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A study of carbon emissions during a tour: A case study of a four-day guided tour in Guilin, China

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ABSTRACT

The purpose of this paper is to calculate carbon emissions associated with tour of four days including flights. The method is based upon a travel documentary that calculates carbon emissions associated travel, food preparation, accommodation, traffic conditions, shopping and entertainment by attributing values derived from other studies to tourist activities. While the study does not claim to have perfectly assessed carbon emissions in a trip, the method is essentially simple and can aid tourist to assess the carbon emissions of alternative travel patterns and activities. In the case study the total carbon emissions of a four day tour were 329.82 kg — which figure is akin to just over 10 times normal emissions associated with daily life patterns.

1. Introduction

With the rapid development of the global economy, tourism has become a part of many people's lifestyle. Tourism brings not only enjoyment to people, but also economic benefits to the society. In China tourism has been recognized as one of the pillars of the national economy, but as with other industries there are dangers of environmental pollution. One major cause of such pollution is the carbon emissions that result. Studies under the auspices of the International Panel on Climate Change (IPCC) indicate potential dangers that arise from an excessive use of fossil fuels such as increases in temperature and rising sea levels, while the manufacturing processes involved can directly lead to environmental degradation through pollution of waterways, lakes and the seas.

In this process the food consumed by tourists, their use of accommodation, travel, shopping and entertainment make incremental additions to environmental damage that might not otherwise occur. The purpose of this research note is to calculate carbon emissions associated with tour of four days including flights and indicate how such a calculation might be done.

2. Literature review

Although possessing a short history, research on low-carbon tourism (LCT) has attracted significant attention and the following brief review serves to indicate some of the concerns that have been expressed.

2.1. Carbon emissions

Tamirisa, Loke, and Leung (1997) suggested an Input-Output Method (IOM) to measure tourists' energy consumption during travels. For her part Becken, Simmons, and Frampton (2003) divided tourism into tourists and tourism industry, defined the boundary of each subsystem of tourism scientifically, and subsequently analyzed energy consumption (EC) and CEs. The United Nations World Tourism Organization (UNWO) and the United Nations Environment Programme (UNEP) (2008) have noted that the carbon emissions (CEs) in 2005 generated by global tourism was thought to be 1.3 billion tons, accounting for 4.9% of the CEs generated by human activities. These emanated from primarily transport (75%) and accommodation (21%) with the remainder being due to tourist activities, shopping and the like. From the macroscopic perspective, Nielsen, Sesartic, and Stucki (2010) measured the CEs and energy consumption of tourism from the data of national average energy usage and environmental accounting and suggest that tourism is accounting for growing proportions of global CEs. Gössling, Garrod, and Aall (2010) analyzed

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the CEs involved in food consumption and further probed ways to adjust food production to decrease tourism CEs. Dwyer, Forsyth, and Spurr (2010) analyzed travel pattern and concluded that the burning of fossil fuel or petroleum, natural gas and coal directly accounted for the major part of tourism CEs.

With respect to China Peihua and Pu (2011) firstly estimated the EC and emissions of CO2 in China's tourism industry and found that the tourism industry has advantages in dealing with the climate change, energy-saving and reduction of CEs. According to the time usage in transportation and cross-sectional data, and the proportion of tourists among the passengers, Yanxu, Gennian, Lijun, and Jing (2012) made a preliminary estimate of CEs to China's tourism transportation. He discovered the CEs are increasing with the development of tourism, and drew a space distribution map of tourism transportation CEs. Qingrong (2012a, 2012b) calculated the energy consumption and CO2 emissions in tourism in Shenzhen city on the basis of carbon emission theory and tourists' consumption structure, and reordered six parts of tourism in CEs, namely "transport" > "food" > "on site travel" > "accommodation" > "shopping" > "entertainment".

