Carbon footprint of tourism destinations in Queensland

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About this report

This project on the carbon footprint of tourism in Queensland is an initiative resulting from the Tourism Sector Adaptation Plan developed by the Queensland Government in partnership with Queensland Tourism Industry Council and Griffith University. The notion of 'measure to manage' underpins the critical task of understanding the extent and distribution of greenhouse gas emissions associated with tourism activity. The findings from this assessment will provide valuable insights in informing future climate-related policy making for tourism in Queensland, including in the development of long-term tourism strategies, plans and directions for the State.

Acknowledgements

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Executive summary

This report presents the methodology and estimates for the ‘carbon footprint’ of tourism across all destinations in Queensland. The emissions in this report include all types of greenhouse gas (GHG) emissions and are presented on the basis of carbon dioxide equivalent (CO_2-e) throughout the report.

Queensland’s tourism sector is the third largest in Australia, after New South Wales and Victoria. Alongside the income contributed to the Queensland economy, the tourism sector also generates emissions that impact the environment. Increased carbon emissions can add higher risks and subsequently costs that can constrain the growth of tourism, as well as other sectors of the economy. The inherent relationship between tourism growth and carbon emissions has become an important issue for both the government and industry because growing tourism emissions undermine the state’s carbon-reduction goals.

This study adopts an integrated approach, which combines the carbon emission account framework with the tourism satellite account (TSA) framework to estimate tourism emissions. The carbon emission account framework was initiated by the United Nations Framework Convention on Climate Change (UNFCCC) and has been applied by the Department of the Environment and Energy (DEE) of the Australian Government to register Australian emissions. The TSA framework was developed by the United Nations World Tourism Organisation (UNWTO) to reflect the tourism sector’s contribution, among all other industries, in an economy. Using these two frameworks, emissions are estimated for all goods and services consumed by visitors to Queensland destinations. Goods and services can be sourced from either domestic or overseas countries. The approach to measuring emissions from international aviation in this report involved combining emission rates per passenger (by country of origin) from the Global Sustainable Tourism Dashboard (2019), and the number of visitors provided by Tourism Research Australia. There are five groups of emissions in this report:

1. Emissions from tourism output (i.e. goods and services) produced by local industries (including domestic air transport)
2. Emissions from goods and services (mainly goods) imported from overseas
3. Emissions from fuel consumption by self-drive visitors
4. Emissions from intermediate inputs used (mainly agricultural products and electricity), and
5. Emissions from international aviation.

At the state level, Queensland reportedly produced 161.2 million tonnes (Mt) of CO_2-e in 2016/17 (DEE, 2019). This report estimates total emissions of 11.6 Mt CO_2-e for tourism across all destinations in Queensland for the same year, making tourism emissions equivalent to about 7.2 per cent of the state’s total. However, this 11.6 Mt also includes emissions associated with international aviation and imports, which are not counted for in Queensland’s 161.2 Mt in 2016/17. Due to different methodologies applied in earlier studies, as well as different characteristics of tourism destinations, it is advisable to exercise care when comparing results from different carbon footprinting studies.

Total Queensland emissions of tourism comprise of the five broad categories shown in Figure 1. The emissions from *tourism inputs* and *tourism output*[1] make up slightly more than 60 per cent of the total emissions across all regions. The rest consists of nearly equal proportions of international aviation (17 per cent) and private use vehicles (19 per cent). Emissions from imported sources are relatively insignificant, considering the approach taken in this study.

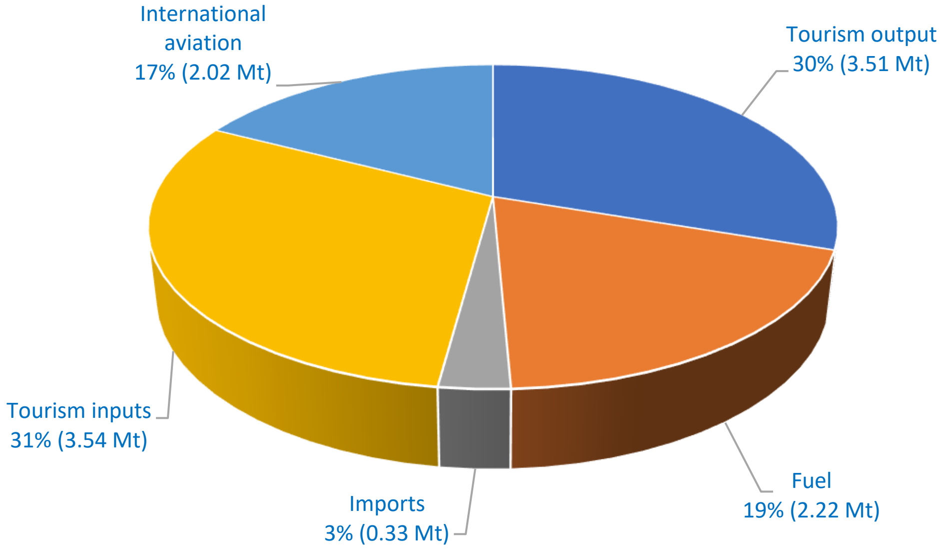

Figure 1**: Profile of tourism emissions in Queensland, 2016/17**

As the most visited tourism destinations in Queensland, Brisbane, the Gold Coast and Cairns (Tropical North Queensland) are the top three regions in terms of GHG emissions. As Figure 2 shows, tourism emissions in these regions are 4 Mt (34 per cent), 1.9 Mt (16.5 per cent) and 1.6 Mt (14 per cent) respectively. The Sunshine Coast, another popular destination, produced nearly 1.2 Mt, or close to 10 per cent of Queensland's tourism emissions.

Tourism consumption for the whole group of Mackay, Townsville, Tropical North Queensland, the Whitsundays, Capricorn and Gladstone – the Great Barrier Reef catchment area – generates 3.14 Mt, accounting for 27 per cent of state tourism emissions.

[1] Goods and services produced domestically

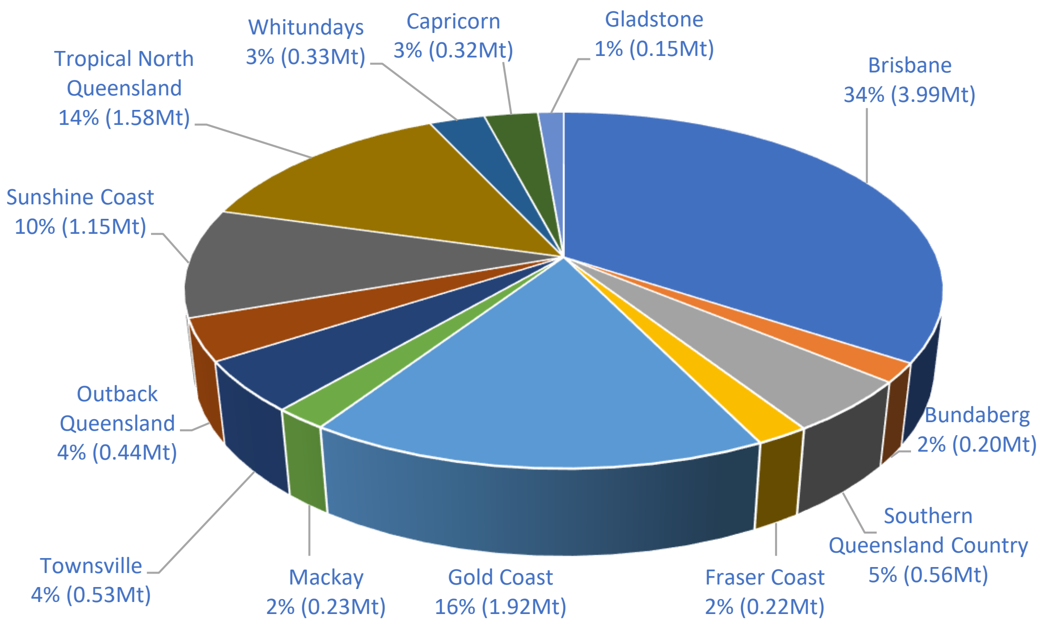

Figure 2**: Emissions by destinations in Queensland, 2016/17**

The emissions of tourism-producing sectors in percentage shares are shown in Figure 3. Overall, air transport and road transport are the two sectors contributing the most to total tourism emissions – 38 per cent and 24 per cent respectively, which is more than emissions from all other sectors added together. Both the restaurant and other food sectors have higher emission shares than the hotel sector. This is mainly due to the fact that agricultural products carry high levels of embedded emissions.

