Journal of Global Change Data & Discovery. 2017, 1(4): 464-469
DOI:10.3974/geodp.2017.04.14
www.geodoi.ac.cn

Carbon Emission Dataset for the Kaifeng Tourism Industry (2007, 2012)

Li, X.[1*] Qin, Y. C.[2] Zhang, Y.[1]

1. School of Environmental Science and Tourism, Nanyang Normal University, Nanyang 475063, China;
2. The College of Environment and Planning, Henan University, Kaifeng 475004, China

Abstract: The collation and accounting of carbon emission data from the urban tourism industry is the basis for studying the carbon emission mechanism of the industry, and is also the basis of the rational formulation of carbon emission reduction measures. Kaifeng city is a famous tourist city in the Zhongyuan region of China, and studies of the carbon emissions from its tourism industry are of great significance for other cities. This dataset was compiled from a survey of the Kaifeng tourism industry, which included a regional input-output table. The methods used to compile it consisted of data sorting, classification, stripping, and building a carbon emissions data matrix, including a calculation of the carbon emissions coefficient matrix and carbon decomposition matrix of Kaifeng tourism through the economic input-output life-cycle assessment (EIO-LCA) model. It was found that among the various tourism sectors in Kaifeng, the carbon emissions from tourism transportation and the accommodation and catering sectors accounted for most carbon emissions. The carbon emissions of the Kaifeng tourism industry displayed an obvious "iceberg" effect. The data is stored in the .xlsx format, with a data volume of about 84 KB.

Keywords: tourism carbon emission data; Kaifeng; carbon dissociation matrix

1 Introduction

Carbon emissions from tourism account for 4.4% of the global carbon dioxide (CO_2) emissions from human activity, and will continue to grow at a growth rate of 3.2% until 2035[1]. The whole tourism sector accounts for 5−14% of the human contribution to global warming[2–3]. Consequently, there has been an increasing number of studies of carbon emissions from the tourism industry[4–6]. With most tourism being urban based, the carbon emissions within cities is the main component of the overall carbon emissions from the tourism industry[7]. Carbon emission data for the Kaifeng city tourism industry[8] were investigated in this study based on a regional input-output table, energy consumption data, and first-hand survey data. The improved economic input-output life-cycle assessment (EIO-LCA) model was applied to assess large scale carbon emissions after extracting carbon emissions from the

Received: 06-11-2017; **Accepted:** 08-12-2017; **Published:** 25-12-2017
Foundation(s): Nanyang Normal University (ZX2016008); National Natural Science Foundation of China (41171438)
***Corresponding Author:** Li, X. N-4171-2016, School of Environmental Science and Tourism, Nanyang Normal University, lixu2056@163.com
Article Citation: Li, X., Qin, Y., Zhang, Y. Carbon emission dataset for the Kaifeng tourism industry (2007, 2012) [J]. *Journal of Global Change Data & Discovery*, 2017, 1(4): 464–469. DOI: 10.3974/geodp.2017.04.14.
Dataset Citation: Li, X., Qin, Y. Tourism carbon emission dataset of Kaifeng city, Henan province, China (2007, 2012) [DB/OL]. Global Change Research Data Publishing & Repository, 2016. DOI: 10.3974/geodb.2016.06.04.V1.

Kaifeng tourism industry, which enabled the direct and indirect carbon emissions from the various tourism sectors of Kaifeng city to be determined.

2 Metadata of Dataset

The metadata for the tourism industry carbon emissions in the Kaifeng city dataset is summarized in Table 1. It includes the dataset full name, short name, authors, year that the dataset refers to, temporal resolution, spatial resolution, data format, data size, data files, data publisher, and data sharing policy.

