Calculation Analysis of Tourism Carbon Emissions Amount—A Case Study

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Tourism is always known as low-carbon industry, but low-carbon emission does not mean no-carbon emission. The correlation effects between tourism and other industries makes tourism a necessary part in dealing with energy-consumption efficiency and carbon-reduction. However, calculation of carbon emissions is rather difficult because of the intricate connections between tourism and other industries. In this paper, the "from bottom to top" method is applied to estimating the tourism carbon emissions in Hubei province. And the result shows the tourism carbon emissions were about 3.4006MT in Hubei province in 2013, among which travel transportation took up about 95.7%, far beyond the national and world proportion. Therefore, travel transportation especially the expressway transportation and civil aviation transportation must be the key in the process of developing low-carbon tourism.

1. Introduction

In recent years, low-carbon economy which aims to decrease greenhouse gases emissions and protect the global environment, has rapidly sprang up and is positively supported by many countries. China in November 2009 solemn commitment that from 2009 to 2020, the carbon emissions per unit GDP would fell 40%-45%. With the goal of reducing greenhouse gases emissions and building a low-energy-consuming economy developing mode based on low pollution and low emissions. Low-carbon economy is another progress in human society after agriculture civilization and industry civilization. With its natural feature of emitting less carbon, tourism should be vigorously developed to achieve the goal of energy-saving and emission-reduction and stimulate the economy growth. Therefore, great importance should be attached to tourism as the whole world is attempting to develop low-carbon economy. However, low-carbon does not equal no-carbon, so the priority task in developing low-carbon tourism is to calculate the carbon emissions in this industry and then analyze the development through combining qualitative method with quantitative method.

Researches on low-carbonization in the world start relatively late. The earliest documents systematically discoursing on low-carbon economy are United Nations Framework Convention on Climate Change published in 1992, and Kyoto Protocol signed in 1997. What's more, the concept of "low economy" was first directly put forward by British government in the report Our Energy Future-Creating a Low Carbon Economy in 2003. Up to now, researches in China and abroad mainly focus on the study in tourism carbon emissions calculation and tourism energy structure adjustments.

Some researchers like (Natalia, 1997) adopted input-output method to estimating tourists' energy demand in Hawaii and analyzed the connection between energy consumption and tour destination. (Rachel, 2008) studied the tourists' and tour agency's attention level to tourism (esp. travel transportation) carbon-dioxide emissions, and got the result that most people attached great importance to the effects carbon-dioxide had on the environment, and would actively advocate tourists to take the responsibility of reducing carbon-dioxide emissions during the tourism.

Inga J.Smith and Craig J.Rodger calculated foreign tourists' carbon emissions amount in New Zealand and the emission amount of New Zealanders in foreign countries in 2005, and acquired the figures 7893kmg and 3948kmg respectively. Both the researchers made some specific suggestions like replacing thermal power generation with wind power generation, improving thermal power generation efficiency, etc. Besides, Karen

Mayora and Richard S.J.Tol believe that carbon emissions in aircraft industry should be decreased if carbon emission tax takes the place of departure tax. Nevertheless, some researchers agree with Christian Hofer, whose idea is that once carbon emission tax is increased significantly, people's demand for aviation will decrease, thus   leading them to choosing vehicles instead of planes for their trip. As a result, carbon emissions of vehicles will increase greatly, which definitely lower the environmental benefits brought by increasing carbon emission tax in aircraft industry. If so, we can not achieve the goal as expected.

Different from highlighting the quantitative and case-study in overseas researches, domestic researches on the suggestions of low-carbon tourism focus on the qualitative and macro theory. Li Dan further analyzed the fundamental state of tourism development in our country, and she gave some correlative advice. Zhou Mei deep elaborated tourism growth's essence in the context of low-carbon economy, and made it clear that low-carbon tourism is inevitable in our tourism evolution, about which she also came up with some advice. Zheng Linlin and Lin Xiqing explicitly expressed the method of accomplishing low-carbon tourism, and built a joint mode in which tourists, tourist destination, tourism enterprise and tourism regulation department can work together. Besides, (Shi, 2010) pointed out that a supportive, encouraging and modeling mode should be built which centers on the government and takes the expanded fields of tourism such as tour sites, accommodation as the carrier. Meanwhile, a consistent policy guarantee system including the process of schedule, marketing and assessment should be formed.

Above all, domestic researches are slower than that at abroad, and the opinions and theories remain to be further improved. With only a few concrete case analysis, the domestic researches concentrate more on the theoretic aspects such as the concept and connotation of low-carbon tourism with a qualitative method. Therefore, domestic research is quite insufficient in quantitative researches on the basis of specific cases and models. Using this as an entry point, and tourism in Hubei province as study object, this paper adopts a method in which documenting and statistic analysis are combined to calculate tourism carbon emissions in Hubei province, which provides the low-carbonization of tourism development in Hubei province with theoretical foundation and scientific basis.