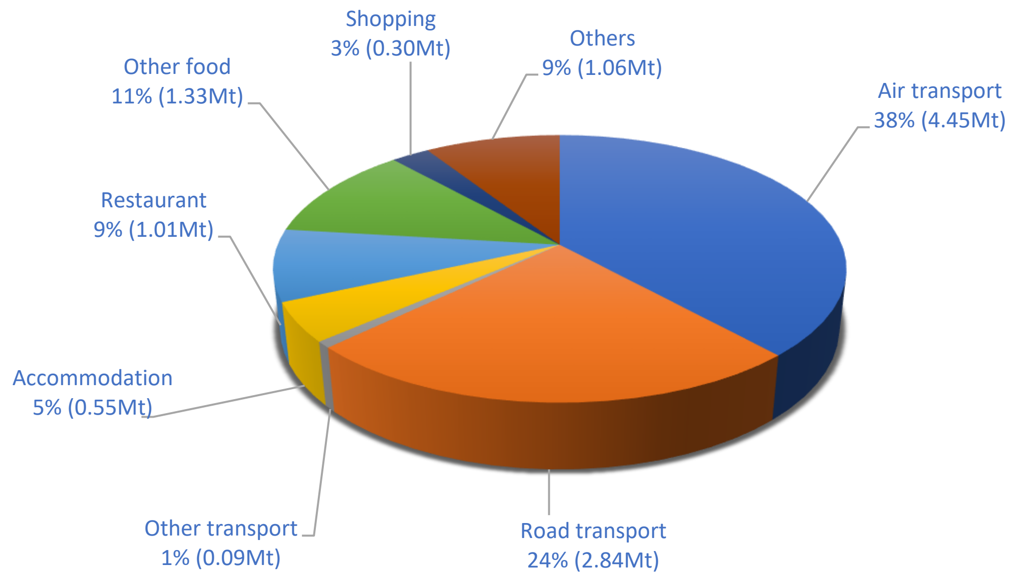

Figure 3**: Emissions by tourism producing sectors in Queensland, 2016/17**

Among all groups of visitors, the domestic overnight group generates more than 50 per cent of total tourism emissions, followed by *inbound* visitors (also interchangeable for *international visitors* in this report) and day visitors (domestic visitors by nature), as Figure 4 shows.

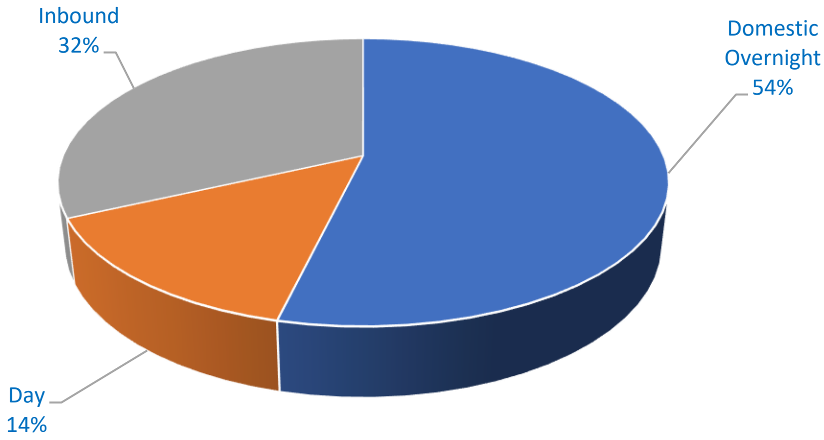

Figure 4**: Queensland tourism emissions by visitor type, 2016/17**

The approach to measuring the carbon footprint for tourism in this report is inclusive so that emissions are meaningful for the development of mitigation policies. Policy options are diverse. Curbing tourism emissions could conflict with volume-based growth of the sector, so it is imperative to understand the linkages of tourism with the rest of the economy so that holistic and sustainable policy development can benefit Queensland, both economically and environmentally, in the long term. This report presents a comprehensive set of tourism emissions that will provide a starting point to explore policies from various angles. It is important to continue with updates to this analysis so that tourism emissions can be monitored over time. Tourism can and should play an active role in emission mitigation.

1. Introduction

Data from the National Visitor Survey (NVS) and the International Visitor Survey (IVS) published by Tourism Research Australia (TRA) show that in 2017/18 Queensland attracted more than 2.7 million visitors from overseas, 22.5 million domestic overnight visitors and 43 million day visitors. The entire tourism sector contributed $12.3 billion (3.7 per cent) to total gross value added (GVA) of the state economy in 2017/18. By comparison, in the same year tourism's GVA was 20 per cent larger than that of agriculture; it was almost 60 per cent of the manufacturing sector's GVA and 30 per cent of the mining sector's GVA. Given strong growth in tourism demand in Queensland at 4.5 per cent on average over the past four years[2], compared with 4.1 per cent of a four-year average growth of total household consumption in the state (ABS, 2019a) over the same period, it is clear that the sector will play an important role in the years to come, not only within Queensland's economy but also nationwide. The Queensland tourism sector is the third largest tourism sector in Australia, behind those of New South Wales and Victoria.

Alongside the income that tourism contributes to the Queensland economy, it also generates emissions that impact the environment. The inherent relationship between tourism growth and carbon emissions has become an important issue for the government and industry alike because growing tourism emissions undermine the state's carbon-reduction goals. There is also a link between increasing greenhouse gas (GHG) emissions and the growing climatic risks, including physical (e.g. extreme weather events) and transitional (e.g. price on carbon). These are particularly pertinent to the tourism sector. Increasing carbon emissions can add business risks in the form of increasing operational costs and undermining investors' confidence, and these may constrain the growth of tourism as well as other sectors in the economy. A Tourism Sector Adaptation Plan – *Queensland Tourism Climate Change Response Plan* was funded by the Queensland Government and developed through a partnership approach led by the Queensland Tourism Industry Council in response to those risks (Becken, Montesalvo & Whittlesea, 2018).

Against this backdrop, coupled with global media coverage of the climate impacts of tourism, the sector's emissions have become increasingly relevant to policy-makers. While tourism can play an important role in the overall process of reducing anthropogenic GHG emissions, it requires a comprehensive approach that simultaneously considers growth and environmental impacts of tourism, as well as interlinkages with other sectors. Isolated approaches are likely to lead to sub-optimal outcomes for long-term sustainable development. It is therefore imperative for policy-makers and industry to understand the full extent of the current emission inventory of the sector. The last estimates of tourism emissions for Australia and Queensland were undertaken nearly a decade ago by the Sustainable Tourism Cooperative Research Centre (STCRC). They were valuable for climate change analysis at both the national and Queensland levels. However, given the time that has elapsed, and substantial changes in the composition of the sector, new estimates are now required.

This current report is part of the Queensland Government's approach to working with priority sectors to increase their resilience and prepare them for both the physical and transitional risks

2 From 2014/15 to 2017/18.

associated with climate change. The need to understand emissions from the tourism destination level and on a whole-of-Queensland scale has been identified as a recommendation in the *Queensland Tourism Climate Change Response Plan*, and this project delivers on this particular action. The aim of this report is to develop critical inputs for policy making and measures that can be used to support the sector in its climate change mitigation efforts. This report provides an estimate of tourism's emissions for all thirteen tourism regions in Queensland. In addition to the geographical dimension, emission data are developed for a variety of perspectives so as to enable a wider range of mitigation policy options that can potentially be explored further.

While the latest tourism expenditure data was available for 2017/18 when this project started, carbon emission data for industries in Queensland were only available for 2016/17, so carbon emissions for tourism in this report have been estimated for 2016/17. The project was jointly funded by the Department of Environment and Science, the Department of Innovation and Tourism Industry Development and Griffith Institute for Tourism at Griffith University.

2. Background

Measuring GHG emissions is a complex task due to the heterogenous nature of emitting processes. The task of estimating emissions for tourism is particularly complex. As tourism emissions originate from the goods and services that visitors consume, the consumption base is a critical element in tourism emission estimates. Some studies have simplified the process by focusing on a selected set of main commodities that visitors consume for the calculation of emissions (Jackson, Kotsovos & Morissette, 2008). Others, such as Patterson and McDonald (2004), Jones and Munday (2007) and Dwyer et al. (2010), have based their estimates on the foundation of tourism satellite accounts (TSA), a comprehensive set of commodities designed by UNWTO for consistency across countries. Other studies attempted to connect macro-scale assessments with bottom-up tourism emission data (Becken & Patterson, 2006). Within the TSA framework, two subsets of tourism data have been applied to estimate tourism emissions, namely the production base and the expenditure base. They generate different emission results for different purposes. In the TSA framework, tourism production is based on the direct tourism output concept while the expenditure base includes both direct and indirect data.

Emission accounts are also often overlaid with multiple categorical definitions of 'carbon emission framework', which differentiate between direct and indirect emissions. These are intertwined with international frameworks on carbon reporting, including the United Nations Framework Convention on Climate Change (UNFCCC), the Kyoto Protocol's criteria and Australia's commitment to the Paris Agreement. The complexity of measuring the indirect emissions is further exacerbated by the existence of various approaches to measuring such emissions from the upstream activities. Lenzen and colleagues (2018), for example, adopted the input–output multiplier to estimate the complete chain of input requirements for tourism consumption and, subsequently, the associated indirect emissions. The estimate of such chain of inputs is often referred to as indirect effects in the input–output modelling technique. Others – for example, tourism businesses that report through various programs or frameworks (e.g. EarthCheck, The Greenhouse Gas Protocol) – often focus only on their direct emissions, or perhaps on selected aspects of their supply chain. The terms 'direct' and 'indirect' are overused and often with different meaning across various accounting frameworks involved in the calculation of tourism emissions. This leads to a situation where the results from tourism emissions research have a wide range, and conceptually are likely to be incompatible among studies. This can create confusion or misinterpretation.

3. Methodology

This report adopts a commonality used by most previous reports or studies on tourism emissions. Essentially, it is anchored in the TSA framework and built upon the principles of the carbon emission framework. This section will describe the two separate frameworks, and the associated data sources, and look at how they are applied in this report (Figure 5). All data refer to 2016/17. It is important to understand the rationale behind the combined framework that determines the types of results captured in this report.