2.2. Carbon footprint

With the calculation of carbon emissions the concept of a carbon footprint (CF) became a popular means of comparing activities. Hence Tukker and Jansen (2006) defined the "carbon footprint" as somprising two parts, one is discharged directly by burning fossil fuels for energy consumption and transportation; the other is generated by the products and services in the process of their usage. These concepts have been applied in a number of ways. For example, Peng, Jihua, Yanfen, and Guihua (2010) built a calculation model of a CF for six four-star hotels in Kunming city, and found that the CF is produced mainly through energy consumption, refrigerant leakage, and trash release, although the effect of hotel size on the CF is not so obvious. Fen, Yongde, and Huaitai (2010) concluded from an initial research literature on CF studies in China and overseas, that CF is the greenhouse gas discharge generated from a product or service in the whole process from its raw material purchase to product processing, sale, and consumption. Subsequently Yongguang (2009) created an evaluation index system to analyze the impact of CF of scenic spots, ranked large to small contributions based on variables such as travel, tourism activities and accommodation.

2.3. Low-carbon tourism

In examining low carbon tourism (LCT) Xiao (2009) defined LCT as a form of green tourism conceived in low carbon economy and dedicated to the proposition of low energy consumption and pollution. Wensheng (2009) also summarized the concept and connotation of low carbon tourism and proposed basic operational procedures for the design of scenic spots that possessed low carbon consumption.

Meng and Yuming (2010) in turn emphasized the role of site design in LCT, which is realized by creating attractive things, constructing facilities, conceiving LCT experience environments and advocating LCT consumption. In turn Zhe (2011) also proposed that the construction of tourist scenic experiences must comply with a low carbon strategy, and he outlined a brief introduction to the measures and significance of creating a low carbon scenic spots in China. Xiaoqin and Yuan (2012) referred to the model put forward by UN Committee of Sustainable Development and built a conceptual model for creating a LCT scenic spot which includes its development, resources and environment, emission reduction technology, consumption management and policy formation.

It is clear that there are a large number of studies of the carbon footprint, carbon emissions, and low-carbon tourism industry, but few specific calculations of carbon emissions involved in the whole process of traveling, and this paper therefore seeks to contribute to this issue.

3. Methodology

3.1. The tour of Guilin

Guilin, a historic and cultural city, is a major Chinese tourist destination and is an access point for Yangshuo, located in the south of Guilin city, which is famous for its beautiful scenery.

The itinerary of a four-day tour in Yangshuo Guilin that is examined here is organized by the Liu Jiayao Sales Department of China Peace Travel in Beijing, which daily is sending its clients on these tours. The routine is as follows:

On the first day, after arriving in Guilin by air from the Beijing Capital Airport, clients visited Duxiu peak (about 90 min), and enjoy a free tour of Wooden Long lake, ASEAN Park (about 60 min), antique ruins of the Song dynasty, the former accommodation of Li Jishen, the half side street, and wooden-dragon tower et al.; experiencing the culture of the ASEAN countries at ASEAN Park and also buying specialties, snacks and/or having dinner through group purchase. At the end of the day the group returns to a four-star hotel in Guilin.

The second day begins with breakfast before traveling the Lijiang River by boat from Mopanshan to Yangshuo (about 4.5 h, with packed lunch on board), followed by a walk through the foreigner's street (Yangshuo West Street) which is famous at for its both European style and Guangxi ethnic characteristics. The tour permits the purchase of snacks and the patronage of both small shops and characteristic bars (about 30 min), before rafting on Yulong River (about 1 h) which is included in the tour fee. At night there is a performance of Liu Sanjie Impression (of about 1 h and 10 min duration) prior to staying at the three-star Hotel in Yangshuo.

The third day involves a drive to visit Silver Cave in Maling (about 60 min) after breakfast, and sightseeing of the Yangshuo landscape and a visit to Butterfly Spring (about 60 min). Finally, client return to Guilin city, to stroll around Guilin Shopping Square and Guilin Street, tasting various local cuisine before returning to a four-star hotel in Guilin.

Finally on the fourth day, after breakfast, clients are taken to Guilin Liangjiang International Airport and fly back to Beijing.

