AUCKLAND UNLIMITED REPORT

The carbon footprint of Auckland tourism

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Executive Summary

Auckland is committed to ambitious actions to reduce emissions and prepare for the impacts of climate change. At the same time, the city experienced a fast-growing tourism sector, and it is expected that tourism continues to form an integral part of the Auckland economy after COVID-19. Decarbonising tourism is a critical element of future-proofing the sector. The first step in achieving this is to systematically measure the carbon footprint. Understanding tourism's greenhouse gas emissions profile will inform Auckland's tourism planning and management.

Building on the academic literature on carbon footprinting in tourism, two methods were applied. One draws on the top-down approach using national and regional statistics provided by Stats NZ. This method focused on three relevant industry groupings, namely: 'Accommodation, food, and arts and recreation', 'Transport', and 'Tourism related industries'. Since this is a production-focused approach, only those emissions that are directly associated with businesses/industry are included. Fuel consumed by visitors in their rented or personal vehicles is not included. Furthermore, emissions associated with electricity generation are not included as these represent an indirect input into a tourism business.

The other method involved a bottom-up approach focused on accommodation, local transport and attractions. The calculations follow the logic of:

*Carbon footprint = volume of tourists * activity volumes * carbon intensity*

For example, the emissions associated with hotels would be derived by identifying the total number of tourists who stayed at a hotel, multiplied with the number of nights spent on average and the carbon emissions per guest night. As is explained in detail in the methodology section, it is difficult to compare these two approaches due to their different approaches and scopes.

In addition, and to complement the two destination-focused methods, it was deemed important to estimate the carbon emissions associated with travel *to* Auckland (international aviation, domestic travel and cruise ships). Whilst some methods of destination footprinting take a strictly territorial (geographic) approach, it is increasingly recommended as good practice that a destination considers the climate impact of transport emissions resulting from tourists getting to their place of visitation. These may count as indirect emissions, but are still an important element of a destination's carbon risk and liability.

The results of the top-down method provided a timeline of carbon emissions, indicating an increase since 2014 – explained by the growth of the sector. In 2018, total emissions attributed to tourism reached 1,190 kilo-tonnes of CO2-e. Transport related to tourism industries was the largest contributor to emissions at 76.9%, whereby a significant part related to domestic air travel from Auckland. Accommodation contributed 16.9% of the total tourism footprint. Other tourism-related industries only made up 6.2% of emissions. Tourism's share of emissions in Auckland was 11.7%.

The bottom up account of emissions resulting from Auckland accommodation (including staying with friends/relatives), attractions, and local transport results in 216 kilo-tonnes of CO2-e emissions. This is a conservative estimate due to the narrow scope. Again, transport was the largest contributor. This means that low carbon transitions are required for transport corridors to popular attractions, both within Central Auckland and to regions. In terms of accommodation, the relative importance of emissions associated with visitors staying in private houses was apparent. A regional analysis of activity patterns was attempted, but more refined data are required for improved analysis.

By far the largest contributor to climate change is international air travel by international visitors to Auckland with 3,513 kilo-tonnes of CO2-e. Domestic visitors and their associated (domestic) air travel, car and ferry emissions added 236 kilo-tonnes, and cruise ship passengers emitted 24 kilo-tonnes (with a high level of uncertainty). However, allocating cruise emissions to specific ports of visit is fraught with difficulty. The findings outlined in this report can be easily misinterpreted. Cruise justifies a depth of analysis that lies beyond the limitations of this report.

This inaugural work on the carbon footprint of tourism in Auckland provides a first baseline, but more work is required to refine the analysis. Several areas for improving the data availability and quality were identified. In the meantime, however, this analysis revealed that tourism is a significant contributor to emissions, and within that transport deserves particular attention. Moreover, non-transport emissions also add substantially to the tourism footprint.

Key recommendations are made for decision-making in the areas of tourism (and other) policy, product development, marketing and, data and research. It is suggested to conduct market analyses to inform a marketing optimisation strategy that is based on rigorous insights into the carbon implications of different visitor segments. Reporting and dissemination of information and advice are also important to further improve awareness and industry practice.

Introduction

Auckland tourism

Auckland is New Zealand's largest urban area by population with 1,571,718 inhabitants (Stats NZ, 2018). It is home to landmarks such as the Sky Tower, the Auckland Art Gallery Toi o Tāmaki, the Harbour Bridge, parks, restaurants, theatres, many museums and two scenic harbours. It also hosts a range of iconic cultural and sporting events, most notably at the time of writing the America's Cup 2021. In 2019, Auckland received a substantial 2.75m international visitor arrivals and 5.47m domestic overnight visits. These generated a total of 7.56m commercial bed nights and total tourism spend of $8.6 billion (Auckland Tourism, Events & Economic Development [ATEED], 2019).

Auckland's tourism sector has averaged 8.4% growth over the last ten years (Infometrics, 2020) and has also averaged 6.6% growth in international visitor arrivals per annum over the last five years (ATEED, 2019). Additionally, in 2019 Auckland's tourism sector made up 29% of New Zealand's regional tourism spend (MBIE, 2020) and employed an average of 65,973 people in Auckland (i.e., 7.3% of Auckland's total employment) (Infometrics, 2020).

In November 2020, ATEED (now Auckland Unlimited), Auckland's economic development agency and a council-controlled organisation, released its first climate change and sustainability report. The sustainability of the visitor economy forms an integral part of the City's plan. Understanding the carbon footprint of tourism is therefore an important step in delivering the vision.

Auckland's commitment to climate action

Auckland is committed to ambitious actions to reduce emissions and prepare for the impacts of climate change. As part of the C40 group of 94 major cities working together on climate action, Auckland aims to deliver on the 1.5 degrees Celsius global emissions reduction target (Auckland Council, 2019). Auckland's targets and leadership has earned C40 Innovator City status from the global C40 Cities Climate Leadership Group (Auckland Council, 2019).

In 2012, Auckland committed to 40% emissions reduction by 2040 with an interim goal of 10-20 per cent reduction by 2020 (Auckland Council, 2019). In addition to joining the C40 Cities Climate Leadership Group in 2015, Auckland and central Government agreed on a strategic approach to reduce transport-related GHG emissions and guide the development of Auckland's transport system over the next 30 years. Also, Auckland has committed to transition to fossil fuel free streets by procuring only zero-emission buses from 2025 and ensuring a major area of Auckland city is zero carbon by 2030 (Auckland Council, 2019). Te Tāruke-ā-Tāwhiri: Auckland's Climate Plan has the goal of reducing the city's greenhouse gas (GHG) emissions by 50% by 2030 and achieving net zero emissions by 2050.

Based on work undertaken by Motu Economic and Public Policy Research (2016) the baseline consumption emissions in Auckland amount to 5.96 tonnes per capita. This assumes an average number of 2.5 people living in one household occupancy with an average household income of $81,067. Using a different methodology and more recent data to derive a production-based account, Stats NZ (2020a) arrive at a per capita footprint for Auckland of 7 tonnes per annum. Per unit of Gross Domestic Product (GDP), Auckland's emissions were lower than those in other regions.

Auckland's carbon footprint is shown in Figure 1. The methodology followed the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (the GPC) developed by several organisations, including the World Resources Institute (WRI et al., 2014). Transport emissions dominate, followed by those related to industrial processes. Relevant to the tourism context are commercial emissions and those related to the residential sector.

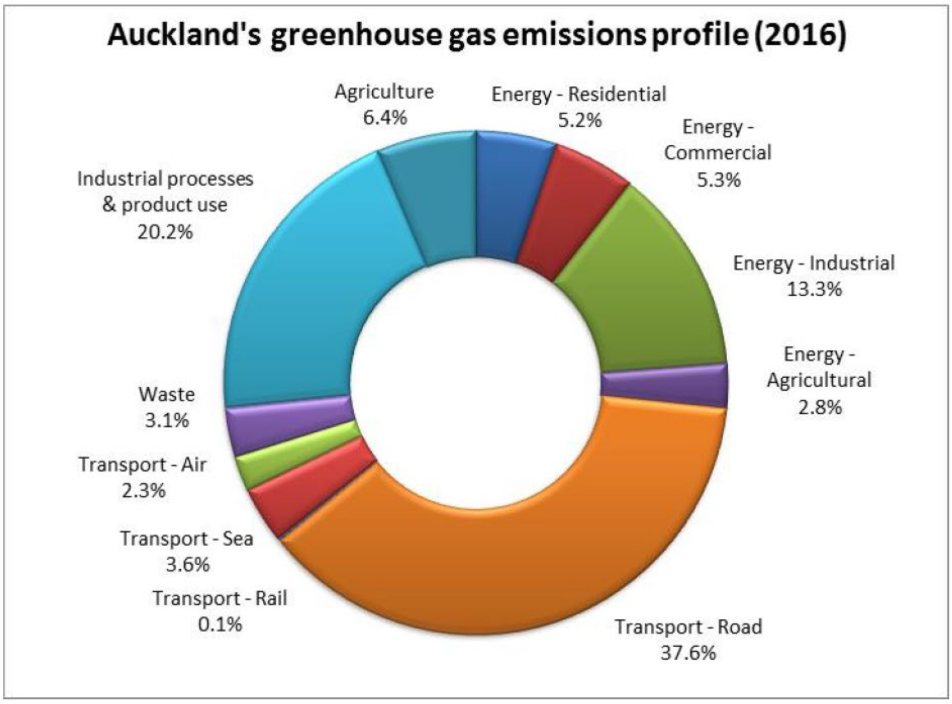

Figure 1 Greenhouse gas inventory of Auckland City in 2016 (Source: Xie, 2019).

Purpose of this report

The Auckland visitor strategy, Destination Auckland 2025 (2018), articulates a sustainable vision for Auckland's visitor economy and seeks to manage the impact of the visitor economy so that Auckland benefits from tourism across all dimensions of sustainability.

The Strategy was developed prior to the outbreak of the COVID-19 global pandemic which has had a significant impact on tourism in Auckland. ATEED are in the process of developing a series of climate and sustainability actions in collaboration with key partners that will guide the recovery of the visitor economy towards a more resilient, adaptable and low impact – or ideally regenerative – sector.

Decarbonising tourism is a critical element of future-proofing the sector. The first step in achieving this is to systematically measure the carbon footprint associated with tourism, and monitor changes so to capture the impact of interventions and improvements over time. Thus, this report provides a method for monitoring tourism's GHG emissions, and it will provide a baseline for pre-COVID-19 tourism. The carbon footprint will serve to:

- Understand tourism's contribution to Auckland's overall footprint.
- Inform future tourism planning and management.
- Help devise marketing strategies towards low-carbon segments.
- Specify particular research questions that inform decarbonisation measures.

Background

The United Nations Sustainable Development Goals 2015-2030 (SDGs) and the Paris Climate Agreement 2015 (L'Accord de Paris) signal the urgent need for transformation in order to stabilize global average temperatures below +2°C relative to preindustrial levels (UNFCCC, 2015). Many Paris signatories have committed to the more ambitious +1.5° C target" (Scott, Hall, & Gössling, 2016), and the IPCC (2018) highlighted the significant differences in impact between a 1.5 and 2.0 degree world.

Tourism is a major source of global carbon emissions (Lenzen et al. 2018). It is clear that global and regional tourism systems must rapidly decarbonize over a thirty-year period (IPCC 2018) alongside other economic sectors, in order for global climate stabilization goals to be achieved (Scott, Hall and Gössling, 2019). Reducing emissions in tourism subsectors is difficult because of infrastructure lock-in and the high cost of technology change (Larsson et al. 2019; Peeters et al. 2016). The tourism industry therefore faces carbon risks in the implementation of mitigation policies (Scott, Gössling, Hall & Peeters 2016). A key starting point is to conduct carbon analyses that can inform new tourism development strategies and decarbonisation policies (Scott et al. 2019; UNFCCC 2019).

The New Zealand government is committed to the Paris Agreement (Ministry for the Environment, 2020) and to move to a low carbon economy (Climate Change Commission, 2021). The Parliamentary Commissioner for the Environment (2021) has recently highlighted the need for new destination management models that, among other things, must account for the high carbon footprint of New Zealand tourism (Sun & Higham, 2020). However, until recently a lack of comprehensive carbon accounting in government data and reporting systems has hitherto been a barrier to addressing the current deficient in tourism carbon policy settings. Since Stats NZ have begun including tourism in national emission accounts, this situation could be addressed, although higher granularity of data would be beneficial (e.g. industry sub-categories, regional differences).

Information asymmetry is a term that describes the strong historic focus on economic measures in tourism system accounting. The economic impacts of tourism have long been measured, reported and celebrated in various forums ranging from the annual national tourism publications (World Travel and Tourism Council, 2020), to regional assessments by national tourism bureaux, and local event impact studies. In contrast, tourism carbon performance is rarely available to inform tourism policy because relevant information is not directly compiled and traced in the national Greenhouse Gases Inventory. The first calls to expand tourism statistics to include a comprehensive tourism carbon analysis was proposed fifteen years ago (e.g., Becken & Patterson, 2006; UNWTO, 2008; WTTC, 2009; Scott et al., 2010), yet tourism carbon analysis, reporting and policy remain neglected or incomplete.

The absence of comprehensive national measures of tourism carbon emissions continues to represent a failure that has hindered the implementation of tourism climate policy at multiple levels, including providing sectoral specific mitigations targets, workable actions, and measures of progress to hold key actors accountable (Becken et al., 2020). Consequently, most national GHG emissions reduction policies remain limited to voluntary instruments (UNWTO, 2019a). The lack of well-defined national tourism carbon mitigation policies will only continue in the absence of performance measures that are based on measurable carbon mitigation targets.

To date, fewer than ten countries have developed a comprehensive tourism carbon evidence base and only Sweden, Canada, Italy and New Zealand have compiled rigorous tourism emissions data (UNWTO, 2019b). New Zealand's system of national accounts is comprehensive. It includes the Tourism Satellite Account (updated annually), energy end use database (updated annually), and national input-output tables (updated once every 5 years). These data sources have been deployed in a recent macro level top-down analysis of New Zealand tourism carbon performance based on the most up to date datasets (2007-2013) (Sun & Higham, 2020).

Within the New Zealand national context, regional and urban destinations have a critical role to play in reducing tourism emissions. Destinations represent regionally defined clusters of tourism stakeholders who can work collaboratively to move onto a net zero emission trajectory. Destination low-carbon transitions will require critical consideration of value generation (Scott et al. 2019) to reduce the focus on tourism volume and offset reduced arrivals through such avenues as increased value and length of stay, combined with reduced economic leakage from national and regional tourism systems (Gössling & Higham, 2020).

Market optimization represents one approach towards a net zero emissions trajectory (Oklevik et al. 2019). Optimisation involves actively managing the destination market mix in order to attract closer rather than more distant markets, given the link between distance and transport carbon emissions under current transport regimes (Smith & Rodger 2009). Reducing air transport dependence in relation to total tourist travel is critical (Peeters et al. 2016; Lenzen et al. 2018). Marketing to domestic tourists, serves to both attract closer regional visitors, while lowering aggregate outbound tourism carbon emissions. The re-orientation of New Zealand tourism marketing arising from the COVID-19 international border closure offers rich opportunities to further develop relative low-carbon regional (domestic) tourism markets. In doing so, destinations must also advance transport infrastructure investment and regional transportation policies aimed at encouraging the use of low-carbon transport modes (Hopkins and Higham 2016).