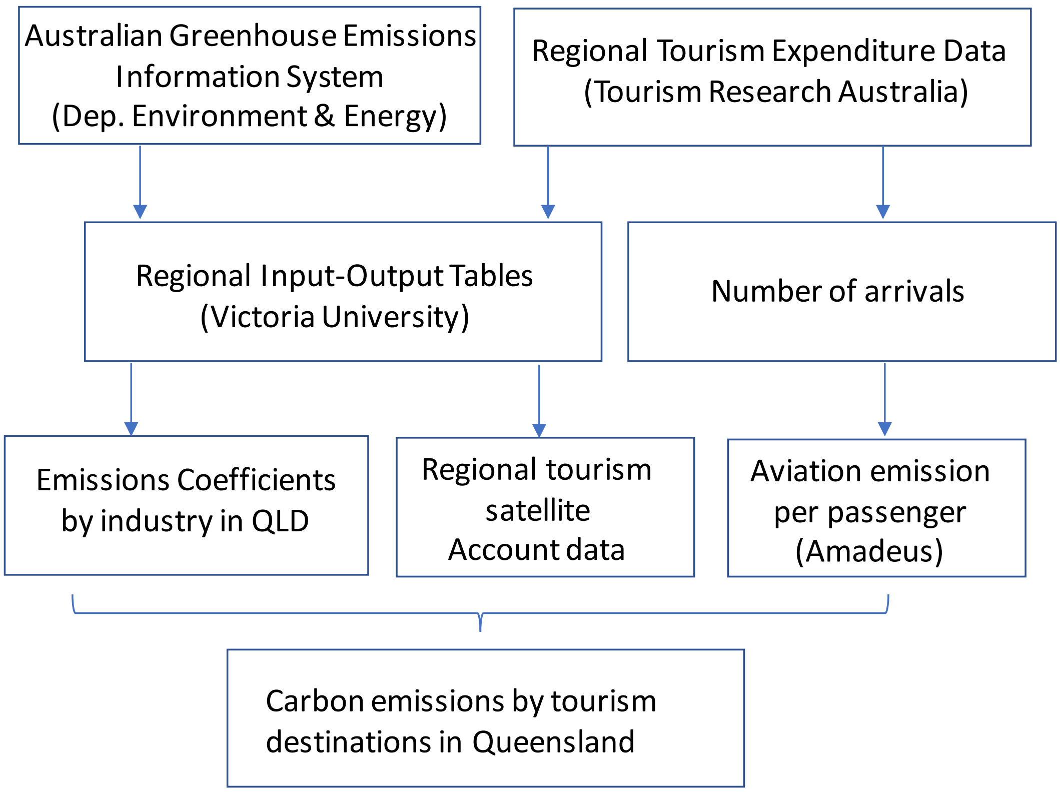

Figure 5: An overview of data flows for constructing carbon emissions of Queensland regions

3.1 Carbon emissions account framework

The official emissions account is delivered through the Australian Greenhouse Gas Emission Information System (AGEIS), developed by the Department of the Environment and Energy (DEE). Emission data from DEE is very comprehensive, covering all industries as well as the household sector for every state and territory in Australia. The emission data are organised at a very detailed level of emitting agents in the state and territory economies. Unfortunately, the database contains a significant number of cells that are concealed by confidentiality; not all data were available for industries at the state level. The initial step was to disaggregate the national emission values to fill in the 'confidential' cells across states and territories so the emission per unit of inputs used in the production process could be estimated. This task was carried out using data from the regional IO tables.[3] This is the basis for subsequently estimating tourism emissions. For a more detailed description of the process, see Appendix A.

An important note related to the accounting framework designed by the AGEIS is that emissions are classified into two main groups: direct and indirect:

> ***Direct emissions*** *are produced from sources within the boundary of an organisation and as a result of that organisation's activity.*
>
> ***Indirect emissions*** *are emissions generated in the wider economy as a consequence of an organisation's activities (particularly from its demand for goods and services), but which are physically produced by the activities of another organisation.*
>
> (*Department of the Environment and Energy, 2018, p. 6*)

An example of direct emissions could be the use of fuel by visitors on their self-drive trips. The concept of the *boundary* in tourism is not restricted to a certain location. It is extended to the entire journey made by visitors. With regards to indirect emissions, electricity used by hotels and restaurants to serve visitors is a good example, as emissions occur at the point of electricity generation, far away from the hotels and restaurants where electricity is used to provide services to visitors.

While the separation of direct and indirect emissions could be helpful in the conventional logic where the boundary of production and economic activity is defined clearly, the need to separate direct and indirect emissions in tourism is not necessary. Both are needed for tourism to occur. To streamline the way data are presented in this report, the results for direct and indirect emissions are combined for the primary purpose of assessing (total) emissions that are generated by the tourism sector in tourism destinations, or regions, of Queensland. Hereafter, the terms 'tourism destination' and 'tourism region' are interchangeable.

3.2 Tourism satellite account framework

In general, satellite accounts 'allow an expansion of the national accounts for selected areas of interest while maintaining the concepts and structures of the core accounts' (ABS, 2019b). As tourism is not part of the conventional System of National Accounts (SNA), the contribution of tourism to an economy is estimated through the TSA framework, which differentiates tourism output into two groups: direct and indirect. Direct tourism output refers to the goods and services consumed by tourists when the producers of such goods and services have physical contact with visitors. In contrast, when the producers do not have direct physical contact with visitors, the output values of such goods and services are classified as indirect tourism output, except for the retail margin where shopfront and retail staff are required to serve visitors during

[3] The database was obtained from the TERM model, a regional Computable General Equilibrium (CGE) model, from Victoria University.

the transaction. The contribution of tourism is based on the direct tourism output, in which values of all manufacturing goods are treated as inputs into the production of the tourism industry, and thus excluded from the calculation of tourism's contribution to the economy. This is the basis of tourism emissions from the production-based approach used in previous studies.

3.3 The integrated framework

The following example highlights the essential components of the adopted framework in the calculation of tourism emissions. For simplicity, let us assume a visitor uses their own vehicle for an overnight trip, that the visitor stays in a hotel and that they eat at a restaurant located at a tourism destination. The visitor's tourism expenditure bundle includes three main items: fuel, hotel and restaurant.

For hotel and restaurant, both *producers* have direct physical contact with the visitor, thus hotel and restaurant expenditure are included in the direct tourism output in the TSA framework. However, the entire fuel bill – $100 for example – is not deemed an output of tourism activity. If part of this amount is the cost of fuel ($70) and the remainder is the cost of running the petrol station ($30), then only the cost of running the petrol station (retail margin) is deemed to be part of the direct tourism output, as the visitor has direct physical contact with the petrol station. The cost of the fuel itself ($70) is treated as a cost to retailers of domestic goods sold directly to the visitor in the TSA. In a broader context, all manufacturing goods are treated in this way. Tourism output includes the retail margin of fuel and the expenditure of hotel and restaurant (direct components) in the above example.

From the national account framework perspective, the separation of direct and indirect tourism output is necessary, as it avoids double counting in the SNA. For the purpose of calculating tourism emissions, however, excluding these manufacturing goods from estimating emissions generated by tourism activities will result in significantly under-estimating tourism emissions. The national account focuses on the value-added component to measure contribution of a producing industry to the economy consistently across all industries in the economy in order to avoid double counting. Within the conventional industry group, the value-added component does not generate emissions; it is the immediate inputs and the domestic production process that generate emissions.

The production structure of tourism is not straightforward, unlike all other conventional industries, where inputs and value-added components are clearly presented. Tourism is portrayed as a broker who gathers and passes on all goods and services to visitors. Effectively, tourism does not have its own inputs and value-added components. These are *extracted* from individual industries supplying goods and services to visitors, and the satellite account is a medium that contextualises inputs and value-added elements of the tourism sector from the bundle of goods and services consumed by visitors. Direct tourism elements constitute the value-added block while indirect tourism elements are simply deemed inputs into *tourism production*. These inputs are either domestically produced or imported. Once they are determined, the value-added amounts from the supplying industries in the direct tourism group are combined to give the tourism value-added magnitude, while the inputs (indirect elements) are excluded from the calculation of 'contribution' to the economy, as they are already accounted for in other industries.

Thus, for the calculation of tourism emissions, including all manufacturing goods – that is, inputs of the tourism sector – is inevitable. If this is not done, the emissions from fuel and electricity used by the hotel and restaurant in the aforementioned example are the obvious components that would be left out, yet they are substantial contributors to tourism GHG emissions. Furthermore, emissions associated with agricultural products (e.g. beef and vegetables) required by the restaurant or purchased directly by the visitor are also left out. This gives rise to incorporate the so-called *input emissions* into the calculation. However, there is a limit to how far one can go back in the upstream of input supply to track emissions related to tourism. The immediate inputs (first round requirement), such as fuel and electricity in the example above, are fully justifiable under the 'indirect emission' rationale. Any further steps beyond the immediate round using the input–output multiplier, such as electricity used by fertiliser producers who supply fertiliser to agriculture to grow fruits and vegetables that are consumed by the visitor, might be considered far-fetched. In principle, the input–output multiplier modelling technique – which is not adopted in this report – measures the full chain of impacts, so it will introduce additional values (double counting effects) to the account (contribution) of a sector in an economy, and subsequently the associated emissions. The task to estimate tourism emissions here is clearly to construct an 'account'. Using an impact analysis tool would not be appropriate.

