distance travelled. There is currently a discussion in the literature on the fuel efficiency of aircrafts and optimal flying distance. There are several studies which state that there in fact exists an optimal flying distance by aircraft type which minimizes emissions per PKM.[8] This optimal flying distance for a wide-body aircraft such as the Boeing 747 is between 3,000 and

5 International Energy Agency (2018a).

6 Global average CO_2 emissions per PKM of car is based on average occupancy of vehicle which ranges between 1.3–2.0, depending on region and distance.

7 Ibid.

8 Agarwal, R.K. and Zhang, Z. (2011), 'Optimization of ETRW (Energy Liberated During a Flight/Revenue Work Done) of an Airplane for Minimizing its Environmental Impact', 2011-01-2524, SAE *Technical Paper*, DOI: https://doi.org/10.4271/2011-01-2524.

Steinegger, R. (2017), 'Fuel economy for aircraft operation as a function of weight and distance', *Working Paper,* Winterthur: ZHAW Zürcher Hochschule für Angewandte Wissenschaften, DOI: 10.21256/ZHAW-3466.

4,000 miles.[9] Shorter flights emit more CO_2 per km travelled because of the increased fuel burn in take off and landing. Flights with distances beyond the optimal range can have a higher emission factor per kilometre travelled due to the additional fuel carried. For example, an 8,000-mile trip could use almost 20% more fuel compared to two 4,000-mile legs.[10] The additional fuel usage would be the result of having more weight in the first part of the journey. This approach is not yet fully verified and is not used by international bodies and agencies and therefore, as mentioned above, the ICAO emissions calculator has been used within this study.

Rail is and will remain the least CO_2-intensive mode of transport, at least in terms of TTW emissions, with bus being close behind.

Emissions from cruise tourism

Cruise tourism is a widely debated subject in terms of transport-related emissions. Cruise ships use energy for various purposes, including transport, accommodation, entertainment and more. Therefore, CO_2 emissions from cruise shipping include emissions from all these categories, which make it difficult to differentiate between them and isolate transport emissions. Nonetheless, there have been some studies that attempted to quantify the total environmental footprint of cruise tourism in terms of CO_2 emissions.

One model suggests analysing fuel consumption from various types of cruise ships and its related total CO_2 emissions. By combing the methodology applied with information about travel lengths globally and number of cruise passengers obtained from annual reports and environmental reports from the major cruise companies, it has been possible to calculate the cruise transportation related CO_2 emissions for 2016.[11]

With that model, we find value ranges between 24 million tonnes (low estimate) and 30 million tonnes (high estimate) of CO_2, with an average of 26.5 million tonnes for the year 2016.[12] As opposed to 2016, it was not possible to find estimates for emissions from cruise for 2030.[13]

9 Steinegger, R. (2017).

10 Park, Y. and O'Kelly, M.E. (2014), 'Fuel burn rates of commercial passenger aircraft: variations by seat configuration and stage distance', *Journal of Transport Geography,* Volume 41 (C), pp. 137–147, DOI: 10.1016/j.jtrangeo.2014.08.017.

11 Simonsen, M.; Walnum, H.J. and Gössling, S. (2018), 'Model for Estimation of Fuel Consumption of Cruise Ships', *Energies 2018,* Volume 11, Issue 5, pp. 1–29, DOI: https://doi.org/10.3390/en11051059.

Simonsen, M.; Gössling, S. and Walnum, H.J. (2019), 'Cruise Ship Emissions in Norwegian Waters: A geographical analysis', *Journal of Transport Geography,* Volume 78, pp. 87–97, DOI: https://doi.org/10.1016/j.jtrangeo.2019.05.014.

12 Ibid.

13 No long-term estimates or forecasts for the future growth of cruise tourism exist. This can be partly attributed to the fact that transport is a means to an end (i.e. helping travellers to reach their destinations where they carry out their tourism activity such as holidays or business), while cruise shipping is an activity on its own. This makes the prognosis of CO_2 emissions for cruise shipping to 2030 very challenging.

Emissions from same-day visitors

The estimates developed for the purpose of this report focus on emissions generated from international and domestic tourist arrivals. The emissions related to same-day visitors are not included in the figures resulting from the modelling exercise. Nonetheless, as same-day visitor volumes have been estimated for 2016 and 2030 and have been aggregated to the overall results, it has also been possible to estimate the related emissions and aggregate them to the overall results.

Distances for same-day trips are generally shorter than those travelled for overnight stays and surface modes are predominantly used. Therefore, same-day trips are considered to be less CO_2-intensive than international and domestic arrivals. Building on the *Climate Change and Tourism – Responding to Global Challenges* publication from 2008 where same-day visitors were estimated to have emitted 133 million tonnes of CO_2 in 2005, in combination with ITF estimates about non-urban activity, it was possible to estimate the emissions from same-day visitors at around 200 million tonnes of CO_2 in 2016. For 2030, using the total number of trips forecast to be generated that year, it was possible to estimate the evolution of CO_2 emissions for same-day visitors. They are expected to increase only marginally, reaching 230 million tonnes of CO_2 in 2030. This minor increase reflects the expected electrification and fuel efficiency increase of surface modes, which remain the main mode of transport for same-day tourist trips.

Allocating emissions: the modelling approach

As mentioned above, the allocation of emissions is connected to the number of PKM travelled by each mode of transport. Nevertheless, when it comes to international tourism across countries and regions, some challenges are found with regards to the allocation of emissions from international tourism aviation.

With regard to aviation, the most common approach used by countries and in satellite accounts (aviation statistics) used by international organizations is allocating emissions based on the country where an airline is registered. However, tourism flows are usually estimated based on aggregated data provided by countries and not by airlines.

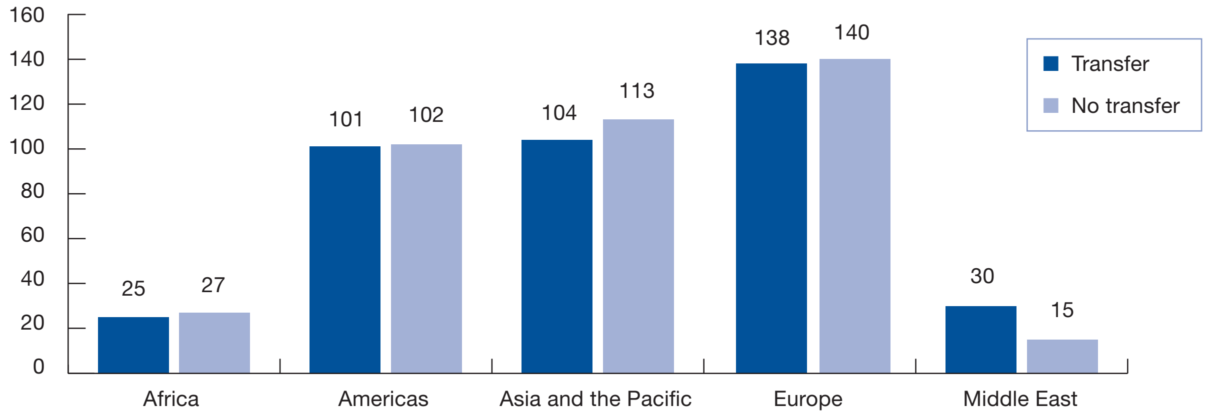
For the purpose of the study, the transfer approach as proposed by ITF was followed to measure and allocate aviation emissions between regions and countries. The information that was provided by Amadeus allowed the inclusion of key considerations in the study, such as the contribution of hubs to the overall trip emissions.

