Analysis of Carbon Footprint in Jinan City

Fang LUO¹,²,* , Pang Li¹, Zhan-hong LIU¹,² and Fang DONG¹,²

¹School of Water Conservancy and Environment, University of Jinan, 250022 Jinan, China
²Shandong Provincial Engineering Technology Research Center for Ecological Carbon Sink and Capture Utilization, 250022 Jinan, China

*Corresponding author

Keywords: Carbon footprint, Carbon emissions, Carbon sinks, Jinan city.

Abstract. Carbon footprint reflects the impact of human activities on the environment and the influence degree, to carry out the carbon footprint and carbon cycle research helps the ecological construction of urban planning. Based on the statistics of Jinan city from 2000 to 2013, by the calculation method of urban carbon emissions and carbon sequestration, the carbon emissions and carbon sequestration situation has been calculated and the total carbon footprint has been calculated. Carbon sinks generally showed a slow growth trend from 2000 to 2011 and a slow decline trend from 2011 to 2013. The carbon footprint grew rapidly between 2000 and 2007, averaging 7.12 per cent. From 2007 to 2013, the carbon footprint showed a fluctuating and slowly declining trend.

Introduction

As the global temperature continues to rise, the related carbon emissions issue has increasingly attracted the attention of all countries and ordinary people. The carbon footprint is a hot research method for the study of carbon emissions and the environmental impact of carbon emissions caused by economic development and energy consumption. The carbon footprint is a new method of measuring the environmental impact of carbon emissions. It was first proposed based on the concept of ecological footprint. It is a measure of direct or indirect CO₂ emissions caused by an activity (or accumulated within the life cycle of a product)[1-7]. As a provincial capital city, JiNan city has long assumed the leading role in regional development, but at the same time, we should also see the severe environmental pressure behind this high-speed development. Jinan City will undergo great changes in terms of urban area, population, and economic and industrial structure. At the same time, it will inevitably face greater pressure to reduce carbon emissions[8,9].

Materials and Methods

Source of Data

This data is derived from the statistical Yearbook of the past years and the research results of relevant government departments and related fields, including: Jinan Statistical Yearbook, Shandong Statistical Yearbook, and China Urban Construction Statistical Yearbook.

Research Methods

Carbon mass in T (tonnes) is used for carbon footprint accounting variables; the basic unit of carbon footprint is hm² (ha). The calculation methods of carbon footprint mainly include process analysis method and input-output method. The calculation of carbon footprint based on the urban level uses life cycle input-yield analysis method. The man-made carbon emissions in Jinan City are mainly derived from the use of fossil energy sources. Carbon sinks mainly include forests, crops and urban green areas. Through the accounting of carbon emissions and carbon sinks, the carbon footprint is converted.
Discussion and Results

Carbon Emissions in Jinan

The carbon emissions of Jinan City mainly come from the carbon emissions caused by human activities, including the energy consumption of industrial production activities, residential energy consumption, carbon emissions from agricultural production activities, carbon emissions from municipal solid waste and sewage disposal, and the respiration of humans and livestock animals[10,11]. Energy carbon emissions are calculated using the energy greenhouse gas emissions calculation method in the IPCC 2006 National Greenhouse Gas Emission Inventory Guidelines[11], energy carbon emissions can be calculated by the formula (Eq. 1, Eq. 2):

\[ CEe = \sum_i (E_i \times EF_{e-i}) \]  
(1)

\[ EF_{e-i} = ALC_i \times CUC_i \times COR_i \]  
(2)

\( CEe \): the total amount of energy carbon emissions, \( i \) : the \( i \) energy source, \( E_i \): the actual consumption of the \( i \) energy source, \( EF_{e-i} \): the carbon emission factor of the \( i \) energy source.

\( ALC_i \): the average low calorific energy of \( i \) energy sources, \( CUC_i \): the carbon content per unit calorific value of \( i \) energy sources, \( COR_i \): the carbon oxidation rate of \( i \) energy sources.

The calculation of the total carbon emissions and the composition of emissions in Jinan City from 2000 to 2013 is shown in Figure 1 and Figure 2.

![Figure 1. 2000-2013 Total carbon emissions.](image-url)
As can be seen from Figure 1, the total carbon emissions of Jinan City have shown an overall upward trend from 2000 to 2006. After 2006, it gradually showed a downward trend. Figure 2 shows that carbon emissions from industrial energy consumption account for the largest share, remaining above 80 per cent and less than 20 per cent. In 2006, industrial carbon emissions accounted for 89.94%, and the corresponding carbon emissions peaked (704.89 × 10^4tC). It shows that the source of carbon emissions in Jinan City is mainly the energy consumption of industrial production activities, followed by human and animal respiration carbon emissions.