In short, the approach adopted in this report is to include both direct and indirect measures of the TSA logic to account for the entire tourism consumption set. This will give us most of the emissions of the "direct emissions" category in the AGEIS. However, the consumption set will not reflect emissions of inputs such as electricity used by hotels and restaurants or fuel consumption by visitors during their trip, thus emissions of those input types are included in an additional step. From this point, for simplicity, the terminologies of *direct and indirect* are only referred to in the carbon emission framework.

Throughout the whole process, international aviation was not included in the tourism consumption bundle of international visitors. This is simply because original TRA expenditure data do not provide the international airfares distributed to the regional level. It is a complicated process.[4] Emissions of international aviation are estimated using a more direct approach. Specifically, we drew on data made available for the Global Sustainable Tourism Dashboard (2019) by Amadeus IT Group. Using monthly data on the carbon associated with all itineraries leading to Queensland (see also work published by Becken & Shuker, 2018), it was possible to estimate average per passenger emissions for specific countries of origin. It was possible to differentiate average emissions for a passenger in economy class and one in premium (business

[4] There is also a further complication in that national climate commitments (e.g. under the Paris Agreement) do not include emissions from so-called bunker fuels, under which aviation fuel falls. As a result, emissions resulting from international travel are not accounted for. Instead, they are addressed through a global framework developed by the International Civil Aviation Organisation. Since tourism is defined through its consumption, and since there is increasing discussion that destinations need to take responsibility of all emissions associated with their tourism activity, it is important that international aviation emissions are included in this present work.

and first) class. An average of emission rate per passenger for both groups was estimated and used in this report.

Data from TRA provide information on the number of international visitors from each country. The data also show the airport where they arrived in Australia and the number of visitor nights that they spent at each subsequent destination during their trip to Australia. By combining the emission rates and the number of visitors from individual countries, total emissions of international visitors by country of origin were estimated. Using the visitor night shares, anchored at the arrival airports, total emissions were then allocated to the individual destinations where the visitors went. In this way, international aviation emissions were distributed to regions depending on the significance of individual destinations that international visitors had placed on their trips. This approach avoids allocating international aviation emissions entirely to the gateway cities where international airports are located, as not all international visitors stay in one city for their entire trip.

The whole procedure to calculate tourism emissions from visitor expenditure and carbon factor per unit cost is described in Appendix B. In general, emissions are provided for five groups:

1. Emissions from the goods and services produced by local industries (including domestic air transport)
2. Emission from goods and services (mainly goods) imported from overseas
3. Emissions from fuel consumption by self-drive visitors
4. Emissions from intermediate inputs used, mainly agricultural products and electricity
5. Emissions from international aviation.

It should be noted here that emissions in this report are calculated using energy content factors, emission factors and formulae that include carbon dioxide (CO_2), methane and nitrous oxide as published in Department of the Environment and Energy (2018). Therefore, all emissions reported in here are CO_2 equivalent (CO_2-e).

4. Results

4.1 Tourism emissions by broad category

The Queensland tourism sector is estimated to generate a total of 11.6 million tonnes (Mt) of CO_2-e in 2016/17 (Table 1 and Figure 6). Being the most visited tourism destinations of the state, Brisbane, the Gold Coast and Cairns (Tropical North Queensland) are the top three regions in terms of GHG emissions in the state: 4 Mt (34 per cent), 1.9 Mt (16.5 per cent) and 1.6 Mt (14 per cent) respectively. The Sunshine Coast is in the mid-level, with nearly 1.2 Mt, or close to 10 per cent. Figure 6 presents proportions of carbon emission across all tourism destinations for comparison.

Table 1: Tourism emissions across Queensland destinations by broad category, 2016/17

	Tourism output	Fuel	Imports	Tourism inputs	International aviation	Total	Shares
			million tonnes			Mt	per cent
Brisbane	1.3687	0.578	0.092	1.059	0.890	3.988	34.3%
Bundaberg	0.034	0.062	0.007	0.060	0.039	0.202	1.7%
Southern Queensland Country	0.117	0.215	0.026	0.158	0.041	0.557	4.8%
Fraser Coast	0.044	0.069	0.008	0.069	0.031	0.221	1.9%
Gold Coast	0.526	0.267	0.054	0.702	0.366	1.915	16.49%
Mackay	0.076	0.065	0.008	0.061	0.015	0.225	1.9%
Townsville	0.205	0.124	0.017	0.131	0.056	0.533	4.6%
Outback Queensland	0.104	0.205	0.021	0.092	0.017	0.440	3.8%
Sunshine Coast	0.265	0.272	0.037	0.449	0.128	1.150	9.9%
Tropical North Queensland	0.538	0.181	0.032	0.507	0.326	1.584	13.6%
Whitundays	0.107	0.034	0.006	0.117	0.064	0.328	2.8%
Capricorn	0.087	0.098	0.014	0.099	0.020	0.317	2.7%
Gladstone	0.037	0.048	0.005	0.037	0.027	0.153	1.3%
Queensland	**3.509**	**2.218**	**0.327**	**3.541**	**2.0190**	**11.61**	**100.0%**

Among the five broad categories, the emissions passed on to tourism through input usage ("Tourism Inputs" column), such as agricultural products and electricity, are nearly the same as the level of emissions generated directly from all other goods and services produced by domestic industries for visitors ("Tourism output" in Table 1). Note that emissions of the domestic air transportation are included in the domestic tourism output. Together, the emissions of these two groups (i.e. tourism inputs and tourism output) take up slightly more than 60 per cent of the total emissions across all regions. The rest is made up of nearly equal proportions of international aviation (17 per cent) and private vehicle use (19 per cent). Emissions from imported sources are insignificant in total tourism emissions generated by visitors to Queensland (Figure 7).

