A Methodology for Carbon Footprinting of Package Tours

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Abstract

This study aims to develop a method for estimating CO_2 emissions for carbon footprinting of package tours. For the calculation, the components of a package tour are categorized into "journey," "accommodation," "meals," and "leisure." This study focuses on the "journey" category and estimates the CO_2 emission factors of major transport modes in package tours: bus, train, airplane, and ship. These factors are calculated on the basis of the number of passengers, vehicle sizes, and urban/rural characteristics. This approach makes it possible to estimate CO_2 emissions from package tours and to analyze the contribution of each tour component. As a case study, package tours from Tokyo to domestic rural areas are examined. In addition, this study estimates how CO_2 emissions vary by price, days of itinerary, and destination. It is clarified that among the tour components, CO_2 emissions from "journey" contribute greatest. Finally, a method to display for carbon footprinting of the tours is proposed.

Keywords: tourism, package tours, carbon footprinting, CO_2 emission factors, disclosing information

1. Introduction

Japan is positively implementing the policy of promoting tourism. In recent years the popular trend is to visit natural areas, referred to as ecotourism. However, at present there are no clear criteria for determining whether a tour is an ecotour or not. On the contrary, taking just CO_2 emissions as one example, the method of estimation is not established. There is an urgent need to develop a method for determining the CO_2 emissions associated with tourism.

Tourist package tours as the subject of this study are different from industrial products for which carbon footprint of products (CFP) have already been assigned. Package tours have the characteristic that it is difficult to determine the CO_2 emissions as follows: 1) package tours consist of many elements; 2) it is necessary to determine the CO_2 emissions before providing the service; and 3) the calculation for each constituent element of a tour must be carried out by non-specialist travel agents.

Therefore the objective of this study is to provide a method of calculating the CFP of package tours that can be applied practically. In particular, it is necessary to determine unit CO_2 emissions for transport modes that are frequently used in package tours, namely railway, bus, airplane, and ship, in accordance with the local characteristics, the number of passengers, the circumstances of operation, etc. In addition, these are applied to actual package tours to determine the trends in CO_2 emissions according to the constituent elements, and to determine the changes in CO_2 emissions due to changes in details of the tour such as the destination or the transport mode.

2. Estimation of CO_2 of Package Tours

2.1 Identifying the constitutive elements of a tour

It is first necessary to classify the constituent elements of a tour with reference to classification of tourist activities and tourist consumption according to Nakao[1] (Fig.1). The elements of tourism in this study are taken to be "journey", "accommodation", "meals", and "leisure".

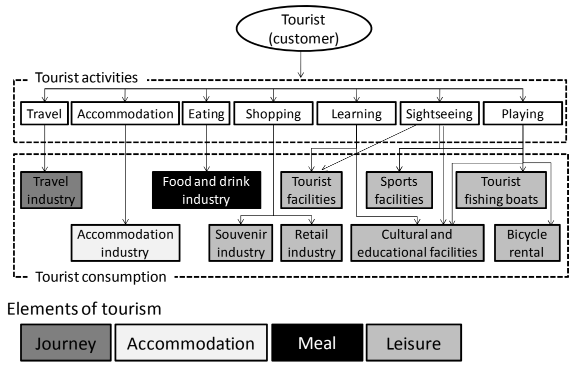

Fig.1: Classification of tourist activities and tourist consumption

2.2 Method of estimating the environmental load using the accumulation method

At the stage prior to the tour, detailed data cannot be obtained. Hence, it is difficult to evaluate the CO_2 emissions at every stage from procurement of raw materials through disposal. Therefore, a standard model is set for each element, LCA is carried out in advance for each. Parts for each element are selected in accordance with the schedule of the tour, and by performing calculations in accordance with the distances and quantities, it is possible to determine the CO_2 emitted from the tour. The standard models of each element and the estimation of CO_2 emissions are described below.

