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Municipal Emissions From Tourism

Final Report for the Pilot Calculation

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Preface

The aim of the *Carbon Neutral Experience – Uudenmaan matkailusektorin matka kohti hiilineutraaliutta* project carried out in 2021–2023 was to promote low-carbon tourism in the Uusimaa region, respond to the carbon neutrality targets and the growth of sustainable tourism, and become a trendsetter in these areas.

The project was coordinated by Novago Business Development Ltd and it included 15 municipalities from the region of Uusimaa: Espoo, Helsinki, Hyvinkää, Järvenpää, Lohja, Porvoo, Raasepori, Sipoo, Tuusula, Vantaa, Hanko, Inkoo, Karkkila, Lapinjärvi, and Siuntio. The project municipalities are interested in promoting sustainable tourism, and some of them have also committed themselves to the *Glasgow Declaration on Climate Action in Tourism*. The climate declaration requires that all emissions related to travel and tourism are reported.

As there are no established methods for calculating municipal-specific emissions caused by tourism, calculations that would allow for the monitoring of emission trends have not been carried out for the project municipalities.

In order to respond to this need, an assessment of the calculation of municipal tourism emissions was launched in the autumn of 2022 as part of the *Carbon Neutral Experience* project. Sitowise Oy was chosen to carry out the assessment.

This final report for the assessment describes the methods available for calculating regional tourism emissions, presents the calculation model developed, and sums up the results of the municipal-specific pilot calculations.

The primary goal of the pilot calculations was to increase understanding of the factors that affect the carbon footprint of tourism, their magnitude, and the possibilities, challenges, and uncertainties concerning the calculation process. We hope that the pilot calculations meet their specified objectives and contribute to the further development of the calculation of the carbon footprint of tourism to allow for even more accurate and comprehensive calculations in the future.

We wish to thank Novago Business Development Ltd and the steering group of the project for their active coordination and the good discussions had during the work.

Authors

Abstract

This report was prepared as part of the *Carbon Neutral Experience – Uudenmaan matkailusektorin matka kohti hiilineutraaliutta* project coordinated by Novago Business Development Ltd, the intention of which was to promote low-carbon tourism in the Uusimaa region. One of the aims of the project was to develop a calculation pilot that could be used to assess the carbon footprint of tourism in a municipality-specific manner. The calculation pilot was also intended to increase understanding of the calculation of the carbon footprint of regional tourism, the scoping, the key emission sectors, and the possibilities, uncertainties, and challenges pertaining to the calculation process.

During the pilot calculations, the carbon footprint of tourism was determined for 15 municipalities in Uusimaa: Espoo, Hanko, Helsinki, Hyvinkää, Inkoo, Järvenpää, Karkkila, Lapinjärvi, Lohja, Porvoo, Raasepori, Sipoo, Siuntio, Tuusula, and Vantaa. The calculation pilot was conducted by Sitowise Oy. This final report expands on the execution of the calculation pilot, the scoping procedure, the assumptions, the initial information, the uncertainties, the results, and the recommendations for further development of the calculation process. In addition to the final report, municipality-specific reports were also prepared for each of the 15 municipalities in Uusimaa that participated in the project as part of the pilot calculation. The results for each municipality are presented in more detail in those reports.

The execution of the calculation pilot began with an initial survey, which consisted of a review of domestic and international materials pertaining to the calculation of the carbon footprint of tourism. The calculation methods and scoping most suitable for the calculation of the carbon footprint of tourism were identified based on these materials. Based on the initial survey, the following sectors were identified as key sources of emissions for tourism: travel to destination, travel at destination, accommodation, food services, activities, and purchases.

The calculation was carried out using a combination of process-based LCA and input-output LCA based on the amounts of money spent. The initial information consisted of various tourism-related statistics that were supplemented with expert assessments where necessary.

The results of the pilot calculation show that travel to destination and purchases are the key emission sectors for the larger participating municipalities. In turn, key emission sectors for smaller municipalities include purchases and food services. Taking into account all the municipalities that were included in the pilot calculations, travel to destination generates 44 percent of the emissions caused by tourism. Purchases account for 30 percent of emissions, food services for 14 percent, accommodation for 6 percent, and travel at destination and activities for 3 percent each. However, the relative distribution of emissions by sector varies significantly depending on the destination municipality.

The total carbon footprint for the 15 municipalities included in the pilot calculation was estimated to be approximately 1517.0 kt CO_2-eq/a in 2021. Of the municipalities

included in the review, Helsinki had the largest carbon footprint caused by tourism, with its tourism emissions accounting for approximately 54 percent of the carbon footprint of tourism for the whole calculation area (822.1 kt CO_2-eq/a). Vantaa’s share was approximately 27 percent (403.9 kt CO_2-eq/a) and Espoo's approximately 5 percent (81.4 kt CO_2-eq/a). The carbon footprint of other participating municipalities in Uusimaa varied from 2.8 to 43.7 kt CO_2-eq/a.

Various challenges pertaining to the accuracy and up-to-dateness of the initial information were identified during the pilot calculation. The results of the calculation included uncertainties due to the quality of initial information and the assumptions made, which should be recognized. Even so, the pilot calculation provides an indicative assessment of the carbon footprint of tourism in the region and its distribution by sector. This calculation model is not, however, suitable for monitoring the impact of emission reduction measures as is. Still, the scoping and the emission components included in the calculation process can be used as a starting point for further development of the calculation of regional tourism emissions.

Terms and Abbreviations

Term	Definition
CO_2-eq	Carbon dioxide equivalent is a metric measure used to compare emissions from different greenhouse gases. Carbon dioxide equivalents are calculated by multiplying the emissions from greenhouse gases by their GWP values.
Global Warming Potential	Global Warming Potential (GWP) is used to express the warming effect of a greenhouse gas in relation to carbon dioxide.
Hybrid LCA	Hybrid LCA is a combination of process-based and IO-based life-cycle assessment procedures.
IPCC	The Intergovernmental Panel on Climate Change produces scientific assessments of anthropogenic climate change and its impacts.
LCA	Life-cycle assessment.
Process-based LCA	The environmental impact of the subject of the assessment is measured and calculated process-specifically based on energy and material flows.
IO-based LCA	The environmental impact of the subject of the assessment is assessed based on the monetary investments made. This method of life-cycle assessment is also known as input-output life-cycle assessment.
Unregistered Accommodation	Tourist accommodation establishments with fewer than 20 bed places.
Registered Accommodation	Tourist accommodation establishments with more than 20 bed places.

1 Introduction

Climate change is the most significant environmental challenge we have faced so far. Its impact can already be seen around the world, including in Finland. Municipalities play an important role as trendsetters for various measures intended to mitigate climate change both nationally and internationally. Finland is aiming to become carbon neutral by 2035, and changes are required in all operating sectors of society in order to reach this target. The determination of carbon footprint is also important for municipal and urban tourism and tourism-related activities, as this will allow us to improve our understanding of how to reduce the emissions generated by tourism and tourism-related activities. Focusing emission reduction measures in the tourism sector is important, as tourism is estimated to account for approximately 8 percent of the global carbon dioxide emissions (Visit Finland, 2022). Thus, the availability and accessibility of sustainable tourism must be improved further.

Carbon footprint refers to climate emissions caused by human action, which can be determined for various activities, products, enterprises, or organizations. The calculation of a carbon footprint takes into account the key greenhouse gases generated by human activity: carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) (Sitra, 2023). Hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6) can also be included in the carbon footprint (Koivula E. and Tuominen R., 2019). Greenhouse gases increase the intensity of the natural greenhouse effect. Emissions from various greenhouse gases can be compared by using carbon dioxide equivalents (CO_2-eq) to express the amount of greenhouse gases. In practice, this means that emissions from other greenhouse gases are multiplied by their GWP value (Global Warming Potential).

The purpose of a carbon footprint is to provide an estimate of the amount of direct and indirect greenhouse gas emissions based on the available data (Koivula E. and Tuominen R., 2019). As carbon footprint calculations can be carried out in multiple ways, such as using process-based LCA, input-output LCA, or hybrid LCA, which combines the two, the number of different calculators available is substantial. Thus, we should keep in mind that different calculation approaches and methods will provide slightly different results, depending on the priorities and the assumptions made during the calculation. This also means that the results of each calculation will always include some uncertainty (Rantsi, 2011). In addition to the carbon footprint, we can also examine the demand of products and services, and their carbon intensity, which refers to the amount of greenhouse gas emissions in proportion to the quantity or amount in euros of a product or service. If emissions are compared to the commodities, services, and quality of life produced at their expense, we can also assess the carbon efficiency (Koivula E. and Tuominen R., 2019).

In 2019, approximately one fourth of the total emissions of the European Union were generated by transport, with road traffic representing the largest share of transport emissions (71.7 percent) (The European Parliament, 2022a). Shipping and air transport within the European Union each generated approximately four percent of the total greenhouse gas emissions of the Union. On the other hand, the share of both continues to grow. (The European Parliament, 2022b). United Nations World Tourism Organization (UNWTO) and the International Transport Forum modeled transport-related emissions in the tourism sector in a study from 2019, and their report concluded that transport accounted for 75 percent of all emissions in the tourism sector, broken down as follows: air traffic 40 percent, road traffic 32 percent, other modes of transport 3 percent, accommodation 21 percent, and other tourism-related activities 4 percent.