The transfer approach calculates the distance between origin, transfer and destination regions, and allocates emissions between all these regions based on the share of traffic that uses each transfer location. In this approach, using transfer information, the share of tourists that do a stopover in a different region is estimated. Then the distance travelled for all the different options between origin and destination is computed, leading to PKM and emissions. For example, for travel between Europe and Africa, 42% of trips were direct, 36% included a transfer in Europe, 13% a transfer in the Middle East, and 9% a transfer in Africa. Emissions from these trips will be allocated to all three regions, and not only to Europe and Africa.

Another possible approach, as proposed by ITF, includes the more simplified calculation of emissions for each country pair and split the emissions between those two. It is called the origin-destination approach.

When comparing the transfer approach with the no-transfer (origin–destination) approach for the emissions of international aviation (see figure 3.1) it can be observed that in 2016, the Middle East, a region which serves as a hub for long distance international travel, is the only region which is allocated more CO_2 emissions using the transfer approach. In fact, the emissions of the Middle East increase by 100% compared to an origin–destination allocation approach. All other regions register fewer emissions with the transfer approach, with Asia and the Pacific and Africa having the biggest decrease – 9% and 7% respectively. This is explained by the presence of multiple European and American airliners in the long distance market, which use their home regions as a transfer point for their flights.

Figure 3.1 **Emissions of international aviation by region according to transfer and no-tranfer (origin–destination) approach, 2016 (Mt of CO_2)**



Notes: New tourism-related transport demand model developed for this study.

Sources: Based on UNWTO and OECD data.

The location of transfer hubs has additional impacts on the aviation and tourism sectors, beyond accurate emission allocation. The presence of these hubs allows airlines to connect destinations for which traffic demand is inadequate to justify a direct flight and can help increase load factors in the aircraft. Higher load factors do not only lead to a more profitable operation, but also decrease CO_2 emissions per PKM travelled.

As the no-transfer approach presents a more simplified version and ignores the importance of hubs in other locations and does not allocate emissions to them, it was decided that for this study, the transfer approach was most suitable. It provides for a more realistic representation of international aviation, leading to more accurate estimation and allocation of CO_2 emissions.

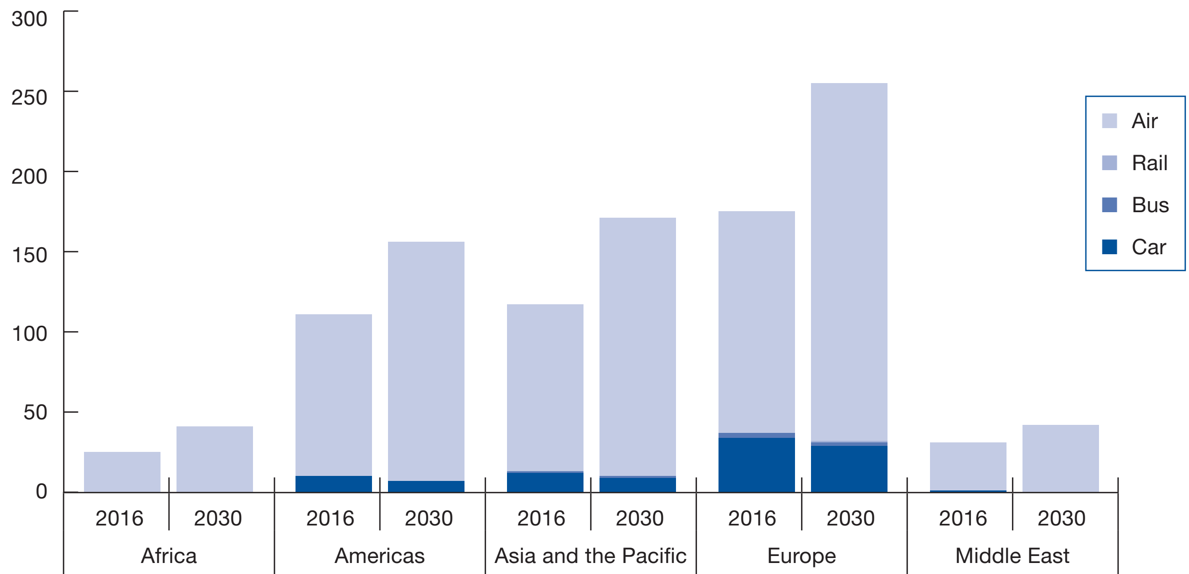
3.1 Transport-related emissions from international tourism

Transport-related emissions from international tourism are expected to grow 45% during the study period (2016–2030) from 458 million tonnes CO_2 in 2016 to 665 million tonnes CO_2 in 2030. Growth per region is expected to be as follows: Africa 62%, the Americas 42%, Asia and the Pacific 47%, Europe 46% and the Middle East 36%. Europe will remain the biggest emitter of CO_2 for international tourism (from 175 million tonnes of CO_2 in 2016 to 255 million tonnes of CO_2 in 2030), as the region is both the biggest origin and biggest destination of international tourism travel and is also a significant transfer hub for international traffic.

Analysis of CO_2 emissions from international tourism by mode of transport (see figure 3.2.) shows air travel as the absolutely dominant mode of transport. The only region where air travel does not represent 90% of the emissions in 2030 is Europe. In 2016, international tourism through surface modes of transport produced 21% of the emissions in Europe, with 19% coming from car travel. By 2030, the share of car emissions from international tourism in Europe will decrease to 11% and aviation emissions will increase to 87%.

When looking at Africa, it can be observed that the continent has very little surface emissions, as there is still a very low propensity to travel and there are many limitations in infrastructure. The same occurs for the Middle East, but in this case a large share of emissions is caused by the region being an international transfer hub.

Figure 3.2 **Regional emissions from international tourist arrivals by mode of transport, 2016 and 2030 (Mt of CO_2)**



	Africa 2016	Africa 2030	Americas 2016	Americas 2030	Asia and the Pacific 2016	Asia and the Pacific 2030	Europe 2016	Europe 2030	Middle East 2016	Middle East 2030
Air	25	41	101	149	104	161	138	223	30	42
Rail	0	0	0	0	0	0	0	1	0	0
Bus	0	0	0	0	1	1	3	2	0	0
Car	0	0	10	7	12	9	34	29	1	0

Notes: New tourism-related transport demand model developed for this study.