2.2.1 Journey

CO_2 emission factors are derived for chartered buses, railway, airplanes, and ships, which are frequently used in package tours as the passenger transport modes used in the journey. The emission factors for each transport mode are described in detail in Chapter 3.

2.2.2 Accommodation

For the CO_2 emission factor from accommodation, the method of estimating the lifecycle CO_2 emissions resulting from energy consumption such as air conditioning and lighting, etc., and amenities for one night's stay in a hotel is used[2]. The CO_2 emissions are calculated by multiplying the amount of energy consumption (electricity and gas) obtained from interview surveys with several hotels by CO_2 emission factors[3-4]. The values obtained are expressed as the correlation Eq.(1) with the accommodation cost using an explanatory variable, and used for estimation.

$$y_h = 10.0x_h \quad (1)$$

where y_h: CO_2 emissions for one night [kg-CO_2], x_h: monetary amount [¥10,000].

For amenities, the value of 1.51 [kg-CO_2] is used per night, based on the results of lifecycle evaluation of toothbrushes, towels, linen, shampoo, etc.

2.2.3 Meals

A method of estimating CO_2 emission factor from cooking meals in tourism is already supplied[5]. As shown in Eq.(2), this obtains the CO_2 emissions from the amount of energy consumed in cooking.

$$y_m = E_c\, e = (E_r/T)e \quad (2)$$

where y_m: CO_2 emissions from meals, E_c: energy consumption, e: CO_2 emission coefficient, E_r: energy required, T: thermal efficiency of cooking equipment

The theoretical quantity of heat required for food is obtained, taking into consideration the efficiency of the cooking equipment. The amount of energy required is estimated for heating water or oil, evaporating water, raising the temperature of the food ingredients, and evaporating water from the food ingredients, and by combining them the CO_2 emissions for cooking by "boiling", "steaming", "frying", "stir frying", and "deep frying" is estimated. In other words, provided the weight of the raw ingredients and cooking methods are known in advance, this is a simple estimating method that does not require the actual cooking.

2.2.4 Leisure

Whether CO_2 emissions from a tourist resort are allocated to tourist customers or not depends on the circumstances and association with the respective tourist resources. In other words, for those natural resources and cultural resources that do not exist for the purpose of being visited by tourists, such as historical remains, temples, and shrines, CO_2 emissions are not allocated. On the other hand, for facilities that have been constructed for the purpose of attracting tourists, their CO_2 emissions should be allocated to the tour. Therefore, all the CO_2 generated during construction, maintenance and repair, disposal, and operation of each facility is divided by the number of visitors, to determine the CO_2 emissions per visitor. This value is obtained by multiplying the annual energy (electricity and city gas) as disclosed in the CSR Report multiplied by the CO_2 emission coefficient, and dividing by the annual number of visitors.

Also, during the schedule of the package tour, the participants will almost certainly visit souvenir shops, where the tourists will shop freely, therefor the CO_2 emissions from souvenirs are not taken into consideration.

Table 1: CO_2 emission factors for journey

Transport mode	Subcategory	Emission factor	Existing data[6]
Bus	Small (capacity: 29 persons)	330 / No. of participants	51
	Medium (capacity: 49 persons)	482 / No. of participants	
	Large (capacity: 58-62 persons)	589 / No. of participants	
Railway	Urban (electrified)	20.1	19
	Subway	16.3	
	Local (electrified)	63.1	
	Local (not electrified)	91.5	
	Shinkansen bullet train	From Eq.(3)	-
Airplane	Propeller airplane	From Eq.(4)	109
	Small jet	From Eq.(5)	
	Medium jet	From Eq.(6)	
	Large jet	From Eq.(7)	
Ship	Ferry (2,300 tons)	1,029	-
	Pleasure boat, scheduled boat (70 tons)	586	

Units: [g-CO_2/passenger-km]

3. Determining the CO_2 Emission Factors for the Journey

3.1 Setting the scope of the evaluation and obtaining data

As the scope of evaluation for each passenger transport mode, manufacture and disposal of vehicles/ machinery is cut off, and operation/travel is only considered.