According to the LIPASTO calculation system, greenhouse gas emissions for transport in the whole of Finland (road, rail, waterborne, and airborne transport, which only includes civil aviation) amounted to approximately 10 Mt CO_2-eq in 2021 (Traficom, 2021). Emission data for Finnish air traffic is available for flights between airports within the European Economic Area, which amounted to approximately 0.93 Mt CO_2-eq in 2022. Thus, the emissions are not a direct representation of air traffic emissions in Finland. (Traficom, 2022a).

2 Background and Objective

This report was prepared as part of the *Carbon Neutral Experience – Uudenmaan matkailusektorin matka kohti hiilineutraaliutta* project. The aim of the project is to promote low-carbon tourism in the Uusimaa region, to respond to carbon neutrality targets and the increased demand for sustainable tourism, and to become a trendsetter in these areas. The project is coordinated by Novago Business Development Ltd, and it includes 15 municipalities in the Uusimaa region: Espoo, Hanko, Helsinki, Hyvinkää, Inkoo, Järvenpää, Karkkila, Lapinjärvi, Lohja, Porvoo, Raasepori, Sipoo, Siuntio, Tuusula, and Vantaa.

Some of the participating municipalities have become signatories of the *Glasgow Declaration on Climate Action in Tourism*, the intention of which is to gain effectiveness and demonstrate commitment to climate action. The Declaration also aims to promote global targets by reaching Net Zero emissions before 2025. In order to monitor the realization of the emission targets, all greenhouse gas emissions related to travel and tourism must be calculated and reported on in accordance with the Glasgow Declaration. The Declaration specifies guiding principles for the calculation of emissions, but it does not clearly define the scoping or methods. Thus, one of the aims of the Carbon Neutral Experience project was to develop a calculation pilot that would define a calculation method and scoping for municipality-specific calculation of the carbon footprint of tourism.

The calculation pilot was executed by Sitowise. The objective was to device a calculation pilot using the carbon footprints of tourism in the participating municipalities such that the results of the pilot would provide additional information on the greenhouse gas emissions from tourism in the region and allow us to better understand the calculation and scoping of the carbon footprint of regional tourism. The starting point for the development of the calculation method was the aim to utilize initial data that was based on easily accessible and public statistics. Work on the calculation pilot began with an initial survey, which was intended to identify and review previous assessments conducted of carbon footprint calculations for tourism in the region. The results of the initial survey were used as the foundation for the scoping and calculation methods used in the pilot calculation. The final pilot calculation method and its scoping were selected during the work such that the calculations can utilize existing data that can be acquired without the operators having to make data queries or municipal data requests. During the calculation pilot, the calculation process was designed such that it can be executed at the project municipalities, while still keeping in mind its repeatability in the future and scalability for other Finnish municipalities as well.

3 Results of the Initial Survey

To support the development of a calculation method for the carbon footprint of tourism, an initial survey was conducted with the aim of reviewing the calculation and assessment methods already used for determining the regional greenhouse gas emissions of tourism. In designing the calculation method, our initial assumption was that regional greenhouse gas emissions caused by tourism could be calculated by combining regional emission calculation methods with methods used for calculating the carbon footprints of individuals and enterprises.

The carbon footprint of tourism has been surveyed using slightly different methods in various countries and destinations. The initial survey was conducted in the form of statistical analysis focused on both domestic and international sources of information, and the results provided an impression of the calculation methods used so far and the results provided by said methods. Materials used for the initial survey were identified through Internet searches.

3.1 Carbon Footprint of Inbound Tourism to Iceland: A Consumption-Based Life Cycle Assessment Including Direct and Indirect Emissions (Iceland)

A study of the carbon footprint of tourism was conducted in Iceland in 2010–2015. The purpose of the calculation was to assess the carbon footprint of foreign tourists visiting Iceland. A tourist was defined as a visitor spending 6–10 nights in Iceland. The emission sectors taken into account for each tourist included 1) their travel to and from Iceland, 2) travel locally, 3) accommodation and restaurant services, 4) purchases, and 5) activities. The calculations did not include the tourist's travel in their country of departure (Sharp, H., et al. 2016).

The calculation method used for the study was a combination of process-based LCA and input-output LCA. Process-based LCA was utilized in the calculations for the energy consumption of local service providers and the fuel consumption of rental vehicles. Environmental impact was otherwise assessed using input-output LCA. The calculations used a consumption-based approach, which means that all emissions caused by tourism activities were allocated on the tourists. The reason given for the decision was that the consumer was identified as the main factor driving the demand for services and that without demand there would be no production. The calculation method accounted for both direct and indirect emissions. The hybrid model was based on the American IO LCA model, as it comprises most models used in industrial sectors. As the Icelandic economy is strongly dependent on imports, the significance of indirect emissions is emphasized (Sharp, H., et al. 2016).

The study was primarily based on information regarding the number of tourists in Iceland during the year under examination and the countries of departure of the tourists. The numbers of tourist visits were acquired for the study from the Icelandic

Tourist Board and information on the tourists' consumption from Statistics Iceland. The carbon footprint of an average tourist visiting Iceland was determined to be 1.35 t CO_2-eq, and the total emissions caused by tourism in Iceland were 1.8 Mt CO_2-eq in 2015 (Sharp, H., et al. 2016).

3.2 The Carbon Footprint of Auckland Tourism (New Zealand)

Understanding the greenhouse gas emission profile of tourism is helpful to tourism planning and management in Auckland, which is why emissions caused by tourism in Auckland were identified in 2018. In the study, two methods sourced from literature were used to determine the carbon footprint of tourism. The first method was based on a top-down approach, and it utilized national and regional data provided by New Zealand's official data agency Stats NZ. The method took into account three emission sectors, which were 1) accommodation, food, art and recreation; 2) local public transport; and 3) industrial sectors linked with tourism. The calculation focused on tourism production, i.e., determining supply side emissions based on regional emission data and sectoral interrelationships between various operators. (Interrelationships were determined in accordance with the System of Environmental-Economic Accounting of the United Nations). This approach only accounts for the emissions that are directly linked with the enterprises/sector, which means that, for example, the fuel consumed by vehicles rented or owned by visitors would not be included in the calculation. Emissions related to the production of electricity are also an indirect contributor in terms of tourism activities, and are thus also excluded from the calculation (Becken, S. & Higham, J., 2021).

The second method used was based on a bottom-up approach that focused on three sources of emissions: 1) accommodation, 2) local public transport, and 3) visits to tourist attractions. The calculations used for this method adhered to the following logic:

Carbon footprint = the number of tourists * activity * carbon intensity

For example, emissions related to hotels were determined by identifying the total number of nights spent at a hotel, the number of tourists that stayed overnight at the hotel, and the carbon dioxide emissions per visitor per night, and multiplying the numbers with each other. For tourist attractions, the bottom-up approach took into account the 10 most popular attractions in Auckland. Visits in other cities were not included in the calculations, as this would have required information on the activities that took place in these locations, and the emission intensity of said activities. Data pertaining to foreign tourists was acquired for the calculation from eight leading operators in the accommodation market. The data was supplemented with information pertaining to the length of stay of visitors sourced through derivation based on the average length of stay for all visitors to New Zealand and Auckland. As information was not available on whether domestic tourists stayed in Auckland for the entire duration of their travel, traffic emissions were assigned to Auckland as a whole. If tourists also visited other areas, the carbon footprint would be larger than the calculated result (Becken, S. & Higham, J., 2021).

According to the results of the top-down approach, total emissions caused by tourism in 2018 amounted to 1.2 Mt CO_2-eq in Auckland. Transport accounted for 76.9 percent of the emissions, substantial proportion of which consisted of domestic flights from Auckland. Of the total carbon footprint of tourism, 16.9 percent was generated by accommodation and 6.2 percent by other sectors linked with tourism. According to the bottom-up method, tourism emissions caused by accommodation (including staying with friends or relatives), tourist attractions, and local public transport amounted to a total of 0.2 Mt CO_2-eq. Transport was once again the largest source of emissions (Becken, S. & Higham, J., 2021).

3.3 Carbon footprint calculation of Valencia Tourist Activity (Spain)

Visit Valencia calculated the carbon footprint of tourism in the City of Valencia in 2019. The calculations included a comprehensive selection of emission sectors: 1) the arrival and departure of tourists; 2) arrival and departure of same-day visitors; 3) arrival and departure of cruise ship passengers; 4) accommodation; 5) meals; activities, and purchases by tourists; 6) meals and activities by same-day visitors; 7) meals, activities, and purchases by cruise ship passengers; 8) consumption of energy by tourism destination; 9) transport at tourist destination; 10) collection and processing of solid waste; 11) wastewater management; and 12) events at tourist destination (festivals, sports, culture, etc.) The calculations included both direct and indirect emissions caused by tourism in accordance with the Scope 1–3 classification (Visit Valencia, 2019).