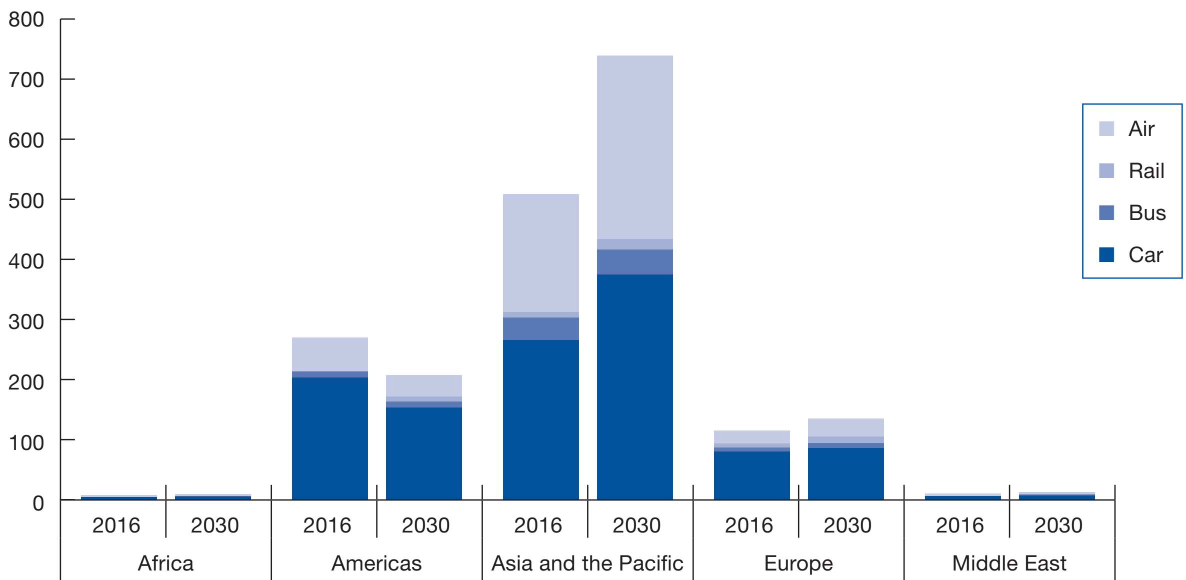
Sources: Based on UNWTO, ITF, IEA, IATA and Amadeus data.

3.2 Transport-related emissions from domestic tourism

Emissions from domestic tourism are expected to grow by 21% during the study period from 913 million tonnes of CO_2 in 2016 to 1103 million tonnes of CO_2 in 2030. Nevertheless, this increase is not uniform across all regions (see figure 3.3). In 2016, the two most CO_2 emitting regions were Asia and the Pacific (509 million tonnes of CO_2) and the Americas (271 million tonnes of CO_2). In the Americas, 79% of emissions come from surface transport (which rises to 83% in 2030), with cars being the main emitters, contributing 75% in 2016 and 74% in 2030 to all emissions of the Americas. In Asia and the Pacific on the other hand, 52% of domestic tourism emissions in 2016 come from car (which will decrease to 51% in 2030) and 39% from air transport (which will grow to 41% in 2030).

In 2030, emissions in the Americas will decrease by one fourth, while in Asia and the Pacific they will increase by 45%. The development of rail transport in the Americas absorbs a big share of the additional tourism demand without producing any additional emissions. The growing middle class of Asian countries and the entrance of low-cost carriers in previously closed markets are pushing emissions from domestic air tourism in the region to grow by 54%. The other regions all experience a modest increase in emissions, ranging between 12% and 18%.

Figure 3.3 **Regional emissions from domestic tourist arrivals by mode of transport, 2016 and 2030 (Mt of CO_2)**



	Africa		Americas		Asia and the Pacific		Europe		Middle East	
	2016	2030	2016	2030	2016	2030	2016	2030	2016	2030
Air	3	3	56	35	197	305	22	30	4	4
Rail	0	0	1	9	9	18	6	11	0	1
Bus	1	1	10	10	37	41	7	8	0	1
Car	4	5	203	153	266	375	80	86	6	7

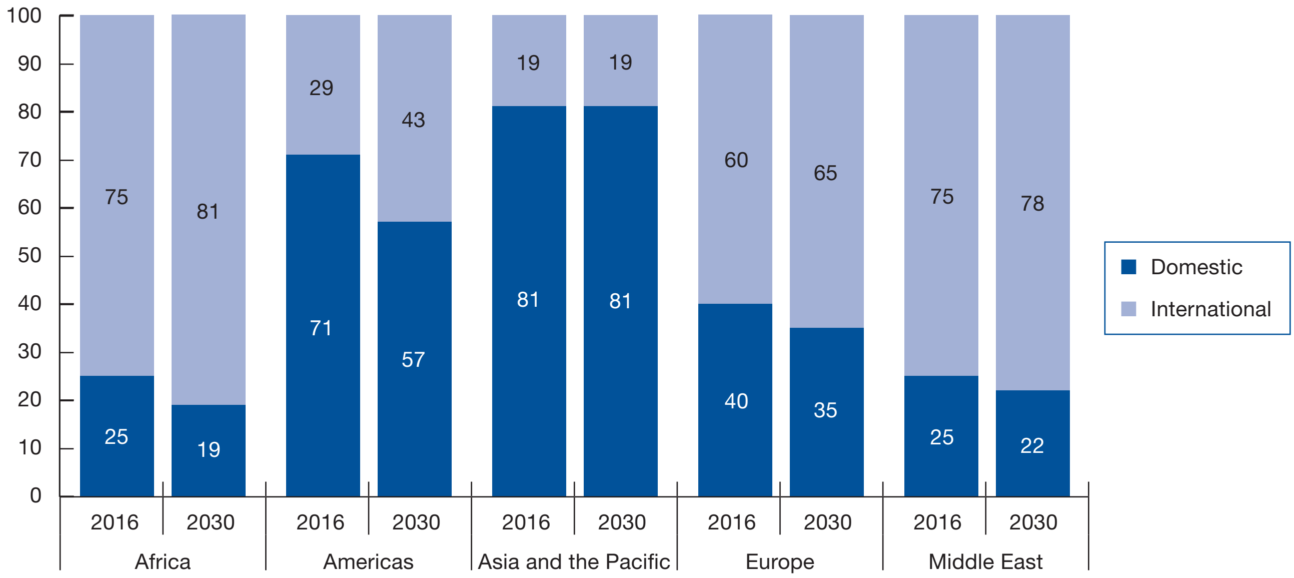
Notes: New tourism-related transport demand model developed for this study.

Sources: Based on UNWTO, ITF, IEA, IATA and Amadeus data.

3.2.1 Comparison of international and domestic emission shares

When comparing the emission shares of domestic arrivals and the shares of international arrivals per region (see figure 3.4), it can be observed that in Asia and the Pacific, the shares are not expected to change although the total emissions for the region are increasing. Analysing the shares of emissions in the other regions, the share of emissions of international arrivals will increase in all regions, translating into a reduction of emission shares generated by domestic arrivals by 2030 in Africa, the Americas, Europe and the Middle East. Furthermore, it can be observed that in three regions of the world (the Middle East, Europe and Africa), emissions from international arrivals represent 60% or more of all emissions from tourism.

Figure 3.4 **Domestic and international transport-related emissions from tourism, 2016 and 2030 (share, %)**



Notes: New tourism-related transport demand model developed for this study.

Sources: Based on UNWTO, ITF, IEA, IATA and Amadeus data.

Chapter 4

Overall transport-related CO_2 emissions from tourism from 2005 to 2030

The evolution of tourism arrivals and emissions

According to the previous UNWTO and UN Environment study on *Climate Change and Tourism,*[1] in 2005, transport-related CO_2 emissions from tourism totalled 982 million tonnes of CO_2, including both overnight and same-day visitors. This represented about 18% of the total transport emissions and 3.7% of all man-made CO_2 emissions (26,400 million tonnes). Out of those, overnight stays accounted for 849 million tonnes (86%) with same-day visitors accounting for 133 million tonnes (14%). These emissions were produced by a total of 9.7 billion tourist trips (overnight and same-day visitors combined), split into 750 million international tourist arrivals, 4 billion domestic tourist arrivals and an additional 5 billion international and domestic same-day visitors.