The United Nations World Tourism Organization (UNWTO) has recently commented that the "*tourism sector continues to need more evidence on essential climate-related information that is needed for better decision making*" (UNWTO, 2019). Fundamental to tourism decarbonization is the development of tourism policy that is based on rigorous data and analysis. A new data and reporting architecture is required to overcome information asymmetry. Such an architecture should regularly report on the tourism carbon footprint as well as benchmarking and decarbonisation trajectories. While the development of such reporting systems is underway at the national scale, the same analytical approaches are required at the level of regional/urban destinations and individual businesses, to inform policy interventions and measure progress towards tourism decarbonisation.

Methodology

Overview of approaches

Whilst some associate tourism with particular industries, such as hotels or cruise ships, technically the tourism sector is not defined by the goods or services it produces, but instead derives from the type of consumers who engage in a range of activities that are linked to goods and services. The UNWTO defines visitors as:

> *"…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 (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" (UNWTO, 2021).*

The implication of this definition is that tourism is defined based on consumption rather than production. This makes accounting difficult and required a tourism-specific solution to understanding the impacts of visitor-related activities. The Tourism Satellite Account was created to extract tourism from the System of National Accounts and allow measurement of tourism's economic contribution to Gross Domestic Product, employment, and other metrics (UN, 2008).

Similarly, tourism does not appear in national carbon accounts, as it forms part of a wide range of other (traditional) industries, including transportation, retail, and hospitality. It is therefore not straightforward to develop a carbon account for tourism.

Broadly, there are two approaches, top-down and bottom-up (Becken & Patterson, 2006). Both would typically report on the six Kyoto greenhouse gases. These are: carbon dioxide (CO_2); methane (CH_4); nitrous oxide (N_2O); hydrofluorocarbons (HFCs); perfluorocarbons (PFCs); and sulphur hexafluoride (SF_6). To simplify reporting, these are aggregated into one metric of carbon dioxide equivalents, or CO_2-e. Figure 2 provides a simple overview of the different ways of approaching the Auckland carbon footprint. More detail is provided below.

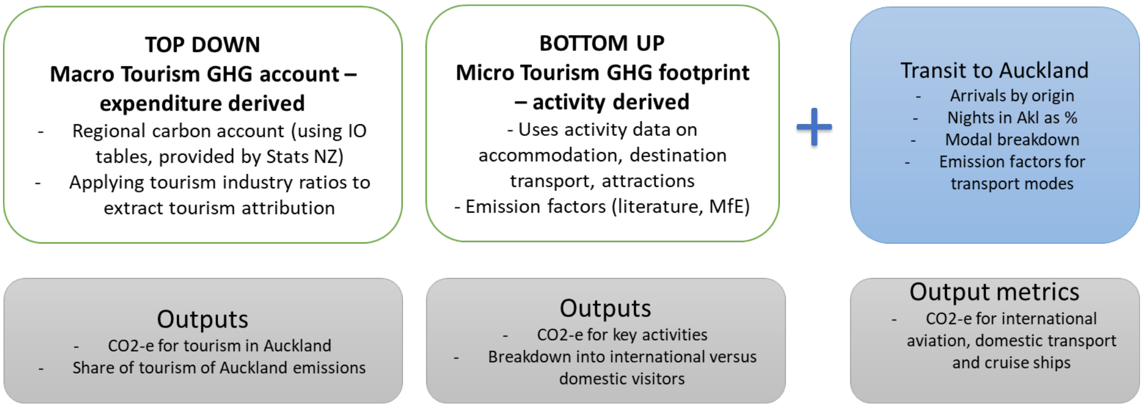

Figure 2 Simplified overview of different approaches.

Top-down methodology

Top-down approaches rely on national accounts for economic activity and GHG emissions. The core idea of Integrated Economic-Environmental Accounting is to provide a macro-economic approach for understanding the links between economic activity/behaviour and environmental impacts. New Zealand builds on the standard framework for developing Integrated Economic-Environmental Accounts developed by the United Nations through the SEEA system[1]. A recent example of a top-down analysis is provided by Pham et al. (2020) who used the TSA framework in combination with Australian's national carbon emission framework to derive a detailed tourism footprint for Queensland.

Statistics New Zealand (Stats NZ, 2020b) provide a detailed explanation of the different approaches to GHG accounting. This present work builds on the so-called *production* approach that focuses on the source of emissions within the 'supply-side'. There are two sub-types of accounting within the production approach, namely the territory-based and residency-based accounting. For the destination footprint of Auckland, the residency-based approach is suitable. It aligns with the principles of the United Nations System of Environmental-Economic Accounting (SEEA) framework.

The national SEEA produced by Stats NZ has already been extended to consider tourism, and this can also be done at a regional level, noting that industries might have to be collapsed due to confidentiality and quality constraints. Furthermore, as a top down model, the uncertainties magnify the more disaggregated data becomes. The benefit of the SEEA approach is that environmental outputs can be contrasted with economic measures (e.g. GDP).

The residency principle requires to assess whether the 'unit' of interest is resident to the region of interest (in this case Auckland), in other words whether their 'centre of economic interest' is in Auckland. Stats NZ provides the example of cruise ships to illustrate this point. Since cruise ships in New Zealand waters are foreign-owned, they are not considered economic residents. This means their emissions are not captured in the production based, resident-focused approach.

In SEEA, emissions are allocated to the 'operator' of the technology/process at the point at which the emission occurs and flows to the atmosphere. For transport, for example, this means that emissions resulting from petrol consumption are allocated to the person/company controlling the vehicle. For transport as an industry, which includes taxis, buses, rail transport, rail freight, water transport, water freight, and air freight, this means that emissions are allocated to these industries. Thus, emissions from taxis go to this industry as they are the 'operator' of the vehicle, the passenger doesn't control the fuel burn and emissions. However, for private vehicle (fuel) use, the emissions go to the individual person and are then accounted for under residential or household emissions. This is the case for domestic travellers, which means that tourism-related fuel use by New Zealanders is not reflected in the tourism emission accounts but forms part of household[2].

Electricity is different because the technology and processes are controlled by the power generating companies. The household/hotel etc may switch on the lights, but this is not the point of production (which is at the power plant). It is therefore not included.

Stats NZ also produce a (macro-level) consumption-based approach within the SEEA framework. This 'demand-side' approach focuses on the consumption of goods and services and the emissions embodied in their production process. It therefore takes the consumer as the end point and connects all emissions throughout the supply chain, that is direct and indirect emissions[3].

This macro 'consumption-based' approach is not to be confused with extracting the tourism component from the production focused emission account. When determining industry/supply side emissions through the SEEA framework, just like in the Tourism Satellite Account, it is important to determine those outputs/emissions that can be attributed to tourism. This is achieved through industry ratios.

Bottom-up methodology

This approach requires a separate analysis of GHG emissions for key tourism industries. The key steps are:

- Identify which 'tourism industries' are within scope.
- Compile GHG (or at least CO2) emission factors related to the consumption of goods or services of these industries.
- Obtain data on visitor activity, i.e. volumes of tourists who engage in a particular activity/industry.
- If possible, disaggregate visitor activity into different markets or tourist types.

The benefit of this approach is that it provides a micro-perspective of tourist behaviour and carbon intensities at the business or activity-level. Analyses therefore provide insights into business operations and potential future interventions to improve carbon efficiency. The collection of carbon intensity data, for example carbon dioxide-equivalent emissions per passenger kilometre, is useful in itself as it helps compare the environmental impact of different transport modes used by visitors. Sun et al. (2020) provide a useful inventory of tourism studies that followed some type of bottom-up approach (Table 1).

[3] To illustrate the difference between the production and consumption approach, Statistics NZ (2020) provide the following example: "…consider an Air New Zealand flight from Auckland to Wellington with New Zealand residents and international tourists on board. The operator is Air New Zealand." From the production perspective within the SEEA, the emissions from the "flight are allocated to New Zealand because what is taken into consideration is the residence of the operator, not the passengers. That some of the passengers are international tourists is significant only from a consumption perspective, in which the share of emissions attributable to international tourists is counted as an export and the share from New Zealanders are included in the estimate of consumption-based emissions."

TABLE 1 TOURISM EMISSIONS STUDIES USING BOTTOM-UP APPROACHES (SOURCE: SUN ET AL., 2020)

Application types	Research study, context and reference
Global tourism	United Nation World Tourism Organization (WTO-UNEP-WMO, 2008).
National tourism	New Zealand (Becken & Patterson, 2006), Norway (Aall, 2011), Sweden (Gössling & Hall, 2008), Switzerland (Perch-Nielsen, Sesartic, & Stucki, 2010), the Netherlands (Eijgelaar, Peeters, de Bruijn, & Dirven, 2017), Maldives, China (Z. Tang, Shang, Shi, Liu, & Bi, 2014) and several Caribbean islands (Gössling, 2013).
Regional tourism destinations	Whistler, British Columbia, Canada (Kelly & Williams, 2007), Penghu island, Taiwan (Kuo, Lin, Chen, & Chen, 2012), the Wulingyuan Scenic and Historic Interest Area, China (C. Tang, Zhong, & Jiang, 2017), and Barcelona, Spain (Rico, et al., 2019)
Tourism itinerary / tourism activity	Brazil (Pereira, Ribeiro, & Filimonau, 2017), New Zealand (Becken, Simmons, & Frampton, 2003), Netherlands (Eijgelaar, et al., 2017), Antarctic (Eijgelaar, Thaper, & Peeters, 2010; Farreny, et al., 2011); Australia (Byrnes & Warnken, 2006); Canada (Dawson, Stewart, Lemelin, & Scott, 2010), China (Huang, Cao, Jin, Yu, & Huang, 2017), Saudi Arabia (El Hanandeh, 2013), and others (Gössling, et al., 2005).
Sector	Hotel (Cerutti, et al., 2016; Filimonau, Dickinson, Robbins, & Huijbregts, 2011; Oluseyi, Babatunde, & Babatunde, 2016; Puig, et al., 2017; Rosselló-Batle, Moià, Cladera, & Martínez, 2010; Tsai, Lin, Hwang, & Huang, 2014), and amusement park (Wang, Wang, Ko, & Wang, 2017)

The bottom-up method is compatible with carbon accounting as outlined by the Greenhouse Gas Protocol (2021) and the key principles should be applied. These are Relevance, Completeness, Consistency, Transparency and Accuracy. Importantly, the Greenhouse Gas Protocol introduces the notion of scopes so to separate direct and indirect emission sources.

- Scope 1, which includes direct GHG emissions that occur from sources that are owned or controlled by the company (e.g. fuel consumption, gas for cooking etc.).
- Scope 2, which relates to electricity consumed by the company.
- Scope 3, which refers to indirect emissions that are related to a company but occur outsides its direct environment, for example staff travel or supply chain emissions. Emissions from waste disposal also form part of Scope 3 accounting.

Comparison of approaches

The top-down and bottom-up approaches are complementary and serve different purposes. They also draw on different data sources. Table 2 provides an overview of the differences.

TABLE 2 COMPARING THE TOP-DOWN (MACRO) AND BOTTOM-UP (MICRO) APPROACHES, ALONGSIDE TRANSPORT TO THE DESTINATION

	Macro-account (production)	Micro-account	Transport to destination
Framework	SEEA Central Framework	GHG Protocol (Scope 1+2)	GHG Protocol (Scope 3)
Purpose	Understand macro-economic contribution of an industry to resource flows	Generate detailed understanding of behaviours (i.e. tourist decisions) that result in resource use and emissions	Measure the direct emissions resulting from transportation.
Supply chain	Direct emissions from producing units (stationary and mobile combustion)	Only direct emissions at source plus electricity (see below)	Direct emissions from transport (fuel combustion)
Electricity	Not included	Included as Scope 2 emissions	Included in the carbon intensity of electric transport
Petrol	Included through transport industries or household consumption	Included in carbon intensity of transport mode	Included in carbon intensity of transport mode
Imports	Not included	Not included	Not included
Non-tourism industry	Included as tourism-related industries (via industry ratio)	Not included	Not included
Geographic relevance	Predominantly within Auckland, includes any direct emissions occurring outside of Auckland (e.g. travel) by producing unit and domestic aviation to Auckland.	Within Auckland, but electricity could come from outside	Outside Auckland

Proposed method for Auckland tourism footprint

This section provides more detail on the methods and assumptions made for the specific task of providing a baseline for Auckland tourism GHG emissions. The year 2019 was chosen as a suitable base year based on data availability and the extraordinary circumstances that arose in early 2020 due to the global pandemic.

Top-down approach

Following the generic explanation of the macro-economic approach that follows the guidelines of the SEEA framework (see above), it was possible to extract an estimate of tourism CO2-e emissions for key industries in Auckland.

Since the focus is on tourism production, emissions associated with tourists directly are only included when they connect to some part of the tourism industry or tourism activity. This means that fuel used by tourists does not form part of this production-focused account. However, fuel used for own-use by rental companies is allocated to the rental industry, with the share of those emissions attributable to tourism being dependent on total output of the rental industry coming from tourism (i.e. the tourism industry ratio).

More specifically, for the Auckland production-based tourism carbon footprint the following steps were necessary:

- Draw on the regional emission account produced by Stats NZ (and specifically Auckland, see Appendix A).
- Use national industry ratios to determine the tourism share. Since Auckland forms a considerable part of the national ratios this simplification is acceptable, even though actual industry ratios for Auckland might differ slightly from national figures.
- Apply industry ratios to relevant industry codes (collapsed into categories that ensure confidentiality.

Statistics New Zealand assisted with extracting and combing the relevant data and provided a timeline from 2007 to 2018. Unfortunately, 2019 data were not available at the time of the research.

Bottom up account of key tourism activities

This section details the specific method developed to derive emissions for key tourist activities, namely accommodation, local transport and visits to attractions. Each section follows the logic of this formula:

Carbon footprint = volume of tourists * activity volumes * carbon intensity

For example, the emissions associated with hotels would be derived by identifying the total number of tourists who stayed at a hotel, multiplied with the number of nights spent on average and the carbon emissions per guest night. To derive each tourist activity and carbon intensity data, several assumptions were necessary. These are explained in more detail below.

Accommodation

This section provides an explanation on how 'accommodation visitor activity' and carbon intensities were derived for different categories.

Visitor activity

Tourist accommodation data were derived from the Commercial Accommodation Monitor (CAM) (see Stats NZ, 2019). The September 2019 (YE)[4] reports were used to determine the volumes of international and domestic visitor guest nights and the visitor guest nights by accommodation type such as hotels, motels/apartments, backpackers, and holiday parks. Given that the months of October, November and December were from 2018 it is likely that the data represent an under-estimate of visitor activity. Also, the CAM misses data on smaller accommodation, thus energy use associated with hosted accommodation such as Bed & Breakfasts is not accounted for.