The report for the study does not describe the calculation methods in a transparent manner. The initial data used for the calculations was sourced from information provided by the Visit Valencia foundation, the tourism community of Valencia, and the Valencia City Council, accommodation capacity surveys conducted for hotels, scientific studies, information provided by Metrovalencia and the municipal public transit authority, and the official carbon footprint registers of the Government of Spain. The results for the distribution of the carbon footprint were presented as CO_2 equivalents per emission sector, but the results or possible uncertainties concerning the results were not analyzed or discussed further (Visit Valencia, 2019).

3.4 Estimation of Carbon Emissions due to Tourism in the Island of Crete, Greece (Greece)

The Island of Crete is a significant and very popular tourist destination in the Mediterranean region, and the island receives visitors by both airplanes and ships. The carbon dioxide emissions resulting from tourism in Crete was assessed in a study published in 2019. The purpose of the study was 1) to prepare an assessment of the carbon dioxide emissions caused by international tourism in Crete, 2) to assess carbon dioxide emissions generated in different tourism sectors, and 3) to compare the previous two with carbon dioxide emissions in other countries. The calculation focused on three sources of emissions, which were 1) travel to destination, 2) accommodation, and 3) various tourism activities. The calculation assumed that 50 percent of internal flights in Crete were linked with tourism. For other activities at the destination, the calculation was based on the assumption that the generated emissions amounted to 27 kg of CO_2 for a single journey, as data on other activities engaged in by tourists at the destination was not available. This emissions estimate was based on the UN Environment Programme (2008) (Vourdoubas, 2019).

Emissions from tourism were calculated by multiplying the number of visitors with the emission factors for the average journey and each mode of transport. Total carbon dioxide emissions caused by accommodations were estimated by multiplying the number of overnight stays with the amount of emissions generated by a single night spent at a place of accommodation. Emission factors pertaining to modes of transport were estimated based on literature as were the carbon dioxide emissions caused by accommodation. The average flight distance for tourists arriving from the Nordic countries, Germany, and England, where most international tourists arrive from, was estimated to be 2 000 kilometers (Vourdoubas, 2019).

According to the estimate presented in the study, the annual carbon dioxide emissions from tourism in Crete were 0.49 t of CO_2 per visitor. The amount of carbon dioxide emissions caused by tourism, including international flights, was estimated to be 3.67 t of CO_2 per capita in Crete. The total carbon dioxide emissions per capita in Crete were 6.2 t of CO_2 per resident, which means that the emissions caused by tourism account for one half of per capita emissions on the Island of Crete (Vourdoubas, 2019).

3.5 Carbon Footprint of Tourism in South Savo – the Responsible Tourism in Southern Savo Project (Finland)

In Finland, the carbon footprint of tourism in the South Savo region was assessed in a study by South-Eastern Finland University of Applied Sciences. In the study, the purpose of the calculations was to recognize the regional carbon footprint of tourism in South Savo. The calculation took into account the proportionately largest factors affecting the carbon footprint, which were 1) travel to destination, 2) travel at destination, 3) accommodation, 4) food services, and 5) activities. The study also accounted for the carbon footprint of holiday residents. Information pertaining to the areas included in the calculations were sourced for the study directly from statistical data or by requesting more detailed information from the party in charge of the statistics. With regard to certain information, it was necessary to use data from previous years for the calculation. Calculations were carried out for 2016 and 2017 (Koivula, E. and Tuominen, R., 2019).

The calculation method used was a combination of input-out LCA, emission-based calculations, and cost-based calculations. The cost-based calculations utilized cost-based emission factors for greenhouse gases from 2005. (Koivula, E. and Tuominen, R., 2019).

The study also determined the impact of holiday residents in the region on the carbon footprint of tourism in South Savo. The calculation of the travel by holiday residents comprised the length of travel, the number of passengers, and the emissions of the transport mode used. Walking, cycling, and rail transport were considered as emission-free modes of transport. The average emissions for a bus were obtained from the statistics compiled by VTT. As the use of public transport is not specified in the travel statistics for holiday residents, the calculations were based on the average emissions of using a bus or train (Koivula, E. and Tuominen, R., 2019).

The majority of the carbon footprint of tourism in South Savo was comprised of travel by tourists and holiday residents. This accounted for almost one half of the carbon footprint. The share of accommodation of the carbon footprint was approximately a quarter, while the running of daily errands, activities, and use of food services by tourists amounted to approximately one tenth (Koivula, E. and Tuominen, R., 2019). The total carbon footprints of tourism in South Savo based on the calculations carried out as part of the study and their distribution among different emission components in 2016 and 2017 are presented in chart 1.

Chart 1. Total carbon footprint of tourism in the region of South Savo in 2016 and 2017 (Source: Koivula, E. and Tuominen, R., 2019).

Emission component	**Carbon footprint in 2016 (t CO_2-eq)**	**Carbon footprint in 2017 (t CO_2-eq)**
Travel to destination, domestic and international tourists and holiday residents	119 119	135 537
Accommodation of tourists and holiday residents	55 836	56 088
Daily errands of tourists and holiday residents	27 600	27 600
Activities of tourists and holiday residents	31 365	31 373
Food services for tourists and holiday residents	23 340	23 340
In total	257 260	273 939

3.6 Defining Sustainable Tourism and Recommendations for Measuring Carbon Dioxide Emissions (Turku)

While the literature review published by the City of Turku did not comprise actual calculations regarding the carbon footprint of tourism in any region, the review did present methods for determining the carbon dioxide emissions caused by tourism. The review also provided a set of links to various carbon footprint and life-cycle assessment calculators designed for different purposes (Haapalehto, K., 2019).

The report concludes that, in general, there is no single correct model or method for calculating carbon footprints. In any event, the calculations are controlled through various standards and instructions, which allow each party carrying out calculations to decide on the method used on a case-by-case basis. By examining the individual areas that affect the carbon footprint, we can specify targets and monitor their realization. Carbon footprint calculation can also be used to measure the cost impact of various measures. Typically, a carbon footprint comprises all life-cycle greenhouse emissions, but the calculators can also be simplified such that the carbon footprint only expresses the generated carbon dioxide emissions (CO_2). The carbon footprint of air traffic, which is intrinsically linked with tourism, also comprises a significant amount of other greenhouse gases beyond carbon dioxide (Haapalehto, K., 2019).

The report also emphasizes that it is important to determine the method of calculation and the scoping for the calculations when calculating the carbon footprint of tourism. A larger amount of data will provide better and more accurate results for the carbon footprint. Even so, the use of generalizations or average values and their impact on the results should still be considered when designing the calculation process, as the sourcing of detailed information will often be quite time-consuming. When calculating the carbon footprint of tourism, the direct emissions caused by travel can be determined by taking into account the largest factors affecting the size of the carbon footprint, such as travel to the destination, travel at the destination, and the consumption of energy. Restricting the calculation to direct emissions can often be reasonable, as this will make it easier to obtain the information required, thus facilitating the calculations as well. If we also want to consider indirect emissions in the calculations, i.e., include the life-cycle emissions of the product used, the amount of data to be processed will be significantly larger (Haapalehto, K., 2019).

3.7 Summary of the Results of the Initial Survey

As there is no single correct model or method for calculating the carbon footprint of regional tourism, each party carrying out calculations will decide on their calculation method on a case-by-case basis. Thus, the methods used and the results produced can vary quite significantly. Based on the literature, the calculation of the carbon footprint of regional tourism is often more difficult to define when compared to the calculation of the carbon footprint of a product or organization. The basic calculation principles, such as transparency, accuracy, and avoidance of double counting, can still be implemented through standards and instructions (Koivula, E. and Tuominen, R., 2019).

Based on the initial survey, challenges may be posed by the accuracy of the calculations, as not all of the statistics used for calculating the carbon footprint of tourism are updated each year and some information is simply not available or is inaccurate, which means that it is sometimes necessary to rely on estimates. For example, in the study of the carbon footprint of tourism in Crete, Vourdoubas (2019) concludes that there is a lack of available data required for the calculation of carbon footprints and that some estimates may not be accurate. The data on accommodation is mentioned as a particular concern, as various accommodations used by tourists are not included in the official records maintained by the statistical authority. Similarly, the study of regional tourism in South Savo also comprised uncertainties regarding, among other things, the estimation of the carbon footprint of secondary residence.

In the studies, the number of carbon components included in the calculations varied from 3 to 12 sources of emissions. Each study took into account the journey to the destination, accommodation, and various activities at the destination. All materials reviewed during the initial survey made the assumption that long-haul tourists arriving at the destination traveled by airplane. The results of the studies show that the majority of carbon dioxide emissions included in the carbon footprint of tourism is generated by international air travel. As the regions covered by the studies and the scoping used differ from each other, a comparison of carbon footprints beyond their magnitude is not practical.

The assessments reviewed during the initial survey, their target areas, the carbon footprint calculation year, the emission sectors included in the calculation, and the method used for the calculation have been compiled into chart 2.

Chart 2. The assessments reviewed during the initial survey, the target area, the carbon footprint calculation year, the emission sectors included in the calculation, and the method used for the calculation.