3.2. Energy consumption types

This research adopted the method of tracking documentary. Every activity created in the travel process was itemized and then converted to carbon emission values.

Table 1 records the activities under classifications of 'food', 'accommodation' etc.

3.3. Formulation of calculation

The second stage the takes the recorded energy consumption associated with each activity and its corresponding carbon emission coefficient; thereby we converting the energy consumption to carbon dioxide emissions, and before aggregating the total tourism carbon emissions. The formula is as follows:

Table 1
Tourism process energy consumption types and uses.

Items	Energy consumption types	Uses
Food	Gas, electricity, natural gas, food preparation	Gas oven, electric cooker, electric baking pan, refrigerator, waste water, Garbage disposition
Accommodation	Electricity, water consumption, gas, heating, air conditioning	Indoor: television, computer, air conditioner, remote controller, bubs (top light, corridor light, desk lamp, wall lamp, floor lamp, down light, night lamp), electric fan, water heater, washing appliance, electric blower, shampoo, bathe, heat up water, charger, wastewater, garbage disposition, disposable slippers, tooth cleaners, bed washing; outdoor: public lighting, operation energy consumption operation energy consumption operation energy consumption operation energy consumption operation energy consumption operation energy consumption operation energy consumption
Transport	Electricity, petrol, diesel, coal	Plane, train, car, ship
On site travel	Electricity	Ferry, car, storage battery cars, electric toys, waste water, garbage disposition
Shopping	Electricity	Lighting, elevator, escalator, accounting
Entertainment	Electricity	Large live-action movie, karaoke

$$C = \sum_{i}^{n} (E_i * A_i)(i = 1, 2, 3, \ldots n) \quad (1)$$

where:

C = carbon dioxide emissions (kg);
Ei = different kinds of energy consumption (MJ);
Ai = carbon dioxide emission coefficient of energy (CO2 kg/MJ);
i = energy.

3.4. Food's carbon emissions

Breakfast on the first day consists of a bowl of porridge, an egg, a piece of bacon meat, two small steamed stuffed buns, a small steamed bun, a variety of pickles, fresh vegetables, a bowl of Guilin rice flour, a cup of milk, an orange. Lunch consists of a braised fish in soy sauce, pork braised in brown sauce, home style tofu, chicken stewed with tea tree and mushroom, bacon and winter bamboo shoots, mixed vegetables, stir-fried rice noodles, fried cabbage, mushroom and egg soup, a barrel of steamed rice, a plate of Steamed buns. Dinner includes a braised hair-tail in brown sauce, a pool of egg, spicy tofu, pork braised with mei cai, bacon and winter bamboo shoots, mixed vegetables, stewed taro with pumpkin in casserole, dry pot baby food, mushroom and egg soup, a basin of noodles, a plate of steamed buns. Table 2 provided the first step in CE calculations.

The total daily energy consumption of food is 2114 calories (The heating capacity of per kg standard coal is 7000 kilocalories; its carbon dioxide emission is 2.620 kg, sulfur dioxide is 0.085 kg, nitrogen oxides is 0.074 kg, adopted comprehensive weighted value of 2.68 kg). The calculation of CE is as follows:

$$E_1 = \sum_{i}^{n} \frac{2.68 x_i}{7000} \cdot T_i = 3.82 \times 10^{-4} (x_b + x_l + x_s) n$$

where

E1 = carbon dioxide emission (kg);
X = heat used (kilocalories);
T = time taken for number of meals provided
N = stands for the days of having meals

The total daily energy consumption of food in the tour of four days is 2114 calories, which is equivalent to 3.230192 kg of carbon dioxide emissions.

3.5. Carbon emission analysis

The items of energy consumption in a hotel include heating, refrigerator, lighting, use of water and the operation of other equipment such as waste disposal. The direct and indirect energy resources used are electricity, gas, fossil fuel, and water etc. The energy usage statistics for every room on every night is as shown in Table 3.

Among the assumptions made for the above calculations were:

Saving 1 kilowatt-hour (kwh) of electricity is equal to saving 0.361 kg of standard coal, thus reducing 1.324 kg of carbon dioxide emissions.