Table 1 Metadata summary of the for the Kaifeng city tourism industry carbon emission dataset

Items	Description
Dataset full name	Tourism carbon emission dataset of Kaifeng city, Henan province, China (2007, 2012)
Dataset short name	TourismCarbonEmissionKaifeng2007_2012
Authors	Li, X. N-4171-2016, School of Environmental Science and Tourism, Nanyang Normal University, lixu2056@163.com Qin, Y. C. N-4027-2016, The College of Environment and Planning, Henan University, qinyc@henu.edu.cn Zhang, Y. N-4142-2016, School of Environmental Science and Tourism, Nanyang Normal University, 512062249@qq.com
Geographical region	Kaifeng city, China (34°11′45″N–35°01′20″N, 113°52′15″E–115°15′42″E)
Year	2007，2012
Data format	.xlsx
Data size	84 KB
Data files	7 .xlsx tables
Foundation(s)	Nanyang Normal University (ZX2016008); National Natural Science Foundation of China (41171438)
Data publisher	Global Change Research Data Publishing & Repository, http://www.geodoi.ac.cn
Address	No. 11A, Datun Road, Chaoyang District, Beijing 100101, China
Data sharing policy	***Data*** from the Global Change Research Data Publishing & Repository includes metadata, datasets (data products), and publications (in this case, in the *Journal of Global Change Data & Discovery*). ***Data*** sharing policy includes: (1) ***Data*** are openly available and can be free downloaded via the Internet; (2) End users are encouraged to use ***Data*** subject to citation; (3) Users, who are by definition also value-added service providers, are welcome to redistribute ***Data*** subject to written permission from the GCdataPR Editorial Office and the issuance of a ***Data*** redistribution license; and (4) If ***Data*** are used to compile new datasets, the 'ten per cent principal' should be followed such that ***Data*** records utilized should not surpass 10% of the new dataset contents, while sources should be clearly noted in suitable places in the new dataset[9]

3 Methods

3.1 Study Area

In the study, energy data was obtained from the Henan Statistical Yearbook and Kaifeng Statistical Yearbook. Due to the lags in the input-output tables, the input-output table of this study was combined with the 135 industry input-output tables of Henan province in 2007 and the energy consumption data for 20 industrial sectors. The costs of tourist transportation, telecommunications, tourism and shopping, accommodation and catering, entertainment, travel and tour services and seven other sectors were included in the combined input-output table, together with data for transportation and warehousing, postal services, information transmission, computer services and software industry, wholesale and retail, accommodation

and catering industry, cultural activities, body, entertainment and residential services, tourism and other service industries, which encompassed all the products and services included in the final consumption. The final demand matrix of the various sectors involved in the tourism industry was then determined.

The cost data for Kaifeng domestic tourists was obtained from a 2012 report on domestic tourism in Kaifeng. Data for the money spent by inbound tourists was considered to match the average estimated for Henan province as a whole, based on a field sampling survey of international tourists in Henan province. The average stay of inbound tourists in Kaifeng per capita was 1.4 days. Revenue and costs to Kaifeng city for tourism activities was determined, with the calculation of income to tourism sectors based on the buyers price. The input-output table was not unified in terms of production price, with the main differences being due to tax. The tourism industry is the third largest industry in Kaifeng city, and all tourism-related activity operates with a 5% business tax and a 12% surcharge (up to 5% of the total value of the 5% business tax) as well as corporate income tax. Therefore, in the accounting process, the data for tourist costs were deducted from the above two taxes. To eliminate the large variations in the statistical calculation, the Kaifeng tertiary industry GDP index was used to reduce the variations in spending by tourists, with 2007 used as the base period. Using the index, the carbon intensity of tourism related sectors in 2012 was found to be about 13.4% lower than in 2007. Carbon emissions from the Kaifeng tourism industry were calculated on the basis of the estimated 2012 carbon intensity values.

3.2 Data Collection and Processing

The advantages of the EIO-LCA model and the input-output method are not only an environmental impact analysis of individual products "from the cradle to the grave", but also the provision of environmental accounting data. This can be combined with the stability of the carbon emissions from economic activity in various industrial sectors, enabling the study of inter industry carbon emissions. This dataset was used to improve the EIO-LCA method in terms of the calculation and analysis of carbon emissions in the Kaifeng city tourism industry.