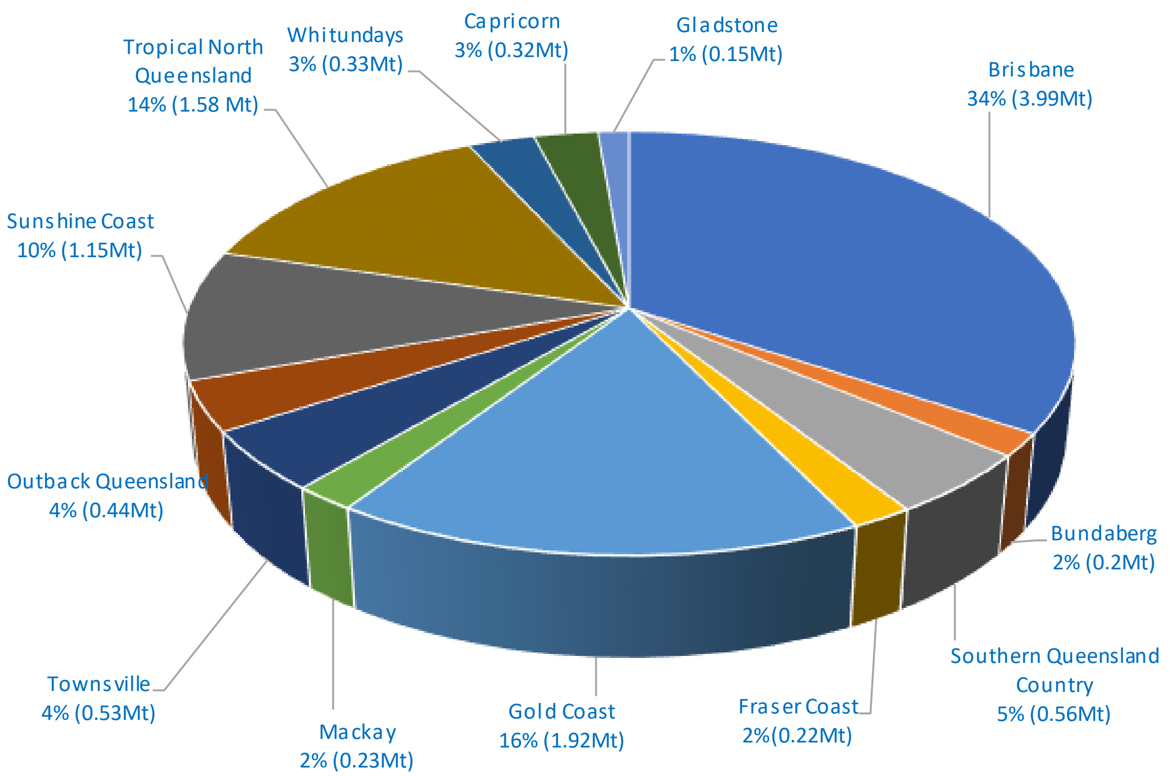

Figure 6**: Emission shares of destinations in Queensland (%), 2016/17**

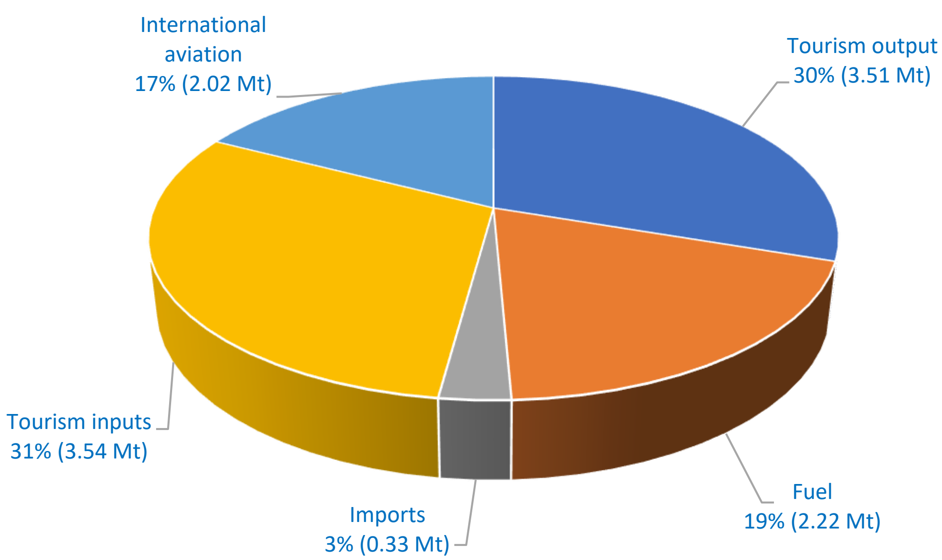

Figure 7**: Profile of tourism emissions in Queensland (%), 2016/17**

4.2 Tourism emissions by tourism producing sector

Emissions of the domestic tourism output group are presented in Appendix C by aggregate commodities. Domestic air transport and road transport are the two major sources of emissions. However, the profile in Appendix C alone is not a complete representation of the tourism emissions by activity when inputs are not part of the output. Table 2 rearranges tourism emissions by combing inputs and output of tourism producing sectors together into a profile of total emissions:

- Emissions from fuel consumption are combined with emissions from road transport in the tourism output group.
- Emissions from domestic air transport are combined with emissions from international air transport.
- Embedded emissions in agricultural products, such as beef and vegetables, are added to the restaurant sector or ‘other food and drink’ for self-catering.
- Emissions from electricity generation are added to tourism industries such as hotels and restaurants.

Table 2: Tourism emissions by tourism-producing sector (Mt), 2016/17

	Air transport	Road transport	Other transport	Accomm.	Restaurant	Other Food	Shopping	Others	Total
					million tonnes				
Brisbane	1.89	0.84	0.02	0.14	0.27	0.39	0.13	0.32	3.99
Bundaberg	0.06	0.06	0.00	0.01	0.02	0.03	0.00	0.02	0.20
Southern Queensland Country	0.11	0.23	0.01	0.02	0.05	0.06	0.02	0.07	0.56
Fraser Coast	0.05	0.08	0.00	0.01	0.02	0.03	0.01	0.02	0.22
Gold Coast	0.69	0.37	0.01	0.13	0.22	0.26	0.05	0.18	1.91
Mackay	0.07	0.07	0.00	0.01	0.02	0.02	0.00	0.02	0.23
Townsville	0.22	0.15	0.01	0.02	0.03	0.04	0.01	0.05	0.53
Outback Queensland	0.09	0.21	0.01	0.01	0.03	0.03	0.00	0.05	0.44
Sunshine Coast	0.28	0.32	0.01	0.07	0.15	0.18	0.02	0.12	1.15
Tropical North Queensland	0.72	0.28	0.01	0.09	0.13	0.20	0.03	0.12	1.58
Whitundays	0.13	0.06	0.00	0.02	0.04	0.04	0.00	0.03	0.33
Capricorn	0.08	0.11	0.00	0.01	0.03	0.03	0.01	0.04	0.32
Gladstone	0.05	0.05	0.00	0.01	0.01	0.01	0.00	0.02	0.15
Queensland	**4.45**	**2.84**	**0.09**	**0.55**	**1.01**	**1.33**	**0.30**	**1.06**	**11.61**

Table 3 presents the combined emissions of tourism-producing sectors in percentage shares, (Figure 8). Overall, air transport and road transport are the two sectors contributing the most to total tourism emissions – 38 per cent and 24 per cent respectively, more than emissions from all other sectors added together. Both the restaurant and other food sectors have higher emission shares than the hotel sector. This is mainly due to the fact that agricultural products carry high levels of embedded emissions.

Table 3: Tourism emission shares by tourism-producing sector (%), 2016/17

	Air transport	Road transport	Other transport	Accomm.	Restaurant	Other Food	Shopping	Others	Total
					per cent				
Brisbane	47.32	21.05	0.513	3.49	6.66	9.75	3.27	7.95	100
Bundaberg	29.31	32.04	0.970	4.52	8.41	12.54	1.84	10.36	100
Southern Queensland Country	19.70	41.39	0.990	3.38	8.28	10.50	2.92	12.85	100
Fraser Coast	23.83	35.41	1.198	4.23	10.40	11.40	2.32	11.21	100
Gold Coast	36.17	19.53	0.666	6.64	11.44	13.42	2.87	9.26	100
Mackay	33.18	32.49	0.975	5.18	7.37	9.14	1.85	9.82	100
Townsville	41.10	28.04	1.046	3.32	6.49	8.39	2.08	9.53	100
Outback Queensland	21.14	48.68	1.188	2.32	5.88	7.84	0.92	12.04	100
Sunshine Coast	24.41	27.49	0.899	6.42	12.66	15.94	2.09	10.09	100
Tropical North Queensland	45.43	17.54	0.890	5.52	8.25	12.87	1.86	7.63	100
Whitundays	40.17	18.47	0.878	7.47	11.53	12.54	1.22	7.73	100
Capricorn	23.92	34.72	1.208	4.02	10.32	10.02	2.91	12.88	100
Gladstone	32.44	35.71	0.725	4.50	7.30	8.46	0.96	9.91	100
Queensland	**38.28**	**24.48**	**0.76**	**4.72**	**8.66**	**11.43**	**2.57**	**9.09**	**100**

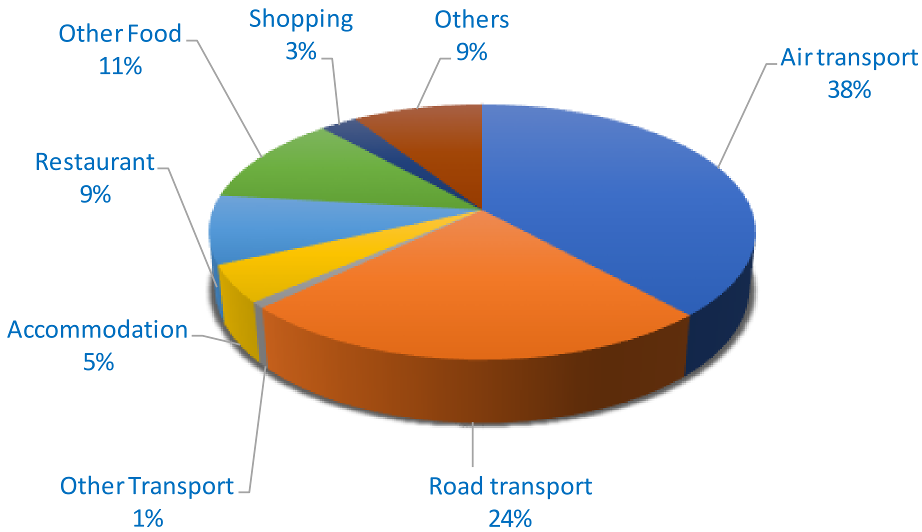

Figure 8**: Emission shares by tourism-producing sectors in Queensland (%), 2016/17**

Comparing destinations, Southern Queensland Country and Outback Queensland have very high shares of emission from road transport, reflecting the fact that road transport is the main means to reach the regions. To some extent, it could even mean that most trips to the regions could be self-drive. To illustrate, it is evidenced from the TRA data for Western Downs[5] that the share of fuel in total consumption in the region was very high (26.8 per cent) compared with the national average (9 per cent). The remoteness and natural attraction of these regions, which invite extensive land travel (e.g. to explore or simply to cover distances between attractions), probably are the main reason for this high share of road transport emission. In contrast, visitors to regions such as Brisbane, Tropical North Queensland, Townsville and the Whitsundays rely mainly on air transport, consequently generating a large proportion of emissions through aviation: 47 per cent, 45 per cent, 41 per cent and 40 per cent respectively.

5 One of the regions within Southern Queensland Country.

The emissions analysis highlights the importance of understanding the context of each destination, its distribution of attractions and its connectedness to wider transport networks and travel itineraries.

It is also interesting to see that tourism regions in Queensland tend to form two groups with distinct expenditure patterns in terms of food consumption. Regions including the Fraser Coast, Gold Coast, Sunshine Coast, Whitsundays and Capricorn generally have high shares of emissions for food consumption, either from meals served in the restaurants or self-catering. Among these regions, the Gold Coast, Whitsundays and Sunshine Coast are well above the state average shares. These are probably tourism destinations for leisure visitors, who seek higher-end experience in their travelling, thus dining out in restaurants (which draw on the inputs of meat and dairy products – with high embedded carbon emissions content) is a necessary part of their trip. In contrast, Outback Queensland, Townsville, Gladstone and even Brisbane are regions with low proportions of emissions from food. Although this is hard to explain in the case of Brisbane, the other three regions seem to offer similar travel experiences to visitors, focused more on natural attractions, so food as a substantial spending category might not be a major part of visitors' requirements.