Accommodation provision during the trip was over three nights, so the carbon emission is 49.19 kg.

3.5.1. Analysis of carbon emissions in traffic

The selected traffic tools in the four-day tour in Yangshuo Guilin are airplane, automobiles, and steamship. The survey shows that the round-trip flight distance is 3774 km, transportation distance by automobile car is 146.3 km, and steamship 20 km. The results of the calculation are shown in Table 4.

3.5.2. Analysis of carbon emissions while at destinations

Energy consumption while traveling within destinations is caused mainly by the use of electrical equipment, vehicles, and guide facilities at different destinations; but it is a relatively small proportion of the total, and thus the decision was made to estimate the power consumption at each scenic spot visited as being 0.6 kwh of electricity. A total of 17 scenic spots were visited during the four days tour in Yangshuo Guilin; thereby leading estimates of the total energy consumption being 10.2 kwh of electricity, while 1 kwh of electricity is equal to 1.324 kg of CEs. Hence the CEs are 13.5 kg.

3.5.3. Analysis of carbon emissions in shopping

The energy consumption in shopping is mainly caused by an attributed cost in indoor temperature adjustment, electrical lighting and display of goods, for which the main energy needed is electric power. This study also includes the energy consumption in shopping created by going up and down a two-floor elevator twice. The estimates are thus based on:

Electricity consumption: 2*2*0.218 = 0.872 (kwh).
Air conditioning: 0.1 (kwh).
Lighting: 0.1 (kwh).

Shopping: for an assessment based on popular purchases that for this tour included Momordica Grosvenori 100 g, 1 bottle of chili paste, and bamboo penholders averaged over the tour party size.

This shopping activity consumes approximately 1.2 kwh of electricity; its carbon dioxide output was estimated at 1.2*1.324 = 1.5888 (kg).

Table 2
Three meals a day of Guilin's tourism energy intake calculation.

Kinds of food		Egg	Fish	Pork	Chicken	Cabbage	Tofu	Mushroom	Taro	Winter bamboo shoots	Steamed Rice	Steamed buns	Steamed stuffed bun	Noodles	Rice noodles	Flour	Other	Total
Criterion		144	92	243	157	15	57	20	79	14	148	221	120	280	335	344		
Breakfast	g/person	63		10		10					20	50	50		20			
	Quantity of heat	90		24		2					30	111	60		69		88	474
Lunch	g/person	25	75	60	60	40	80	20	60	40	50	50			60			
	Quantity of heat	36	151	148	94	6	46	4	47	8	74	111			134		60	919
Dinner	g/person	25	75	60		60	80	10	60	40	50			50				
	Quantity of heat	36	151	148		9	46	2	47	8	74			140			60	721

Standard unit: Calories/100 g measurement unit: g, Calories.

3.5.4. Analysis of carbon emissions in entertainment

Entertainment is an important part of the tours, and includes song and dance shows, and occasionally participation in such shows. The energy consumed by such shows is mainly generated from electric power and gasoline, and for ease of calculation it was these two sources that formed the basis of calculations.

The main shows used in the four-day tour in Yangshuo Guilin are "Impression·Lijiang" and "Fisher Fishing". The performance of "Impression·Lijiang" in the evening consumed a large amount of energy including sound, light and electricity. This was estimated at 0.8 kwh of electricity per person; while the fishing performance is 0.3 kwh of electricity per person, and the total energy consumption per person was 1.1 kwh of electricity. These were equivalent to 1.4564 kg of carbon dioxide emission.

3.6. Total analysis

According to formula (1), the CEs of four days tour in the Yangshuo Guilin are derived from the "food", "accommodation", "transport", "on site travel", "shopping", and "entertainment". By adding these together the total carbon emissions are aggregated thus:

$$\begin{aligned} ET &= E1 + E2 + E3 + E4 + E5 + E6 \\ &= 3.23 + 49.19 + 260.85 + 13.5 + 1.59 + 1.46 \\ &= 329.82 \text{ (kg)} \end{aligned}$$

4. Results

Tourism is a high carbon industry. According to the calculations above, the carbon emissions for each of these categories are shown in Table 5. From this it can be noted that transport between stops accounting for 79.09% of the total carbon emissions was ranked first.