Name of assessment	Coun-try/re-gion	Year	Emissions sectors included	Calculation method
Carbon Footprint of Inbound Tourism to Iceland: A Consumption-Based Life Cycle Assessment Including Direct and Indirect Emissions	Iceland	2016	1) travel to and from Iceland by tourists, 2) local travel, 3) accommodation and restaurant services, 4) purchases, 5) activities	Hybrid LCA
The Carbon Footprint of Auckland Tourism	New Zealand, Auckland	2021	Top-down approach: 1) accommodation, food, art and recreation; 2) local public transport; and 3) industrial sectors linked with tourism and arrival in Auckland Bottom-up approach: 1) accommodation, 2) local public transport, and 3) visits to tourist attractions + arrival in Auckland	In the top-down approach the calculations were based on prices, and in the bottom-up approach on consumption
Carbon Footprint Calculation of Valencia Tourist Activity	Spain, Valencia	2019	1) arrival and departure of tourists (including same-day visitors and cruise ship passengers), 2) accommodation, 3) meals, activities, and purchases by tourists (including same-day visitors and cruise ship passengers), 4) energy consumption at tourist destination, 5) transport at tourist destination, 6) collection and processing of solid waste, 7) wastewater management, and 8) events at tourist destination	The calculations appear to be based on consumption
Estimation of Carbon Emissions Due to Tourism in the Island of Crete, Greece	Crete, Greece	2019	1) travel to destination, 2) accommodation, and 3) various tourism activities	Consumption-based calculation
Carbon Footprint of Tourism in South Savo – the Responsible Tourism in Southern Savo Project	Finland, South Savo	2016 and 2017	1) travel to destination, 2) travel at destination, 3) accommodation, 4) food services, and 5) activities	Emission-based and cost-based calculations (hybrid LCA)
Defining Sustainable Tourism and Recommendations for Measuring Carbon Dioxide Emissions	Finland, Turku	The assessment did not comprise actual calculations. The publication presented methods for determining the carbon dioxide emissions of tourism and provided links to various carbon footprint and life-cycle assessment calculators designed for different purposes.		

4 Calculating the Carbon Footprint of Tourism for Municipalities in Uusimaa

The results of the initial survey showed that the carbon footprint of tourism can be calculated effectively applying various scoping procedures based on different methods and initial data. Based on the initial survey, this means that a single method used generally for determining the carbon footprint of tourism cannot be identified. In order to devise a pilot calculation model, the scoping for the calculations in the project was defined by utilizing approaches used in various assessments. On the whole, however, the method used for calculating the carbon footprint of tourism in South Savo was considered the most suitable for this assessment, which means that the pilot calculations were carried out largely in line with its definitions.

4.1 Calculation Model and Scoping

The calculation model used for the carbon footprint of tourism in the municipalities is comprised of the following six sectors: travel to destination, travel at destination, accommodation, food services, activities, and purchases. The scoping procedure was based on the results of the initial survey, and it accounts for all significant emission sectors identified during the survey. The calculation took into account the greenhouse gas emissions caused by commercial tourism including both overnight stays and same-day visits. Travel to personal holiday homes was excluded from the assessment.

4.2 Travel to Destination

Emissions from travel to destination comprise the emissions caused by traveling to the destination municipality under review and returning to the country or municipality of departure. Emissions from travel to destination have been calculated based on the number of arriving tourists and their travel distances.

4.2.1.1 Tourist Numbers

Tourists arriving in their destination municipality have been divided into four categories for the calculation: overnight visitors from other countries, domestic overnight visitors, same-day visitors from other countries, and domestic same-day visitors.

4.2.1.2 Tourists Staying at Registered Accommodation Establishments

For overnight visitors, the initial data has been divided further into tourists staying at registered accommodation establishments and those staying at unregistered accommodation establishments. Registered accommodation refers to stays in accommodation establishments with more than 20 bed places. Accommodation establishments with fewer than 20 bed places are referred to as unregistered accommodation.

The figures for foreign and domestic tourists staying at registered accommodation establishments were obtained from the accommodation statistics included in Visit Finland's Rudolf database, which presents annual arrivals and overnight stays broken down by country of residence (Visit Finland, 2021). The statistics in question provided information on the number of tourists arriving in Espoo, Helsinki, Vantaa, Lohja, Hanko, Raasepori, Porvoo, and the whole of Uusimaa, who stayed overnight at registered accommodation establishments. Corresponding information was not specified in the statistics for Hyvinkää, Inkoo, Järvenpää, Karkkila, Lapinjärvi, Sipoo, Siuntio, or Tuusula.

The numbers of tourists arriving in these municipalities were estimated for the calculation based on the number of bed places in the municipality in proportion to the number of tourists arriving in the whole of Uusimaa.

$$\text{Matkailijoiden lukumäärä kunnassa X} = \frac{\text{Vuodepaikkojen lukumäärä kunnassa X}}{\text{Vuodepaikkojen lukumäärä koko Uudellamaalla}} * \text{Saapuneiden matkailijoiden määrä koko Uudellemaalle}$$

The number of bed places per municipality is included in the Accommodation Statistics maintained by Statistics Finland (Statistics Finland, 2021a). However, the statistics did not include the number of bed places for all of the municipalities under assessment. For these municipalities, the number of bed places was estimated based on the information available for the other municipalities. The available data for the number of bed places was made proportional with the number of residents in each municipality, which provided a linear fit that could be used to estimate the number of bed places for those municipalities that data was unavailable for based on the number of residents. The relative distribution of tourists arriving in municipalities in the Uusimaa region is presented in chart 3.

Chart 3. Relative distribution of tourists arriving in municipalities in the Uusimaa region and staying overnight by municipality,

Destination municipality	Share of overnight visitors
Espoo	5.9%
Hanko	1.7%
Helsinki	60.3%
Hyvinkää	0.7%
Inkoo	0.1%
Järvenpää	0.7%
Karkkila	0.2%
Lapinjärvi	0.1%
Lohja	3.4%
Porvoo	3.8%
Raasepori	2.1%
Sipoo	0.4%
Siuntio	0.1%
Tuusula	0.3%
Vantaa	17.0%

Other municipalities in Uusimaa	3.1%

4.2.1.3 Tourists Staying at Unregistered Accommodation Establishments

Statistical information on international or domestic tourists staying at unregistered accommodation establishments was unavailable. The numbers of international or domestic tourists staying at unregistered accommodation establishments were estimated based on the municipality-specific information from Visitory (Visitory, 2021). Information on the share of overnight stays at unregistered accommodation establishments compared to stays in registered accommodation establishments was available for Espoo, Hanko, Helsinki, Lohja, and Porvoo. The number of tourists staying at registered accommodation establishments was assumed to be in proportion to the number of overnight stays at unregistered accommodation establishments. However, the statistics from Visitory did not include information on the share of overnight stays at unregistered accommodation establishments for all municipalities included in the assessment. For Vantaa, the assumption was made that the ratio of tourists arriving at registered and unregistered accommodation establishments was the same as in Espoo. The share of tourists staying at unregistered accommodation establishments in the remaining municipalities was estimated based on the average of the figures for Hanko, Lohja, and Espoo, as they were considered to closest represent the municipalities for which information was not available. For tourists staying at unregistered accommodation establishments, the assumption was made that they arrive from different countries in the same proportion as those staying at registered accommodation establishments. Chart 4 below presents municipality-specific estimates of the shares of tourists staying at registered and unregistered accommodation establishments.

Chart 4. The shares of overnight stays at registered and unregistered accommodation establishments of all overnight stays.

Destination municipality	Share of registered overnight stays	Share of unregistered overnight stays
Espoo	77%	23%
Hanko	64%	36%
Helsinki	82%	18%
Hyvinkää	71%	29%
Inkoo	71%	29%
Järvenpää	71%	29%
Karkkila	71%	29%
Lapinjärvi	71%	29%
Lohja	77%	23%
Porvoo	71%	29%
Raasepori	71%	29%
Sipoo	71%	29%
Siuntio	71%	29%
Tuusula	71%	29%
Vantaa	77%	23%

4.2.1.4 Domestic Same-Day Visitors

In addition to overnight visitors, Uusimaa also receives same-day visitors from both Finland and outside of the country. Data on the number of domestic same-day visitors was available in the Finnish Travel statistics maintained by Statistics Finland (Statistics Finland, 2021b). These statistics provided information on the number of same-day visitors arriving in Uusimaa. The number of same-day visitors to Uusimaa was divided by municipality based on spending by tourists. Information on tourism revenue is available for 14 municipalities in Uusimaa region and the whole of Uusimaa in the Uudenmaan matkailutulo ja työllisyys kunnittain 2021 report produced by the City of Helsinki (City of Helsinki, 2021). The materials are based on information from Visitory. For the 12 missing municipalities, tourism revenue was estimated based on the information available for the other municipalities. The available data for tourism revenue was made proportional with the number of residents in each municipality, which provided a linear fit that could be used to estimate tourism revenue for those municipalities that data was unavailable for based on the number of residents. Finally, the tourism revenue estimates for each municipality were reconciliated such that, together with the municipality-specific tourism revenue information, they corresponded to the statistical data on the total tourism revenue for Uusimaa. The relative distribution of domestic same-day visitors to municipalities in the Uusimaa region is presented in chart 5.

Chart 5. Relative distribution of domestic same-day visitors to municipalities in the Uusimaa region.