4.3 Tourism emissions by visitor type

Table 4 examines tourism emissions by three broad types of visitor: domestic overnight visitors, domestic day visitors and international visitors. Among them, domestic overnight visitors contribute 53.8 per cent of total emissions, followed by international (or inbound) visitors (31.8 per cent) and day visitors (14.4 per cent) across the whole of Queensland (Figure 9).

Table 4: Emissions by visitor types (Mt), 2016/17

	Domestic Overnight	Day	Inbound	Total	Domestic Overnight	Day	Inbound	Total
	million tonnes				*shares (per cent)*			
Brisbane	1.8143	0.583	1.590	3.99	45.5	14.6	39.9	100.0
Bundaberg	0.113	0.040	0.049	0.20	55.8	19.9	24.3	100.0
Southern Queensland Country	0.341	0.159	0.057	0.56	61.2	28.5	10.3	100.0
Fraser Coast	0.129	0.051	0.041	0.22	58.3	23.1	18.6	100.0
Gold Coast	0.993	0.221	0.701	1.91	51.8	11.6	36.6	100.0
Mackay	0.170	0.033	0.022	0.23	75.6	14.5	9.9	100.0
Townsville	0.355	0.084	0.094	0.53	66.6	15.7	17.7	100.0
Outback Queensland	0.340	0.078	0.022	0.44	77.2	17.8	5.0	100.0
Sunshine Coast	0.738	0.213	0.199	1.15	64.1	18.5	17.3	100.0
Tropical North Queensland	0.748	0.109	0.727	1.58	47.2	6.9	45.9	100.0
Whitundays	0.177	0.016	0.136	0.33	53.8	4.8	41.4	100.0
Capricorn	0.236	0.057	0.025	0.32	74.3	17.9	7.8	100.0
Gladstone	0.093	0.026	0.035	0.15	60.4	16.8	22.8	100.0
Queensland	**6.245**	**1.671**	**3.699**	**11.61**	**53.8**	**14.4**	**31.8**	**100.0**

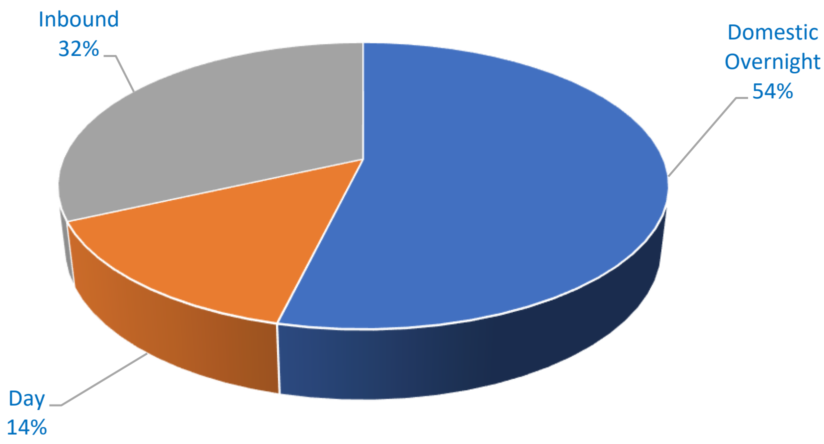

Figure 9**: Queensland tourism emissions by visitor type, 2016/17**

Brisbane, the Gold Coast, Tropical North Queensland (Cairns) and the Whitsundays are regions with large shares of emissions from the international market, most noticeably the last two. Regions that have high domestic overnight visitor shares are Mackay, Outback and the Capricorn Coast. Southern Queensland Country and the Fraser Coast see more emissions from the day visitors than most other regions. While Southern Queensland Country could attract visitors from within many other areas in the state, day visitors to the Fraser Coast are more likely to be from organised day tours for visitors staying on the Sunshine Coast. This explains a relatively high share of road transport emissions (35 per cent) for the Fraser Coast, shown in Table 3 earlier.

Emissions are further assessed on a per visitor basis across all types. Table 5 shows that on a state-wide average basis, an individual tourist from overseas (i.e. an international visitor) generates more than three times the amount of emissions of a domestic overnight visitor. The differences in emissions vary across tourism destinations, with the largest gaps being observed in Brisbane, Bundaberg and Southern Queensland Country: from 4.7 to 6.6 times larger. These differences can be due to many factors, including the visitor mix of the region – mainly from New Zealand, the United Kingdom, the United States, Canada and Germany, involving mainly long-haul flights.

Table 5: Emissions per visitor (tonnes), 2016/17

	Overnight	Day	Inbound
	tonnes per visitor		
Brisbane	0.268	0.039	1.261
Bundaberg	0.205	0.061	1.201
Southern Queensland Country	0.184	0.047	1.219
Fraser Coast	0.229	0.064	0.290
Gold Coast	0.282	0.036	0.693
Mackay	0.196	0.048	0.507
Townsville	0.328	0.046	0.735
Outback Queensland	0.373	0.130	0.753
Sunshine Coast	0.217	0.035	0.693
Tropical North Queensland	0.418	0.048	0.838
Whitundays	0.347	0.051	0.590
Capricorn	0.247	0.040	0.351
Gladstone	0.204	0.060	0.611
Queensland	**0.269**	**0.042**	**0.877**

5. The Great Barrier Reef

Queensland is well known for the astounding beauty of its Great Barrier Reef (GBR). The GBR is the world's largest coral reef system – one of the Seven Natural Wonders of the World and World Heritage listed by UNESCO since 1981. The GBR is located off Australia's east coast and stretches more than 2200 kilometres from Cape York to Gladstone.

Many visitors travel to Queensland to see the GBR, thus contributing both income and inevitably emissions to the state. It is difficult to attribute an exact economic value to calculate emissions to the GBR as an attractor. Technically, both contributions should only be associated with visitors who actually visit or engage in any activity that involves the GBR. While the task to disentangle the proportions of visitors' consumption and the associated emissions between GBR versus non-GBR purposes is doable, it is very time consuming, and is beyond the scope of this report. Hence this section presents emissions for regions in the GBR catchment instead.

Table 6: Tourism emissions of the GBR catchment by broad category (Mt), 2016/17

	Tourism output	Fuel	Imports	Tourism inputs	International aviation	Total	Shares
			million tonnes			Mt	per cent
Brisbane	1.3687	0.578	0.092	1.059	0.890	3.988	34.3%
Bundaberg	0.034	0.062	0.007	0.060	0.039	0.202	1.7%
Southern Queensland Country	0.117	0.215	0.026	0.158	0.041	0.557	4.8%
Fraser Coast	0.044	0.069	0.008	0.069	0.031	0.221	1.9%
Gold Coast	0.526	0.267	0.054	0.702	0.366	1.915	16.49%
Outback Queensland	0.104	0.205	0.021	0.092	0.017	0.440	3.8%
Sunshine Coast	0.265	0.272	0.037	0.449	0.128	1.150	9.9%
Great Barrier Reef	1.050	0.550	0.081	0.952	0.508	3.141	27.0%
Queensland	**3.509**	**2.218**	**0.327**	**3.541**	**2.019**	**11.61**	**100.0%**

Table 7: Tourism emission of the GBR catchment by tourism producing sector, 2016/17

	Air transport	Road transport	Other transport	Accomm.	Restaurant	Other Food	Shopping	Others	Total
				million tonnes					
Brisbane	1.89	0.84	0.02	0.14	0.27	0.39	0.13	0.32	3.99
Bundaberg	0.06	0.06	0.00	0.01	0.02	0.03	0.00	0.02	0.20
Southern Queensland Country	0.11	0.23	0.01	0.02	0.05	0.06	0.02	0.07	0.56
Fraser Coast	0.05	0.08	0.00	0.01	0.02	0.03	0.01	0.02	0.22
Gold Coast	0.69	0.37	0.01	0.13	0.22	0.26	0.05	0.18	1.91
Outback Queensland	0.09	0.21	0.01	0.01	0.03	0.03	0.00	0.05	0.44
Sunshine Coast	0.28	0.32	0.01	0.07	0.15	0.18	0.02	0.12	1.15
Great Barrier Reef	1.27	0.73	0.03	0.16	0.26	0.36	0.06	0.28	3.14
Queensland	**4.45**	**2.84**	**0.09**	**0.55**	**1.01**	**1.33**	**0.30**	**1.06**	**11.61**

Table 8: Emissions by visitor types in the GBR catchment, 2016/17

	Domestic Overnigh	Day	Inbound	Total	Domestic Overnight	Day	Inbound	Total
		million tonnes				*shares (per cent)*		
Brisbane	1.81	0.58	1.59	4.0	45.5	14.6	39.9	100.0
Bundaberg	0.11	0.04	0.05	0.2	55.8	19.9	24.3	100.0
Southern Queensland Country	0.34	0.16	0.06	0.6	61.2	28.5	10.3	100.0
Fraser Coast	0.13	0.05	0.04	0.2	58.3	23.1	18.6	100.0
Gold Coast	0.99	0.22	0.70	1.9	51.8	11.6	36.6	100.0
Outback Queensland	0.34	0.08	0.02	0.4	77.2	17.8	5.0	100.0
Sunshine Coast	0.74	0.21	0.20	1.2	64.1	18.5	17.3	100.0
Great Barrier Reef	1.78	0.32	1.04	3.1	56.6	10.3	33.1	100.0
Queensland	**6.25**	**1.67**	**3.70**	**11.6**	**53.8**	**14.4**	**31.8**	**100.0**

6. Discussion

6.1 Comparison

In this report, emissions are presented as a comprehensive measure that includes all necessary activities and experiences for tourism to occur. To some extent, the account presented here is more compatible with the *expenditure* approach, as it includes emissions from all sources, including tourism inputs, fuel consumption of private or hire cars, imported goods and international aviation.[6] It is, however, more comprehensive than the expenditure approach in that it also encompasses the imputed consumption, where the costs were not directly incurred by visitors. The nature of emission measures in this report needs to be kept in mind when comparing results with previous studies, as not all studies use the same approach or methodology.