According to the calculations, the carbon dioxide emissions of per person when on this tour are equivalent to 7.8 kg of per person a day. This represents about 10.57 times the normal daily figure.

5. Conclusion and discussion

5.1. Recommendations

The results lead to a few conclusions and suggestions. First, tourism is a high-carbon industry. In cutting down global carbon emissions, there seemingly remains much work to be done. Second, transportation contributes most of the CEs in tourism. While aircraft are considered to be the fastest means of transportation means, they are also high polluters and wherever possible alternative forms of transport should be explored such as High Speed Trains (HST), while efforts into new, lower carbon emitting fuels need to be continued.

Third, the CEs in "food" are less, so what we should do is just to advocate a reasonable diet. Strictly speaking, the energy intake of Chinese people is obviously insufficient, and unreasonable. In the restaurant industry, we can take some steps to reduce carbon dioxide emissions. First and foremost, we should enhance food safety and cultivate CE saving awareness among tourists and the workers in tourism catering enterprises. And we should encourage the catering industry to promote technological innovation, such as the use of freezing technologies that are energy-saving to reduce the energy consumption. Secondly, we should also save water (in the process of food production, manufacturing, sale) to reduce water

Table 3
A four-star hotel energy consumption statistics in Guilin.

Energy consumption type	Power (watts)	No.	The use of time	Energy consumption (KW/hour)
Television	200	1	6.00–12.00 pm; 7:00–8:00 am	1.200
Computer	270	1	7:00–9:00 pm	0.540
Air-conditioning	Central air-conditioning	1	6:00 pm–8:00 am	3.000
Refrigerator	150 w	1	intermittent use over 24 h	3.600
Room lamp	Lamp in front of mirror 40 w	2	6:00–10:00 pm	0.320
	Top light 25 w	2	6:00–10:00 pm	0.250
	Tube light 15 w	4	6:00–10:00 pm (alternative with top light).	0.300
	Night lamp 5 w	2	12:00 pm–8:00 am	0.080
	Wall lamp 18 w	2	10:00–12:00 pm	0.072
Mobile phone and camera charging	0.01 degree/time	2	Charge one time one day	0.02
Electric blower	2000 w	1	2 min/per minute	0.067
Heater	2000 w	1	3 min/per minute	0.1
Fixed telephone			Occasional use	
Burning a mosquito repellent incense			Occasional use	
Bathing	40 °C	2	Men:10 min/20 L; Women:20 min/50 L	
Washing face and mouth, brushing teeth,	0.05 L	2	0.1 (per ton of water consumes 1° electricity)	0.1
Flush the toilet	0.09 L	8	0.72 (per ton of water consumes 1° electricity)	0.72
Other:				
Washing sheets	240	1	Each sheet 1 h	0.5
Garbage removing		1		0.1
Vacuum cleaner	1500 w	1	3 min/time	0.075
Total energy consumption indoor				9.284
Outdoor: elevator	11,000 w	4 times up and down	3 min/time	0.22
Corridor lamp, emergency lamp				0.01
Restaurant lighting	10 w/person		2 times morning and night, 0.5 h/time	0.01
The power to maintain the environment			Garbage cleaning	0.1
Public water, steam, boiler	50 w/person	24 h	Water (cold, hot), steamed water(vapor, self_produced or finished product)	0.2
Total				12.424

Table 4
From Beijing to Guilin transportation energy consumption calculation.

