

Carbon Safety Assessment based on Tourism Carbon Footprint and Tourism Carbon Capacity Model in Gansu Province

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Abstract. Based on Carbon Footprint model, we calculated the tourism carbon footprint and tourism carbon capacity of Gansu Province in 2019 and 2020. The results indicate that: 1. Tourism carbon deficit is $-119824/10^4\text{t}$ in 2019 and $-64999/10^4\text{t}$ in 2020, which indicates a negative impact on ecosystem. 2. The number of tourists in 2020 is lower than 2019. Therefore, the tourism carbon footprint in 2020 was reduced compared to 2019. 3. From the information in this study, indicate the tourism industry in Gansu Province is unsustainable.

Keywords: tourism carbon footprint; tourism carbon capacity; life cycle assessment.

1. Introduction

Since the beginning of the industrial revolution, the concentration of greenhouse gases in the environment is increasing ceaselessly[1]. The prime criminal of this phenomenon is various greenhouse gases especially carbon dioxide, methane and nitrox[2]. These kinds of gases are largely emitted via various human activities and the accumulation of greenhouses gases in the atmosphere leads climate changes and global warming[3]. Greenhouse effect was first discovered by Joseph Fourier in 1824[4], it brings a series of problems such as flood, drought and aridity and many other problems, among them, climate change is the most dangerous problem because of the greenhouse effect[5].

Regarding the topic of carbon footprint, foreign scholars have long been aware of the impact of greenhouse gases on the earth and the environment and they had been studying this topic for many years. But in our country, this problem has only begun to attract the attention of many researchers in recent years. Although we started later than many developed countries, Through the research of more and more domestic scientific researchers devoted a lot of times to study this topic, we have also made a lot of achievements in this regard. With many natural disasters occurred, many scientists and researchers both from China and foreign countries realized the seriousness of the matter and appealed to people to take actions to deal this phenomenon. Wang et al. shows that since the reform and opening up, the emission of carbon dioxide in China has increased largely, the research suggest that China should immediately take doable actions to mitigate the large emission of greenhouse gases and encourage sustainable development in China[6]. Dong et al. calculated the tourism carbon footprint of Jiangsu province from 2000 to 2015, the results show that from 2000 to 2015 the tourism carbon footprint is always larger than tourism carbon capacity, in another words during this period of time the tourism industry of Jiangsu province is unsustainable[7]. Kyoko Kusakabe et al. taking Hue city in Vietnam as an example and suggests that the best way to keep urban tourism sustainable is combine low carbon development policies with people's social responsibilities[8]. Jin et al. calculated the tourism carbon footprint of Shanxi province and the result shows from 2000 to 2021, the tourism carbon footprint of Shanxi province increased ceaselessly until 2018. However, because of the novel coronavirus this phenomenon slowed down a bit in 2019[9]. Kong. scientifically measured and dynamically compared the carbon footprint and carbon carrying capacity of the tourism industry in Qinghai province from 2010 to 2019. The results showed that the carbon carrying capacity had always been higher than the carbon footprint. Which

indicate that There is also enough space for the development of tourism industry in Qinghai province[10].

The notion of carbon footprint originated from ecological footprint, it's the index to measure the impact of human activities on the environment. Mainly refers to the total emissions of greenhouse gases from a specific population, system or activity[11]. Carbon footprint is a large system with a variety of complex relationships. Calculating a total carbon footprint is also very difficult and complex. In this study, we chose to study one of the offcuts in the carbon footprint, tourism carbon footprint. There are two classification of carbon footprints based on real evidence. The first type is direct carbon footprint that emit via the use of fossil fuel and it's the main leading of carbon accumulation in the atmosphere. The second type is indirect carbon footprint hidden in our daily life such as the produce and transportation and recycling process of a commodity[12].

Gansu is located in northwest of China with its unique geographical features. Gansu is the seventh largest province in China. However, with the rapid development of our society, the natural resources of Gansu are seriously contaminated due to human activities[13]. To investigate the sustainable development tourism industry in Gansu Province, this study calculated the tourism carbon footprint and tourism carbon capacity of Gansu Province in 2019 and 2020. Corresponding results may provide available measures and recommendations for balance the ecological environment and the development of tourism industry.