It is important to note that emissions in this report are not estimated using the input output multipliers, as such an approach will mix 'impact' results with the 'contribution' in the national accounts. Further, the concept of adding emissions from the construction of infrastructure (hotels) to the account for tourism emissions would violate the national account principle. The national accounts, and subsequently the emission accounts, are on the flow basis of goods and services consumed within a year. While the construction costs and the associated emissions of such construction could occur in a limited period of time, hotels themselves operate over a long time period – often decades. Construction values of hotels are added to capital stocks, and usage of hotels is treated as depreciation over time, so using the emission of the entire construction to allocate emissions to a single year is highly questionable in the national accounts framework, as visitors do not use up the values of hotels in a single year.

Apart from the methodology, each country has different infrastructure and different types of tourism experience for visitors, so the structure and the relative share of the associated tourism emissions in total emissions would not be compatible across countries. Australia is far away from the rest of the world; long-haul flights are unavoidable for international visitors. Tourism destinations of the country have different climates, landscapes and cultural characteristics, offering diverse tourism experiences. Visitors from overseas often try to maximise their experiences by visiting as many places as possible during their visit. Tourism destinations in Australia are scattered over a large area of the country, inherently leading to itineraries marked by long travel distances, both for domestic and international visitors. This type of geography is not the same in other countries, where closer concentration of attractions results in short travel distances, including those that can be served by public transport. It is also evidenced from this report that even within Queensland, there are substantial differences between regions, so care must be taken when comparing results.

At the state level, Queensland was estimated to produce 161.2 Mt of CO_2-e in 2016/17 (DEE, 2018). This report estimated total emissions of 11.6 Mt for tourism across all destinations in

[6] Emissions from imported goods and international aviation are not included in the state total emissions reported by the Department of the Environment and Energy.

the state for the same year, making tourism emissions equivalent to about 7.2 per cent of Queensland's total. This includes emissions associated with imported goods and international aviation, which are not counted in Queensland's total emissions. This result is within the range of previous studies, including a contribution of 11.2 per cent found by Dwyer and colleagues (2010) for Australia nationally, 9.1 per cent cited by De Bruijn et al (2010) for the Netherlands, 6 per cent noted in Becken and Patterson (2006) for New Zealand, and 8.3 per cent for Queensland in Hoque and colleagues (2010).

Among all previous reports, the results from Hoque and colleagues (2010) are perhaps more directly relevant and warrant some discussion, due to the focus on emissions of Queensland's tourism sector. Although estimated for 2003/04, the total tourism emissions cited by Hoque and colleagues were higher than the tourism emissions estimated for 2016/17 in this report. This is due to two main reasons: (1) the total emissions across all Queensland industries adopted in Hoque et al. (2010) were higher than the official level from DEE for 2003/04 and even higher than the total for 2016/17 used in this study; and (2) the emissions for imported goods and services were unusually high compared with a modest ratio of imports in total tourism consumption of goods and services – approximately 5.7 per cent for 2003/04.

6.2 Policy implications

It is important that tourism policy development considers total (ie direct and indirect emissions) and per capita emissions, as this will provide a more comprehensive basis for mitigating tourism's climate change effects. More specifically, while domestic tourism is the main contributor to tourism emissions in Queensland, the carbon footprint for each individual international visitor is relatively higher. Thus, additional promotion and increase in international visitation will lead to a much faster increase in tourism emissions, compared with growth in domestic tourism. There is increasing global demand to address tourism's carbon footprint, and it is also in the interest of Australia (and Queensland) to promote a low-carbon development path for tourism. The inherent relationship between emissions and tourism growth requires a proper modelling framework to examine scenarios that could lead to reductions in emissions while minimising adverse impacts on tourism growth. This could be done through a combined framework in which the carbon emission accounts are embedded in a tourism CGE model, so that changes in tourism demand and resultant emissions can simultaneously be captured in what-if scenarios.

Given the geographic position of Australia in the world, emissions from international aviation seem to be inevitable (at least with current technologies), although there are considerable differences between different markets and also between airlines. Similarly, the natural configuration of domestic destinations across Australia seems to induce large emissions from internal air transportation as well as road transport through self-drive activity (fuel consumption). Perhaps, through the carbon accounts, it is possible to identify emission-producing sources that are unavoidable versus avoidable, and to develop policy measures to minimise those that can be avoided. If carbon offsets represent a potential policy option, then the carbon footprint for tourism developed in this report is the key to work out the level of offsets required to compensate for tourism emissions. A possible long-term sustainable solution would be to aim to decarbonise transportation as one of the key contributors to tourism carbon emissions. While train travel presents some challenges, there could be opportunities to replace some air travel towards lower carbon land-based options. Some airports are taking an interest in electric aviation, but this is restricted to shorter distances in the medium-term future. Biofuels and other alternative fuels (e.g. synthetic) are being explored, but at present their scale is small and for some feedstocks there are considerable sustainability challenges. The Queensland Government is investing in the electrification of land transport, and tourism could become a more active player in the adoption of these new technologies (e.g. rental vehicle companies).

The examination of different types of visitors and their respective carbon footprints should be of considerable interest, especially when developing new marketing campaigns and developing air links to other countries in order to effect changes in visitor mix; a proactive approach to mitigate emissions whilst retaining economic contribution. Thus, metrics such as the eco-efficiency (e.g. $/CO2) could be useful ways to assess the impact of future market compositions.

At the individual level, the pattern of emission per passenger could be examined further to understand the cause of emissions for each visitor type. This could be followed up and complemented by surveys on visitor behaviour with special reference to emission objectives so that both the carbon accounts and the survey results can provide a deep understanding of strategies to reduce tourism emissions. This is even more important given that an increasing number of visitors feel very conscious of their carbon footprint, to the extent of experiencing ‘flight shame’. Offering better alternatives and choices may become an important ingredient of the Queensland tourism portfolio.

7. Concluding remarks

Calculations of tourism emissions are a complex process, and can be different across studies and cases. This report focuses on a comprehensive measure that incorporates all aspects of emissions involved in tourism activities in regions of Queensland so that the carbon footprint of tourism can be estimated. Importantly, this report develops a tourism carbon footprint for Queensland’s tourism sector as a multifaceted tool for policy development.

Total tourism emissions in Queensland were estimated to be 11.6 Mt CO_2-e for 2016/17, with air and road transport being the main sources of emissions. As for tourism destinations, Brisbane, the Gold Coast, Tropical North Queensland and the Sunshine Coast are the regions that generate the most tourism emissions in the state. Overall, more emissions are generated from the domestic overnight market than from international tourism. It is important to note though that the per capita emission of international visitors are about three times those of domestic visitors.

Undoubtedly, curbing tourism emissions also means constraining the growth of the sector, at least when measured on a volumetric (rather than value-based) metric. The combination of the aforementioned factors poses an interesting question about how strategic policy measures can be tailored to individual markets to mitigate emissions. It is not a straightforward solution to target certain activities alone to mitigate emissions, as tourism requires a cohesive set of goods and services that make up certain tourism expenditure patterns, reflecting the type of experience visitors seek.

The construction of the emission accounts in the report is not the end; rather, it serves as a starting point for a more comprehensive (policy) modelling process to be explored. Thus it is important that updates of these emission data continue in order to monitor changes in tourism emissions in the short- and medium-term future.

Appendix A: National GHG emission disaggregation

In the Australian Greenhouse Gas Emission Information System, emissions are classified into five main groups for all states and territories of Australia. Under each group, the emissions are attributed to various sectors, but some emissions data at the sectoral level are not published due to confidentiality reasons. Based on the national greenhouse accounts factors (DEE, 2019), as well as other information, the five groups of emissions are mapped out for industries in each state.

Group 1: Energy (including industries and household)

This group includes emissions from stationary and non-stationary combustion of fuels as well as fugitive emissions from fuels. DEE (2019) provides the energy content factor and emission factor for each type of fuel. By applying these factors to the fuel usage by industries in all states, which are available in the input–output tables, the emissions are disaggregated into different industries of all states and territories. The per unit emission rates at the state level were then established and applied to tourism regions.

Group 2: Industry processes

Emissions in this group are generated from specific industrial processes, such as the production of cement clinker, lime, soda ash, ammonia, etc. Since DEE used national average emissions factors to estimate this type of emissions, they are proportional to the sectoral output for any given sector of different regions. As a result, this group of emissions is disaggregated according to sectoral output ratios across states and territories.

Group 3: Agriculture

Emissions in this group are mainly from grazing, particularly from feed digestion by ruminant livestock, as well as cropping, agricultural burning, including the decay or burning of biomass, animal manure nitrogen leaching and runoff. The emissions for the use of fuels in agricultural sectors (e.g. vehicle fuel use and burning fuels in plant and equipment) are already counted in Group 1: Energy. They are excluded from this group to avoid double counting. Similarly, the emissions and removals due to land conversion, tree planting, crop and grazing management are included in Group 4: Land use. They are also excluded from this group.