Destination municipality	Share of same-day visitors
Espoo	5.7%
Hanko	0.7%
Helsinki	37.5%
Hyvinkää	2.7%
Inkoo	0.5%
Järvenpää	2.2%
Karkkila	0.8%
Lapinjärvi	0.2%
Lohja	2.7%
Porvoo	3.2%
Raasepori	1.7%
Sipoo	0.7%
Siuntio	0.6%
Tuusula	1.8%
Vantaa	21.9%
Other municipalities in Uusimaa	17.1%

4.2.1.5 Same-Day Visitors from Other Countries

Statistical information is not available on the number of same-day visitors from other countries. Based on a study of tourism in the Helsinki Metropolitan Area produced by the City of Helsinki using data from Visitory, same-day visitors from other countries were assumed to arrive from the following countries of departure: Estonia, Sweden, Germany, Great Britain, and other countries. The numbers of same-day visitors from other countries were estimated in relation to the number of overnight visitors from other countries. The ratio between the number of same-day visitors from Estonia and that of Estonian overnight visitors was estimated based on a visitor survey by Visit Finland (Visit Finland, 2018). The ratio between the number of same-day visitors from Sweden, Germany, Great Britain, and other countries and the number overnight visitors from said countries was estimated based on the study on tourism in the Helsinki Metropolitan Area produced by the City of Helsinki using data from Visitory mentioned above. With regard to same-day visitors from other countries, the assumption was made that each municipality receives same-day visitors in the same proportion as they do overnight visitors. Chart 6 presents the estimates used in the calculations on the relative distribution of overnight and same-day visitors from other countries.

Chart 6. Relative distribution of overnight visitors and same-day visitors from other countries by country of departure.

Country of departure	Overnight visitors	Same-day visitors
Estonia	60%	40%
Sweden	77%	23%
Germany	89%	11%
Great Britain	91%	9%
Other countries	83%	17%

4.2.1.6 Distance of Travel and the Means of Transport Used by Tourists

With regard to the emissions generated by travel to the destination, the fact that tourists arrive to their destination municipalities from various countries of departure and from different parts of Finland was taken into account in the assessment. Tourists can also travel to their destination municipality using different means of transport or combinations of means. For travel, the assumption was made that a single tourist arrives at their destination using a maximum of two means of transport. Where a tourist arrives by road (by passenger car or bus), it is assumed that they have used a single means of transport for their entire journey from their place of departure to their destination. Where a tourist arrives by airplane, train, or ship, they are assumed to arrive at Helsinki Airport, Helsinki Central Station, or one of the passenger terminals in Helsinki. Tourists who arrive by ship to a passenger terminal in Helsinki are assumed to continue onward to their destination using a suitable connection from the Helsinki Central Station. The onward journey was primarily assumed to be by train if train was a possible option for the destination municipality in question. Where a railway link to the destination municipality did not exist, the onward journey was assumed to have taken place by bus. Detailed information on onward journeys and their distances is presented in chart 7.

Chart 7. Onward connections used for traveling to the destination municipality and the distance of travel.

	Arrival by airplane		Arrival by train or ship	
Destination municipality	Means of transport used for onward journey	One-way distance with the chosen means of transport from Helsinki Airport to the destination municipality (km)	Means of transport used for onward journey	One-way distance with the chosen means of transport from the Helsinki Central Station to the destination municipality (km)
Espoo	Train	37	Train	20
Hanko	Bus	145	Bus	122
Helsinki	Train	24	-	0
Hyvinkää	Train	51	Train	59
Inkoo	Bus	75	Bus	57
Järvenpää	Train	30	Train	37
Karkkila	Bus	61	Bus	59
Lapinjärvi	Bus	103	Bus	91
Lohja	Bus	72	Bus	49
Porvoo	Bus	49	Bus	55
Raasepori	Train	102	Train	81
Sipoo	Bus	43	Bus	32
Siuntio	Train	68	Train	51
Tuusula	Bus	24	Bus	29
Vantaa	Train	8	Train	16

4.2.1.7 Travel to Destination Municipality by Foreign Tourists

Foreign tourists were assumed to travel to Finland exclusively by airplane, except for those arriving from Estonia, Sweden, and Russia. The distances traveled by airplane were estimated based on the country of departure, and the tourists were assumed to fly from the capital of their country of residence to Helsinki Airport, from where the tourist was assumed to continue their journey onward to the destination municipality, as necessary. For foreign tourists, travel to the airport at the country of departure was not included in the calculations.

Tourists from neighboring countries also arrive in Finland using other means of transport. In addition to airplanes, tourists arrive in Finland by ship from Sweden and

Estonia, and those coming from Russia can do so by road. The distribution of transport means for foreign tourists is based on an expert evaluation provided by the City of Helsinki, and it is presented in chart 8.

Chart 8. Distribution of transport means used by foreign tourists.

Country of departure	Airplane	Boat	Car
Estonia	5%	95%	0%
Sweden	20%	80%	0%
Russia	20%	0%	80%
Other countries	100%	0%	0%

The one-way travel distance for tourists arriving by boat from Estonia is estimated as 80 km, while the corresponding figure for Sweden is 400 km. As tourists arriving by car from Russia can arrive directly in their destination municipality, the travel distances here may vary to some degree depending on the destination. According to the visitor survey published by Visit Finland, 67 percent of Russian tourists arriving in Finland come from the Saint Petersburg region (Visit Finland, 2018). Based on the survey in question, the assumption was made that Russian tourists traveling to Uusimaa by car depart from Saint Petersburg. In this case, the approximate one-way travel distance for tourists arriving by car from Russia would be 340–525 km depending on the destination municipality. The same assumptions regarding the distribution of transport means and travel distances were used for both same-day visitors and overnight visitors from other countries.

4.2.1.8 Travel to Destination Municipality by Domestic Tourists

The distribution of transport means and travel distances of domestic tourists were estimated for each destination municipality based on chargeable data sets from Statistics Finland. The data was used to determine dedicated distributions of transport means and travel distances for domestic overnight visitors and same-day visitors.

Statistical information from Statistics Finland was used to estimate how many journeys to each destination municipality were made with each mode of transport. The number of journeys for each mode of transport was available separately for overnight visitors and same-day visitors. This information was available for all municipalities in Uusimaa, even the smaller ones. However, it should be noted that the distributions of transport means for the smaller municipalities comprise more uncertainty due to the smaller number of observations on which the data is based. The distribution of transport means for overnight visitors is presented in chart 9, and distribution of transport means for same-day visitors in chart 10.

Chart 9. Distribution of travel mode for domestic overnight visitors.

Destination municipality	Passenger car	Bus	Train	Ship, ferry, motorboat or sailboat	Airplane	Other modes
Espoo	63%	9%	26%	0%	0%	2%
Hanko	82%	1%	10%	6%	0%	0%
Helsinki	58%	4%	36%	2%	1%	0%
Hyvinkää	74%	6%	20%	0%	0%	0%
Inkoo	90%	0%	0%	10%	0%	0%
Järvenpää	95%	0%	5%	0%	0%	0%
Karkkila	93%	0%	7%	0%	0%	0%
Lapinjärvi	100%	0%	0%	0%	0%	0%
Lohja	86%	6%	4%	0%	0%	4%
Porvoo	90%	5%	0%	3%	0%	2%
Raasepori	85%	0%	8%	4%	0%	3%
Sipoo	51%	7%	0%	42%	0%	0%
Siuntio	93%	0%	7%	0%	0%	0%
Tuusula	37%	0%	63%	0%	0%	0%
Vantaa	66%	6%	26%	2%	0%	0%

Chart 10. Distribution of travel mode for domestic same-day visitors.

Destination municipality	Passenger car	Bus	Train	Ship, ferry, motorboat or sailboat	Airplane	Other modes
Espoo	78%	11%	7%	2%	0%	2%
Hanko	80%	7%	4%	5%	3%	2%
Helsinki	80%	7%	4%	5%	3%	2%
Hyvinkää	88%	0%	11%	0%	0%	1%
Inkoo	80%	0%	3%	3%	0%	14%
Järvenpää	85%	0%	15%	0%	0%	0%
Karkkila	94%	6%	0%	0%	0%	0%
Lapinjärvi	100%	0%	0%	0%	0%	0%
Lohja	93%	4%	0%	0%	0%	4%
Porvoo	86%	8%	1%	2%	0%	3%
Raasepori	90%	3%	5%	0%	0%	2%
Sipoo	97%	0%	3%	0%	0%	0%
Siuntio	100%	0%	0%	0%	0%	0%
Tuusula	100%	0%	0%	0%	0%	0%
Vantaa	84%	5%	10%	0%	0%	1%

Another data set from Statistics Finland was used to estimate the number of journeys made to each destination municipality from each municipality of residence. This information was available separately for overnight visitors and same-day visitors. The data set presented journeys from the largest municipalities to municipalities in Uusimaa. Due to the limited number of observations, smaller municipalities of residence were not included in the data set. The number of tourists' municipalities of residence was still sufficient (approximately 100 municipalities) to allow us to reliably estimate the average travel distances of tourists. Travel distances were determined as the weighted average of completed journeys.