According to previous research, the basic expression of the EIO-LCA model is[10]:

$$E = RX = R(I - A)^{-1}F \tag{1}$$

Where E is the CO_2 emission matrix of energy consumption in all sectors, and R is an environmental pressure matrix of k_n order. The element r_{ij} in R represents the environmental burden of j units of output k (e.g., carbon emissions), A is the direct demand coefficient matrix, $(I–A)^{-1}$ is the Leon Leontief inverse matrix, X is the output vector for all sectors, and F is the final demand vector.

According to the expression of the EIO-LCA model, the basic input-output relationship can be expressed as:

$$x = (I + AA + AAA + \cdots \quad {}_{INV} + y_{\Delta EXP}) = (I - A)^{-1} y \tag{2}$$

The column vector x is the output (billion yuan) of the products or services in the industry chain, and I is the unit matrix. A is a direct consumption coefficient matrix, which reflects the technical and economic ties between industries. y_R, y_{INV}, and $y_{\Delta\ EXP}$ column EXP are consumption, investment, and net exports (million yuan), respectively, with a combination of the three reflecting the final demand structure. The column vector y represents the final demand for each industry, which is the sum of consumption, investment, and net export. Because tourism is a consumer based industry, it provides little production for other industries. Therefore, the column vector y represents the final consumption of various industries.

Carbon emissions from various industries in the production chain can be expressed as[11]:

$$c = CI \times x \tag{3}$$

The column vector c is expressed to meet the final consumption of y, and the industry producing the CO_2 (million t). CI is a diagonal array, the diagonal element is the direct carbon emission from the unit economic output, i.e., the carbon emission intensity (Mt/M yuan) of each industry, which is calculated as follows:

$$CI_i = C_i / x_i \tag{4}$$

where C_i is the carbon emission of industry i and x_i is the total output of the same industry.

To analyze the carbon emissions generated by various industries in the industrial supply chain, y was changed to a diagonal matrix, and the direct carbon emissions of various industries were decomposed into the final demand of various industries. Equations (2)–(4) were used to construct the carbon emission matrix, which was expressed as:

$$C = CI(I - A)^{-1} y^* \tag{5}$$

where C is the carbon matrix of various industries; $(I–A)^{-1}$ is the Leon Leontief inverse matrix, which reflects the complex economic ties between the various industries; y^* is the diagonal matrices for the final consumption of various industries (y).

Because the system involves a wide range of tourism businesses that provide products and services to the overall tourism industry, as well as other industries that provide associated products or services, it is very difficult to distinguish between them. This needs to be improved in the calculation, so that the carbon emissions from the various sectors of the tourism industry can be considered alongside the total carbon emissions of the industry as a whole.

According to the principle of matrix operation:

$$\begin{bmatrix} a_{11} & a_{12} & \cdots & & \cdots & & \cdots & \\ a_{21} & a_{22} & \cdots & & \cdots & & \cdots & \\ \vdots & \vdots & & \vdots & \vdots & \vdots & \vdots & \vdots \\ a_{m1} & a_{m2} & \cdots & & \cdots & & \cdots & \end{bmatrix} \times \quad = \quad \tag{6}$$

If the $\begin{bmatrix} \lambda_1 & 0 & \cdots \\ 0 & \lambda_2 & \cdots \\ \vdots & \vdots & \vdots \\ 0 & 0 & \cdots \end{bmatrix}$ in the formula is replaced with the $\begin{bmatrix} \lambda_1 & 0 & \cdots \\ 0 & \lambda_2 & \cdots \\ \vdots & \vdots & \vdots \\ 0 & 0 & \cdots \end{bmatrix}$, then the upper form is changed to:

$$\begin{bmatrix} a_{11} & a_{12} & \cdots & & \cdots & & \cdots & \\ a_{21} & a_{22} & \cdots & & \cdots & & \cdots & \\ \vdots & \vdots & & \vdots & \vdots & \vdots & \vdots & \vdots \\ a_{m1} & a_{m2} & \cdots & & \cdots & & \cdots & \end{bmatrix} \times \quad = \quad \tag{7}$$