The specific steps taken include:

- Identified the total numbers of international and domestic visitor commercial accommodation guest nights in Auckland in 2019 (YE September).
- Identified the total number of commercial accommodation guest nights in Auckland in 2019 (YE September) by accommodation type. There were no details on visitor nights by accommodation type and disaggregated into international and domestic visitors.
- Used the CO_2-e estimate derived from the literature to determine the carbon footprint for each accommodation type. That is, the total number of visitor nights was multiplied by the estimated factor. See Table 3 below for carbon intensities.

<u>Emission intensities</u>

There is a growing body of literature on the carbon intensity of tourist accommodation (Warren & Becken, 2017). The different studies highlight the vast diversity of values, depending on geographic location, business type and various other factors. It was therefore decided to collate New Zealand-specific estimates, even if they are dated.

Table 3 shows the suggested carbon intensity to be used for the Auckland carbon footprint. This was derived based on expert assessment of the existing intensities and consideration of trends since the time the respective studies were conducted. For example, since 2001 (the year of a New Zealand study on energy use and carbon intensity) businesses are likely to have invested into energy efficiency, slightly reducing emissions. On the other hand, more visitors carry with them devices that need charging. This would add to the per-guest-night energy demand.

TABLE 3 CARBON INTENSITIES (CONSUMPTION-BASED) DERIVED FROM THE LITERATURE WITH A FOCUS ON NEW ZEALAND

Category	Description	Factor	Unit: CO2-e per	Source
Hotel (NZ)	Based on business surveys	7.90	Per visitor-night (kg)	Becken et al. (2001)
Hotel (NZ)	MfE data	12.80	Per room-night (kg)	Ministry for the Environment, 2020
Hotel (global average)	Benchmarking data	26.80	Per visitor-night (kg)	EarthCheck global database
Hotel (global average)	Cornell hotel study	17.47	Per room-night (kg)	Cornell and Greenview
Estimate for AKL hotels 2019		**10.00**	**Per visitor-night (kg)**	
Motel New Zealand	Based on business surveys	1.40	Per visitor-night (kg)	Becken *et al*. (2001)
Motel New Zealand	Based on business surveys	2.56	Per visitor-night (kg)	Becken & Cavanagh (2003)
Estimate for AKL motels 2019		3.00	**Per visitor-night (kg)**	
Backpacker (NZ)	Based on business surveys	1.62	Per visitor-night (kg)2	Becken et al. (2001)
Backpacker (NZ)	Based on business surveys	2.12	Per visitor-night (kg)	Becken & Cavanagh (2003)
Backpacker (NZ)	Based on energy audits	3.60	Per visitor-night (kg)	Becken (2013)
Estimate for AKL backpackers 2019		**3.60**	**Per visitor-night (kg)**	
B&B (inc. boats and farmstay)	Based on business surveys	4.14	Per visitor-night (kg)2	Becken et al. (2001)
Estimate for AKL Bed&Breakfast 2019		**4.10**	**Per visitor-night (kg)**	

Campgrounds (inc. cabins, huts)	Business survey	1.36	Per visitor-night (kg)2	Becken et al. (2001)
Holiday Park (NZ)	Based on energy audits, lowest value	0.37	Per visitor-night (kg)2	Becken (2013)
Holiday Park (NZ)	Based on energy audits, highest value	2.27	Per visitor-night (kg)2	Becken (2013)
Estimate for AKL campgrounds 2019		**2.00**	**Per visitor-night (kg)**	

In addition to commercial accommodation it was necessary to derive a carbon intensity for staying in a private Auckland household. This is to ensure that visitors who reportedly stayed with 'friends and relatives' are also accounted for in the carbon footprint. This was achieved as follows:

- Derived data for international and domestic visitors who reported 'Visiting Family and Relatives' (VFR) from the Auckland Visitor Survey (AVS, 2020).
- Identified the average length of stay (nights) for international visitors VFR in Auckland in 2019 (9.5 nights).
- Identified the overall average length of stay (nights) for domestic visitors visiting Auckland in 2019 (1.97 nights). As the average length of stay nights for domestic visitors VFR was not available, the overall average length of stay was used.
- Derived the guest nights for international and domestic visitors by multiplying VFR visitors by the average stay.
- Used a C02-e estimate (see Table 4) for staying in a private home in Auckland to multiply that with the number of VFR guest nights.

TABLE 4 CARBON INTENSITY OF STAYING AT A PRIVATE HOME IN AUCKLAND

	Volume	Unit
Residential sector, stationary energy only (from Xie, 2019)	591,332	Tonnes of C02-e
Population size (Stats NZ)	1,571,718	People
Per capita average emissions (Auckland)	0.38	Tonnes of C02-e
Per capita per night (divided by 365)	1.03	Kilograms of C02-e

Local transport

Very little is known about the local mobility patterns of visitors in Auckland. Whilst tracking is possible via technologies such as mobile phone pinging or GPS tracking, such data were not available for this analysis. Such a big-data driven approach could form part of future in-depth studies of destination-based visitor flows.

Visitor activity

In the meantime, tourist mobility was derived from visitation data available from the Auckland Visitor Survey. The December 2019 report was used to determine the share of visitors who reported having travelled to North, East, South, West Auckland or the Hauraki Golf. The specific steps taken were:

- Use proportion of the total volume of international and domestic visitors to Auckland who visited the five sub-regions within Auckland.
- Based on information on the types of attractions or locations visited within each of these sub-regions, a plausible distance (return) from the Auckland CBD was determined, and this was assumed for each visitor.
- In addition, a return travel distance from Auckland airport to the CBD was allocated for all international visitors and domestic visitors. Whilst many domestic visitors would not have arrived by air, they would have still had to enter the Auckland City boundary at some point, and the airport is a good proxy for this.
- Used information on the proportion of visitors who travelled by car, public transport (rail or bus), or other (the difference to 100%) to identify suitable emission factors.
- For visitors to Hauraki Gulf Islands, Waiheke Island was assumed as a proxy and an emission factor for water transport was applied.

Emission intensity

The Ministry for the Environment (2020) provides vehicle emission factors for different transport types. Since there are no data on the type of car tourists were using, a standard petrol car was assumed.

It is not known to what extent tourists used bus or rail, and emission intensities vary vastly for the different options. Further, there was no specific information on what ‘other’ meant, and the emission factor for ‘taxies’ was assumed. It is understood that ‘other’ could also mean zero-carbon walking or biking. The following factors were used in the calculation.

- Private petrol car: 0.264657 kg of CO2-e per vehicle kilometre for domestic tourists. This was divided by a factor of 2 on the assumption that there were two passengers on average.
- Rental petrol car: 0.210709 kg of CO2-e per vehicle kilometre for international tourists. This was divided by a factor of 2 on the assumption that there were two passengers on average.
- Public transport: the carbon intensity of ‘Average Bus’ was assumed, using the value of 0.108391263 kg of CO2-e per passenger kilometre.
- Taxi was assumed for ‘other transport’ with 0.224697 kg of CO2-e per vehicle kilometre.
- Ferry emission data was obtained from the Auckland air emissions inventory 2016 (Auckland Council, 2018). Passenger numbers were available from Auckland Transport (2019). The calculated average emissions per ferry passenger amounted to 5.6 kg.

Does the above approach for local transport under- or overestimate emissions?

The following assumptions affect the estimate of GHG emissions from local tourist transport.

Under-estimate:

- Most visitors would have made several journeys that are not recorded in the visitor survey (e.g. to drive to the supermarket, to visit a friend), leading to an under-estimate in travel distance.
- Travel within a subregion is unknown, for example tourists to North Auckland may have visited several places. This means that travel distance is likely underestimated.
- If the average number of passengers in a car is lower than 2 then the carbon emissions per passenger are higher than estimated.

- *Over*-estimate:
  - The carbon intensities used for cars were not the most efficient vehicles. If a substantial share of visitors uses modern cars or electric cars, then emissions might have been over-estimated.
  - If there were more than 2 passengers in a car then the carbon footprint per passenger is lower than assumed in this work.
  - If people who indicated public transport mainly used electric buses or rail then the carbon intensity used here is too high.
  - If the remaining share of transport which was declared to be 'other transport' was mainly walk or bike than the assumed carbon intensity of taxis resulted in an over-estimate of emissions.

Overall, the under-estimate of travel distance is likely to outweigh the over-estimate of carbon intensities. This means that the carbon emissions of local transport are likely to be a conservative estimate.

Attractions

Visitor activity

The analysis of emissions arising from tourist activities drew primarily upon two key data sources; the ATEED (December 2019) Auckland Destination Overview and the Auckland Visitor Survey (AVS) (2020). These sources provided current (pre-COVID) visitor data, specifically total visitor numbers (international and domestic), and a breakdown of international and domestic visitors to six regions within the study area, as expressed as a percentage of total international and domestic tourists. Data was available for six regions, Central Auckland, North Auckland, South Auckland, West Auckland, East Auckland and the Hauraki region. The ten attractions most visited by international and domestic tourists were expressed as percentages of total visitors to those regions. The classification of places visited included both 'attractions' (e.g., Sky City) and 'activities' (e.g., Queen Street).

These data sources provided quite specific insights into similarities and differences between the attractions visited and activities engaged by international and domestic visitor markets. The five attractions most visited by international visitors based on AVS (2020) were: Sky Tower, Auckland Museum, Auckland Art Gallery, Mount Eden and Waiheke Island. The five attractions visited by domestic tourists based on AVS (2020) were: Sky Tower, Auckland Museum, Auckland Zoo, Sky City Casino and Kelly Tarlton's.

Emissions intensity

The emission intensities of different types of attractions drew upon the previously published work of Becken & Patterson (2006). In this paper the authors present emission intensity estimates for six general categories of attractions types as measured in grams of CO_2 per visitor (Table 5); non-CO_2 emissions are not included. These emissions intensities allowed for Auckland attractions to be identified and classified within this six-fold categorization. Total carbon emissions could then be calculated based on total visitor numbers.

The assignment of attractions to different emissions categories (Table 5) does require some explanation. Nature-based activities feature prominently among Auckland visitor attractions, particularly is some of the sub-regions (most notably Hauraki Gulf). In reference to nature-based visitor activities, Becken & Patterson (2006) specify:

1. Nature attractions (417g per visitor): These are nature activities that are publicly available (e.g., beach visits, bush walks). They are likely to have low emissions per person.
2. Nature recreation (1674g per visitor): This category refers to visitor settings that include some forms of visitor provision that may include sales offices, cafeteria, souvenir shops, heating and perhaps shuttle van services, all of which require electricity or gas.

The assignment of specific visitor attractions to broad emissions intensity categories is an inexact science. Some that fall into the 'nature attractions' category will inevitably have lower emissions than others. Indeed given that transport to and from the activity site is excluded from this part of the analysis (i.e.

accounted in the estimates made for local transport), it may be that some have emissions per person that are close to zero (e.g., Rangitoto Island). The same applies to other categories. The Manukau Lighthouse and Sylvia Park are both buildings (172g per person) and are unlikely to have similar emissions per person.

TABLE 5 EMISSION INTENSITIES (CONSUMPTION-BASED) FOR DIFFERENT TYPES OF ATTRACTIONS

Type of attraction	Emission intensity (grams of CO2 per participation)
Buildings (e.g. museums)	172
Nature attraction	417
Air activity	27,697
Motorised water activity	15,312
Adventure recreation	2,241
Nature recreation	1,674

Assumptions and limitations

Our analysis assumes the rigour of the Auckland Destination Overview (2019) and the Auckland Visitor Survey (2020). These sources provide the most up-to-date pre-COVID data based on comprehensive sampling procedures.

- The visitor numbers and emissions attributed to visitor attractions within each of the six study sub-regions are presented in aggregate form only for reasons of confidentiality.
- Individual attractions were not contacted to request 2019 visitor numbers (international and domestic) to cross check the AVS (2020).
- The top 10 attractions in each of the sub-regions, for both international and domestic tourists, are included in this analysis. Attractions that fall outside the top 10 in each of the sub-regions are not included in the calculations. This approach captures the more popular visitor attractions but is not cumulatively inclusive of all attractions.
- Transport to attractions/activity locations is excluded from our analysis, to avoid double counting of emissions arising from the analyses of transport emissions (see 5.2.3).
- We assume that international and domestic tourists have the same emission intensities associated with visits to the same attractions. Given that transport to attractions was excluded this seems reasonable.

Emission intensities for attractions and activities are derived from Becken and Patterson (2006) based on research that was conducted over fifteen years ago. While this represent the most current and comprehensive emission intensities currently available, it is noted that these are likely to have been dated by the passage of time.

Visits to urban locations such as Queen Street, K Road, Devonport, and Ponsonby are defined as ‘activities’ as opposed to ‘attractions. Such activities are likely to be engagements in shopping activities and/or dining (cafés and restaurants). These activities are not included in the current analysis. Inclusion of activities in this analysis would require data that address the activities that take place at these locations, and the emission intensities of those activities.

Transport emissions to Auckland

The emissions associated with tourists travelling to Auckland fall under Scope 3 in the Greenhouse Gas Protocol. Reporting is not mandatory but there are good reasons for measuring them. Previous research has shown that transport to the destination results in significant emissions and it would be untransparent to not disclose them (e.g. Pham et al., 2020). The Parliamentary Commissioner for the Environment (2021) argues that tourism must account for Scope 3 emissions, including international aviation emissions. The Climate Change Commission (2021) draft report, which is currently open for submissions, does not address international aviation emissions directly but they are included in their current modelling and their likely inclusion from 2024 is clearly signalled.

A discussion can be had whether emissions associated with travel to a destination should include the whole journey, that is return travel, or whether only one way of the trip should be included in an emission inventory. Previous literature (e.g. Becken, 2002; Becken & Shuker, 2018) has opted for attributing one-way emissions to the destination, with the logic that the other half of the return trip is attributable to the place of origin. Should Auckland wish to include the full journey, then all Scope 3 transport emissions presented here need to be doubled.

There are three different types of 'arrival flows', namely those linked to international air travel, domestic tourism, and cruise ship tourists.

International aviation

International visitors to New Zealand typically arrive by air, and the majority do so by via Auckland International Airport. However, some visitors begin their journey in other international airports (predominantly Christchurch) but might depart from Auckland. It is difficult to trace those patterns in the absence of detailed visitor flows data.

The starting point of any footprint analysis related to international air travel is the total number of visitors to New Zealand by country of origin (Appendix B, Stats NZ, 2020c). The next step is to identify the number of nights spent in Auckland by market, and in New Zealand as a whole. This allows calculation of a ratio of Auckland nights, which can then be used to apportion carbon to Auckland as one regional destination among others in New Zealand (Table 6).

ATEED provided data on the top 8 markets visiting Auckland, which was derived from the number of visitors arriving at Auckland International airport. The volumes for the other markets had to be estimated. First, an average share of 76% (visitors to Auckland out of total visitors to New Zealand) was calculated, based on the top 8 markets. In other words, 76% of international tourists visit Auckland. However, when applying this share to the remaining 22 markets, the total volume of visitors to Auckland fell substantially short of ATEED's number of 2.75 million international tourists for 2019. When applying a ratio of 90% to all countries, then the total number of international tourists to Auckland reached 2.6 million. This was deemed acceptable.