The same municipality-specific travel distance was assumed for all overnight visitors from Finland arriving by passenger car, train, bus, or boat, which was determined as the weighted average of all journeys completed. It was also assumed that a tourist traveling more than 400 kilometers to arrive at their destination municipality could also travel by airplane in addition to the means of transport mentioned above. The average flight distance was determined as the weighted average of all journeys exceeding 400 kilometers.

With regard to the travel distances of same-day visitors, the calculations were based on the assumption that tourists arrive by passenger car, train, bus, or boat only when the distance is less than 400 kilometers. All journeys exceeding 400 kilometers were assumed to take place by airplane. The average one-way travel distance for overnight visitors is presented in chart 11, and the average one-way travel distance for same-day visitors in chart 12.

Chart 11. Average one-way travel distance for domestic overnight visitors.

Destination municipality	Passenger car, train, bus, boat (km)	Airplane (km)
Espoo	210	540
Hanko	160	
Helsinki	240	
Hyvinkää	120	
Inkoo	60	
Järvenpää	140	
Karkkila	130	
Lapinjärvi	90	
Lohja	140	
Porvoo	120	
Raasepori	130	
Sipoo	60	
Siuntio	70	
Tuusula	110	
Vantaa	240	

Chart 12. Average one-way travel distance for domestic same-day visitors.

Destination municipality	Passenger car, train, bus, boat (km)	Airplane (km)
Espoo	80	570
Hanko	120	
Helsinki	110	
Hyvinkää	70	
Inkoo	70	
Järvenpää	70	
Karkkila	70	
Lapinjärvi	140	
Lohja	70	
Porvoo	70	
Raasepori	90	
Sipoo	50	
Siuntio	70	
Tuusula	80	
Vantaa	90	

4.2.2 Emissions from Travel to Destination

The emissions caused by travel to the destination were determined based on fuel consumption. Fuel consumption was estimated based on the different transport means' coefficients for specific fuel consumption based on passenger kilometers. Information from the Lipasto emission database, the annual report of VR Group (VR, 2021), and Autokalkulaattori service of the Finnish Climate Change Panel and SYKE (Finnish Climate Change Panel and Finnish Environmental Institute, 2021) were used in the estimation of fuel consumption. For passenger cars, the assumption was made that each passenger car carried two passengers on average. It was estimated that 72 percent of journeys by passenger car were completed with diesel-powered and 28 percent of journeys with gasoline-powered cars (Traficom, 2022b). In accordance with the distribution obligation for transport fuels, the share of renewable diesel was determined to be 12 percent of the diesel consumed (Finnish Government, 2022). Correspondingly, the share of bioethanol of the gasoline consumed was determined to be 10 percent (The Finnish Information Centre of Automobile Sector, 2021). The use of renewable fuels in passenger cars was assumed to only occur as indicated by the distribution obligation. Electric or natural gas vehicles were not taken into account in the calculations. The fuels used by different means of transport are presented in chart 13.

Chart 13. Means of transport used for travel and the fuels used.

Means of transport	Fuel
Passenger car	72% diesel, 28% gasoline
Bus	Diesel
Train	Electricity
Airplane	Aviation fuel
Boat	Heavy fuel oil
Motorcycle	Gasoline

Fuel consumption was used to estimate the indirect emissions caused by the production of fuels and the direct emissions caused by the burning of fuels. The emissions caused by the production and burning of fuels was primarily estimated based on the GLEC Framework of the Global Logistics Emissions Council (GLEC, 2019).

4.3 Travel at Destination

Emissions from travel at the destination comprise all emissions caused by the travel. The assumption was made, that tourists would travel at their destination by public transport or taxis as well as by private cars.

4.3.1 Travel by Public Transport and Taxi

Travel by public transport or taxis at the destination was estimated based on spending in euros. Information on the amount of money spent by foreign and domestic tourists on local passenger transport for each municipality was included in the Internal Tourism Consumption statistics maintained by Visit Finland (Visit Finland, 2019). The statistics in question provided information on the amount of money spent on local passenger traffic in Uusimaa, but information on the municipal level was not available. The amount of money spent on local passenger traffic in Uusimaa was allocated for each municipality based on tourism revenue similarly to the procedure described in paragraph 7.2.1.3 for the allocation of region-specific information regarding the number of same-day visitors.

With regard to the municipalities in Uusimaa included in the review (Except for Helsinki, Espoo, and Vantaa), it was assumed based on an expert evaluation from Sitowise that one half of the money spent on local passenger traffic would be used on travel by bus, tram, or subway, and the rest on taxi fares. For Helsinki, Espoo, and Vantaa, the assumption was made that one third of the money spent on local passenger traffic would be used on travel by bus, tram, or subway, one third on taxi fares, and the remaining third on train journeys.

4.3.2 Travel by Private Car

In addition to travel by public transport and taxis, tourists are also assumed to use private cars for travel at their destination. The calculations assumed that each domestic overnight or same-day visitor arriving in their destination municipality by passenger car would use a private car for some travel at the destination. For overnight visitors, the assumption was made that they would travel a total of 200 km while at their destination municipality, whereas the corresponding figure for same-day visitors was 50 km. For foreign tourists, the assumption was that they would only use public transport or taxis to travel at their destination. These assumptions are based on an expert evaluation from Sitowise.

4.3.3 Emissions from Travel at Destination

Emissions caused by travel by public transport or taxi were determined based on the amount of money spent. Emissions from local passenger traffic were estimated based on spending in euros using information included in the ENVIMAT model, which is based on Finnish accounting data (Nissinen, A. and Savolainen, H., 2019).

The emission intensities based on the ENVIMAT model are presented based on the 2015 price level. For this reason, the amount of money spent on local passenger traffic has been made proportional to the price level in 2015 using category-specific indices from the COICOP (Classification of Individual Consumption According to Purpose) consumer price index (Statistics Finland, 2021c).

Chart 14 presents the emission factors and consumer price indices used for public transport means and taxis.

Chart 14. Emission factors used for commodities and the consumer price index (2015=100)

Commodity	**Emission intensity ($kg\ CO_2$-eq/€)**	**Index point figure in 2019**
Bus, tram, and subway journeys	0.7	105.91
Taxi journeys	0.2	112.26
Train journeys	0.6	86.33

Emissions from the use of a private car were determined based on fuel consumption similarly to the procedure described in paragraph 7.2.3 for estimating the emissions caused by the use of a passenger car to travel to the destination.

4.4 Accommodation

Emissions from accommodation comprise all emissions caused by the use of accommodation in the destination municipality. The emissions comprise overnight stays at both registered and unregistered accommodation establishments. The calculation of emissions from accommodation is based on the amount of money spent on accommodation in euros, which was estimated based on the number of overnight stays.

4.4.1 Number of Overnight Stays

The figures for overnight stays by foreign and domestic tourists in registered accommodation establishments were obtained from the same accommodation statistics maintained by Visit Finland that also provided the data regarding the number of tourists staying at registered accommodation establishments (Visit Finland, 2021). The statistics in question include the number of overnight stays per year in Espoo, Helsinki, Vantaa, Lohja, Hanko, Raasepori, Porvoo, and the whole of Uusimaa. Where municipality-specific information was not available, the number of overnight stays at registered accommodation establishments was allocated similarly to the procedure described in paragraph 7.2.1.1. The number of overnight stays in unregistered accommodation establishments was also estimated similarly to the procedure described in paragraph 7.2.1.2 for estimating the number of tourists staying at unregistered accommodation establishments.

4.4.2 Accommodation Costs

The amount of money spent on accommodation in both registered and unregistered accommodation establishments was estimated based on the number of overnight stays and the average price of an overnight stay. The average price of an overnight stay was estimated based municipality-specific information from Visitory (Visitory, 2021). Municipality-specific data on the average price of an overnight stay was available for Espoo, Hanko, Helsinki, Lohja, Porvoo, Raasepori, and Vantaa. The average price of an overnight stay in Uusimaa was used for the remaining municipalities included in the assessment. Chart 15 presents the average price of an overnight stay in each municipality used for the calculation.

Chart 15. Average price of an overnight stay per municipality in 2021.

Destination municipality	**Average price of an overnight stay (€/stay)**
Espoo	40.7
Hanko	54.4
Helsinki	59.9
Hyvinkää	57.5
Inkoo	57.5
Järvenpää	57.5
Karkkila	57.5
Lapinjärvi	57.5
Lohja	44.0
Porvoo	75.4
Raasepori	44.0
Sipoo	57.5
Siuntio	57.5
Tuusula	57.5
Vantaa	58.4

4.4.3 Accommodation Emissions

Emissions from accommodation services were estimated based on the amount of money spent. Emissions from accommodation services were estimated based on spending in euros using information included in the ENVIMAT model, which is based on Finnish accounting data (Nissinen, A. and Savolainen, H., 2019).

The emission intensities based on the ENVIMAT model were calculated based on the 2015 price level. For this reason, the amount of money spent on accommodation has been made proportional to the price level in 2015 using category-specific indices from the COICOP (Classification of Individual Consumption According to Purpose) consumer price index (Statistics Finland, 2021c).

Chart 16 presents the emission factor and consumer price index used for accommodation services.