From this operation, we can see that the change in the result is closely related to the value of the change in the result column, and the proportional relation between the column vectors will not change. Because the Leon Leontief matrix for the industry reflects the fixed proportion of the relationship, by changing an element of the final demand in the matrix, the column vector value reflects the change of carbon emissions in the final matrix. The relative relationship between the elements is the same, which is the basis of the improved model. Therefore, to reflect the carbon emission status of the relevant sectors involved in tourism activities, the total demand of tourism related sectors is deducted after tax deduction and consumption, and the final demand of tourism related sectors can be expressed. The final demand is y' instead of y^*, which is expressed as:

$$C = CI(I - A)^{-1} y' \tag{8}$$

Where $CI(I–A)^{-1}$ is CB, which consists of the element cb_{ij}, in which i provides the serial

number of the product production / service industry; j is the serial number of the product/ service $i=1,...n$; $j=1,...n$ and n are the number of industries in the input-output table; cb_i is the row vector of the line i of C; cb_j is the column vector of the C column j; c_i is the sum of row vectors; and c_j is the sum of the column vectors. This can analyze the distribution structure of carbon emissions in the tourism sector, and at the same time the relationship between direct and indirect carbon emissions can be analyzed.

4 Results and Validation

Based on the industry input-output table calculated by 144 departments in Henan province, the data results and illustrative information of the carbon emission dataset of Kaifeng tourism industry are extracted from the improved EIO-LCA model. The dataset is composed of .xlsx tables. The carbon emissions of various tourism departments (tourism transportation, post and telecommunications, shopping, accommodation and catering, travel agency, entertainment, browsing and others) in Kaifeng are analyzed.

Table 2 The result and discription of carbon emission dataset in Kaifeng city tourism industry

Order number	Data name	Discription
Tab.1	20 Department input-output table of Henan province in 2007	The integration of input-output table in the 144 sector of Henan province
Tab.2	Leon Leontief input-output matrix of Kaifeng city in 2007	Using the weighted average value as the standard, peeling out Kaifeng Industry data from Henan province stripping, and constructing Leon Leontief matrix of Kaifeng
Tab.3	Final demand matrix of Kaifeng city in 2007	Based on the tourist survey data of Kaifeng city, According to the formula (6) and (7) the tourist industry data of Kaifeng city are extracted from the Tab.2
Tab.4	Carbon emission coefficient matrix of Kaifeng city in 2007	Based on the energy statistics and survey data of Kaifeng city，According to the formula (3) and (4) the carbon emission coefficient is calculated and the matrix is constructed
Tab.5	Carbon emission matrix of Kaifeng city in 2007	Based on Tab.3 and Tab.4, According to the formula(5) calculate the carbon emission matrix of Kaifeng city in 2007
Tab.6	Carbon emission matrix of Kaifeng city in 2012	Estimation of the carbon emission matrix of Kaifeng city in 2012 based on Tab.5
Tab.7	Carbon emission decomposition of various departments of tourism industry in Kaifeng city in 2012	Based on Tab.6, According to the formula (1) and (2) calculate the carbon emission decomposition of various departments of tourism industry in Kaifeng city in 2012

5 Discussion and Conclusion

It was determined that tourist traffic and transportation accounted for the largest proportion of direct carbon emissions within the Kaifeng tourism industry, followed by accommodation and catering. From the perspective of indirect carbon emissions, accommodation and catering made the largest contribution, while travel agencies had the lowest indirect emissions. From the total carbon emissions for different sub-sectors, tourism traffic still accounted for the most carbon emissions in the Kaifeng tourism industry, while travel agencies accounted for the least. These results suggest that the direct carbon emissions accounted for the largest proportion of the total carbon emissions from small tourism businesses, with an obvious “iceberg effect” being apparent. There was a large difference between the overall and direct carbon emissions of each tourism sector. When considered alongside the carbon emissions from other sectors of the national economy, the tourism industry is not a “smokeless industry”, but can be referred to as a “low carbon industry”. Energy saving and emission reduc-

tion within this sector had an important role to play.