2. Present situation of tourism development in Hubei province

Surrounded by mountains in the east, west and north, Hubei province is located in the southern part of central China. Covering from 29°05′ to 33°20′ north latitude, and from 108°21′ to 116°07′ east longitude, Hubei province has many neighboring cities: Anhui province in its east, Jiangxi province and Hunan province in its south, Chongqing province in its west, Shanxi province in its northwest and Henan province in its north. Hubei province is granted with fairly abundant natural, cultural and social tourism resources. There are totally 17 cities and states in the province, in which many freshwater lakes distribute everywhere, thus making Hubei known as the "land of a thousand lakes". Currently, there are 269 scenic spots in the province, among which you can enjoy 8 5A scenic spots, 98 4A scenic spots, 109 3A scenic spots, 51 2A scenic sports and 3 1A scenic spots. The National and Provincial nature reserves and scenic spots have distinctive characters and are quite excellent for tourists. Besides, many of them are perfectly reserved because of the restrictions of transportation and social economy development in the past. Therefore, Hubei province can greatly meet the tourists' demand for being close to nature, going back to nature and low-carbon tourism.

In 2014, the number of foreign tourists in Hubei province is 470 million, which increases by 15%; the consolidated revenue is 375.2 billion Yuan, which increases by 17%. In the same year, the scheduled investment to tourism programs is 60.814 billion Yuan, and the final accomplished investment is 71.1 billion Yuan, which increases by 41%. Among all these programs, there are 261 valued beyond 100 million Yuan, 78 beyond 1 billion Yuan (32 more than that in last year), 22 beyond 5 billion Yuan and 13 beyond 10 billion Yuan. After construction and propaganda, Hubei Province tourism brand has begun to take shape. The visibility of tour destinations such as Three Gorges of Changjiang River, the Wudang Mountain, the Shenlong, Yellow Crane Tower, have gradually increase at home and abroad. The annual reception of tourists also increased year by year, the resulting economic effect is more and more obvious.But compared with the national tourism developed provinces (such as Guangdong, Shanghai and Sichuan Province, etc.) the total tourism income has a big gap. In the central region, in 2015, the total tourism revenue and the total number of tourists in Hubei Province are also lower than which in Hunan province.

On the basis of statistical analysis, from the total economic contribution of tourism industry in Hubei province in 2015, nearly 75% tourist production concentrated in Wuhan, Yichang, Xiangfan, and Shiyan, Wuhan city is concentrated on the province's nearly half of the value of tourism. While the tourism value was lack of 1% in Xiantao, Tianmen, Qianjiang, and Shennongjia. tourism revenues accounted for the proportion of GDP accounted for the proportion of the province. The province's tourism revenues from the proportion of GDP, Wuhan (10.28%), Yichang (9.98%), Shiyan (8.56%), Enshi (12.03%), Shennongjia (34.57%) and other 5 regions were higher than the provincial average (7.20%). The tourism industry accounted for the proportion of

the third industry, Wuhan (20.82%), Yichang (28.27%), Shiyan (19.70%), Enshi (32.92%), Suizhou (18.95%), Shennongjia (72.79%) and other 6 areas are higher than the provincial average (18.03%).

3. The calculation of tourism carbon emissions in Hubei province

Tourism carbon emissions mainly refer to the CO2 emissions in tourism, and figuring out carbon emissions amount is a necessary prerequisite in studying tourism low-carbonation. There is no exact method in calculation of carbon emissions in tourism in the world because of many factors. However, carbon emissions calculation can generally be classified as two methods according to various scholars' work: one is "carbon footprint" method while the other is "from the bottom to the top" method. Due to the interruption of the complex connection between tourism and other industries and the difficulties in getting relevant data, this paper adopts "from bottom to top" method in calculating, which means we will first figure out carbon emissions amount in every link during the tour, and consequently work out the total amount.
This can be expressed by a mathematical equation as:

$$E_T = \sum_{i=1}^{n} E_{im} \times C_i \tag{1}$$

Here E_T stands for total carbon emissions amount, E_{im} shows the scale of the i_{th} activity, and Ci refers to carbon emissions factors. Tourism carbon emission is relevant to many factors which consist of direct emissions and indirect emissions, so it's difficult to exactly calculate the carbon emissions amount in all the links. Based on other scholars' achievements, we will take the major fields in tourism carbon emissions as the object of our study. So, the carbon emissions in tourists' activities are divided into 3 parts: transportation, accommodation and tourists' activities. The data in this paper is mainly obtained from THE YEARBOOK OF CHINA TOURISM 2014 and Statistical yearbook of Hubei province 2015. Therefore, our calculation concentrates on relevant data in 2013.