Chart 16. Emission factors used for commodities and the consumer price index (2015=100)

Commodity	Emission intensity (kg CO_2-eq/€)	Index point figure in 2021
Accommodation Services	0.4	117.91

4.5 Food Services, Activities, and Purchases

Emissions from food services comprise all emissions caused by the use of restaurant services in the destination municipality. Correspondingly, emissions from activities comprise all emissions caused by the use of cultural, sports, and recreational services. Emissions from purchases comprise all emissions caused by the purchase of foodstuffs and other goods. The calculation of emissions for each of these sectors is based on spending in euros.

4.5.1 Cost of Food Services, Activities, and Purchases

Information on the amount of money spent by foreign and domestic tourists on food services, activities, and purchases for each municipality was included in the Internal Tourism Consumption statistics maintained by Visit Finland (Visit Finland, 2019). The statistics in question provide information on the amount of money spent on food, cultural, sports, and recreational services and foodstuffs and other goods in Uusimaa, but it does not include municipality-specific data. The amount of money spent was allocated for each municipality based on tourism revenue similarly to the procedure described in paragraph 7.2.1.3 for the allocation of region-specific information regarding the number of same-day visitors.

4.5.2 Emissions from Food Services, Activities, and Purchases

Emissions from food services, activities, and purchases were estimated based on the amount of money spent. The emissions were estimated based on spending in euros using information included in the ENVIMAT model, which is based on Finnish accounting data (Nissinen, A. and Savolainen, H., 2019).

The emission intensities based on the ENVIMAT model were calculated based on the 2015 price level. For this reason, the amount of money spent on food services, activities, and purchases has been made proportional to the price level in 2015 using category-specific indices from the COICOP (Classification of Individual Consumption According to Purpose) consumer price index (Statistics Finland, 2021c).

Chart 17 presents the emission factors and consumer price indices used for food services, activities, and purchases.

Chart 17. Emission factors used for commodities and the consumer price index (2015=100)

Commodity	Emission intensity (kg CO_2-eq/€)	Index point figure in 2019
Food services	0.3	106.74
Cultural services	0.2	112.53
Sports and recreational services	0.2	100.87
Foodstuffs and goods	0.6	101.03

4.6 Key Uncertainties

Established methods for the calculation of the carbon footprint of tourism in a municipality-specific manner do not exist, and the currently available initial data does not allow for accurate estimates. The calculation comprises several factors of uncertainty, and thus the results should be considered as best estimates of the magnitude of the carbon footprint of tourism in the municipalities. However, the results can be useful for assessing the key factors that impact the carbon footprint of tourism and comparing the magnitude of emissions in different municipalities.

One factor increasing the uncertainty of the results of the calculation is the availability of initial data and the related generalizations and assumptions. The calculation was conducted such that it utilized as much existing data based on statistics as possible, which allows for the comparability of results between different municipalities. Data queries were not issued in the context of this assessment.

One of the factors affecting the uncertainty of the results, was the poor availability of statistical data on the required level of precision. While the availability of statistical data on the regional level was good, there was a lack of municipality-specific data. Where municipality-specific data was available, it typically only existed for the larger municipalities in Uusimaa. This meant that we had to rely on various methods of allocation to ensure that the regional data could be distributed on the municipal level. Thus, the uncertainties concerning the allocation of municipality-specific data were emphasized in the results of the calculations conducted for the smaller municipalities. Using this method, assessments on the regional level will provide much more accurate results than those carried out on the municipal level.

The emissions caused by the tourists' travel could be estimated accurately in the sense that statistics on the tourists' countries of departure were available. Using this information, we were able to calculate the travel of tourists based on estimated fuel consumption figures, which means that a more precise level can be achieved in the calculations. The estimation of fuel consumption does still comprise a measure of uncertainty, as it was not possible to determine the travel distances or distribution of travel means for foreign tourists exactly. Nevertheless, the calculations were conducted based on the best available expert evaluations with regard to these aspects. For domestic tourists, the travel distances and distribution of transport means could be assessed more accurately, as Statistics Finland offers paid data sets pertaining to this information. Coefficients for specific fuel consumption and the emission factors for the manufacturing and burning of fuels used in assessing the emissions from travel were available from reliable sources. Taking all these factors into account, the level of precision achieved in calculating the emissions from travel to destination as a whole was good considering the available initial data.

The measure of uncertainty concerning the calculation of emissions for accommodation, food services, activities, and purchases was more significant than that pertaining to travel emissions. This is caused by the fact that these emissions were estimated based on the amount of euros spent, which entails its own uncertainties. First, even the estimation of spending in each municipality includes uncertainty, as spending information was only available on the regional level. Furthermore, the estimation of emissions based on emission intensities from the ENVIMAT model based on Finnish accounting data is uncertain, as the emission intensity based on euros spent does not account for the fact that the carbon footprint of services and products in the same price category can vary widely or that a low-carbon product or service could be more expensive than an emission intensive one. The emission intensities of the ENVIMAT model are based on the price level in 2015, and while the amounts spent on accommodation, food services, activities, and purchases have been indexed to correspond to the 2015 price level, this does comprise a measure of uncertainty linked with generalizations and assumptions.

5 Results of the Calculation of the Carbon Footprint of Tourism for Municipalities in Uusimaa in 2021

The carbon footprint of tourism in municipalities in the Uusimaa region is comprised of the activities engaged by domestic and foreign tourists, taking into account both overnight and same-day visitors. Figure 1 present the total emissions caused by tourism in all municipalities included in the pilot calculation.

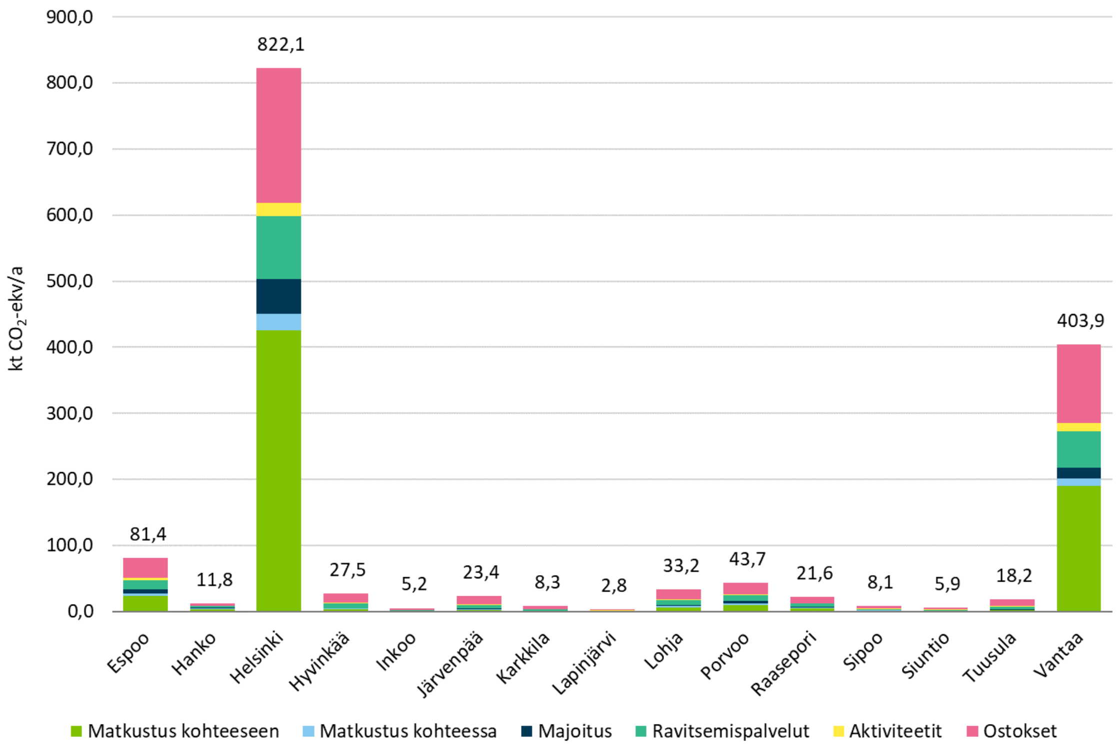

Figure 1. Greenhouse gas emissions caused by tourism in each municipality. Emissions from purchases are only partially caused by tourism.

Chart 18 presents the distribution of the total emissions presented in the above figure by sector.

Chart 18. Greenhouse gas emissions from tourism per municipality and broken down by emission sectors.