Second, Table 6 below presents information on length of stay. It is important to note that the available data for length of stay in New Zealand are only available as the median, whereas data for Auckland are arithmetic means. This leads to a positive ratio for the United Kingdom. There are two other issues with the data in Table 7 below. The first relates to different accounting frames (March versus December) and the other one that length of stay for the markets outside the top 8 had to be derived from averages across all visitors to New Zealand and Auckland.

TABLE 6 LENGTH OF STAY IN AUCKLAND AND NEW ZEALAND (INFORMATION FOR MARKETS OUTSIDE THE TOP 8 REPRESENTS AVERAGES AS NO SPECIFIC DATA WAS AVAILABLE)

Origin	2019 (AKL)	Nights spent in AKL (YE Mar 2020)	Nights spent in NZ (Median YE December 2019)	Ratio of nights in AKL
Australia	865,515	4.9	7	0.70
China, People's Republic of	341,754	3.7	8	0.46
United States of America	289,665	5	6	0.83
United Kingdom	169,858	11	6	1.83 (replaced by 1)
Germany	71,556	10.7	23	0.47
Japan	87,879	6.4	18	0.36
Korea, Republic of	64,382	4.6	13	0.35
Canada	60,350	5.4	9	0.60
India	60,098	6.5	11.3	0.57
Singapore	58,117	6.5	11.3	0.57
Hong Kong (SAR)	48,348	6.5	11.3	0.57
Taiwan	48,108	6.5	11.3	0.57
Malaysia	37,601	6.5	11.3	0.57
France	36,699	6.5	11.3	0.57
Fiji	30,267	6.5	11.3	0.57
Netherlands	27,303	6.5	11.3	0.57
Samoa	25,789	6.5	11.3	0.57
Thailand	25,540	6.5	11.3	0.57
Indonesia	24,927	6.5	11.3	0.57
Philippines	24,755	6.5	11.3	0.57

South Africa	23,666	6.5	11.3	0.57
French Polynesia	23,662	6.5	11.3	0.57
Switzerland	19,473	6.5	11.3	0.57
Tonga	19,219	6.5	11.3	0.57
New Caledonia	18,670	6.5	11.3	0.57
Brazil	14,909	6.5	11.3	0.57
Sweden	13,080	6.5	11.3	0.57
Spain	12,755	6.5	11.3	0.57
Argentina	12,686	6.5	11.3	0.57
Cook Islands	12,632	6.5	11.3	0.57

Note: The GHG emissions associated with international air travel are largely determined by travel distance. Table 7 below provides estimates of travel distances between countries of origin and Auckland. These are based on Becken (2002) and an online tool that helps determine flight distance (www.distance.to). The average emission intensity per passenger-kilometre differs for medium and long-haul flights and this is reflected in the different emission factors (see MfE, 2020). Furthermore, emission factors take into account the non-CO_2 impacts of emissions in the upper troposphere on radiative forcing.

TABLE 7 DISTANCES TO KEY MARKETS AND EMISSION FACTOR BASED ON MFE (2020)

Origin	Travel distance to Auckland	Emission factor (MFE) CO2-e (kg/pkm) with RF
Australia	3,000	0.1555
China, People's Republic of	9385	0.1909
United States of America	12000	0.1909
United Kingdom	18353	0.1909
Germany	18565	0.1909
Japan	8806	0.1909
Korea, Republic of	9641	0.1909
Canada	11500	0.1909
India	12400	0.1909

Singapore	8410	0.1909
Hong Kong (SAR)	9233	0.1909
Taiwan	8950	0.1909
Malaysia	8825	0.1909
France	19024	0.1909
Fiji	2158	0.1555
Netherlands	18,753	0.1909
Samoa	2894	0.1555
Thailand	9570	0.1909
Indonesia	7665	0.1909
Philippines	8012	0.1909
South Africa	24190	0.1909
French Polynesia	4094	0.1909
Switzerland	18588	0.1909
Tonga	1882	0.1555
New Caledonia	8806	0.1909
Brazil	12334	0.1909
Sweden	17860	0.1909
Spain	19735	0.1909
Argentina	10338	0.1909
Cook Islands	3015	0.1555

Domestic tourists

Data on domestic travel was provided by FreshInfo, drawing on the AA domestic travel data year ended 2019. The data included volumes of visitors by New Zealand origin, and length of stay in Auckland. Information on how many nights domestic visitors stayed in Auckland as a part of their whole trip was not available, and it was decided to attribute transport emissions to Auckland in full. This results in a slight over-estimate if visitors also travelled to other destinations as part of the same trip.

In addition, it was necessary to estimate average travel distances for domestic visitors from different regions. This was achieved by assuming one central point of origin (e.g. Dunedin for Otago) and using two online calculators for air and road distance, respectively (Table 9). The calculators were:

- Air Travel Distance: https://airport.globefeed.com/New_Zealand_Distance_Between_Airports.asp
- Road Travel Distance: https://www.aa.co.nz/travel/time-and-distance-calculator/

In addition, an average share of air versus road arrivals was estimated. Since there was no data on this, a simple rule was created as follows:

- 90% of visitors from origins in the North Island close to Auckland were assumed to arrive by car.
- 20% of visitors from origins in the North Island further away from Auckland were assumed to arrive by car.
- 10% of visitors from origins in the South Island other than Otago, Southland and West Coast were assumed to arrive by car. Those three remaining origins were assumed to have a drive share of 5%.

The same emission factor for 'private cars' was applied as in the method described for local transport emissions. Further, a factor of 2 was applied to account for an estimated average load factor of two passengers per vehicle. For air travel, the emission factor for short-haul travel was used (0.15553 kg CO_2-e per passenger-kilometre) and for the 100km journey on the Cook Strait Ferry (for South Island drive tourists) the carbon intensity of 0.16518 kg CO_2 per passenger-kilometre was used from Becken and Patterson (2006) (note that this figure does not include non-CO_2 GHGs).

TABLE 8 DOMESTIC TOURISTS' ORIGIN AND TRANSPORT RELATED ASSUMPTIONS

Origin	Visitor nights	Avg length of stay	Assumed city of origin	Assumed % of drive visitors	Drive (km)	Fly (km)	Ferry (km)
Auckland	2,880,711	1.76	Auckland	1.00	30	0	0
Bay of Plenty	1,259,965	1.85	Tauranga	0.90	144	206	0
Canterbury	706,901	2.54	Christchurch	0.10	745	975	100
Gisborne	94,889	2.28	Gisborne	0.20	335	481	0
Hawke's Bay	362,067	2.16	Napier	0.20	328	412	0
Manawatu-Wanganui	463,601	2.16	Wanganui	0.20	329	445	0
Marlborough	52,128	2.59	Blenheim	0.10	508	673	100
Nelson	138,777	3.02	Nelson	0.10	496	750	100
Northland	1,222,639	1.96	Kerikeri	0.90	209	242	0
Otago	279,515	2.51	Dunedin	0.05	1,062	1,328	100
Southland	79,462	2.32	Invercargill	0.05	1,174	1,557	100
Taranaki	446,352	2.21	New Plymouth	0.20	229	358	100
Tasman	76,042	2.24	Picton	0.10	488	636	100
Waikato	1,633,934	1.77	Hamilton	0.90	106	121	0
Wellington	1,291,833	2.30	Wellington	0.20	480	644	0
West Coast	47,898	2.76	Greymouth	0.05	680	986	100
TOTAL	11,036,713	1.97					

Cruise ships

Cruise ship tourism is the most difficult to measure, and the methodology presented below will require future refinement. Emissions from this type of tourism therefore only represent an indicative and very conservative estimate of cruise emissions attributable to Auckland only. This approach cannot be considered reflective of the total carbon footprint associated with the cruise industry in New Zealand, which is known to be high (Howett, Revol, Smith & Rodger, 2010).

Statistics New Zealand (2020d) provides cruise ship passenger numbers for Auckland and the rest of New Zealand (Table 9) for Year Ended June. This means that the data used here as 2019 refer to July 2018 to June 2019, raising some issues around comparability with the other transport data. Overall, the impact of different timeframes is unlikely to materially affect results. Based on these data is possible to derive a share of passengers to Auckland as one of their ports. In 2019, for example, 74.3% of all cruise ship passengers visited Auckland.

TABLE 9 STATISTICS NZ (2020D) CRUISE SHIP VOLUMES

	2015	2016	2017	2018	2019
Auckland(1)(3)	179,430	217,243	193,220	211,352	238,975
Total	194,451	237,383	221,536	259,489	321,841
Share visiting AKL	**92.3%**	**91.5%**	**87.2%**	**81.4%**	**74.3%**

Based on a more detailed breakdown into countries of origin and the above ratios, it is possible to estimate the number of cruise ship passengers to Auckland by market (Table 10).

TABLE 10 CRUISE SHIP PASSENGERS TO AUCKLAND BY REGION/MARKET

	2015	2016	2017	2018	2019
Australia	84,128	107,410	82,373	90,352	107,098
New Zealand	94,276	119,156	95,732	92,806	116,441
Asia	13,376	17,980	10,512	20,670	19,700
Europe	17,645	21,564	24,153	20,476	20,207
Americas	28,066	27,574	32,970	40,169	44,637
Other	590	724	550	767	766
Total	238,081	294,409	246,289	265,240	308,849

Statistics New Zealand has undertaken some analysis on cruise ship tourism. Based on analysis for 2015–2020, it emerged that about 75% of cruise ship passengers who visit New Zealand are transit passengers. The remaining quarter are passengers who enter or leave New Zealand by air. This means that they are already captured in arrival statistics at the airport. The combination of fly-cruise packages is not uncommon. It seems fair to assume that a 75% share of the cruise ship passengers in Table 10 above are not counted and need to be considered in a different way to complement the air travel footprint. Crew are not included in the carbon calculations.

It is not known what cruise itineraries these passengers participated in, and any assumption carries substantial levels of uncertainty. It is proposed to assume a travel distance on the vessel of 1,240 km around New Zealand water. This was based on a popular route provided by Viking Ocean Cruises (see https://www.vikingcruises.com.au/oceans/cruise-destinations/asia-australia/australia-new-zealand/index.html). It is acknowledged that several other itineraries exist and future research could explore the carbon footprint of different cruise packages.

For all passenger except those from New Zealand, it was assumed that in addition to the 1,240 km distance on a cruise ship around New Zealand, tourists would have completed an international journey of 2,463 which corresponds to the one-way distance from Sydney to Auckland. It is understood that not every cruise ship passenger would have come from or via Australia. However, this is a conservative estimate, noting that any other assumption (e.g. fly from America) would result in a higher carbon footprint.

The carbon intensity is taken from Carnival Cruise ships and their sustainability reporting in 2017, when the figure of 250 gCO2-e per available berth kilometre (ALBkm) was made public.

Finally, assuming a 10-day cruise itinerary, of which one day is spent in Auckland requires us to apportion the Auckland share to the cruise ship emissions. This is achieved by multiplying CO2-e emissions with a factor of 10%.

Results

The results will first present findings from the top-down analysis, followed by bottom-up results. These are structured into local emissions and transport emissions arising from visitors travel to Auckland.

Regional tourism footprint – top down approach

The top-down approach to carbon footprinting in Auckland focused on three categories:

- accommodation, food, arts and recreation;
- transport, including 'rental and hiring services', 'air, road, rail, and water transport' and 'other transport, transport support, and travel and tour services' (this does not include international aviation, but does include some domestic air travel);
- tourism-related industries (education and retail trade).

The timeline in Figure 3 provides some interesting information that can be extracted from the regional emission account after applying tourism industry ratios. Notably, tourism carbon emissions have grown since 2014, but before that they had been stagnant or even declining slightly. In 2018, total emissions attributed to tourism reached 1,190 kilo-tonnes of CO2-e. Second, tourism-related transport is the largest contributor to emissions at 76.9% in 2018. Just under one third of the transport emissions allocated to tourism is due to domestic aviation from Auckland. Further, in 2018, accommodation contributed 16.9% of the total tourism footprint. Other tourism-related industries only made up 6.2% of emissions.

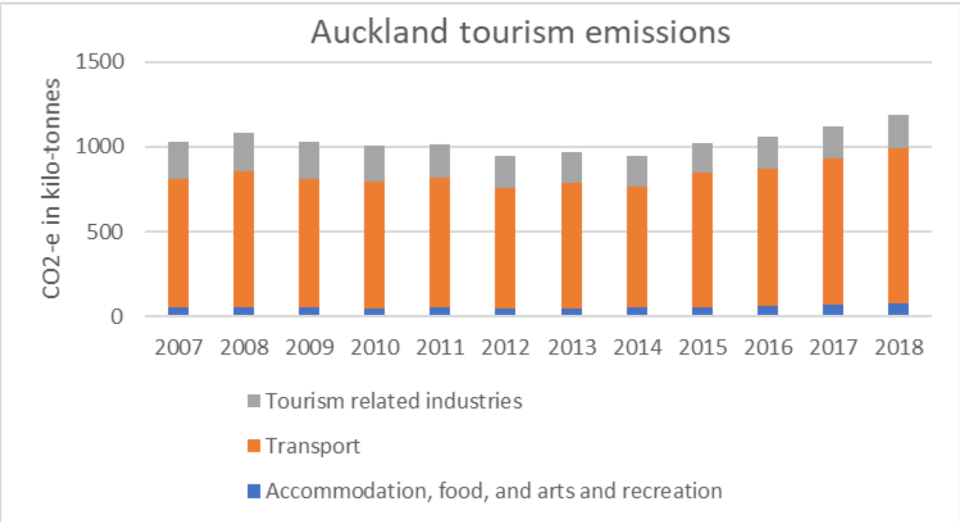

Figure 3 Carbon emissions attributed to tourism in Auckland for three broad categories (Source: data provided by Statistics New Zealand).

Tourism's emissions can be contrasted with total emissions in Auckland. Total Auckland emissions are available from Stats NZ's (2020a) regional greenhouse account. To avoid double counting, the tourism emissions were first deducted from the Auckland total and then a share was derived (Figure 4). In 2018, this share was 11.7%.

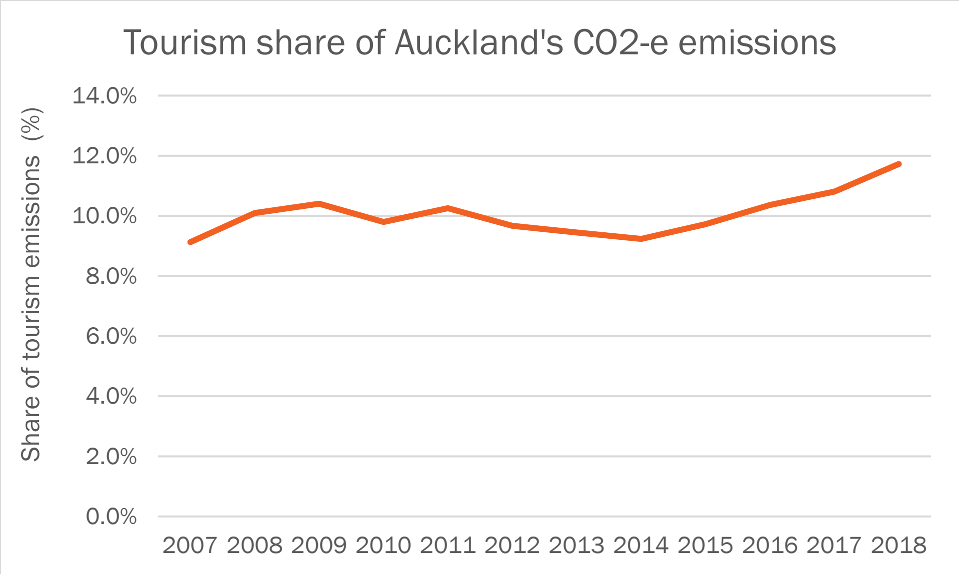

Figure 4 Share of tourism production emissions relative to all emissions in Auckland.