There are four methods to calculate or measure carbon footprint. The first one method is life cycle assessment method (LCA)[14]. LCA method is mainly for calculate the carbon footprint of the product and it is a “from beginning to end” process. This method mainly for calculate commodity carbon footprint. For-instance, if we need the carbon footprint of a bottle of water, first we need to exploit row materials from nature resources, followed the transportation and process, sell and use and recycle. The sum of the emissions in this whole process is the carbon footprint of a bottle of water.

The second method is Intergovernmental Panel on Climate Change (IPCC) method. It is an intergovernmental body jointly established by the World Meteorological Organization (WHO) and the United Nations Environment Program (UNEP) in 1988. Its main task is to assess the current state of scientific knowledge about climate change, the potential social and economic impacts of climate change, and possible responses to climate change adaptation and mitigation[11]. The other two methods are input-output method (IO) and Kaya carbon emission identity, these two methods are not that common and accurate. Therefor we use IPCC method in our following calculations.

Through Intergovernmental Panel on Climate Change (IPCC) method, carbon emissions are assessed by calculating the corresponding amount of fossil fuels and energy used. This method is more accurate and comprehensive than other methods, in this study we use this method to calculate tourism carbon footprint. The formula is

$$CF = A \cdot E \quad (1)$$

CF is carbon footprint, A is active data, in this paper A represents tourism revenue. E is the corresponding carbon emit intensity. The other two methods are input-output method (IO) and Kaya carbon emission identity, these two methods are not that common and accurate. Therefor we use IPCC method in our following calculations.

2. Methods and data resources

2.1 The tourism carbon footprint model.

The tourism carbon footprint reefers to the amount of carbon dioxide that emitted by the use of commodity by visitors. In this study we use the second method (IPCC) to calculate the data. The tourism carbon footprint model is following this

$$TCF = R \cdot E \quad (2)$$

$$TCF' = \frac{TCF}{N} \quad (3)$$

TCF is the tourism carbon footprint, R is the revenue of tourism industry, E is the carbon emission intensity, we use the value of $623.13\text{kg}/10^3\text{USD}$ [15] in this study, it is the global average carbon emission intensity in tourism related industry. TCF' is the per capita tourism carbon footprint, N is the population of travelers in Gansu province in 2020.

2.2 The tourism carbon capacity model.

The tourism carbon capacity refers to the maximum capacity of a regional ecosystem to absorb CO₂ emissions from tourism under certain time and space conditions, that is, the carbon sequestration capacity of green vegetation in Gansu province. TCC determine whether the amount of carbon dioxide in the environment can be absorbed by vegetation in certain region. The model is followed as [16]

$$TCC = \frac{44}{12} \cdot N_* \cdot V_* \cdot r \quad (4)$$

$$TCC' = \frac{TCC}{N} \quad (5)$$

TCC is the tourism carbon capacity, V_* is the vegetation area of Gansu province, which including forest area, grassland area and farmland. N_* is the Net Ecosystem Productivity (NEP). According to paper [11], in this paper we take the average value of NEP $0.026\text{t} \cdot \text{hm}^{-2} \cdot \text{a}^{-1}$. r is the proportion of total local tourism revenue in total local production in corresponding year percentage of value. $\frac{44}{12}$ is the conversion factor between CO₂ and V_* .

2.3 The tourism carbon deficit model.

The tourism carbon deficit is way to verdict whether the tourism of a region is sustainable and the model is following this

$$TCD = TCC - TCF \quad (6)$$

$$TCD' = \frac{TCD}{N} \quad (7)$$

TCD is the tourism carbon deficit in Gansu province in 2020. If $TCD > 0$, its indicated that the TCC is larger than TCD and there is enough vegetation in the area to absorb carbon dioxide, the tourism industry of Gansu province is sustainable. When $TCD < 0$, the TCF is larger than corresponding TCC and the vegetation in Gansu Province is not enough to absorb carbon dioxide from the environment, which means there is excess amount of carbon dioxide in the environment and the tourism industry of Gansu province is unsustainable.