3.1 Calculation of tourism transportation carbon emissions in Hubei province
Along with industry, architecture, transportation belongs to high carbon-emission industries. Gossling S believes tourism transportation carbon emission occupies 94% of the overall tourism carbon emission. And the amount can be computed through the following formula:

$$E_{Tf} = \sum_{i=1}^{n} P_i \times D_i \times C_{Tf} \tag{2}$$

E_{tf} stands for total carbon emission amount in tourism. P_i and D_i respectively refer to tourists' number and travel distance(km) and C_{Tf} expresses carbon emission factors(kg/pkm) while taking the ith vehicle (such as planes, cars, trains, etc.). $P_i D_i$ shows the scale of tourism transportation. C_{Tf} can be calculated with the formula:

$$C_{Tf} = \frac{F_i}{e_i M_i} \tag{3}$$

In the formula, F_i stands for the carbon emission amount while the ith vehicle consumes a unit of fuel(kg/l), e_i shows the fuel efficiency(km/l), and Mi expresses the average number of passengers carried.
There is no specific statistic data about tourism transportation in our domestic tourism statistics, so the exact data of carbon emissions in China can not be obtained. Considering that tourism transportation is inseparable with passenger transportation, this paper will indirectly estimate the results. Therefore, formula (2) should be adapted into the following:

$$E_{Tf} = \sum_{i=1}^{n} \alpha_i N_i C_i \tag{4}$$

In the ith passenger transportation, αi shows the proportion that tourism takes up in the overall passengers transportation. Besides, Ni and Ci respectively refer to the turnover volume of passenger traffic and carbon emission factor. According to Sun Gennian's and some other researchers' studies, α respectively equals 13.8% in expressway transportation, 31.6% in railway transportation, 64.7% in civil aviation transportation, and 10.6% in water transportation. Moreover, on the basis of Kuo's and other researchers' achievements and the practical situation of transportation industry in Hubei province, carbon emission factors picked up in this paper

respectively are 133g/km in expressway transportation, 27g/km in railway transportation, 137g/km in civil aviation transportation, and 106g/km in water transportation.

Table 1: Tourism Transportation Carbon Emission in Hubei Province

	Tourism transportation emission amount(MT)	Expressway (MT)	Railway (MT)	Civil aviation (MT)	Water transportation(MT)
2000	0.9797	0.546	0.1979	0.2259	0.0099
2013	3.2554	1.6376	0.6454	0.9689	0.0035
Growth rate	232%	199.93%	226%	328.91%	-64.65%

Calculation results are shown above in the chart. Hubei province's total tourism carbon emission amount in 2013 was 3.225MT, increased by 232% compared with that in 2000, which was 0.9797MT. In comparison with data in the year 2000, expressway transportation carbon emission was 1.638MT, 199.93% higher; railway transportation carbon emission was 0.645MT, 226% more; civil aviation transportation carbon emission was 0.969MT, 328.91% more. And the civil aviation transportation's carbon emission grew at the fastest speed. Meanwhile, Water transportation carbon emission was 0.0035MT, 64.65% less than that in 2000. The high growth of carbon emission in civil aviation transportation and decrease in water transportation are consistent with tourists' increasing demand for transportation efficiency and Chinese economy boost in the last decades. Nevertheless, Hubei expressway transportation occupies 50.32% in overall tourism transportation carbon emissions, thus making expressway transportation an important resource of carbon emission as well as a necessary part of reducing carbon emission.

3.2 Calculation of Tourism Accommodation Carbon emissions in Hubei province
Accommodation carbon emission is an essential part of tourism carbon emissions. Because of the restrictions of data, this paper chooses star hotels as the study object. Based on correlative data in 2014 China Tourism Statistic Annual, Hubei province boasted 378 star hotels in 2013, among which there are 19 five-star hotels, 70 four-star hotels, 172 three-star hotels, 113 two-star hotels, 4 one-star hotel. Totally, the number of beds in these hotels is 73239, whose average occupancy rate is 55.29%.

As different countries share various attitudes to low-carbon accommodation and developing levels, the researches on energy-consumption and carbon emission factor in global tourism accommodation vary from each other. In Shi Peihua's opinion, Becken's research achievement of New Zealand conforms to the current state of China. Therefore, in this study, the energy consumption of every bed is set to be 155MJ, and carbon emission amount is 43.2gC/MJ. Consequently, tourism accommodation carbon emission amount was 0.099Mt in Hubei province in 2013.