Furthermore, when deducting tourism-production related emissions (see three categories above) from 'Services' related emissions, it is possible to display a tourism component as part of Auckland's regional GHG account (Figure 5). All non-service sectors shown in Figure 5 remain unchanged from the regional emission accounted provided by Stats NZ.

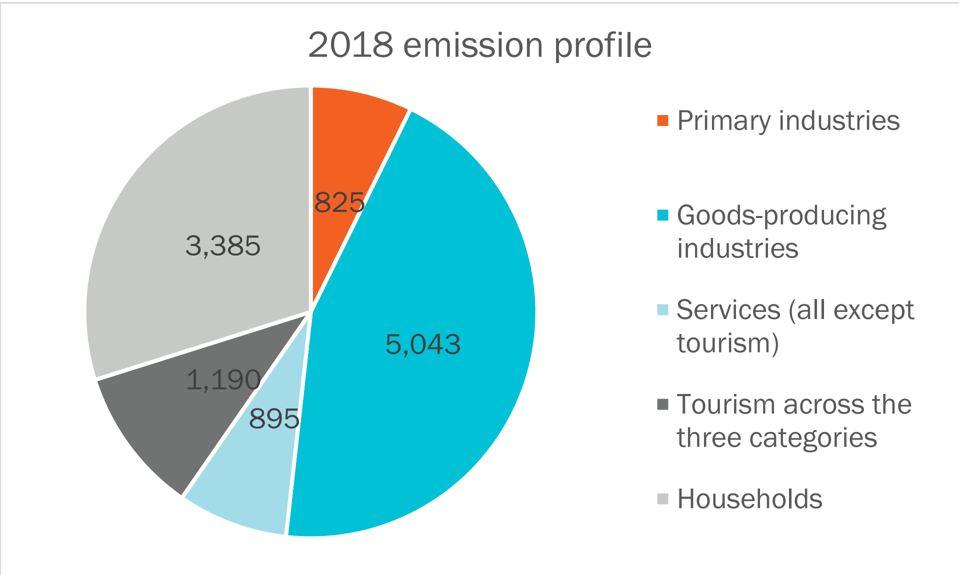

Figure 5 Tourism production emissions (in kilo-tonnes) relative to all industry and household emissions in Auckland in 2018.

Activity based carbon footprint – bottom up approach

This section provides a brief overview of three key bottom-up sectors, namely accommodation, local transport and attractions. It then presents more detailed results on each sector.

Overview to show accommodation, attractions, transport

The bottom up account of emissions resulting from Auckland accommodation (including staying with friends/relatives), attractions, and local transport results in 216 kt of CO2-e emissions. This is a conservative estimate due to the narrow scope. Furthermore, for attractions, non-CO2 emissions are not included, which leads to a slight underestimate compared with the two other categories.

Similar to the top-down assessment, the largest contributor to emissions is transport with 133 kt of CO2-e (62%). One third of emissions (32%) is due to accommodation and the rest comes from attractions (Figure 6). It is important to note that restaurants, cafes and retail activities are not included; however, these could contribute significantly to emissions.

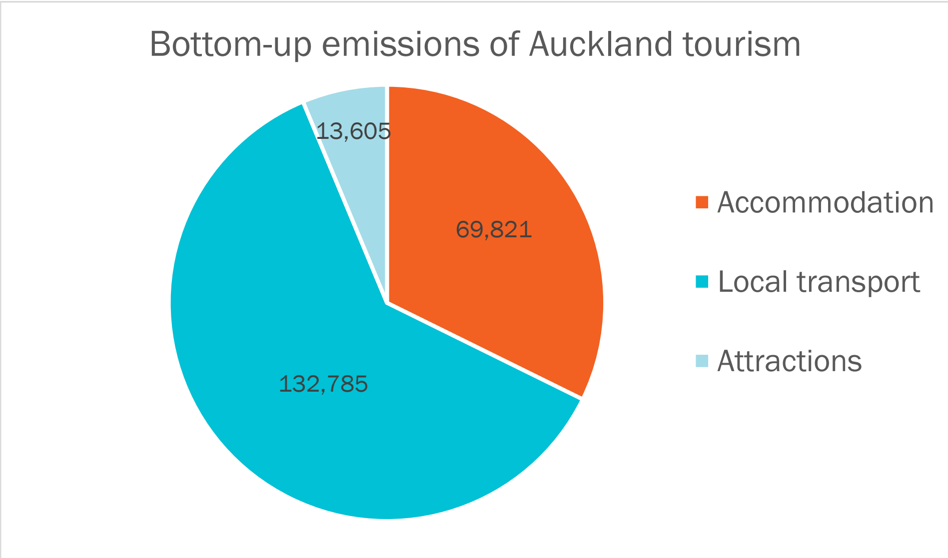

Figure 6 Overview of CO2 (in tonnes) Auckland tourism emissions by sector.

Accommodation

Commercial accommodation comprises of different categories, including hotels, motels/apartments, backpackers, and holiday parks. The total estimated emissions for commercial accommodation amounts to 56,123 tonnes of CO2-e. This would represent about 9% of all commercial sector emissions in Auckland when compared to 2018 levels of 600 kt of CO2-e (Xie, 2019). In addition, the estimate of emission for private homes is 13,698 tonnes of CO2-e. These are added to commercial accommodation emissions shown in Figure 6.

Among the commercial accommodation types, hotels contribute the most emissions (85%). This is both due to the number of tourists who opt for hotel accommodations (compared to other commercial accommodation types) and hotels' higher carbon intensity per guest night. Overall, for commercial accommodations, international tourism contributes more emissions (53%) than domestic tourism (47%). This is likely due to the higher proportion of domestic tourists who travel as visiting friends and relatives visitors (VFR) and stay in Auckland homes (Figures 7 and 8).

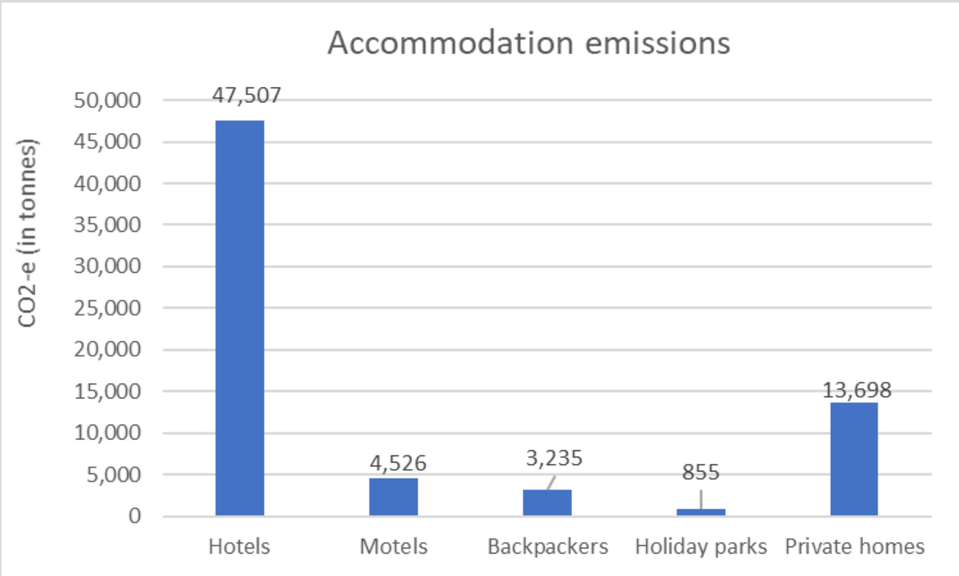

Figure 7 Accommodation emissions by accommodation type in Auckland combined for international and domestic visitors.

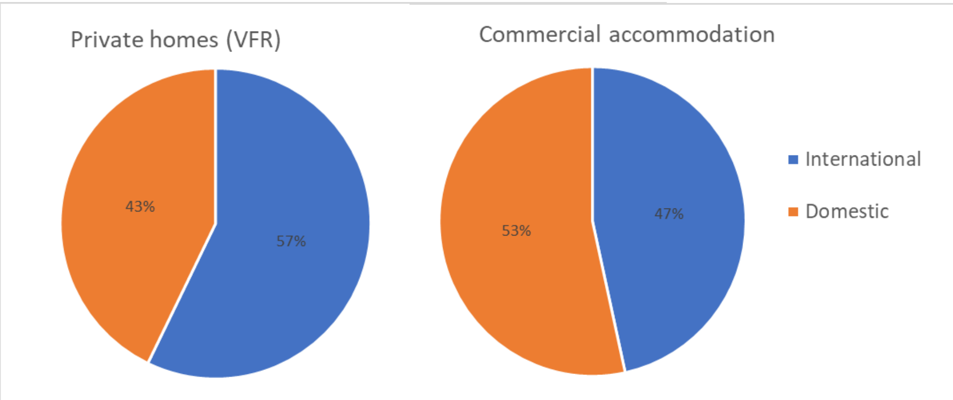

Figure 8 Share of accommodation emissions by visitor type in Auckland.

Local transport

Local transport emissions are made up of car, public transport, other (assumed to be taxi) and ferry emissions. The total 2019 emissions amount to 132,785 tonnes of CO_2-e. This would equate to about 3% of Auckland transport emissions as measured in the 2016 greenhouse gas inventory (Xie, 2019).

Overall, domestic tourism contributes more than international tourism. This is mainly due to larger use of a personal car (82.5% of car emissions) and ferries (64.4% of ferry emissions). For public transport and other transport, the emissions are almost evenly split (Figure 9).

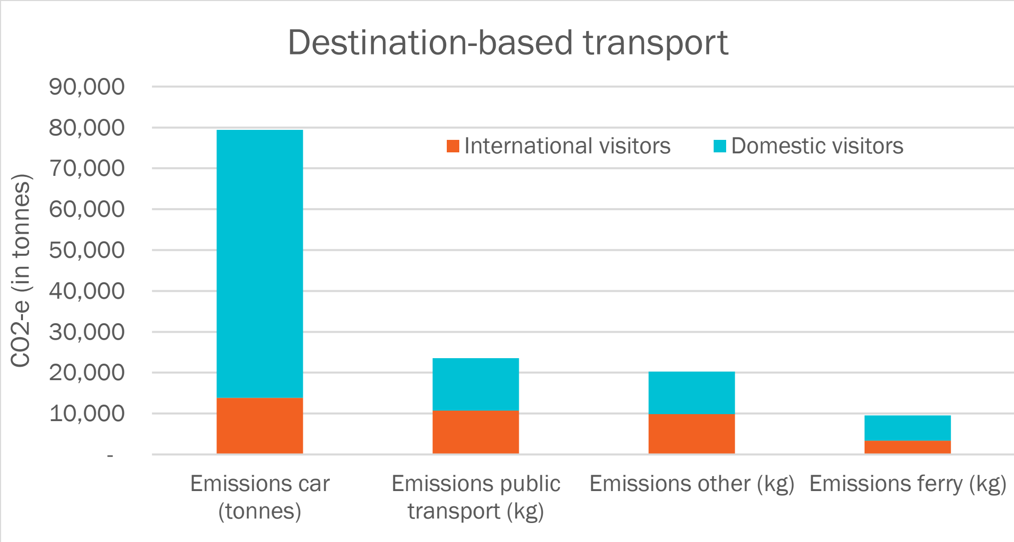

Figure 9 Destination-based (local) transport emissions for international and domestic visitors in Auckland.

The emissions were derived based on visitation to six sub-regions in Auckland. Figures 10 and 11 show the split of emissions by sub-region. In both cases, the 'baseline distance' assumed to be equivalent to return travel from Auckland airport to the city contributes the most. This result is sensitive to the assumption that every visitor travelled at least this distance to get to their location of visit in Auckland. The emissions for the other sub-regions are based on assumed visitation patterns derived from Auckland's visitor survey. Because of the relatively further distance, the largest contributor is West Auckland with attractions such as Piha Beach.

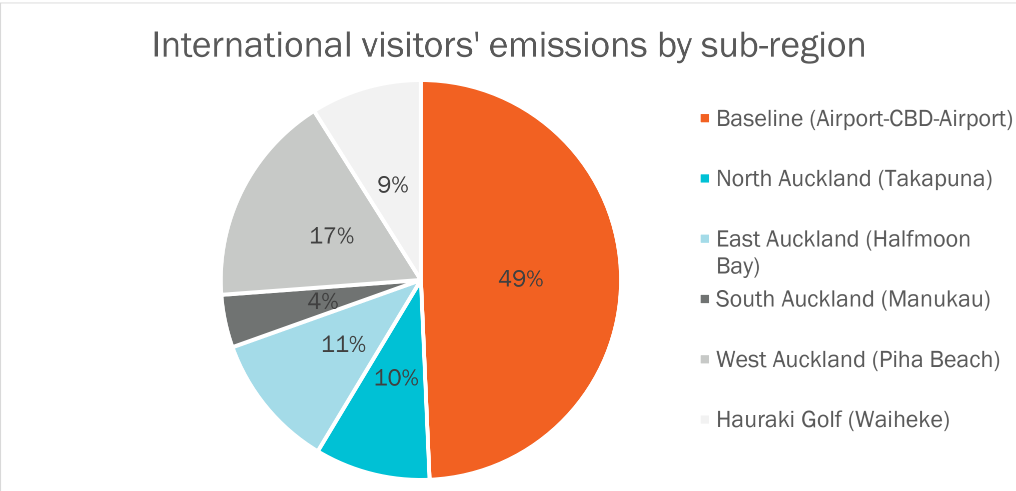

Figure 10 Local transport (destination-based) emissions by international visitors to Auckland.

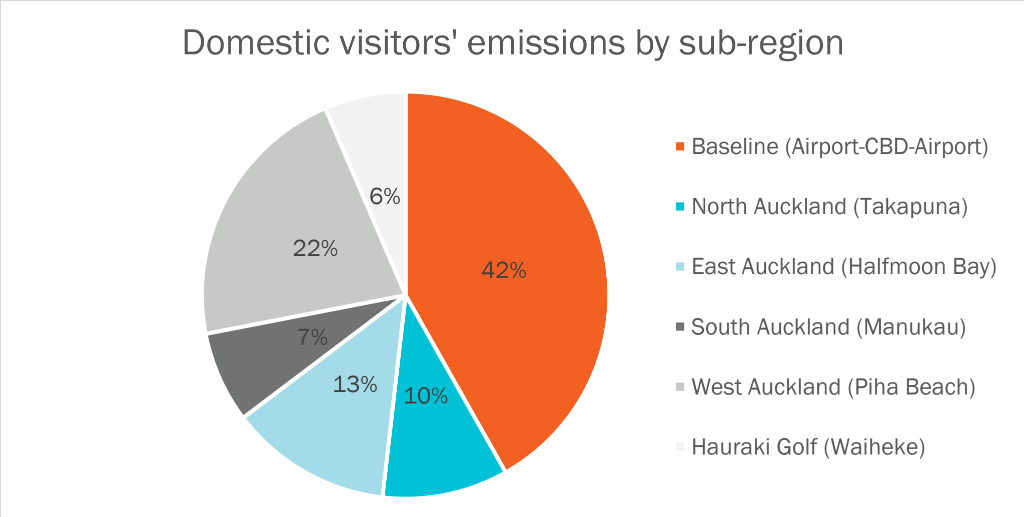

Figure 11 Local transport (destination-based) emissions by domestic visitors to Auckland.