In 2016, eleven years later, international tourist arrivals reached 1.2 billion, representing a 65% increase from 2005. Domestic tourist arrivals reached 8.8 billion, representing a 119% increase from 2005. In addition, international and domestic same-day visitors doubled in comparison to 2005 (counting then 10 billion). This means that in 2016, an estimated 20 billion tourist trips were taking place. This number translates into transport-related emissions from tourism of a total of 1,597 million tonnes of CO_2, with 1,371 million tonnes of CO_2 accounting for all overnight stays and same-day visitors accounting for 200 million tonnes. The total transport-related tourism emissions represented about 22% of the total transport emissions and 5% of the overall man-made emissions (32,100 million tonnes) in 2016.[2]

In 2030, the total number of tourist trips is expected to reach 37.4 billion, of which 17.4 billion will be international and domestic overnight arrivals (1.8 billion international/15.6 billion domestic). For international arrivals, this means a 45% growth from 2016 while domestic arrivals grow 78% from 2016, indicating the strong role of domestic tourism for the sector's overall growth. In terms of same-day tourist trips in 2030, it is expected that this number will double again from 2016, reaching an estimated 20 billion trips.[3] Total transport-related tourism emissions (excluding cruise) in 2030 are forecast to reach 1,998 million tonnes of CO_2, with 1,768 million tonnes of CO_2 accounting for all overnight emissions and same-day visitors accounting for 230 million tonnes. This would represent 23% of the total expected transport emissions and 5.3% of the overall forecast man-made emissions (37,800 million tonnes) under IEA's current policies scenario/"baseline scenario".[4]

1 World Tourism Organization and United Nations Environment Programme (2008).

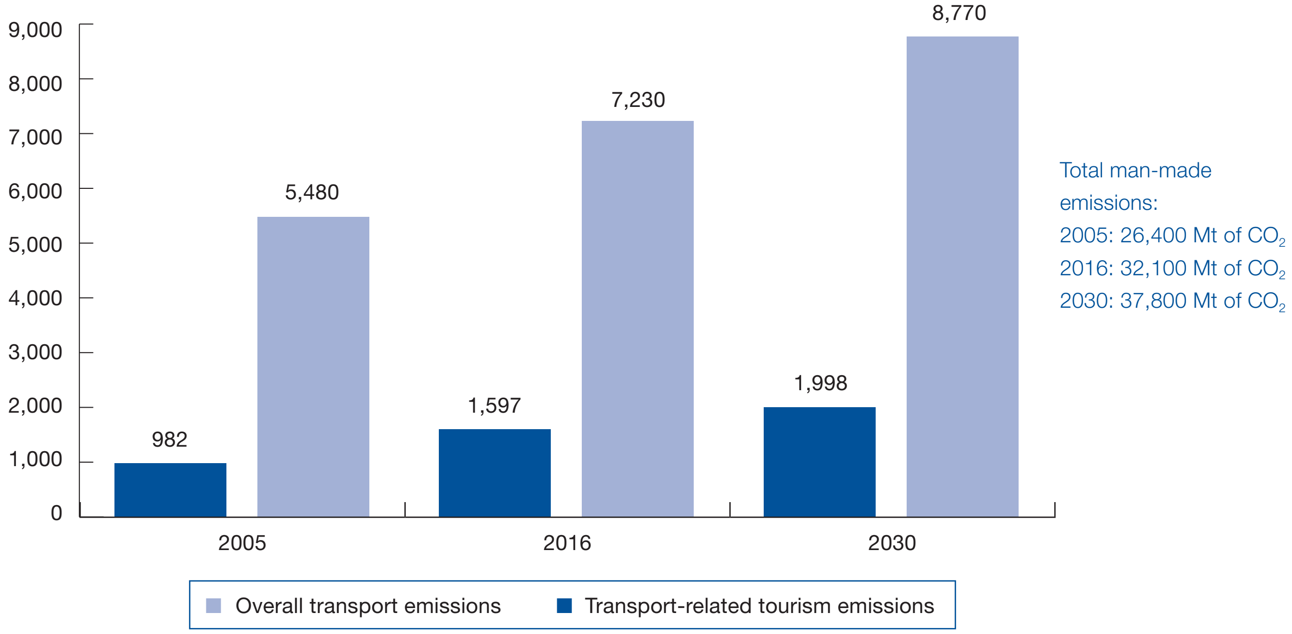
2 The transport-related tourism emissions estimated for 2016 include the estimates for the cruise ship sector, while this is not the case for the 2030 forecasts.

3 These numbers are not the product of a specific modelling exercise; instead they are extrapolations from the ITF non-urban model.

4 International Energy Agency (2018b), World Energy Outlook 2018, IEA, Paris, DOI: https://doi.org/10.1787/weo-2018-en.

All in all, from 2005 to 2016 the total transport-related emissions from tourism over the total man-made emissions grew from 3.7% to 5%, whereas from 2016 to 2030 this proportion is expected to increase to 5.3% (see figure 4.1).

Figure 4.1 **Overall transport emissions and transport-related emissions from tourism, 2005, 2016 and 2030 (Mt of CO_2)**



Notes: New tourism-related transport demand model developed for this study.

Sources: Based on UNWTO, ITF, IEA, IATA and Amadeus data.

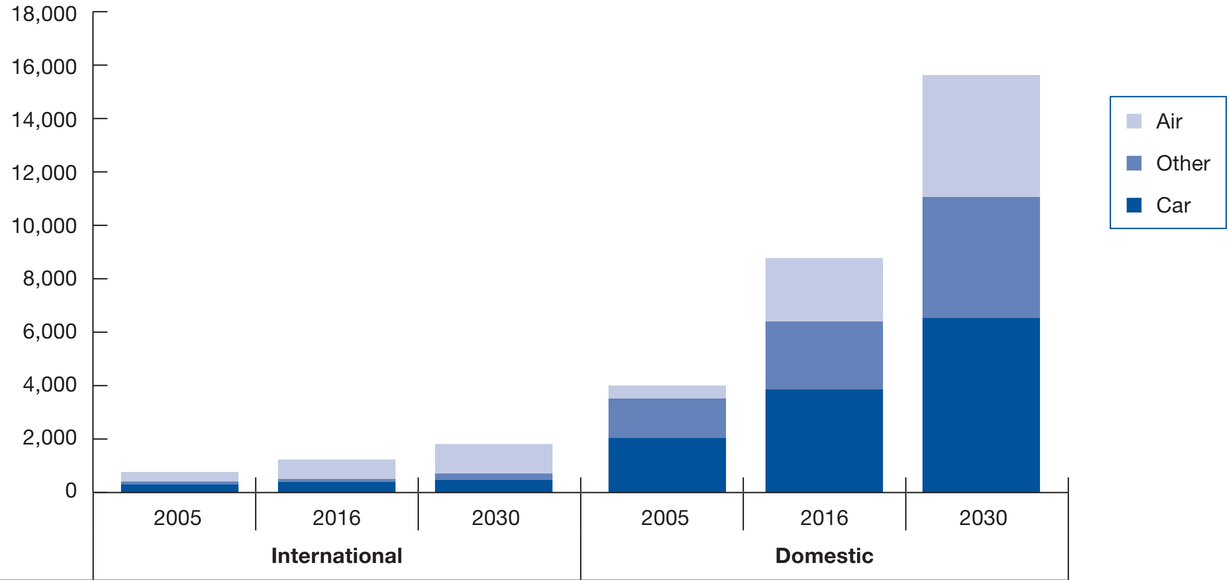
Figures 4.2 and 4.3 below present the evolution of tourism arrivals and emissions from 2005 to 2016 and projections up to 2030, following the three main categories (car, air, other – which includes bus and rail and cruise ships)[5] included in the UNWTO and UN Environment study of 2008[6] to facilitate comparison over a 25-year period.