There were some problems identified in the study when using the EIO-LCA model to interpret carbon emissions from the Kaifeng city tourism industry. There were limited data sources available and the accuracy of industryal classification was problem. These two problems were directly related to the appropriateness of carbon emission accounting results. The solutions of these problems in this study were as follows: (1) for tourism at the city level, tourism data is mainly based on first-hand survey data and information regarding emission sources is not comprehensive. The solution to this issue could be to convert carbon emission data into the consumption of electricity, coal, oil and other energy sources. (2) The input-output matrix can be a crude mechanism, and the proposed solution is to use the improved EIO-LCA model to separate the carbon emissions from the whole industry into data for all sectors of the industry. These data processing and computing methods are most effective when using the existing tourism and energy statistics data in China. However, the high level of carbon emissions in the tourism industry requires further research to improve the accounting accuracy and scope of the required assessment.

Acknowledgments

Qin, Y. C. designed the algorithms of the dataset. Li, X. contributed to the data processing and analysis. Zhang, Y. performed the data validation. Li, X. wrote the paper. The authors would like to thank the Kaifeng city Tourism Bureau for help with data collection.

References

[1] Peeters, P., Dubois, P. Tourism travel under climate change mitigation constraints [J]. *Journal of Transport Geography*, 2010, 18(3): 447−457.

[2] UNWTO-UNEP-WMO. Climate Change and Tourism-Responding to Global Challenges [C]. Madrid: UNWTO, UNEP & WMO, 2008,169−172.

[3] Gössling S, Scott D, Hall C M. Inter-market variability in CO_2 emission-intensities in tourism: implication for destination marketing and carbon management [J]. *Tourism Management*, 2015, 46(2): 203−212.

[4] Xie, Y. F., Zhao, Y. Measuring carbon dioxide emissions from energy consumption by tourism in Yangtze River Delta[J]. *Geographical Research*, 2012, 31(3): 429−438.

[5] Roberto, R. M., Pedro, R. S. Ecological footprint analysis of road transport related to tourism activity: the case for Lanzarote Island [J]. *Tourism Management*, 2010, 31(1): 98−103.

[6] Han, Y. J., Wu, P. The measurement and comparative study of carbon dioxide emissions from tourism industry of Beijing-Tianjin-Heibei [J]. *Human Geography*, 2016, 131(4): 127−134.

[7] Qin, Y. C., Li, X., Rong, P. J. Urban tourism carbon accounting based on improved EIO-LCA model: a case study of Kaifeng city in Henan province [J]. *Progress in Geography*, 2015, 34(2): 132−140.

[8] Li, X., Qin, Y. C. Tourism carbon emission dataset of Kaifeng city, Henan province, China (2007, 2012) [DB/OL]. Global Change Research Data Publishing & Repository, 2016. DOI: 10.3974/geodb.2016.06.04.V1.

[9] GCdataPR Editorial Office. GCdataPR Data Sharing Policy [OL]. DOI: 10.3974/dp.policy.2014.05 (Updated 2017).

[10] Chen, H. M. Analysis on embodied CO_2 emissions including industrial process emissions [J]. *China Population, Resources and Environment*, 2009, 19(3): 25−30.

[11] Ji, J. P., Liu, L., Ma, X. M. Greenhouse gas emissions by Chinese economy: an assessment based on EIO-LCA model [J]. *Acta Scientiarum Naturalium Universitatis Pekinensis*, 2011, 47(4): 741−749.