Attractions

The contribution of attractions (6%) to Auckland tourism emissions is significantly less than transport and accommodation (see Figure 5), which collectively make up the majority of Auckland tourism emissions (94%) in the bottom-up account.

International visitors account for 3,611 tonnes of CO2 compared to domestic visitors who account for 9,994 tonnes of CO2 (Figure 12). Aggregate emissions from Auckland attractions are 13,605 tonnes of CO2. It is highly likely that these numbers underestimate the real emissions of the attraction and activity sub-sectors as many smaller attractions are not included.

Clearly there is wide variation in the emissions attributed to different attractions as evident in the emissions intensities applied in this analysis (Becken & Patterson, 2006). This suggests that in order to mitigate emissions from tourism attractions low-carbon attractions/activities should be the priority of high emissions attractions and activities (Figure 11).

This is also indicative of the need for attractions/operators to conduct their own carbon analyses, and to develop and implement mitigation efforts based on those analyses. A commitment to carbon footprinting is already evident among some vanguard attraction operators. Indeed, some have conducted and acted upon carbon analysis for some years. The Toitū Envirocare website makes public the disclosures of some tourism attractions that are demonstrating leadership in carbon analysis and mitigation at the level of individual businesses. They include:

- Auckland Zoo: https://www.toitu.co.nz/our-members/members/auckland-zoo
- Maritime Museum and Auckland Art Gallery: https://www.toitu.co.nz/our-members/members/regional-facilities-auckland-limited
- Sudima Auckland Airport: https://www.toitu.co.nz/our-members/members/sudima-auckland-airport
- Auckland War Memorial Museum: https://www.toitu.co.nz/our-members/members/auckland-war-memorial-museum

The relative contributions to the attractions carbon footprint attributed to international and domestic tourists (Figure 12) are reflective of respective total visitor numbers.

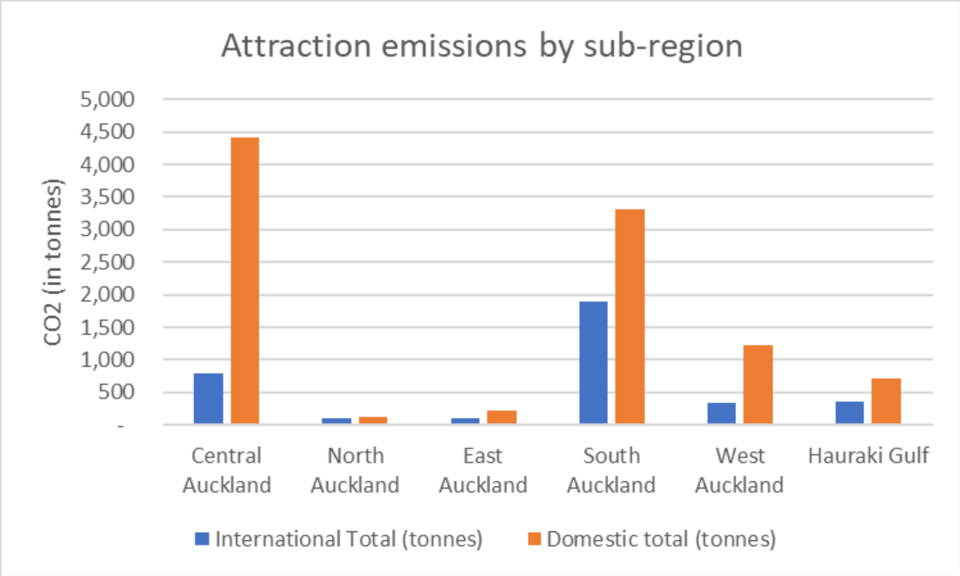

Figure 12 Emissions for key attractions visited by international and domestic visitors in Auckland's sub-regions.

Transport to Auckland

The largest contributor to transport-to-Auckland emissions is international air travel by international visitors with 3,513,841 tonnes of CO2-e (Figure 13). Domestic visitors and their associated (domestic) air travel, car and ferry emissions contribute 235,960 tonnes or 5%, and cruise ship passengers add 23,429 tonnes (or 1%). It is important to note that these emissions are for one-way travel. Further, cruise ship emissions carry the highest level of uncertainty (and likely are underestimated due to very conservative assumptions) and deserve further investigation.

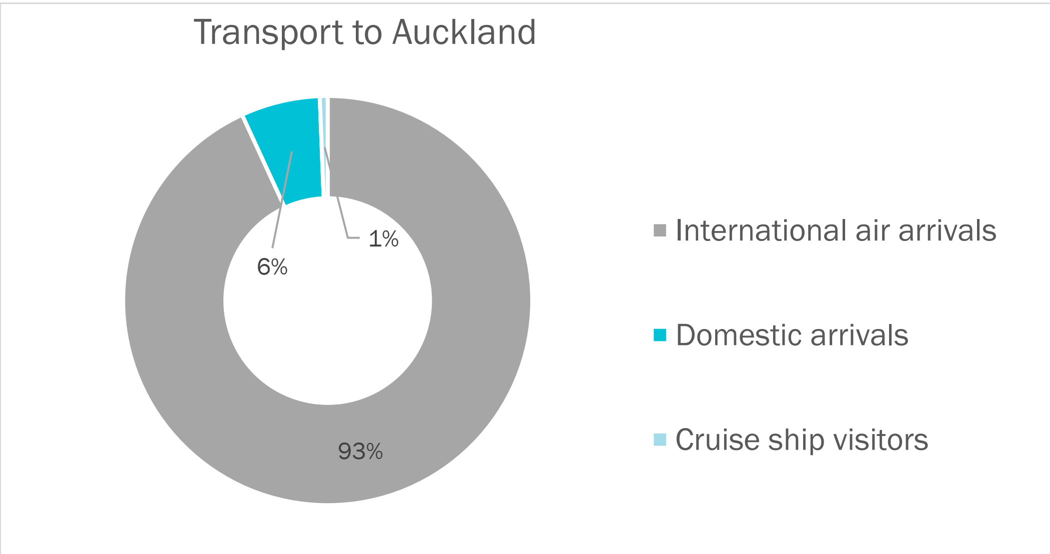

Figure 13 Overview of one-way emissions resulting from transport to Auckland.

Within the international air travel emissions, visitors from the United Kingdom are the highest contributor (Figure 14). This is a combination of long distance (resulting in emissions of 3.5 tonnes per person) and high visitor numbers (231,712 in 2019).

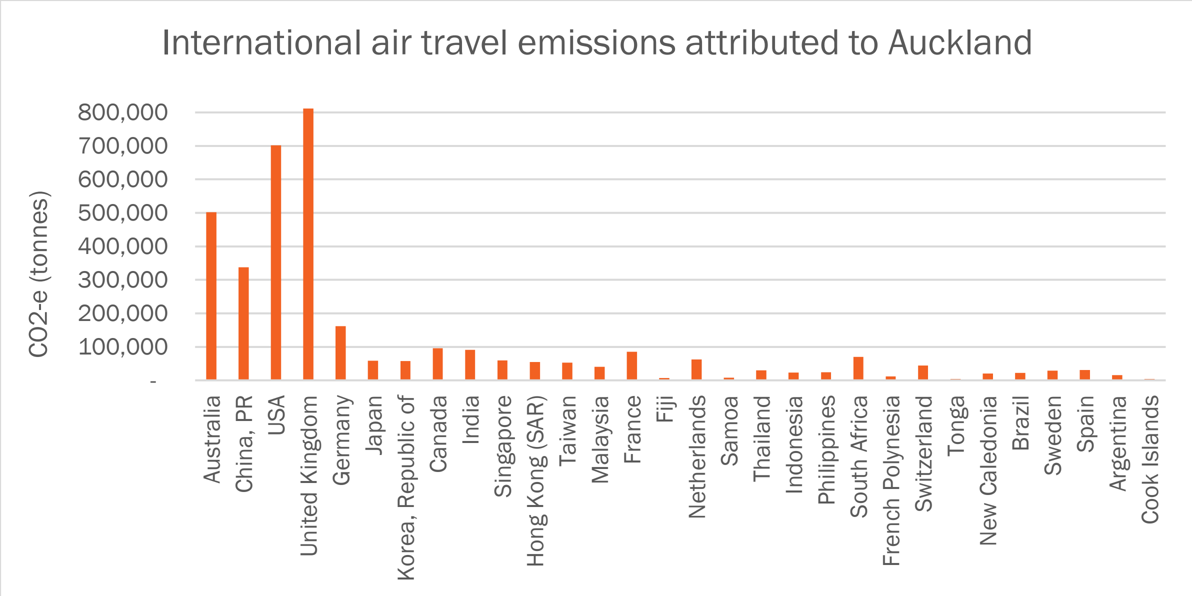

Figure 14 Auckland's share (based on visitor nights) of international air travel emissions (one way) by country of origin.

It is useful to contrast the number of arrivals (y-axis in Figure 15) with the aggregate emissions for (one way) international air travel for each market. The line in the Figure can be used to identify those markets that produce above-average emissions relative to their arrival volumes. For example, Germany, India, France and South Africa are more carbon intensive markets compared with Australia, Japan or Fiji.

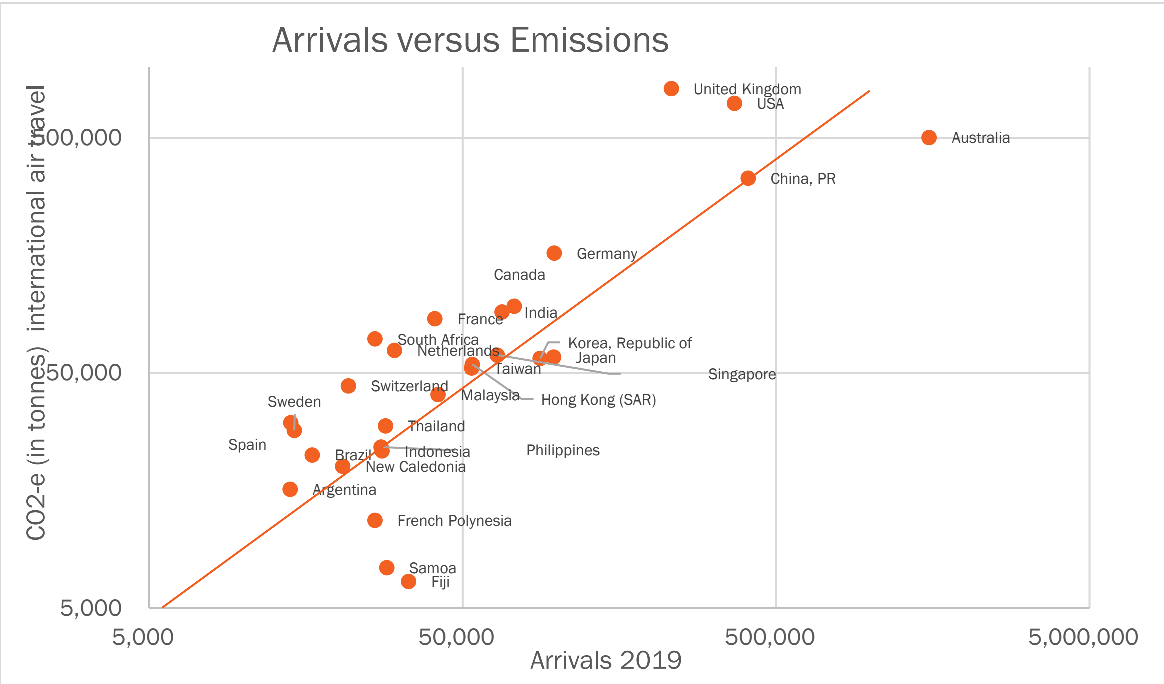

Figure 15 Comparison of arrivals with carbon emissions for apportioned international air travel to Auckland.

The largest contributor to domestic tourist transport emissions is Wellington, followed by Canterbury. The most important market in terms of visitor numbers, Waikato with 922,274 visitors in 2019, contributes only 13,379 tonnes of CO2-e (or 6%) because of its close distance (Figure 16). The Figure below also shows emissions by transport mode.

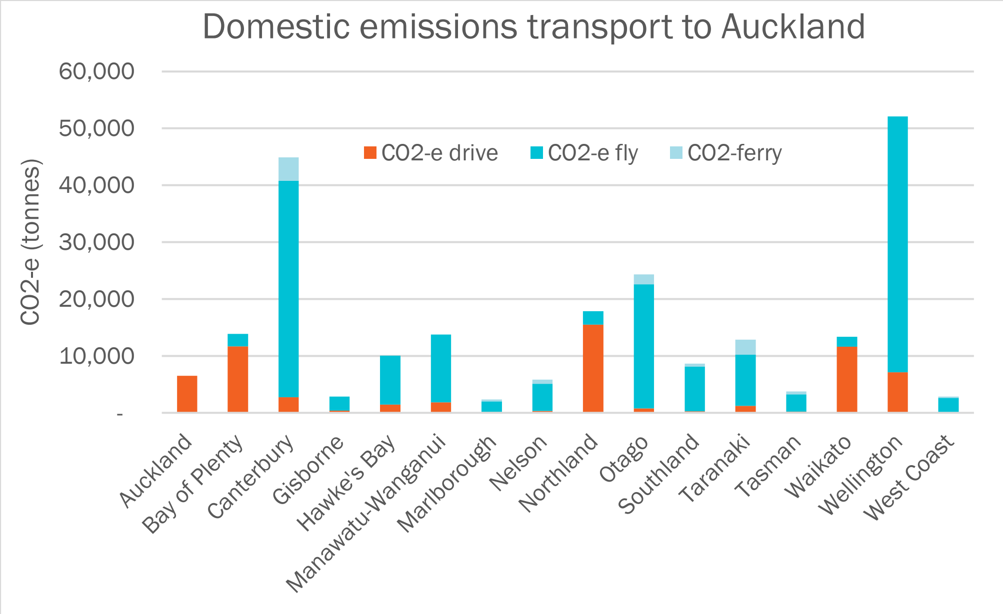

Figure 16 Domestic air/car/ferry travel emissions (one way) by domestic region of origin.

In terms of cruise ship passengers, the largest contributor to emissions is Australia, followed by New Zealand and visitors from the Americas (Figure 17).