5 2030 data does not include cruise data.

Figures 4.2 and 4.3 do not differentiate between the two surface modes bus and rail in order to be consistent with the 2005 figures where only air and surface were the two categories analysed, with the latter combining train, coach and ship.

6 World Tourism Organization and United Nations Environment Programme (2008).

Figure 4.2 **Overview of domestic and international tourist arrivals by mode of transport: air, car and other, 2005, 2016 and 2030 (million)**



	International 2005	International 2016	International 2030	Domestic 2005	Domestic 2016	Domestic 2030
Air	340	730	1,099	480	2,383	4,574
Other	123	131	242	1,492	2,538	4,526
Car	287	378	462	2,028	3,849	6,530

Notes: New tourism-related transport demand model developed for this study.

Sources: Based on UNWTO, ITF, IATA and Amadeus data.

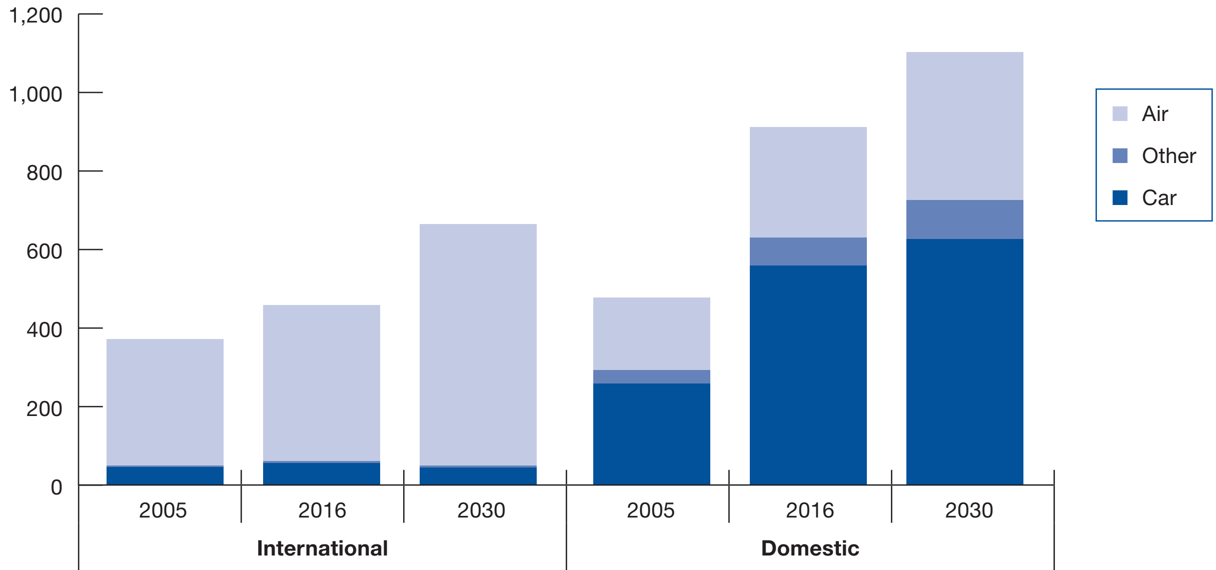
The longer distances associated with international travel make aviation the dominant mode of transport. The share of international travel done by air is expected to grow marginally from 59% to 61% during the study period (2016–2030). In comparison, in 2005, international tourist arrivals by air represented 45% of all international arrivals and the remaining 55% used surface modes of transport. In absolute numbers, the threshold of 1 billion international tourist arrivals by air will be broken in the second half of the next decade, with the total number of international tourist arrivals by air expected to reach 1.1 billion in 2030.

Regarding surface modes of transport, the flexibility of private vehicles and the lack of high quality international connections by rail make car the preferred surface mode for international travel. In 2016, 41% of all international tourists arrived in destinations by surface modes of transport: 31% used cars, 7% buses and only 3% rail as their means of transport. This is less compared to 2005, where the share of arrivals by surface modes was 55%: 38% by car and 16% by bus and rail combined. By 2030, car will still be the main surface mode with 26% of all international arrivals using cars, yet it is especially the share of rail trips which will double from 3% to 7%. The three time points offer us a clear trend for the mode of transport of international arrivals. Arrivals by air transport are becoming more common, whereas arrivals by car are decreasing.

For domestic tourism, surface modes of transport dominate tourism arrivals and will account for 71% of all domestic tourism arrivals in 2030. They are decreasing however, down from 73% in 2016 and 88% in 2005. Arrivals by air are expected to represent 29% of all domestic arrivals in

2030, from 27% in 2016 and 12% in 2005. Similar to the scenario for international arrivals, car will continue to be the preferred mode for domestic travellers, carrying 42% of them (in 2016 this was 44% down from 51% in 2005). In 2030, rail will carry 17% of all domestic tourist arrivals, from 13% in 2016. The percentage of buses as modes of transport will decrease from 16% in 2016 to 12% in 2030, but due to the overall increase of domestic tourism, bus will still carry more domestic travellers in 2030 than in 2016. In 2005, rail and bus combined represented 37% of domestic arrivals.

Figure 4.3 **Overview of transport-related emissions from domestic and international tourist arrivals by mode of transport: air, car and other, 2005, 2016 and 2030 (Mt of CO_2)**



	International 2005	International 2016	International 2030	Domestic 2005	Domestic 2016	Domestic 2030
Air	321	397	616	185	282	376
Other	4	5	4	34	71	99
Car	46	56	45	259	559	627

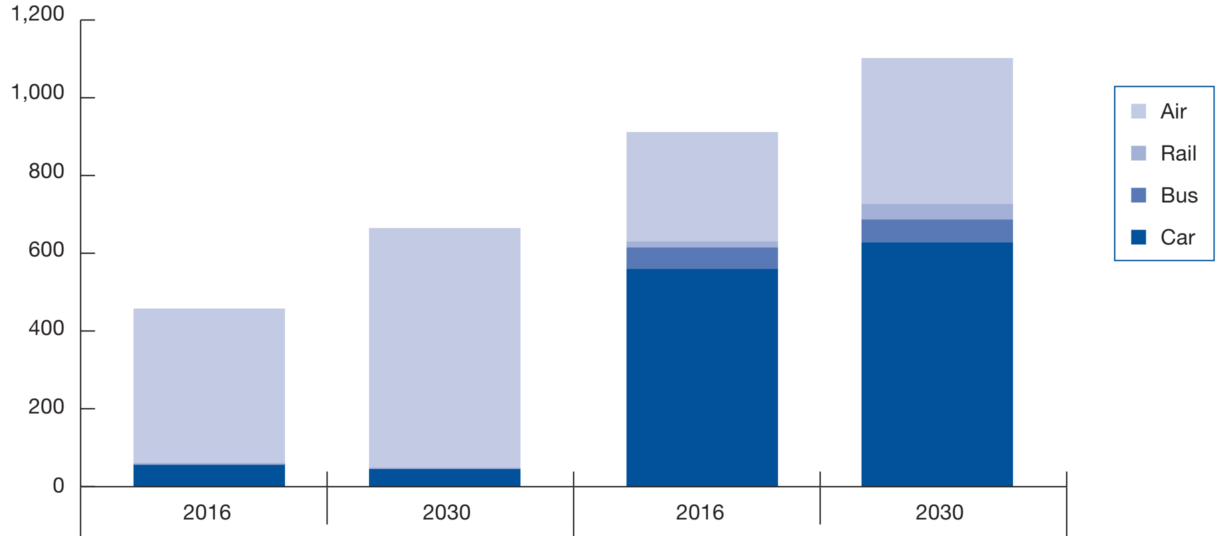
Notes: New tourism-related transport demand model developed for this study.