The data for determining the unit CO_2 emissions is basically data that is available to the public. This is to enable analizers to re-examine the emission factors in accordance with the actual circumstances.

3.2 Method of calculating the emission factors

Table 1 is a summary of the existing data and the CO_2 emission factors derived in this study. The following describes the calculation process.

3.2.1 Bus

The emission factor by the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) is for a passenger bus, therefor it differs from the chartered bus used in package tours. Therefore in this study the emission factors for a chartered bus are estimated.

Using data published by the MLIT for the fuel performance of automobiles, the CO_2 emissions per traveled-km by a vehicle are obtained for each passenger car capacity category. By dividing the values obtained by the number of tour participants, the value obtained can be used as the emission factor per passenger-km.

3.2.2 Railway

The emission factor for railways depends on the number of passengers, the fuel used, and the route. Therefore, the emission factors per passenger-km is calculated for each route, and values are used for four types of route, namely urban electrified railway, subway, local electrified railway, and local non-electrified railway. The CO_2 emissions for travel on each route is calculated by obtaining electricity and fuel consumption, and data on passenger-km from the Railway Statistical Yearbook and the magazine "SUBWAY," and multiplying by the CO_2

Table 2: Summary of case studies

Tour	Destination	No. of days	Price [¥]	No. of participants	Transport mode, distance	Accommodation cost [¥1,000]	No. of meals
Basic	Okinawa	3 days & 2 nights	39,800	30	Large jet: 3,374km Large bus: 224km	1st night: 21 2nd night: 17	Breakfast: 2 Dinner: 2
A	Okinawa	3 days & 2 nights	29,900	30	Large jet: 3,374km Large bus: 215km	1st night: 8 2nd night: 4	Breakfast: 2 Dinner: 1
B	Okinawa	4 days & 3 nights	59,800	25	Large jet: 3,374km Large bus: 357km	1st night: 6 2nd night: 13 3rd night: 8.5	Breakfast: 3 Lunch: 3 Dinner: 3
C	Hokkaido	3 days & 2 nights	45,800	30	Medium jet: 786km Large jet: 894 km Large bus: 460km	1st night: 8.5 2nd night: 9	Breakfast: 2 Dinner: 1
D	San-in	3 days & 2 nights	39,800	35	Tokaido Shinkansen: 1,465km Urban electrified railway: 32km Local electrified railway: 16km Large bus: 525km	1st night: 21 2nd night: 17	Breakfast: 2 Dinner: 2

emission factors[3-4] for electricity (according to the region) and fuel to obtain the emission factors.

For Shinkansen bullet train, the CO_2 emissions are calculated from Eq.(3) based on the results of a travel simulation for the series 700 Shinkansen vehicles in reference [7] which gave 12.25 [kg-CO_2/train-km].

$$y_s = 12.25/(S_s\ r_s) \tag{3}$$

where y_s: CO_2 emissions [kg-CO_2/passenger-km], S_s: number of seats [seats/train], r_s: occupancy rate [%]/100.

3.2.3 Airplane

The fuel consumption for an airplane is high when taking off or landing. Hence the greater the distance traveled, the lower the CO_2 emissions per traveled-km. Therefore, emission factors are derived that are capable of taking into consideration the aircraft type, the seat occupancy rate, and the distance traveled. Using data from the Air Travel Statistical Yearbook and IPCC, and based on the methods using analysis results for the calculation of greenhouse gas emissions, the fuel consumption is calculated separately for takeoff and landing and cruising, to obtain equations for estimating CO_2 emissions. The CO_2 estimation equations are provided separately for each aircraft type in Eqs.(4) to (7).