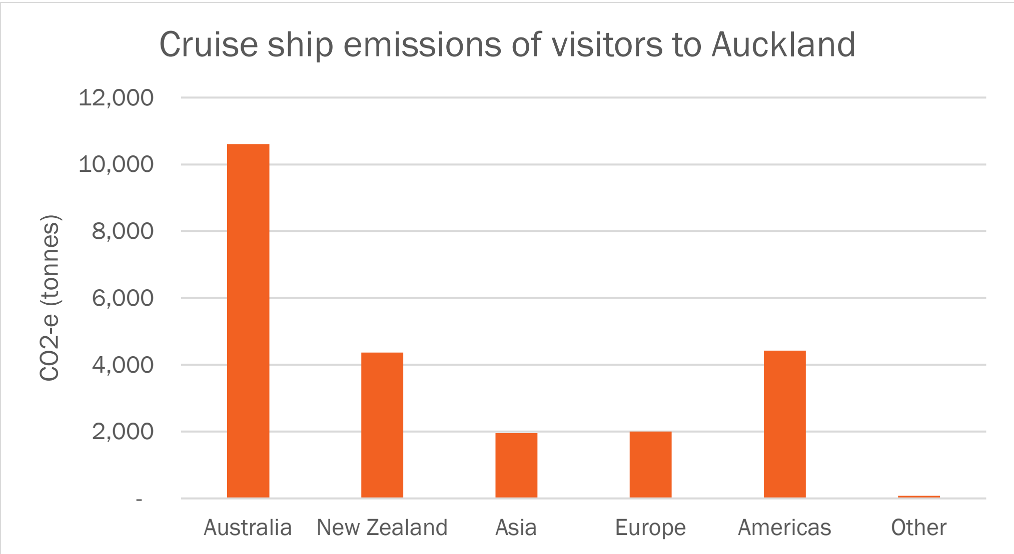

Figure 17 Auckland's share (based on assumed itinerary days) of cruise ship travel emissions (one way) by country of origin.

Cruise ships also produce emissions whilst in port. For Auckland, a Ports of Auckland Cruise Vessel Emission Reduction Technologies feasibility study estimated that the volume of vessel emissions was 7,756 tonnes of CO2-e in 2017, whereby 33% of vessels used shore power.

Recommendations

Two different methods were applied to provide insight into the climate impact of Auckland tourism. The first approach involved a macro-assessment of tourism-related emissions based on the regional Auckland emission account produced by StatsNZ. Transport emerged as the main contributor at 76.9% of emissions, whereas the second largest driver – accommodation and other tourism-related industries – contributed 16.9%. In contrast, the bottom up analysis that specifically looked at accommodation, local transport and key attractions provided an estimate of transport's contribution in the order of 62%. Accommodation was found to make up 32% and attractions 6%.

These differences between the two methods are not surprising given that transport behaviour by visitors in Auckland is captured in a much more comprehensive way in the top down analysis compared with the rather basic estimates in the bottom up methodology. Also the top-down approach includes some emissions related to half of the domestic air travel related to Auckland. In this sense, some of the otherwise as Scope 3 reported emissions, form part of this account. In addition, and in terms of the relatively larger contribution of accommodation emissions in the bottom up account, the method included emissions associated with electricity use (which is typically the single most important source of energy in a hotel), and these had been excluded in the top down approach as they constitute an intermediate input.

What can be learned from both approaches? Both methodologies highlight three key points. One is that tourism is a significant contributor to emissions. The second one is that transport is clearly the most important source of emissions. But thirdly, non-transport emissions also add substantially to the tourism footprint and deserve attention in terms of climate mitigation measures.

This inaugural work on the carbon footprint of tourism in Auckland brings to the forefront several issues, and whilst more work is required to refine the analysis, some key recommendations can be made. These are structured into policy, product development, marketing and, importantly, data and research.

Policy

- Carbon accounting has emerged as a critical aspect of destination management. A continued commitment to measuring the carbon footprint of Auckland tourism is important to overcome information asymmetry. Measurement, benchmarking, developing decarbonisation trajectories and monitoring performance over time is critical. This commitment also demonstrates leadership for other regions in New Zealand that must do the same.
- Establish and commit to decarbonisation targets for Auckland tourism, that at least align with New Zealand's climate commitments, as outlined by the Climate Change Commission (2021), or are more ambitious to deliver on the reductions required to deliver on the 1.5 degree goal.
- Ensure that the Auckland Transport Infrastructure Strategy aligns with key priorities such as:
  - Continue transition to zero carbon public transport;
  - Identify the key corridors of tourist transportation in the city and implement measures to assist decarbonisation (e.g. electric busses on key routes);
  - Continue transition to active transport (e.g., cycleways, ebike adoption);
  - Marketing optimisiation strategy (see below)
- Consider incentivising decarbonisation in visitor accommodation and key attractions:
  - Supporting energy audits and providing technical expertise;
  - Requesting carbon reporting as part of the rate payer process;
  - Awards for low carbon tourism sustainability champions.

Product

- Clearly transport is a key driver of emissions. Low carbon transitions are required for transport corridors to popular attractions, both within Central Auckland and to regions. Electrification of tourist transport corridors and fostering the use of public and active transport modes in Central Auckland and between the sub-regions, is required.

- Work with accommodation providers, particularly hotel accommodation, to offer low-carbon products, for example related to electric charging stations, public transport tickets, bicycle hire, carbon offsetting programs, or other partnerships with low carbon operators.
- Provide assistance and templates (e.g. emission factor sheets, excel spreadsheets) to encourage all tourism attractions to measure, benchmark and report on their annual Scope 1-3 carbon emissions, and to implement recommendations to mitigate emissions.
- Consider whether there is a role for the City to encourage attractions/operators to report emissions to Auckland Unlimited to enhance carbon reporting and transparency at the regional destination level.
- Drive innovation in industry to come up with new low-carbon tourism products, including those that relate to gastronomy and events.

Marketing

- Conduct market analyses to inform a marketing optimisation strategy that is based on rigorous insights into environmental (CO_2) and economic (GDP) measures.
- Advance a domestic tourism marketing strategy aimed at attracting low carbon regional/domestic visitor markets, while simultaneously reducing outbound international tourism (and associated high emissions).
- Develop and advance a strategy to target low distance/low emissions domestic markets given the centrality of transport to the findings of this report.
- Build on existing strategies to increase length of stay in Auckland.

Data and research

- This analysis would have been impossible without the detailed data insights provided by the AVS (2020). This data source should be periodically repeated, modified and extended where necessary, and further developed in collaboration with businesses that may disclose important data (e.g., visitor data)
- The cruise sector is a significant contributor to New Zealand tourism sector emissions. Allocating cruise emissions to specific ports of visit is fraught with difficulty. The findings outlined in this report can be readily misinterpreted. Cruise justifies a depth of analysis that lies beyond the limitations of this report. The need for a deep dive into the carbon (and other) externalities associated with cruise is acknowledged by the Parliamentary Commissioner for the Environment (2021) who also noted that an analysis of the impacts of cruise lies beyond the scope of a general report. Consultancy or University research resources are required to perform a critical and in - depth analysis of cruise tourism.
- The classification of emissions as Scope 3 as presented in this report should be expanded by other categories that fall within Scope 3 (e.g. waste), to increase detailed insight into necessary Scope 3 mitigation efforts.
- Contact selected attractions to request data that might inform this research if repeated in future years. Such data might include visitor numbers (international and domestic) which can be used to inform a more detailed picture of patterns of visitation to key attractions. This is likely to afford greater accuracy than the sampling procedure used in the AVS (2020). Some attractions may publicly disclosure visitor data in their annual reporting.
- Visitor flows data is required, preferably by transport mode, to better understand how to mitigate the emissions associated with tourist transportation to attractions. The potential to provide detailed insights into destination visitor flows using big data (e.g., mobile technologies and GPS) should be actively explored.
- Some attractions/operators may collect comprehensive data on visitor origins and transport to the attraction); some already conduct carbon footprint analyses and report their emissions. Such reporting, if publicly available, can be used to triangulate the findings presented in this report.
- Some tourism business have performed or commissioned their own carbon analyses. The Toitū Envirocare website makes public the disclosures of some tourism attractions that are demonstrating leadership in carbon analysis and mitigation at the level of individual businesses. These disclosures are important. They demonstrate leadership in climate action, with each report benchmarking emissions, making quite specific recommendations to mitigate emissions, and

monitoring progress over time to reduce emissions. They also offer the opportunity to cross check the more general (regional) emissions reported here.

- We recommend that emission intensities for attractions and activities be specifically researched and updated. This is an exercise that would afford more detailed insights into the carbon intensities of different tourism sub-sectors, and should be extended based on insights into activities that take place a different locations with the six sub-regions that make up the study area. Emissions intensities are central to the current analysis and should be regularly reviewed.
- Conduct additional research on 'eco-efficiency' to determine high economic value – low carbon visitor types. For example, identify market segments of interest to Auckland (e.g. convention visitor, fly-cruise, short break etc.) and undertake a visitor type specific assessment of carbon to contrast this with expenditure patterns (and possibly other metrics of interest, for example engagement in nature activities).

Reporting and dissemination (including information, collaboration and advice)

- Advance a collaborative approach to achieve radical reductions in regional tourism carbon emissions:
    - Collaborate with regional tourism stakeholders to agree and advance mitigation measures;
    - Collaborate with the Climate Change Commission's technical specialists to set regional tourism mitigation trajectories and key targets set with defined time periods.
    - Collaborate with other Regional Tourism Organisations (RTOs) to advance a collective commitment to the decarbonisation of tourism in regions across New Zealand.
    - Collaborate with non-tourism parts of the City (e.g. transport, commercial services) to exchange information, best practice and opportunities for synergies in climate mitigation.

References

Aall, C. (2011). Energy use and leisure consumption in Norway: an analysis and reduction strategy. *Journal of Sustainable Tourism, 19*, 729-745.

ATEED (2019). Destination Overview. https://www.aucklandnz.com/sites/build_auckland/files/media-library/documents/auckland-destination-overview-december-2019.pdf

Auckland Visitor Survey (AVS) (2020). Insights into visitors' characteristics, behaviour, experience and perceptions of the Auckland region. Insights Report. December 2019. January 2020. Research and Insights Unit. Aucklandnz.com

Auckland Council (2018). Auckland air emissions inventory 2016 – sea transport. July, 2018. https://knowledgeauckland.org.nz/media/1092/tr2018-017-auckland-air-emissions-inventory-2016-sea-transport.pdf

Auckland Transport (2019). Annual Report 2019. Auckland.

Becken, S. (2002). Analysing international tourist flows to estimate energy use associated with air travel. *Journal of Sustainable Tourism,* 10(2), 114-131.

Becken, S., Frampton, C. & Simmons, D. (2001). Energy consumption patterns in the accommodation sector – the New Zealand case. Ecological Economics, 39(3), 371-386.

Becken, S. & Cavanagh, J. (2003). Energy efficiency trend analysis of the tourism sector. Research Contract Report: LC02/03/293. Prepared for the Energy Efficiency and Conservation Authority. Becken (2013)

Becken, S., Simmons, D. G., & Frampton, C. (2003). Energy use associated with different travel choices. *Tourism Management, 24*, 267-277.

Becken, S., & Patterson, M. (2006). Measuring National Carbon Dioxide Emissions from Tourism as a Key Step Towards Achieving Sustainable Tourism. *Journal of Sustainable Tourism, 14*, 323-338.

Becken, S. (2013). Operators' perceptions of energy use and actual saving opportunities for tourism accommodation. Asia Pacific Journal of Tourism Research, 18(1-2), 72-91.

Becken, S. & Shuker, J. (2018). A framework to help destinations manage carbon risk from aviation emissions. Tourism Management, 71, 294-304.

Byrnes, T. A., & Warnken, J. (2006). Greenhouse gas emissions from marine tours: A case study of Australian tour boat operators. *Journal of Sustainable Tourism, 14*, 255-270.

Cerutti, A. K., Beccaro, G. L., Bruun, S., Donno, D., Bonvegna, L., & Bounous, G. (2016). Assessment methods for sustainable tourism declarations: the case of holiday farms. *Journal of Cleaner Production, 111*, 511-519.

Climate Change Commission (2021). Draft recommendations to government. https://www.climatecommission.govt.nz

Cornell and Greenview (2019). Cornell Hotel Sustainability Benchmarking Index (CHSB). Available https://greenview.sg/benchmarks/

Dawson, J., Stewart, E. J., Lemelin, H., & Scott, D. (2010). The carbon cost of polar bear viewing tourism in Churchill, Canada. *Journal of Sustainable Tourism, 18*, 319-336.

Eijgelaar, E., Peeters, P., de Bruijn, K., & Dirven, R. (2017). Travelling large in 2016: The carbon footprint of Dutch holidaymakers in 2016 and the development since 2002. In. Breda, Netherlands: NHTV Breda University of Applied Sciences.

Eijgelaar, E., Thaper, C., & Peeters, P. (2010). Antarctic cruise tourism: the paradoxes of ambassadorship, “last chance tourism” and greenhouse gas emissions. *Journal of Sustainable Tourism, 18*, 337-354.

El Hanandeh, A. (2013). Quantifying the carbon footprint of religious tourism: the case of Hajj. *Journal of Cleaner Production, 52*, 53-60.

Farreny, R., Oliver-Solà, J., Lamers, M., Amelung, B., Gabarrell, X., Rieradevall, J., Boada, M., & Benayas, J. (2011). Carbon dioxide emissions of Antarctic tourism. *Antarctic Science, 23*, 556-566.

Filimonau, V., Dickinson, J., Robbins, D., & Huijbregts, M. A. J. (2011). Reviewing the carbon footprint analysis of hotels: Life Cycle Energy Analysis (LCEA) as a holistic method for carbon impact appraisal of tourist accommodation. *Journal of Cleaner Production, 19*, 1917-1930.

Gössling, S. (2013). National emissions from tourism: An overlooked policy challenge? *Energy Policy, 59*, 433-442.

Gössling, S., & Hall, M. (2008). Swedish Tourism and Climate Change Mitigation: An Emerging Conflict? *Scandinavian Journal of Hospitality and Tourism, 8*, 141-158.

Gössling, S., & Higham, J. (2020). The low-carbon imperative: Destination management under urgent climate change. *Journal of Travel Research*, 0047287520933679.

Gössling, S., Peeters, P., Ceron, J.-P., Dubois, G., Patterson, T., & Richardson, R. B. (2005). The eco-efficiency of tourism. *Ecological Economics, 54*, 417-434.

Greenhouse Gas Protocol (2021). Corporate Standard. https://ghgprotocol.org/corporate-standard

Hopkins, D., and Higham, J. E, eds. (2016). Low carbon mobility transitions. Goodfellow Publishers Ltd.

Howitt, O. J., Revol, V. G., Smith, I. J., & Rodger, C. J. (2010). Carbon emissions from international cruise ship passengers’ travel to and from New Zealand. *Energy Policy*, *38*(5), 2552-2560.

Huang, Z., Cao, F., Jin, C., Yu, Z., & Huang, R. (2017). Carbon emission flow from self-driving tours and its spatial relationship with scenic spots – A traffic-related big data method. *Journal of Cleaner Production, 142*, 946-955.