Sources: Based on UNWTO, UNEP, WMO, ITF, IEA, IATA and Amadeus data.

In 2005, 17% of arrivals (domestic and international) were done by air and yet they produced 60% of transport-related emissions from tourism. In 2016, the share of aviation in tourism increased to 31%, leading to a share of 50% of transport-related CO_2 emissions. This reduction in the share (not in the amounts of CO_2 which are growing) can be explained by the improvements made in airplane fuel efficiency during this period. Another factor that is likely to have influenced it is the expansion of tourism by surface modes of transport in areas where vehicle fuel efficiency is low. This increases the share of CO_2 emissions caused by surface modes of transport in those regions and the world as a whole. CO_2 emissions per PKM from aviation vary depending on the distance, the passenger load factor and the aircraft used. Compared to the “most efficient” flights in terms of emissions, car activity can sometimes produce similar or even higher CO_2 emissions per PKM. During this and the upcoming decade, surface modes of transport such as car, bus and rail (bus and rail are grouped under other) are expected to reduce their CO_2 emissions as a result from the increased electrification and hybridization of their engines. Tourism arrivals by surface modes of transport will grow by 70% between 2016 and 2030 (almost 5 billion trips more), but emissions from these trips will grow only by 12% (691 to 775 million tonnes of CO_2), representing 44% of the total (compared to 50% in 2016). In contrast, in 2030, tourism arrivals by air (both international and domestic) are expected to represent 33% of the total arrivals, but produce 56% of emissions.

Within the present study, a more detailed breakdown of emissions of surface modes was done for the years 2016 and 2030 separating car, bus and rail (see figure 4.4). This breakdown highlights the importance of surface modes for domestic tourism, where bus and rail play a more significant role compared to international tourism. The projections show increased emissions from rail in the domestic segment (from 2% to 4%), something that can be attributed to the increased tourism demand in Asia, a place where many rail systems still rely on fossil fuels, in contrast with electrified rail in Europe. The produced emissions from domestic tourism arrivals by bus will remain approximately the same (5%–6%) despite the growth in absolute trip numbers (500 million more trips), in line with expected vehicle fuel efficiency improvements. This combined trend can also be attributed to the increased GDP levels in many Asian countries, a shift that is combined with reduced bus and increased rail usage.

Figure 4.4 **Overview of transport-related emissions from domestic and international tourist arrivals by mode of transport: air, rail, bus and car, 2016 and 2030 (Mt of CO_2)**



	International 2016	International 2030	Domestic 2016	Domestic 2030
Air	397	616	282	376
Rail	4	3	16	39
Bus	1	1	55	60
Car	56	45	559	627

Notes: New tourism-related transport demand model developed for this study.

Sources: Based on UNWTO, ITF, IEA, IATA and Amadeus data.

Chapter 5

Conclusions and way forward

The study provides insights on the evolution of tourism demand (international and domestic arrivals) from 2016 to 2030 based on two new models that were developed for the purpose of this research. In the case of international tourism, the findings complement the results of UNWTO's *Tourism Towards 2030 – Global Overview* with a more detailed breakdown of surface modes of transport and information on average travel distances. With regards to domestic tourism, the study presents the first assessment of the evolution of domestic tourism to 2030, including regional and subregional breakdowns, as well as information on modes of transport and average travel distances. Both the projected growth and importance of domestic tourism are remarkable, with domestic arrivals representing more than 70% of all projected arrivals (international and domestic) in all regions for 2030 (and up to 96% in Asia and the Pacific).

Moreover, the study analyses the transport-related CO_2 emissions of the tourism sector using the ITF's non-urban transport passenger model. The *Climate Change and Tourism – Responding to Global Challenges* report published in 2008 concluded that 982 million tonnes of transport-related CO_2 were attributable to tourism in 2005. The results of the model attribute 1,597 million tonnes of transport-related CO_2 to tourism in 2016 (an increase of 62% from 2005) and forecast 1,998 million tonnes of transport-related CO_2 to be attributable to tourism in 2030[1] (an increase of 25% from 2016). This means that in a *current ambition scenario,* transport-related CO_2 emissions of the tourism sector will increase by 103% from 2005 to 2030 due to the growing demand, challenging the tourism sector's ambition to meet the targets of the Paris Agreement.

Transport-related CO_2 emissions of the tourism sector remain a major challenge and call for it to work closely with the transport sector in order to support its commitment to accelerate decarbonisation and the implementation of a *high ambition scenario.* Nevertheless, the tourism sector can no longer be just dependent on the decarbonisation strategies of related sectors and must determine its own additional *high ambition scenario* beyond transport; a scenario where tourism would transform and advance towards significantly decoupling growth from emissions in order to grow within the agreed targets. Transforming tourism for climate action requires embracing a low carbon pathway with awareness and optimization as key elements. Awareness – through measurement and disclosure of the emissions related to tourism activities and the setting of evidence-based targets. Optimization – through instruments and strategies to scale up mitigation and adaptation in the tourism sector with all stakeholders having to play a role. In this regard, developing a set of actionable policy recommendations in consultation with UNWTO Member States will be the next step to this study.

1 The findings for 2030 do not include transport-related CO_2 emissions from cruise as research is not available.

Annex 1

International tourism demand model

The proposed model for international tourism demand does not use complex formulas and region specific assumptions and parameters. Increasing complexity would likely improve results and the explanatory power of the model. Nonetheless, such a model would depend on all additional parameters remaining stable throughout the study period. As reality rarely remains stable over a longer period of time, it was found preferable to use a *simple* model that follows general economic trends and projections.

The model used to predict the demand for international tourism between two countries during the study period is described by the following formula, where on top of the notation introduced for domestic tourism,
d_{ij} stands for the *distance* between countries *i* and *j,* whereas
K_{ij} is also introduced, which takes the value of 1 if the two countries belong to the same region and 0 otherwise.

$$T_{ij}=Ce^{\delta K_{ij}}\frac{P_i^{\alpha I_i}(P_jI_j)^{\beta}}{d_{ij}^{\gamma}}$$

Estimates for the coefficients are given in table A1.1 below. There is no indication about the significance of individual parameters, because the calibration procedure is not standard. Indeed, the required data is not available; only regional aggregates are.

Table A1.1 **Calibration results for the international tourism demand model**

Variable	Coefficient estimate
Constant	2.2
Origin potential (income), 2005 (USD PPP)	0.0064
Destination potential (GDP), 2005 (USD PPP)	0.85
Distance (km)	-0.67
Same region	2.2

Note: PPP: purchasing power parity.

Annex 2

Domestic tourism demand model

Several factors affect the number of overnight tourist trips made within a country. The first one is income, by proxy of GDP per capita. There is a strongly significant relationship between income and the average number of overnight stays an average resident of a country makes, with an average direct elasticity of 0.7. However, the elasticity is not constant. Rather, it grows with income, even though stagnation – or even a decrease – of the number of overnight stays per inhabitants has been witnessed in some countries. This can be seen in figure A2.1, which shows the number of overnight stays per capita as estimated using the domestic tourism dataset against GDP per capita. To capture this phenomenon, we include three elasticity levels corresponding to different income groups.