1)Propeller aircraft

$$y_{a1} = \{225{,}180\ln(x_a)/x_a + 13{,}596\}/(S_{a1}\ r_{a1}) \tag{4}$$

2)Small sized jet (capacity about 100 persons)

$$y_{a2} = \{520{,}916\ln(x_a)/x_a + 12{,}956\}/(S_{a2}\ r_{a2}) \tag{5}$$

3)Medium sized jet (capacity about 150 to 200 persons)

$$y_{a3} = \{998{,}297\ln(x_a)/x_a + 11{,}923\}/(S_{a3}\ r_{a3}) \tag{6}$$

4)Large sized jet (larger than medium sized jet)

$$y_{a4} = \{1{,}858{,}270\ln(x_a)/x_a + 10{,}062\}/(S_{a4}\ r_{a4}) \tag{7}$$

Where y_{ai}: CO_2 emissions [g-CO_2/passenger-km], x_a: distance [traveled-km], S_{ai}: number of seats, r_{ai}: seat occupancy rate [%]/100.

3.2.4 Ships

The fuel consumption depends on vessel type (gross tonnage and cruising speed). Hence the emission factors are derived for two types of vessel, a vessel of gross tonnage approximately 2,300 tons used as a ferry, etc., and a vessel of gross tonnage approximately 70 tons used as a pleasure boat or scheduled boat. Fuel consumption during transport obtained in an interview survey with shipping companies determines emission factors. They can be divided by the distance traveled and the number of passengers obtained.

4. Application to Package Tours

4.1 Case study

After setting a basic tour, the CO_2 emissions are calculated for various prices, number of days, and destination. Table 2 shows a summary. In all cases the values are provisionally set.

The basic tour is a tour from Tokyo to Okinawa for 3 days and 2 nights costing ¥39,800. Travel from Haneda Airport to Naha Airport is by large sized jet, with travel to the famous tourist spots on Okinawa island by chartered bus.

In Tour A, the difference in CO_2 emission due to price is investigated. The destination and number of days are the same as the basic tour, but the cost is cheaper. In Tour B, the difference in CO_2 emission due to number of days in the tour is investigated. Traveling from Tokyo to Okinawa is by large sized jet, the same as the basic tour, and on Okinawa island, the famous tourist spots are visited, but the number of days is one day longer (four days and three nights) and meals are provided nine times (an extra five times). There is no major difference in price between Tour C and Tour D; the number of days is the same but the destination is different. Tour C is mainly for viewing the Sapporo Snow Festival, and involved departure by medium sized jet from Haneda Airport to Hakodate Airport, traveling around Hakodate, Sapporo, and Otaru, and returning to Haneda Airport from Shin-Chitose Airport by large sized jet. All road travel is by a bus. Also, Tour D visited the western area in Honshu, traveling from Tokyo Station to Kurashiki Station, and visiting the beauty spots of Kurashiki on the first day. Travel on the second and subsequent days is mainly by bus, visiting Adachi Museum of Art and Izumo Grand Shrine, traveling by San-in local trains.

The minimum passenger count is used as the number of participants for each tour. Also, to equalize the CO_2 emissions due to type of aircraft used, a large sized jet is used for transport between Haneda Airport and Naha Airport. The meals are calculated assuming the quantities for each meal shown in the pamphlets. Also, for meals that are not indicated, food menus provided in a local survey are used as an alternative. For leisure, the facilities included in the schedule are facilities that do not depend on tourists, therefor CO_2 emissions are not allocated to the tourists, and are outside the scope of the estimation.

4.2 Results and discussion

The calculation results are shown in Fig.2. The CO_2 emissions for the basic tour are 315 [kg-CO_2/person] originating from journey, and 377 [kg-CO_2/person] from the tour as a whole. Also, the journey accounted for 82.4% of the total, showing that its effect is large.

The CO_2 emissions for Tour A are 29.4 [kg-CO_2/person] smaller than for the basic tour. The size of the rooms and the size of the hotel as a whole is smaller than for the basic tour, and hence it is considered that the CO_2 arising from air-conditioning or lighting and heating is smaller. The CO_2 emissions resulting from the journey are a greater percentage of the whole, but the tourist destinations are virtually the same as the basic tour, therefor there is no major difference in the CO_2 emissions.