IPCC (2018). Global Warming of 1.5°C. Summary for Policymakers. Available (14/11/18) http://report.ipcc.ch/sr15/pdf/sr15_spm_final.pdf

Kelly, J., & Williams, P. W. (2007). Modelling Tourism Destination Energy Consumption and Greenhouse Gas Emissions: Whistler, British Columbia, Canada. *Journal of Sustainable Tourism, 15*, 67-90.

Kuo, N.-W., Lin, C.-Y., Chen, P.-H., & Chen, Y.-W. (2012). An inventory of the energy use and carbon dioxide emissions from island tourism based on a life cycle assessment approach. *Environmental Progress & Sustainable Energy, 31*, 459-465.

Larsson, J., Elofsson, A., Sterner, T., and Åkerman, J. (2019). International and national climate policies for aviation: a review. *Climate Policy* 19 (6): 787-799.

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

Ministry for the Environment (2020). New Zealand’s national determined contribution. https://www.mfe.govt.nz/climate-change/why-climate-change-matters/global-response/paris-agreement/new-zealand’s-nationally

Ministry for the Environment (2020). Measuring Emissions: Summary of Emission Factors 2020. https://www.mfe.govt.nz/publications/climate-change/measuring-emissions-summary-of-emission-factors-2020

Motu Economic and Public Policy Research (2016). Who’s Going Green? Decomposing the Change in Household Consumption Emissions 2006 – 2012. Motu Working Paper 16-20. November 2016

Oklevik, O., Gössling, S., Hall, C. M., Steen Jacobsen, J. K., Grøtte, I. P., and McCabe, S. 2019. Overtourism, optimisation, and destination performance indicators: a case study of activities in Fjord Norway. *Journal of Sustainable Tourism,* 27(12), 1804-1824

Oluseyi, P. O., Babatunde, O. M., & Babatunde, O. A. (2016). Assessment of energy consumption and carbon footprint from the hotel sector within Lagos, Nigeria. *Energy and Buildings, 118*, 106-113.

Parliamentary Commissioner for the Environment (2021). Not 100% but four steps closer to sustainable tourism. https://www.pce.parliament.nz/publications/not-100-but-four-steps-closer-to-sustainable-tourism

Peeters, P., Higham, J., Kutzner, D., Cohen, S., and Gössling, S. (2016). Are technology myths stalling aviation climate policy? *Transportation Research Part D: Transport and Environment,* 44, 30-42.

Perch-Nielsen, S., Sesartic, A., & Stucki, M. (2010). The greenhouse gas intensity of the tourism sector: The case of Switzerland. *Environmental Science & Policy, 13*, 131-140.

Pereira, R. P. T., Ribeiro, G. M., & Filimonau, V. (2017). The carbon footprint appraisal of local visitor travel in Brazil: A case of the Rio de Janeiro-São Paulo itinerary. *Journal of Cleaner Production, 141*, 256-266.

Pham, T., Meng, S. & Becken, S. (2020). Carbon footprint of tourism destinations in Queensland. DES and DITID. Brisbane, Australia. https://www.griffith.edu.au/institute-tourism/publications/research-report-series

Puig, R., Kilic, E., Navarro, A., Alberti, J., Chacon, L., & Fullana, I. P. P. (2017). Inventory analysis and carbon footprint of coastland-hotel services: A Spanish case study. *Sci Total Environ, 595*, 244-254.

Rico, A., Martínez-Blanco, J., Montlleó, M., Rodríguez, G., Tavares, N., Arias, A., & Oliver-Solà, J. (2019). Carbon footprint of tourism in Barcelona. *Tourism Management, 70*, 491-504.

Rosselló-Batle, B., Moià, A., Cladera, A., & Martínez, V. (2010). Energy use, CO2 emissions and waste throughout the life cycle of a sample of hotels in the Balearic Islands. *Energy and Buildings, 42*, 547-558.

Scott, D., Gössling, S., Hall, C. M., and Peeters, P. (2016). Can tourism be part of the decarbonized global economy? The costs and risks of alternate carbon reduction policy pathways. *Journal of Sustainable Tourism,* 24(1), 52-72.

Scott, D., Hall, C. M., & Gössling, S. (2016). A report on the Paris Climate Change Agreement and its implications for tourism: why we will always have Paris. *Journal of Sustainable Tourism, 24*(7), 933-948.

Scott, D., Hall, C. M., and Gössling, S. (2019). Global tourism vulnerability to climate change. *Annals of Tourism Research*, 77, 49-61.

Scott, D., Peeters, P., & Gössling, S. (2010). Can tourism deliver its "aspirational" greenhouse gas emission reduction targets? *Journal of Sustainable Tourism, 18*(3), 393-408.

Smith, J., and Rodger, C. J. (2009). Carbon offsets for aviation-generated emissions due to international travel to and from New Zealand. *Energy Policy,* 37 (9), 3438-3447

Stats NZ (2018). Auckland Region. https://www.stats.govt.nz/tools/2018-census-place-summaries/auckland-region

Stats NZ (2019). Commercial Accommodation Monitor. September 2019. Auckland.

Stats NZ (2020a). Greenhouse gas emissions by region (industry and household): Year ended 2018. https://www.stats.govt.nz/information-releases/greenhouse-gas-emissions-by-region-industry-and-household-year-ended-2018

Stats NZ (2020b). Approaches to measuring New Zealand's greenhouse gas emissions. Wellington. https://www.stats.govt.nz/methods/approaches-to-measuring-new-zealands-greenhouse-gas-emissions#production

Stats NZ (2020c). International travel: December 2019. https://www.stats.govt.nz/information-releases/international-travel-december-2019

Stats NZ (2020d). Cruise ship traveller and expenditure statistics: Year ended June 2020. Available https://www.stats.govt.nz/information-releases/cruise-ship-traveller-and-expenditure-statistics-year-ended-june-2020

Sun, Y.Y. & Higham, J.E.S. (2020). Overcoming information asymmetry in tourism carbon management: The application of a new reporting architecture to Aotearoa New Zealand. *Tourism Management* https://doi.org/10.1016/j.tourman.2020.104231

Sun, Y.Y., Cadarso, M.A. & Driml, S. (2020). Tourism carbon footprint inventories: A review of the environmentally extended input-output approach. Annals of Tourism Research, 82, 102928,

Tang, C., Zhong, L., & Jiang, Q. o. (2017). Energy efficiency and carbon efficiency of tourism industry in destination. *Energy Efficiency, 11*, 539-558.

Tang, Z., Shang, J., Shi, C., Liu, Z., & Bi, K. (2014). Decoupling indicators of CO2 emissions from the tourism industry in China: 1990–2012. *Ecological Indicators, 46*, 390-397.

Timmer, M. P., Dietzenbacher, E., Los, B., Stehrer, R., & de Vries, G. J. (2015). An Illustrated User Guide to the World Input–Output Database: the Case of Global Automotive Production. *Review of International Economics, 23*, 575-605.

Tsai, K.-T., Lin, T.-P., Hwang, R.-L., & Huang, Y.-J. (2014). Carbon dioxide emissions generated by energy consumption of hotels and homestay facilities in Taiwan. *Tourism Management, 42*, 13-21.

UNFCCC. (2015). *Report of the Conference of the Parties on its twenty-first session, held in Paris from 30 November to 13 December 2015*. https://unfccc.int/resource/docs/2015/cop21/eng/10.pdf

UNFCCC. (2019). The Paris Agreement. https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement

United Nations (2008). Tourism Satellite Account: Recommended Methodological Framework 2008.

UNWTO (2021). Glossary. https://www.unwto.org/glossary-tourism-terms

UNWTO. (2019a). *Baseline Report on the Integration of Sustainable Consumption and Production Patterns into Tourism Policies*. Madrid: World Tourism Organization.

UNWTO. (2019b). Climate Change & Tourism. http://sdt.unwto.org/en/content/climate-change-tourism

Wang, J. C., Wang, Y.-C., Ko, L., & Wang, J. H. (2017). Greenhouse gas emissions of amusement parks in Taiwan. *Renewable and Sustainable Energy Reviews, 74*, 581-589.

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

WRI (World Resources Institute) et al., (2014). Global Protocol for Community-Scale Greenhouse Gas Emission Inventories, http://www.ghgprotocol.org/about-ghgp.

WTO-UNEP-WMO. (2008). Climate Change and Tourism: Responding to Global Challenges. Spain: World Tourism Organization.

Xie, S (2019). Auckland's Greenhouse Gas Inventory to 2016. Auckland Council technical report, TR2019/002.

APPENDIX A – REGIONAL GHG ACCOUNT FOR AUCKLAND PROVIDED BY STATS NZ (2020A)

Auckland's emissions profile[1][2][3]

2007–18

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
	Kilotonnes of carbon dioxide equivalent											
Industry (ANZSIC06) and households												
Primary industries	888	846	750	768	824	794	783	748	810	973	868	825
Agriculture	812	778	684	707	764	725	707	679	745	902	805	755
Forestry, fishing, and mining	76	68	66	61	60	69	76	69	65	71	63	70
Goods-producing industries	6,718	6,240	5,460	5,820	5,469	5,359	5,847	5,785	5,801	5,179	5,269	5,043
Manufacturing	3,410	3,277	3,100	3,278	3,112	3,158	3,464	3,587	3,575	3,538	3,527	3,278
Electricity, gas, water, and waste services	3,069	2,694	2,091	2,276	2,091	1,941	2,134	1,927	1,938	1,288	1,298	1,282
Construction	239	269	268	266	266	259	249	270	289	353	443	483
Services	1,814	1,885	1,865	1,842	1,813	1,741	1,766	1,749	1,836	1,869	1,959	2,085
Transport, postal, and warehousing	722	764	727	719	742	689	721	693	772	786	838	891
Services excluding transport, postal, and warehousing	1,092	1,122	1,137	1,123	1,071	1,052	1,045	1,056	1,065	1,083	1,121	1,195
Total all industries	9,420	8,971	8,075	8,430	8,106	7,894	8,396	8,282	8,448	8,021	8,095	7,953
Households	2,874	2,792	2,799	2,825	2,829	2,829	2,857	2,897	3,089	3,238	3,413	3,385
Total all industries and households	12,293	11,763	10,874	11,255	10,935	10,723	11,253	11,179	11,537	11,259	11,508	11,339
Source[4]												
Agriculture	732	704	620	639	698	653	635	609	672	829	722	679
Energy	8,376	8,042	7,348	7,508	7,140	6,992	7,499	7,404	7,599	7,189	7,468	7,374
Industrial processes and product use	1,988	1,908	1,884	2,096	2,124	2,126	2,191	2,226	2,335	2,325	2,404	2,394
Waste	1,198	1,108	1,022	1,011	973	952	928	939	930	916	915	891
Gas												
Carbon dioxide equivalents	12,293	11,763	10,874	11,255	10,935	10,723	11,253	11,179	11,537	11,259	11,508	11,339
Carbon dioxide	9,941	9,510	8,812	9,180	8,802	8,632	9,188	9,124	9,378	8,924	9,228	9,067
Methane	1,845	1,716	1,546	1,538	1,545	1,491	1,450	1,443	1,477	1,569	1,504	1,439
Nitrous oxide	274	273	251	254	267	255	249	243	261	298	271	268
Fluorinated gases	233	264	265	284	320	345	366	369	420	467	505	566
Supplementary statistics[5]												
Regional GDP ($millions)	66,917	66,060	68,438	71,364	75,300	77,864	82,114	88,256	95,743	101,951	108,714	114,148
Population[6]	1,390,400	1,405,500	1,421,700	1,439,600	1,459,600	1,476,500	1,493,200	1,526,900	1,569,900	1,614,500	1,657,200	1,618,400
Persons employed[7]	771,132	763,563	737,331	749,781	766,758	780,435	805,038	839,115	874,902	913,785	938,139	..

1. Production of greenhouse gases by Australian and New Zealand Standard Industrial Classification 2006 (ANZSIC06), and households on a residence basis. The national accounts' residence principle means that emissions by resident economic units are included even if these occur outside the territory.

2. Data includes direct emissions only, indirect emissions are excluded.

3. Emissions are expressed in carbon dioxide equivalents which are the emissions of greenhouse gases weighted by their 100-year global warming potential (GWP). The GWP's are based on those from the Intergovernmental Panel on Climate Change, Fourth Assessment Report, 2007.

4. Based on Greenhouse Gas Inventory sectors. The land use, land-use change, and forestry (LULUCF) sector has not been incorporated.

5. Regional GDP and persons employed are based on March years, population statistics on June years. March year data are aligned to the closest December year (eg March 2018 is recorded as 2017).

6. Population estimates for 2014-18 are subject to revision on 23 September 2020 to fully incorporate results from the 2018 Census of Population and Dwellings and the 2018 Post-enumeration Survey

7. Person counts by region. Measure is the total of persons whose main earnings source in the tax year is wages and salaries, or self-employment.

Note: Due to rounding, individual figures may not always sum to the stated totals.

Source: Stats NZ

APPENDIX B - ARRIVAL DATA FOR TOP 30 MARKETS (SOURCE: STATS NZ, 2020C).

	2015 (NZ)	2016 (NZ)	2017 (NZ)	2018 (NZ)	2019 (NZ)
Australia	1,326,800	1,409,200	1,472,160	1,494,541	1,537,988
China, People's Republic of	355,904	409,008	417,872	448,189	407,141
United States of America	243,104	291,392	330,128	352,074	367,958
United Kingdom	203,952	220,976	249,264	237,166	231,712
Germany	84,544	96,848	104,864	102,087	98,050
Japan	87,328	100,736	102,048	99,784	97,682
Korea, Republic of	64,992	82,384	91,168	87,853	88,481
Canada	52,352	59,760	67,280	71,261	73,037
India	46,000	52,016	61,440	67,953	66,775
Singapore	49,584	57,344	58,544	61,464	64,574
Hong Kong (SAR)	36,288	44,768	54,688	58,763	53,720
Taiwan	31,200	37,056	35,712	44,659	53,453
Malaysia	34,240	51,792	53,840	56,430	41,779
France	33,376	39,728	42,560	43,606	40,777
Fiji	26,352	28,256	28,960	30,876	33,630
Netherlands	22,256	26,000	29,248	30,813	30,337
Samoa	21,184	23,168	24,384	26,300	28,654
Thailand	21,696	27,104	27,616	31,447	28,378
Indonesia	16,176	19,632	23,872	26,070	27,697
Philippines	14,016	20,384	23,936	28,822	27,505
South Africa	17,008	20,240	19,120	22,117	26,296
French Polynesia	16,912	19,488	22,448	24,605	26,291
Switzerland	19,136	21,840	23,600	22,484	21,637

Tonga	17,600	20,480	20,208	20,956	21,354
New Caledonia	17,728	18,656	20,192	20,595	20,744
Brazil	13,152	13,248	17,664	19,017	16,566
Sweden	13,920	14,896	16,368	15,919	14,533
Spain	10,144	12,320	13,424	14,332	14,172
Argentina	5,392	15,344	18,624	21,724	14,095
Cook Islands	10,560	10,784	11,632	12,075	14,036

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AUCKLAND UNLIMITED AND GRIFFITH UNIVERSITY/OTAGO UNIVERSITY WELCOME COMMENT AND FEEDBACK ON THIS REPORT.

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