3.3 Calculation of tourism activity carbon emissions in Hubei province
Tourism activities can be divided into five categories according to the goals for vacation: sightseeing tour, vacation tourism for leisure, business travel, visiting friends and relatives and anything else. Carbon emission influences brought by various travel goals differ from each other. For the convenience of study, this paper adopts Shi Peihua's research achievements on carbon emission factors of different tourism activities. The fixed carbon emission factors of various tourism activities are as follows:

Table 2: Corresponding carbon emission factors of tourism activities (based on traveling goals)

	sightseeing tour	vacation tourism for leisure	business travel	visiting friends and relatives	anything else
Carbon emission factor (g/per person, per day)	417	1670	786	591	172

In 2013, there are 2679623 visitors to Hubei province, each of whom averagely stayed for 2.24 days and the sum of the staying days is 6009111. Also, because of the data restrictions, national average data is applied to the calculation. In the light of 2014 China Tourism Statistic Annual, the national travel activities rates for different goals can be shown in the following chart:
Since relevant proportion is rather difficult to obtain, in this paper the writer weighs the proportions above on the basis of the ratio of urban residents and rural residents in China in 2013, and acquire the final data: 23.8% for sightseeing tour, 21.4% for vacation tourism of leisure, 11.1% for visiting friends and relatives and 6.1% for anything else. Therefore, total tourism carbon emission amount in Hubei province is 0.0466 MT, which consists of 0.006MT in sightseeing tour, 0.0215MT in vacation tourism of leisure (the highest proportion of

about 46.14%), 0.0052MT in business travel, 0.0133MT in visiting friends and relatives and 0.0006MT for anything else.

Table 3: Proportion of the number of tourists for different goals(based on traveling goals)

Proportion	sightseeing tour	vacation tourism of leisure	business travel	visiting friends and relatives	anything else
Urban areas	28.1%	25.6%	10.6%	33.1%	2.6%
Rural areas	18.8%	16.6%	11.7%	42.8%	10.1%

4. Conclusions

4.1 Major Findings

According to all the calculation results above, the whole carbon emission in 2013 is 3.4006MT, in which tourism carbon emission takes up as high as 95.7% in Hubei province, much higher than that in the world--90% and even far more beyond the national proportion of 67.72% figured out by Shi Peihua. So there is still a long way to go for Hubei low-carbonization. Moreover, expressway transportation carbon emission occupies 48.1% in the overall tourism carbon emissions, which ranks the first and civil aviation transportation ranks the second with a ratio of 28.49%. Therefore, tourism low-carbonization development in Hubei province must concentrate on improving expressway transportation and civil aviation transportation.

4.2 suggestions for low carbon tourism in Hubei province

The development of low carbon Tourism in Hubei Province, combined with the results of the analysis, the paper made the following considerations: low carbon tourism as a result of the low carbon economy, low carbon tourism must according to the needs of the development of low carbon economy, make the corresponding countermeasures. On one hand, the Hubei Province tourism low carbon development rely on the development of low carbon economy in Hubei Province, low carbon economy every further, will from the whole driven tourism low-carbon development; on the other hand, low carbon Tourism in Hubei Province also has its own particularity, it must be tailored to the high feasibility, operability and various forms of countermeasures.

Firstly, we must adhere to the mentality "top-down, internal-external, heavy-light". The "top-down" means from the government level to strengthen the thoughts of low-carbon tourism in tourism industry and other relevant departments in Hubei province. Make the concept of low-carbon tourism to implement in the daily work. The management department should start from the tourism planning, formulate technical specification of low carbon tourism planning, set up the quantitative evaluation of low carbon efficiency, strengthen the component of low carbon development in tourism planning review. According to the status quo of development of tourism in Hubei Province, select a number of low-carbon tourism demonstration area with social influence, good operating conditions, and low carbon emission, and steadily push forward the implementation of low-carbon tourism, carry out low-carbon tourism policies and measures as soon as possible in the limited time; estimates of low carbon Tourism on tourism environment, tourism income and tourist bias As well as the positive, negative effect, after the summary of science, foster strengths and circumvent weaknesses, make positive benefits of low carbon Tourism to be maximized.

"internal-external" refers to strengthen the research and income of advanced low carbon technologies and low carbon equipment, then going in an regional co-operation and international way, developing the rules of low-carbon tourism, reinforce the relationship of tourism and other advanced manufacturing industry, high-tech industry and other modern service industry, advocating rational consumption, green business, and low carbon emission, Spreading the low carbon lifestyle to the tourists from tourism, Positively changing the tourist style in public and social.

"heavy-light" refers to determinate the main body of tourism carbon footprint, Focus on strengthening the work of energy saving and water saving of the main body of tourism carbon footprint, Increasing the carbon emissions of tourism transportation and tourism hospitality industry, Speed up the research process of energy saving and water saving and emission reduction of tourism transportation and accommodation.

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