**Carbon Sinks in Jinan**

Carbon sinks mainly refer to the carbon absorption capacity of productive land in the research area, namely green land and farmland. The main carbon sinks in Jinan City are forests, urban green spaces, farmland and orchards, which can be calculated using the following formula (Eq. 3).

\[
CI = \sum (Area_i \cdot NEP_i)
\]  

(Eq. 3)

\(CI\): the amount of carbon absorbed by the carbon sink,

\(i\): types of carbon sinks, namely forests, urban green spaces and orchards,

\(Area_i\): the area of type \(i\) carbon sinks,

\(NEP_i\): net productivity of \(i\) vegetation types

![Figure 2. The average proportion of carbon emissions.](image)

![Figure 3. 2000-2013 Total carbon sinks.](image)
According to the area and carbon absorption intensity of each productive land, the carbon sinks of Jinan City are calculated as shown in Figure 3. From Figure 3, the overall growth trend of Jinan’s carbon sinks is divided into two major phases: the overall slow growth trend from 2000 to 2011 and the slow decline trend from 2011 to 2013. In 2002, due to the severe drought that led to the reduction of crops, the carbon sink decreased, and the carbon sink decreased from $343.76 \times 10^4$ tC in 2001 to $290.99 \times 10^4$ tC. While total carbon sinks decreased significantly between 2011 and 2013, forest carbon sinks increased, indicating a decrease in arable land and an increase in forest afforestation.

Among the total carbon sinks, farmland accounted for the largest proportion of carbon sinks, such as 85.11% in 2000 (2898,300 tC in carbon sinks), mainly because of the largest area of farmland, the improvement of farmland irrigation facilities and the strength of crop manual management. Make farmland have higher productivity. Followed by forests, orchards.

**Carbon Footprint in Jinan**

The carbon footprint of Jinan City can be calculated by the proportion of each type of productive land and the corresponding NEP. The calculation method is shown in the formula (Eq. 4).

\[
CF = CE \cdot \sum \left( \frac{R_f}{NEP_f} + \frac{R_c}{NEP_c} + \frac{R_v}{NEP_v} + \frac{R_s}{NEP_s} \right)
\]

(4)

**CF**: the carbon footprint (hm²), \(CE\): the total anthropogenic carbon emissions, \(R_f, R_c, R_v\) and \(R_s\): as a proportion of total carbon sinks in farmland, urban green space, orchards and forests;

**NEPf, NEPc, NEPv and NEPs**: the NEPs of farmland, urban green areas, orchards and forests, respectively.

Jinan City was calculated based on the NEP and the proportion and corresponding carbon absorption intensity of various productive lands (Figure 4). According to the relevant methods and literature, the carbon footprint of as can be seen from Fig. 4, the overall carbon footprint of Jinan City has grown during the 14 years from 2000 to 2013, which can be divided into two phases:

The first stage, from 2000 to 2007, the carbon footprint grew rapidly, with an average growth rate of 7.12 per cent, roughly corresponding to an average increase of 8 per cent in carbon emissions. From 2000 to 2007, the growth of the carbon footprint increased from $87.17 \times 10^4$ hm² to $137.54 \times 10^4$ hm², and reached a peak. The second phase, from 2007 to 2013, shows an overall downward trend in the carbon footprint, which is closely related to the slowdown in economic growth and the continued growth of productive land areas.
Conclusion

Based on the relevant urban carbon footprint calculation research results and calculation method model, the paper analyzes the carbon footprint and carbon cycle pressure based on the actual economic development of JiNan city and the corresponding carbon carbon dioxide profile. Based on the calculation of carbon emissions and carbon sinks, the main conclusions of this paper are as follows:

The main source of carbon emissions in Jinan City is energy consumption, including industrial and domestic energy. The carbon emissions of industrial energy consumption have remained at more than 80% of the total carbon emissions all year round. The peak of total carbon emissions occurred in 2006, and carbon emissions have been declining since 2006.

Jinan's carbon sinks have continued to grow since 2000, with farmland accounting for the largest proportion of carbon sinks, followed by forests. The area of forest and urban green space in productive land has grown significantly, and the proportion of carbon sinks has continued to increase. Overall, farmland carbon sinks have grown slowly in a fluctuating manner, which is mainly related to the intensity of human intervention in farmland and the impact of climate factors. It is also closely related to the current rapid urbanization.

Jinan's carbon footprint grew rapidly from 2000 to 2007, with an average increase of 7.12%. From 2007 to 2013, the carbon footprint showed a fluctuating and slowly declining trend. The overall change trend of the carbon footprint corresponds to the trend of social and economic growth in Jinan City. With the slowdown in economic growth since 2007, carbon sinks have continued to grow and the carbon footprint has shown a downward trend.

References