2.4 Data resources.

The data we use to calculate index above are all from Gansu Development Yearbook-2022 and China Environmental Statistical Yearbook.

3. Results

Table1. Tourists and earnings in Gansu Province in 2019 and 2020.

Year	International Tourists.		Domestic Tourists.	
	Tourists/person-times.	Earnings/ 10^4USD \$	Tourists/ 10^4 person-times.	Earnings/ 10^8US \$
2019	198228	5905	37423	375
2020	25446	697	21288	202

Tourism carbon footprint and per capita is calculated by formula (2) to (3).

Table2.The value of TCF in Gansu Province in 2019 and 2020.

Year	International Tourists		Domestic Tourists		Total	
	TCF/ 10^4t	TCF'/kg	TCF/ 10^4t	TCF'/kg	TCF/ 10^4t	TCF'/kg
2019	26.40	1331	119835.03	3202	119861.43	62.40
2020	3.11	1224	65031.97	3054	65035.08	59.20

Table3.The proportion of tourism-related industries in GDP in Gansu Province in 2019 and 2020.

Year	GDP/ 10^8 yuan	Transport, storage, post. / 10^8 yuan	Wholesale and retail trades. / 10^8 yuan	Hotels and catering services. / 10^8 yuan	Total (r).
2019	8718.30	646.28	438.39	158.27	14.26%
2020	9016.70	659.34	420.20	144.69	13.58%

Table 4. The value of V_* and NEP in different land type in 2019 and 2020.

Year	Forest area./ 10^4h	Grassland./ 10^4h	Farmland./ 10^4h
2019 and 2020	796.28	1430.71	520.95

Use formula (5) to (7), tourism carbon capacity and tourism carbon deficit are as follows

Table 5. The Tourism carbon capacity of Gansu Province in 2020.

Year	TCC/ 10^4t	TCC'/kg	TCD/ 10^4t	TCD'/kg
2019	37.36	1.00	-119824	-3200
2020	35.58	1.70	-64999	-3052

4. Conclusions and Recommendations.

This study compared the tourism carbon footprint of Gansu province in 2019 and 2020 by using some models above. Corresponding results can be sum up as the following conclusions.

- (1) The whole tourism carbon footprint of Gansu province in 2019 and 2020 are 119861.43×10^4t and 65035.08×10^4t . Domestic tourism carbon footprint leads the total tourism carbon footprint of Gansu Province.
- (2) The tourism carbon capacity of Gansu Province in 2019 and 2020 are 37.36×10^4t and 35.58×10^4t
- (3) The tourism carbon deficit in 2019 and 2020 are all negative, which indicate the tourism carbon footprint of Gansu Province is exceeded local carbon carry capacity.
- (4) The tourism carbon footprint reduced due to the decrease of tourists because of the COVID-19 pandemic.
- (5) The tourism carbon deficit reduced due to the decrease of tourism carbon footprint.

From the conclusions above, the tourism carbon deficit of Gansu Province in 2019 and 2020 are both negative, meaning the concentration of carbon dioxide in the atmosphere is beyond the tolerance of the environment, which indicate the tourism industry in Gansu Province is unsustainable. Based on the contents of this study, the corresponding recommendations are as follows:

First, rational measures should be taken to appropriately reduce the number of tourists, especially domestic tourists.

Second, the Tourism Carbon Deficit in 2019 and 2020 are always negative, which meaning the vegetation area of Gansu Province is not enough to absorb carbon dioxide from the atmosphere. Gansu province should expand the area of forests and cultivate green plants.

Third, Government and related enterprises should advocate low-carbon life style among citizens, decrease the emit of carbon dioxide in our daily life.

Last, the planet is our common home, and it is constantly affected by regional degradation. As we have done in this study, results like this happen all the time in the world. Since the beginning of the industrial revolution, the concentration of greenhouse gases in the environment is increasing ceaselessly. The corresponding result is, our planet is gradually weakening its ability to repair. The best way to keep sustainable is combine low carbon development policies with people's social responsibilities, every member of our society should take the initiative to support sustainable development of our planet.

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