The methodology of estimating emissions for this group is documented in the *National Inventory Report 2017* (Volume 1). Due to the complexity of the agricultural system, the estimation is also complicated. By and large, the emissions are positively related to output level of different type of products and the emission intensity of each product. Since the same type of agricultural sector produces the same types of product, with the same emission intensity, the output ratios are used to disaggregate emissions of each agricultural sector to different regions.

Group 4: Land use

This group includes GHG emissions and carbon sequestration from land use change and forestry, such as deforestation, afforestation and reforestation, forest management, cropland and grazing land management, and revegetation. This group of emissions is closely related to the land area of different types across regions, so land area data are obtained to disaggregate emissions in this group.

The Australian Bureau of Statistics (2018) provides farming land data at A4-statistical region level. This is the main source for land area disaggregation. The farming land types include crop land, grazing land, forestry and other land. The first three types of land are mapped into corresponding agricultural sectors, while the last one, 'other land', is mapped into the remaining agricultural sectors based on the land rental ratios in the input–output tables. The A4 statistical areas are also mapped into the sub-state regions.

The farming land data from the ABS are based on surveys of farmers. Since some farmers did not respond to the survey, not all existing farming land areas appear in the database. This situation is indicated by the fact that, in the input–output tables, agricultural sectors in some regions show positive land rental, but there is no farming land in these regions. To overcome the deficiency in the databases and inconsistency with the input–output tables, two steps are used to compute land areas for these inconsistent regions. First, the average rate of land rental per acre is calculated for each state. Second, the land area for an industry in inconsistent regions is obtained by dividing the sectoral land rental of the regions by the average rate of per-acre land rental of the corresponding state. Due to this computation, the total land areas is about 3.3 per cent higher than those in the ABS farming land database.

Group 5: Wastes

This group of emissions comes from waste disposal and management – for example, methane released from landfills, biological treatment of solid waste at the landfill, wastewater handling and so on. The DEE's estimation of emissions in this group is based on emission intensities in different treatment processes. Since wastes are managed by two sectors in the input–output tables, which do not display different waste treatment processes, the regional disaggregation is done approximately based on the sectoral output shares of the regions.

Appendix B: TSA framework

Figure 10 outlines the initial step where the TSA framework is combined with the carbon emission framework. Regional tourism expenditure data were obtained initially from Tourism Research Australia (TRA, 2019). Expenditure is often reported by visitors during their travel. Thus expenditure alone does not adequately reflect the total tourism demand (consumption) when visitors are provided with food, drink and even accommodation by the hosts. At the national and state levels, both the ABS and TRA impute an additional values of tourism consumption for this purpose.

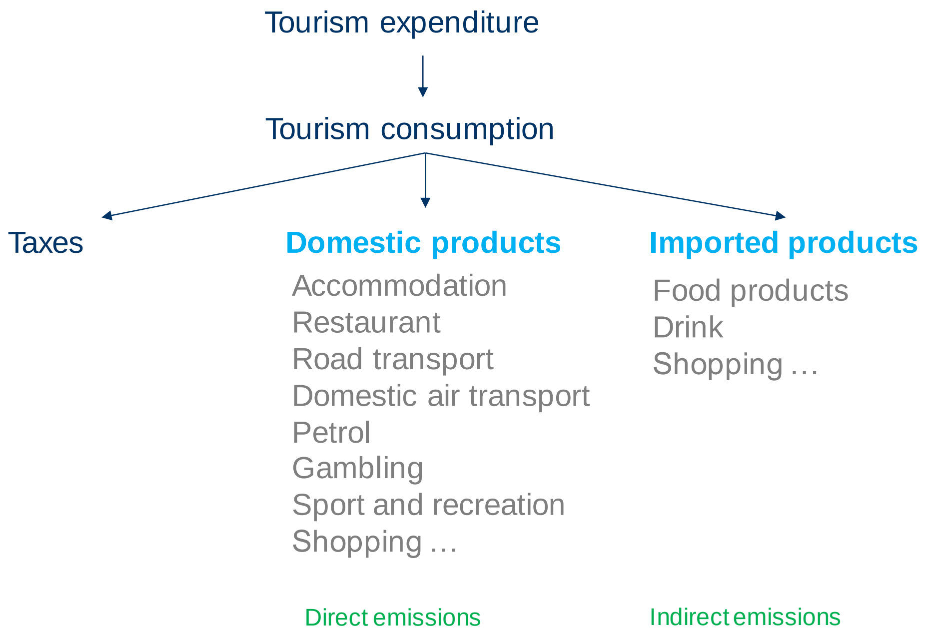

Figure 10**: TSA inputs into the emission calculation**

In this report, the imputed tourism consumption in Queensland was distributed to destinations using the number of VRF[7] visitors, for both domestic overnight visitors and international visitors. This ensures emissions related to tourism consumption, not necessarily incurred by the visitors, are fully captured.

Tourism consumption by commodity at this stage is measured at purchasers' prices, which include net commodity tax payable to the government, transport margins and the costs of goods and services either produced locally or imported from overseas. All these components are decomposed explicitly and converted into consumption measured at basic prices. Transport margins are allocated back to the margin producing industries.

Tourism consumption at basic prices is organised by sources as indicated in Figure 10. It is important to note that all manufacturing goods are not removed from the consumption bundle. Using the emission rates per unit cost that were derived previously, tourism emissions are estimated for goods and services produced locally. For the import source, we assumed that the production technology in overseas countries would be similar to its counterparts in Queensland,

[7] Visiting relatives and friends

so we applied the corresponding emission rates per unit cost on the imported values to estimate the emissions.

Appendix C: Tourism output emissions

Table 9: Details of tourism output emissions, 2016/17

	Air transport	Road transport	Other Transport	Accomm.	Restaurant	Other Food drink	Shopping	Others	Total
				million tonnes					
Brisbane	0.93	0.25	0.02	0.02	0.03	0.02	0.01	0.09	1.4
Bundaberg	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.0
Southern Queer	0.06	0.01	0.00	0.00	0.01	0.00	0.00	0.02	0.1
Fraser Coast	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.0
Gold Coast	0.30	0.10	0.01	0.02	0.03	0.01	0.00	0.05	0.5
Mackay	0.06	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.1
Townsville	0.15	0.02	0.00	0.00	0.00	0.00	0.00	0.01	0.2
Outback Queen	0.07	0.01	0.00	0.00	0.00	0.00	0.00	0.02	0.1
Sunshine Coast	0.14	0.04	0.01	0.01	0.02	0.01	0.00	0.03	0.3
Tropical North (	0.37	0.09	0.01	0.01	0.02	0.01	0.00	0.03	0.5
Whitundays	0.06	0.03	0.00	0.00	0.00	0.00	0.00	0.01	0.1
Capricorn	0.05	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.1
Gladstone	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Queenslland	**2.26**	**0.59**	**0.07**	**0.07**	**0.12**	**0.06**	**0.03**	**0.30**	**3.51**

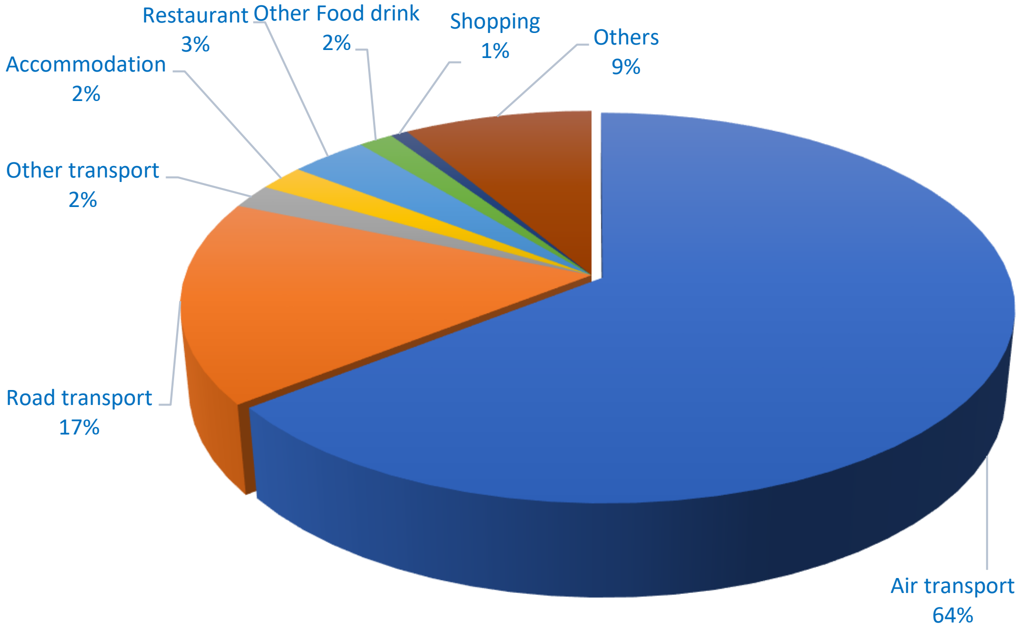

Figure 11: Profile of tourism output emissions (%), 2016/17

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