Figure A2.1 **Number of domestic tourist arrivals per capita compared with GDP**

Note: Number of domestic tourist arrivals per capita compared with GDP.

Sources: Based on ITF (2019) and UNWTO data.

The number of overnight stays within a country also depends on the number of tourism destinations within that country. On average, this number is higher in larger or more inhabited areas, as well as in countries with higher GDP. In this model, we proxy the number of destinations by population.

The formula for the proposed model is, with
T_i the number of domestic tourist arrivals in country *i;*
P_i its population; and
I_i the average income.

$$log\left(\frac{T_i}{P_i}\right)=\alpha_k log\ (I_i)+log\ (P_i)$$

The index *k* in the parameter reflects the proposed differentiation for the elasticity by income group. Table A2.1 summarizes the results of the estimation.

Table A2.1 **Estimation results for the domestic tourism demand model**

Variable	**Coefficient estimate (standard error)**
Income, 2005 (USD PPP)	
Low-income countries	0.30 (0.05)
Middle-income countries	0.50 (0.03)
High-income countries	0.60 (0.03)
Population	0.15 (0.03)

Note: PPP: purchasing power parity.

Annex 3

ITF's non-urban passenger model

The ITF non-urban passenger model is an update and expansion of the 2017 ITF International Air model.[1] It models all non-urban passenger segments under one single modelling framework differentiating between inter-city travel and regional travel. The overall modelling framework is presented in figure A3.1.

The model is designed to evaluate the impact of various disruptive scenarios on non-urban travel. It is organized as follows:

1. **Inter-city passenger component**
   a) Propensity to travel: Poisson model with population and tourism activity as exposition factor. The model differentiates national to international travel, but also the different ranges of distances;[2]
   b) Destination choice model: Logit model that estimates the probability of attraction between city pairs giving their respective characteristics and their connectivity;
   c) Mode choice model: For each origin–destination (OD pair) a logit model is computed to assess the modal split given the attributes of existent (or plausible) transport alternatives. The existent services within a region, price, connectivity but also cultural elements are relevant for the probability of each mode of transport for each OD pair;
   d) Value-to-weight model: converts the trade in value into weight, given the economic profile of each OD pair but also the existing connectivity (log-sum indicator of the transport supply costs for the OD pair);
   e) Route choice model: assigns air traffic to all routing alternatives generated as possible, including the possibility of intermodality. Other modes are assigned to the shortest path; and
   f) Network update: given the expected population increase in each urban centre there is an assessment in each simulation year of the evolution of the network in four fronts: variation of frequency of services, creation of new service links (air or rail) or removal of air links, the variation of the presence of low cost carriers on an existing air link, and the upgrade of technology (energy source or type of rail service speed). These updates are performed as a function of the scenario.

1 International Transport Forum (2019).

2 The model differentiates for travel within EU, North America and other regions where no passport control is required.

2. Regional non-urban passenger component

a) Travel generation: Poisson regression model with socioeconomic variables and size of the country. The estimate retrieves the estimated total passenger-km of regional mobility within each country; and

b) Mode choice model: Logit model amongst surface transport alternatives. Each utility function includes variables representing the alternative (e.g. car ownership, rail network length).

3. Environmental assessment

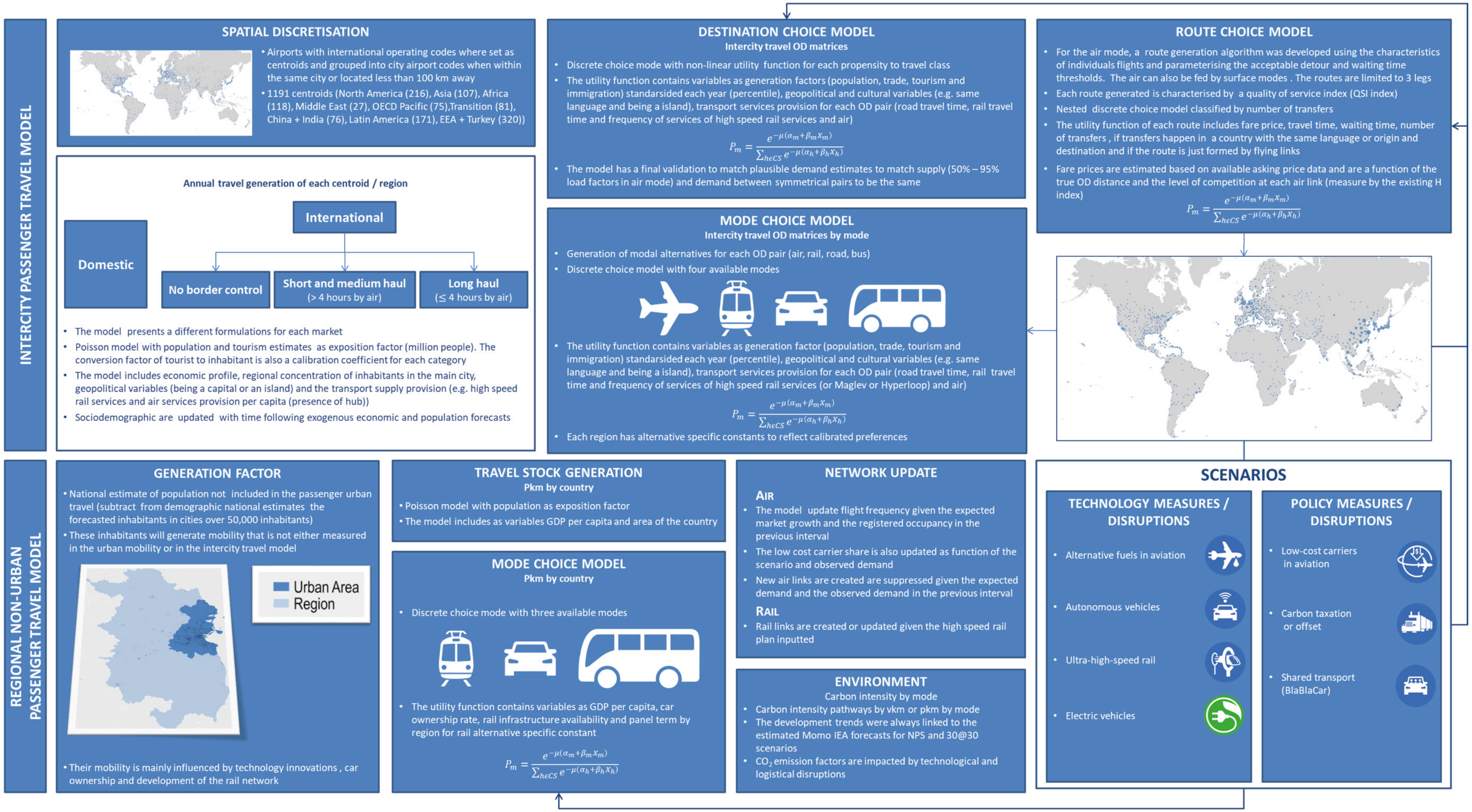
The CO_2 emissions of each OD pairs and mode are estimated for the intercity and regional component. The carbon intensity by mode is mainly derived from the IEA MoMo.[3]

As the present study only estimates overnight tourist arrivals, not all components of the model are taken into account. In particular, the ITF non-urban passenger model is used to provide the following information for the analysis of both domestic and international tourism:

- Modal shares on a country/country-pair level;
- Trip distances on a country/country-pair level by mode; and
- CO_2 emission factors per PKM travelled by mode and by region.