Traffic tools	Airplane (Boeing 737–800) (170people)	Automobiles (19 Gold Cup)	Steamship
Distance (km)	1887*2 = 3774 (opening ceremony)	146.3 (per hundred kilometers/17 L)	20
Per capita	106 L/people (round-trip)	6.72 (group/10 people)	0.5
Carbon dioxide coefficient	2.3 kg/L	2.3 Kg	3.1863 kg
Carbon dioxide emissions	243.8 kg	15.46 kg	1.59 kg
Total	260.85 kg		

Table 5
Guilin tourism line product carbon dioxide emissions calculation result.

Carbon footprint	Food	Accom.	Traffic	On-site travel	Shopping	Entertainment	Total
Carbon emission	3.23	49.19	260.85	13.5	1.59	1.46	329.82
Share of carbon emissions	0.98%	14.91%	79.09%	4.09%	0.48%	0.44%	100%

consumption. Thirdly, we should implement classification and recycling of the wastes and guide the catering industry to comply with standard low-carbon operation procedures that are helpful in reducing carbon emissions. Additionally we can reduce carbon dioxide emissions by establishing scientific and healthy consumption conception, eliminating waste of food and resources, and refuse to use disposable chopsticks and packing boxes.

Fourth, the CEs of ‘accommodation’ is significant and creating ‘Green Hotels’ will play a big role in CE reduction. Some luxury products that consume much energy should be used less frequently, such as refrigerators. To create a green and low-carbon hotel, staff needs to reduce the equipment that consumes much power, advocate green consumption and guide customers to better use towels etc. And staff should encourage guests staying two or more nights to require fewer changes of by voluntary action and minimize the use of disposable wash items. Ordinary slippers may be used to reduce the use of disposable ones and replace incandescent with efficient light bulbs; Among other energy saving devices may be a reduction in the provisions of hot water after 1 p.m. in night in order to realize energy conservation and emission reduction. Energy-conservation and emission-reduction training for staffs should be provided to cultivate employees' consciousness of low-carbon environmental protection. And low carbon and energy conservation should become an important

Three meals a day of Guilin's tourism energy intake calculation

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Fixed telephone			Occasional use	
Burning a mosquito repellent incense			Occasional use	
Bathing	40℃	2	Men:10 minutes /20L;	

Fig. 1. It is a pie chart, which shows the carbon emissions of six parts of tourism in the four-day guided tour in Guilin.

management objective for the hotel in order to regulate customers' behavior. Finally, energy-saving campaigns should be carried out regularly where customers can take part and save energy consciously.

Fifth, the CEs are related to personal habits, so it is important to change tourists' inherent concepts and behaviors in favor of low-carbon tourism. At present, although there are some tourists who are in favor of low-carbon tourism, putting low-carbon life strategies into practice is not enough. Many tourists still hold the traditional concept, thinking that tourism will not cause serious damage to the environment, and turn a deaf ear to the low-carbon tourism. The passion for participating in low-carbon tourism is not high among many tourists; and some hold ‘wait-and-see’ attitudes, not intending to immediately adopt good practices. In order to change tourists' traditional concept for tourism, we should carry out in-depth campaigns and education programmes on low-carbon tourism for them, calling on them to cultivate a habit of green travel and create a healthy tourism atmosphere, thus promoting the awareness of low-carbon tourism in the whole society.

Washing face and mouth, brushing teeth,	0.05L	2	Women:20 minutes /50L 0.1 (per ton of water consumes 1 degree electricity）	0.1
Flush the toilet	0.09L	8	0. 72（per ton of water consumes 1 degree electricity）	0.72
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Total	260.85kg		

Fig. 1. (*continued*).

5.2. Limitations and delimitations

Irrespective of the significant findings, this study is not without limitation. First, the tour does not include a large number of shopping activities, so the amount of carbon emissions in shopping is relatively less. Second, this tour belongs to leisure tourism; its energy consumption is relatively less compared with the tours in other conditions. Therefore, the proportion of CEs of sightseeing ranks the last. Future research is needed that will explore the carbon emissions of different tourism types, such as sport tourism, VRF, business travel etc. to really reveal the Carbon Emissions during a Tour. In short – there continue a need for more such monitoring and benchmarking exercises to obtain better results that can aid managers in their planning decision.

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