The CO_2 emissions from Tour B are 32.6 [kg-CO_2/person] (8.6%) greater than for the basic tour. The percentage of CO_2 emissions originating from transport is a large proportion of the total, but the distance traveled by airplane, which accounted for the largest proportion of the CO_2 emissions, is unchanged, so the CO_2 emissions due to air transport are unchanged. The increase in CO_2 emissions due to transport is due to the increase in the number of tourist destinations as a result of the increase in the number of days. Also, the number of meals provided is greater, therefor the CO_2 emissions originating from meals increased.

For Tour C to Hokkaido, the CO_2 emissions originating from travel are virtually unchanged from the basic tour. For Tour D to San-in, the CO_2 emissions for each element as a percentage of the total are journey 57%, accommodation 33%, and meals 10%. Tour D to San-in do not use an airplane but used railway and bus only, therefor the emissions originating from the journey are smaller, and there is a difference of a factor of more than five compared with Tour C (Hokkaido).

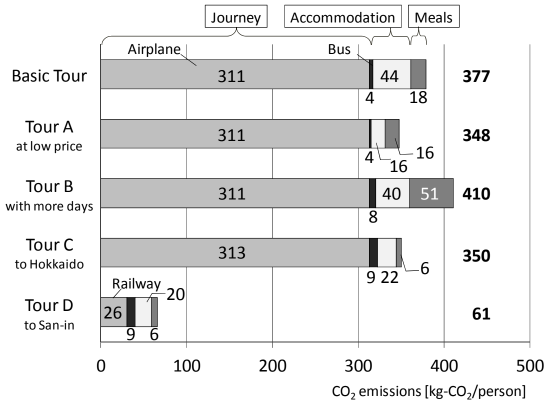

Fig.2: Comparison of CO_2 emissions per person each tour

5. Proposal of Methods of Indicating the Carbon Footprint

In order to assign a CFP to a package tour in advance, it is necessary to make various assumptions in the calculation. Although providing a single value in the form of CFP is easy for consumers to understand and easy for making comparisons with other products, on the other hand, depending on the circumstances, there is a possibility of misunderstanding when the assumptions made during the calculation are not suitable.

Therefore, when assigning the CFP, in addition to the CFP mark it is necessary to also provide a description of the method used to calculate the CO_2 emissions and a summary of the assumptions that affect the results. In particular, it is necessary to pay attention to the size of the aircraft and stopovers en route. It is possible to consider display methods such as providing the detailed calculation assumptions and methods, etc., on the homepage, and providing a QR code beside the CFP mark on the pamphlet to enable access to each tour. Publishing a graph showing the percentages of emissions from each element as indicated in this study can also be considered.

Also, if a company actually assigns the CFP, and if this is a tour that is conscious of reduction in CO_2 emissions, the points of improvement from a conventional tour can be used to appeal to customers. For example, 1) change of transport mode, 2) comparison with use of private car or rented car, 3) selection of accommodation facilities that positively incorporate energy efficiency and other environmental initiatives, and 4) the use of food ingredients produced locally, and so on can be considered.

6. Conclusions

In this study, the constituent elements of package tours are identified, and by deriving the CO_2 emission factors for each constituent element, it is possible to simply estimate the CO_2 emissions from package tours, and to assign a CFP. In particular, for the journey which accounts for a large percentage of the CO_2 emissions, the CO_2 emission factors for passenger transport modes (bus, railway, airplane, ship) are derived separately, so that it is possible to take into consideration the characteristics of the route, the number of passengers, the transport circumstances, etc. As a result of calculating the CO_2 emissions of package tours using these emission factors, it is found that the emissions originating from the "journey" account for 60 to 80% of the total for the tour, and the percentage is particularly large when air travel is used. In addition, methods of displaying the carbon footprint are proposed together with points to note so that consumers will not misunderstand.

7. Acknowledgement

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