Destination municipality	Travel to destination	Travel at destination	Accommodation	Food services	Activities	Purchases
Espoo	28%	4%	8%	18%	4%	38%
Hanko	30%	8%	13%	14%	3%	31%
Helsinki	52%	3%	6%	12%	3%	25%
Hyvinkää	11%	4%	3%	25%	5%	53%
Inkoo	14%	4%	3%	24%	5%	51%
Järvenpää	11%	4%	3%	24%	5%	52%
Karkkila	11%	4%	2%	24%	5%	52%
Lapinjärvi	19%	5%	4%	22%	5%	46%
Lohja	17%	7%	7%	21%	5%	44%
Porvoo	22%	6%	10%	19%	4%	40%
Raasepori	21%	6%	7%	20%	4%	42%
Sipoo	15%	4%	5%	23%	5%	49%
Siuntio	11%	5%	3%	24%	5%	52%
Tuusula	11%	4%	1%	25%	5%	53%
Vantaa	47%	3%	4%	14%	3%	29%

Chart 18 shows that, as assumed, the larger municipalities in Uusimaa have significantly more substantial tourism carbon footprints. We can also see that the majority of the carbon footprint of tourism in Helsinki and Vantaa is caused by travel to destination. With regard to the other municipalities included in the assessment, we can conclude that purchases, i.e., store-bought foodstuffs and other goods, comprise the single largest emission sector. However, it should be noted with purchases that the resulting emissions are only partially linked with tourism. Purchases that are directly connected with tourism include such items as foodstuffs consumed at the destination municipality during a trip. In turn, any goods bought during the trip that the tourist would have purchased in any event are not directly linked with tourism. However, these purchases cannot be distinguished from each other based on the initial data used. Neither can the initial data also be used to determine the type of purchases made by tourists. In the assessment, an averaged figure of 0.6 kg CO_2-eq/€ was used as the emission intensity for purchases, which is higher than the emission intensities for food, cultural, sports, and recreational services (see chart 17). The emission intensity of purchase can still vary depending on the type of purchase, such as clothing (0.3 kg CO_2-eq/€) or animal-based foodstuffs (1.1 kg CO_2-eq/€).

For larger municipalities, the substantial share of emissions caused by travel to destination can be explained by the proportionally larger number of tourists and the longer average travel distance. During the compilation of initial data, it was concluded that domestic overnight visitors in particular would arrive in the larger municipalities from further away than the smaller ones.

The share of emissions caused by accommodation remains relatively small, as the assessment included both overnight visitors and same-day visitors, whose emission burden impacts all sectors except accommodation. The shares of emissions accounted for by travel at the destination and activities were quite similar regardless of the destination municipality.

Chart 19 presents the share of emissions caused by tourism in each municipality of the tourism emissions for the whole calculation area. The chart also presents the carbon footprint of tourism per single tourist arriving in the municipality.

Chart 19. The destination municipality's share of emissions caused by tourism of the tourism emissions for the whole calculation area, and the carbon footprint of tourism per single tourist.

Destination municipality	Destination municipality's share of emissions caused by tourism of the tourism emissions for the whole calculation area	Carbon footprint of tourism per tourist (t CO_2-eq/tourist)
Espoo	5.4%	0.15
Hanko	0.8%	0.12
Helsinki	54.2%	0.20
Hyvinkää	1.8%	0.13
Inkoo	0.3%	0.14
Järvenpää	1.5%	0.13
Karkkila	0.5%	0.14
Lapinjärvi	0.2%	0.14
Lohja	2.2%	0.12
Porvoo	2.9%	0.13
Raasepori	1.4%	0.12
Sipoo	0.5%	0.13
Siuntio	0.4%	0.13
Tuusula	1.2%	0.14
Vantaa	26.6%	0.20

As we can see from chart 19, the carbon footprint of tourism does not vary significantly between different municipalities. For the larger municipalities (Helsinki and Vantaa), emissions per tourist were higher than in other municipalities, as these municipalities receive more foreign tourists than the smaller ones. This increases the emissions per tourist in the larger destination municipalities.

Figure 2 presents the average proportional distribution of emissions for all municipalities included in the pilot calculation. As the figure shows, the data is dominated by the emissions caused by travel to the destination due to the higher results in Helsinki and Vantaa.

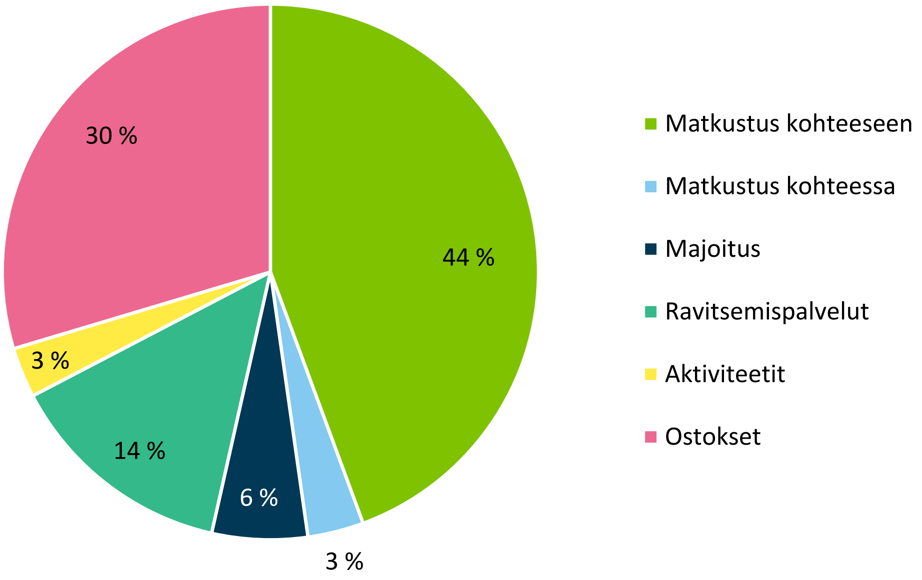

Figure 2. Relative distribution of carbon footprint for all municipalities participating in the pilot calculations broken down by sectors. Emissions from purchases are only partially caused by tourism.

6 Conclusions and Recommendations for the Development of the Calculation Method

Pilot calculations were conducted for 15 municipalities in Uusimaa. The objective was to obtain information on the regional carbon footprint of tourism, and to increase our understanding of the calculation of the carbon footprint of tourism and the related scoping. The aim was to conduct the pilot calculations such that the procedure could, at the very least, be repeated in the project municipalities. However, our goal was to develop a calculation model that could be implemented and repeated as effectively as possible in all other Finnish municipalities as well.

The model was devised such that it utilizes as much existing data based on statistical information as possible. However, the availability of data that was suitable for the calculation was quite poor. The availability of information on a more general level, i.e., the regionally, was much better.

The use of data based on statistical information poses its own challenges on the updateability of the calculations, as not all statistics are necessarily updated each year, and significant delays may occur in the publication of statistics from the year for which the data was compiled. Calculations based on statistical data provide an estimate of the emissions based on volume, i.e., the number of arriving tourists, or the amount of money spent in euros by the tourists. Thus, this calculation model does not allow us to see the impact of emission reduction measures on the results and instead the emissions caused by tourism will generally speaking continue to increase in proportion to the number of arriving tourists. This means that the statistical data available could not be used to conduct calculations that would account for the impact of various emission reduction measures.

In order to make the calculation of a carbon footprint more precise, the availability of initial data should be improved through questionnaires, for example. In this model, the emissions caused by tourism have been calculated based on the best available statistical data, generalizations, and assumptions. At present, the model does not, for example, consider the share of tourists arriving by passenger car that are powered by renewable fuels or electricity. The change in the energy sources of vehicles is not reflected in the calculations except in terms of the increased distribution obligation. Transport use by overnight visitors could be reviewed more closely through surveys conducted during their stay at an accommodation establishment. The closer monitoring of travel by same-day visitors is more challenging.

Emissions from accommodation could, for example, be affected by improving the energy efficiency of accommodation establishments or by switching the source of purchased electricity and heat. However, because the emissions resulting from accommodation were determined in the pilot calculations based on spending in euros, the above measures are not visible in the results. Accommodation emissions could be monitored more closely through operator-specific emission calculations. If a dedicated emission calculation procedure existed for accommodation activities, a fairly precise level could be achieved in the calculation and monitoring of emissions from accommodation. For example, accommodation establishments could calculate their annual emissions with a uniform emission calculator, and report the results to municipalities after verification for the calculation of tourism emissions. With this, the figures for accommodation emissions would be based on factors other than the amount of money spent, and changes in emissions and the impact of possible emission reduction measures could be monitored more effectively.

The calculation of emissions caused by food services and activities was similarly based on the amount of money spent. Here, the accuracy of the calculations and effectiveness of emissions monitoring could be improved through similar methods as those used for the calculation of accommodation emissions. However, the primary issue for the calculation of tourism emissions in these sectors is how to separate the share of emissions from food services and activities that is caused specifically by tourists, as the services are in any event used to some extent by locals.

The scoping and methods used for the pilot calculations can also be utilized in other Finnish municipalities. This does, however, mean that the initial data used in the calculation should be examined specifically for each region and municipality, as the assumptions made with regard to the Uusimaa region may not be valid in other areas of the country. For example, the distribution of transport means used by domestic tourists and the average travel distance is very different in Lapland compared to Uusimaa.

The pilot calculations provide an indicative assessment of the carbon footprint of tourism in the region and its distribution by sector. As the calculation model was devised based on statistical data, it cannot be used for monitoring the impact of emission reduction measures. Still, the scoping and the emission components included in the calculation model can be used as a starting point for further development of the calculation of regional tourism emissions. To ensure that the model could be used to answer questions regarding emission trends, it should primarily be developed further such that it combines emission results from sector-specific calculations. Thus, the development of the calculation of emissions caused by tourism should be targeted in a sector-specific manner, ensuring that the calculation of emissions within each sector is consistent and comparable.

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