3 For more information on the Mobility Model: https://www.iea.org/etp/etpmodel/transport/.

Figure A3.1 **ITF non-urban passenger model**



Notes: Information on the model will be updated online by ITF by end 2019.

Source: International Transport Forum.

Annex 4

Current and high ambition scenario specifications

Table A4.1 **Current and high ambition scenario specifications for non-urban transport**

	Current ambition	High ambition
Mitigation measures		
Carbon pricing	US 100 per ton of CO_2	US 500 per ton of CO_2
Efficiency improvements and electric vehicles	Across regions the share of electric vehicles in use varies between 0.4% and 17.4% for cars and between 1% and 31.7% for busses.	Across regions the share of electric vehicles in use varies between 29.4% and 53.7% for cars and between 10.5% and 56.5% for busses.
Potentially disruptive developments		
Long-haul low-cost carriers	Very low share of low-cost carriers on long-haul flights (current trend).	
Energy innovations in aviation	Alternative fuel cost four times higher relative to 2015 conventional fuel prices. Range of electric planes increases up to 1,000 km by 2050.	Alternative fuel cost three times higher relative to 2015 conventional fuel prices. Range of electric planes increases up to 1,600 km by 2050.
Autonomous vehicles	Share of autonomous vehicles in use varies between 0% and 2.5% for cars and 0% and 1.25% for busses across regions.	
Shared mobility	The percentage of shared trips of total car trips equals 6.7%.	The percentage of shared trips of total car trips varies between 13.3% and 20% across regions.
Ultra-high-speed rail	High speed rail operational where current projects exist or are planned.	

Source: International Transport Forum.

Key definitions and terms

(provided by UNWTO and ITF)

Adaptation: Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities.

Anthropogenic: Resulting from activities of human beings.

Current ambition scenario: A scenario developed by ITF that reflects the continued implementation of existing mitigation policies, as well as announced mitigation commitments. The scenario includes potentially disruptive developments in the transport sector at current (i.e., non-disruptive) levels and technological assumptions that are broadly in line with International Energy Agency's New Policies Scenario.

Details can be found in the latest ITF *Transport Outlook:* https://doi.org/10.1787/transp_outlook-en-2019-en.

Destination of a trip: The main destination of a tourism trip is defined as the place visited that is central to the decision to take the trip.

Domestic tourism: Comprises the activities of a resident visitor within the country of reference, either as part of a domestic tourism trip or part of an outbound tourism trip.

Domestic tourism trip: A domestic tourism trip is one with a main destination within the country of residence of the visitor.

International tourism: International tourism comprises inbound tourism plus outbound tourism, that is to say, the activities of resident visitors outside the country of reference, either as part of domestic or outbound tourism trips and the activities of non-resident visitors within the country of reference on inbound tourism trips.

Is divided in this analysis and report into intraregional and interregional tourism.

Interregional tourism: Refers to tourist movements from one country to another country in another region.

Intraregional tourism: Refers to tourist movements from one country to another country within the same region.

Mitigation: An anthropogenic intervention to reduce the output or enhance the sinks of greenhouses gas.

Non-urban transport: Transport happening outside of urban areas.

Region: Refers to the countries covered by a given UNWTO Regional Commission, together with non-member countries in the same geographical region. This definition was adopted for strictly geographical and technical reasons. Regions and subregions used for this study are broken down according to UNWTO's geographical distribution of Member States.

For detailed information on UNWTO regions please consult: www.unwto.org.

Same-day visitor: A visitor (domestic, inbound or outbound) is classified as a tourist (or overnight visitor), if his/her trip includes overnight stay, or as a same-day visitor (or excursionist) otherwise.

Tourism: Tourism comprises the activities of persons travelling to and staying in places outside their usual environment for not more than one consecutive year for leisure, business and other purposes.

Tourism destination: A tourism destination is a physical space with or without administrative and/or analytical boundaries in which a visitor can spend an overnight. It is the cluster (co-location) of products and services, and of activities and experiences along the tourism value chain and a basic unit of analysis of tourism.

A destination incorporates various stakeholders and can network to form larger destinations. It is also intangible with its image and identity which may influence its market competitiveness.

Tourist: A visitor (domestic, inbound or outbound) is classified as a tourist (or overnight visitor), if his/her trip includes an overnight stay, or as a same-day visitor (or excursionist) otherwise.

Travel/traveller: Travel refers to the activity of travellers. A traveller is someone who moves between different geographic locations, for any purpose and any duration.

Trip: A trip refers to the travel by a person (visitor) from the time of departure from his/her usual residence until he/she returns; it thus refers to a round trip. Trips taken by visitors are tourism trips.

Usual environment: The usual environment of an individual, a key concept in tourism, is defined as the geographical area within which an individual conducts his/her regular life routines.

Visitor: A visitor is a traveller taking a trip to a main destination outside his/her usual environment, for less than a year, for any main purpose (business, leisure or other personal purpose) other than to be employed by a resident entity in the country or place visited. A visitor can be categorized as same-day visitor or as overnight visitor (i.e. tourist) if his/her trip includes an overnight stay – with the latter being accounted in statistical terms as domestic tourist arrivals or international tourist arrivals.

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CO_2	carbon dioxide
GDP	gross domestic product
GHG	greenhouse gas
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
IEA	International Energy Agency
IEA MoMo	International Energy Agency's Mobility Model
ITF	International Transport Forum
kg	kilogram
Mt	1 million tonnes = 1 mega tonne
NO_x	nitrogen oxides
OD pairs	origin–destination pairs
OECD	Organisation for Economic Co-operation and Development
PKM	passenger kilometre
SDGs	Sustainable Development Goals
SIDS	small island developing states
SO_2	sulphur dioxide
TTW	tank-to-wheel
UN DESA	United Nations Department of Economic and Social Affairs
UN Environment	United Nations Environment Programme
UNWTO	World Tourism Organization
WMO	World Meteorological Organization

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The number of tourists travelling across borders is expected to reach 1.8 billion a year by 2030, according to the latest UNWTO predictions. This will be alongside a further 15.6 billion domestic tourist arrivals. Such growth will bring many opportunities, including socioeconomic development and job creation. At the same time, however, greenhouse gas emissions linked to tourism-related transport are also rising, challenging the tourism sector's ambition to meet the targets of the Paris Agreement.

UNWTO and ITF embarked on this research project with the aim of providing evidence of the CO_2 emissions from tourism and the implications of the different modes of transport. The report provides insights into the evolution of tourism demand across the different global regions up to the year 2030. It also presents the expected transport-related CO_2 emissions of the tourism sector against the current ambition scenario for the decarbonization of transport.

The **World Tourism Organization (UNWTO),** a United Nations specialized agency, is the leading international organization with the decisive and central role in promoting the development of responsible, sustainable and universally accessible tourism. It serves as a global forum for tourism policy issues and a practical source of tourism know-how. Its membership includes 159 countries, 6 territories, 2 permanent observers and over 500 Affiliate Members.

The **International Transport Forum (ITF)** at the OECD is an intergovernmental organization with 60 member countries. ITF is the only global body for all modes of transport and works for transport policies that improve peoples' lives. Acting as a think tank for transport policy, its mission is to foster a deeper understanding of the role of transport in economic growth, environmental sustainability and social inclusion, and to raise the public profile of transport policy.

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