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Research on Characteristics and Effecting Factors of Crop Farming Carbon Emission in Henan Province, China

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Abstract. The greenhouse gas emissions from crops were calculated, and the LMDI model were used to analyze the influencing factors of carbon. The results indicate: The total carbon emissions of crops in Henan Province from 1991 to 2015 showed an overall upward trend, from 9.7651 million tons of CO₂-eq in 1991 to 17.235 million tons of CO₂-eq in 2015. The dominant position in greenhouse gas production in Henan Province is N₂O for agricultural land, followed by rice field CH₄. Compared with 1991, in 2015, the carbon emission intensity of unit GDP in Henan Province decreased by 59.52%, and the carbon emission intensity per unit of grain output decreased by 12.34%. LMDI analysis shows that the most important factors affecting the increase of carbon emissions in crop production in Henan Province are the agricultural economic level and industrial structure.

1. Introduction

In recent years, the development level of China's planting industry has been effectively improved. However, as a traditional agricultural country, its traditional planting production methods have led to the utilization efficiency of planting resources, the low production efficiency of planting, and the redundancy of production resources in a large number of crops [1]. The entire crop production process and redundant agricultural resources have led to higher agricultural carbon emissions [2]. At present, the carbon emissions caused by agricultural activities in China account for about 17% of the total national total [3]. Under the background of increasingly severe climate warming, the inevitable choice to realize the harmonious and sustainable development between agricultural economic growth and agricultural environment is to accelerate the improvement of agricultural production efficiency and to actively carry out the agricultural carbon abatement work [4]. Henan Province is an important economic province in China. In 2016, its GDP ranked 5th in China, with a cultivated area of 71.792 million hectares. The grain planting area was 10286.15 thousand hectares. The purpose of this study is to calculate the carbon emission of planting industry in Henan province from 1991 to 2015, and to explore the driving factors based on the LMDI model, so as to provide theoretical basis for the economic development of low-carbon agriculture and meet the industrial demand.



2. Organization of the Text

2.1. Planting industry carbon emission calculation

The carbon dioxide equivalent emissions from planting industry are due to the CH₄ emissions and N₂O emissions, which the previous comes from rice farming and the latter mainly comes from the production of using agricultural means of production including farm machinery, rural electricity, chemical fertilizer application and irrigation (6, 7). So, carbon dioxide equivalent emissions are sum of CH₄ emissions and N₂O emissions multiplied by their global warming potential.

$$\text{Emission} = \text{Emission}_{CH_4} \times WGP_{CH_4} + \text{Emission}_{N_2O} \times WGP_{N_2O} \quad (1)$$

Where Emission_{CH_4} represents the CH₄ emissions from rice paddies (kgCO₂/ha); Emission_{N_2O} represents the N₂O emissions agricultural land (kgN₂O/ha); WGP_{CH_4} and WGP_{N_2O} denote the direct GWP of CH₄ and N₂O at the 100 yr horizon, 25 and 298.

2.2. Planting industry carbon emission intensity

The intensity of carbon emissions is mainly refers to the carbon emissions produced by unit GDP, which is an important indicator to measure the level of economic development and carbon emissions of agricultural production. We calculated the GHGI by dividing total Global Warming Potential (GWP)-weighted emissions from planting industry by farming gross domestic product:

$$\text{GHGI} = T_c / T_GDP \quad (2)$$

Where GHGI represent the intensity of carbon emissions (kgCO₂eq/t); T_c is the total greenhouse gas emissions from planting industry; T_{GDP} is the total gross domestic product of planting industry.

2.3. Decomposition of planting industry carbon emissions impact factors

The CO₂ emissions can be expressed as an extended Kaya identity, which is a useful tool to decompose total carbon emissions. The LMDI method has the advantage of being able to be used for the decomposition of incomplete data sets and benefits from the lack of an unexplainable residual in the results caused by using other methods, which make the model more convincing. Based on the existing literature in past research and combined with the actual situation of the planting industry carbon emissions, the method is shown as follows:

$$C = \frac{C}{PGDP} \times \frac{PGDP}{AGDP} \times \frac{AGDP}{AL} \times AL \quad (3)$$

For simplification, it can be expressed as:

$$C = CI \times EI \times SI \times AL \quad (4)$$

Where C, PGDP, AGDP, AL separately represent planting industry carbon emission, the total gross domestic product of planting industry, agricultural gross output value and the employment labor of agricultural industry. EI, CI, SI represent efficiency factor, structure factor, economy factor and labor factor respectively. The total agricultural carbon emissions of the base period and the T period were set as C₀ and C_t, and ΔC_t is the change in planting husbandry carbon emissions from the base period to period t. By use plus decomposition, the expression of contribution value of each decomposition facto can is as follows:

$$\begin{aligned}
\text{Efficiency factor: } \Delta CI &= \sum \frac{C_t - C_o}{\ln C_t - \ln C_o} \cdot \ln \frac{CI_t}{CI_o} \\
\text{Structure factor: } \Delta EI &= \sum \frac{C_t - C_o}{\ln C_t - \ln C_o} \cdot \ln \frac{EI_t}{EI_o} \\
\text{Economy factor: } \Delta SI &= \sum \frac{C_t - C_o}{\ln C_t - \ln C_o} \cdot \ln \frac{SI_t}{SI_o} \\
\text{Labour factor: } \Delta AL &= \sum \frac{C_t - C_o}{\ln C_t - \ln C_o} \cdot \ln \frac{AL_t}{AL_o} \\
\text{The total effect is: } \Delta C_{tot} &= C_t - C_o = \Delta EI + \Delta SI + \Delta AL \quad (5)
\end{aligned}$$

2.4. Data description

The data in this study come from the China Rural Statistical Yearbook (1991-2015) and China Agricultural Yearbook (1991-2015), in which fertilizers, pesticides, plastic sheeting, diesel oil, rice planting area, irrigation area, crop seeded area, crop yields are in actual situation; Taking into account of the planting husbandry production value which was calculated in actual price couldn't be compared longitudinally, we used the price in 1990 as the benchmark year of price by using comparable price of GDP.

3. Results and discussion

3.1. Carbon emissions

The greenhouse gas emissions of planting industry in Henan Province from 1991 to 2015 are shown in Figure 1. As can be seen from the figure, the overall carbon emissions in Henan Province are fluctuating. In general, carbon emissions show positive growth. Compared with 1991, carbon emissions increased in 2015, from 9.7651 million tons in 1991 to 17.235 million tons in 2015, an increase of 76.49%. According to the agricultural greenhouse gas emissions of Henan Province from 1991 to 2015, the annual growth rate of carbon emissions is calculated by the calculation. Among them, the largest increase was in 1994-1995, with a growth rate of 39.22%.

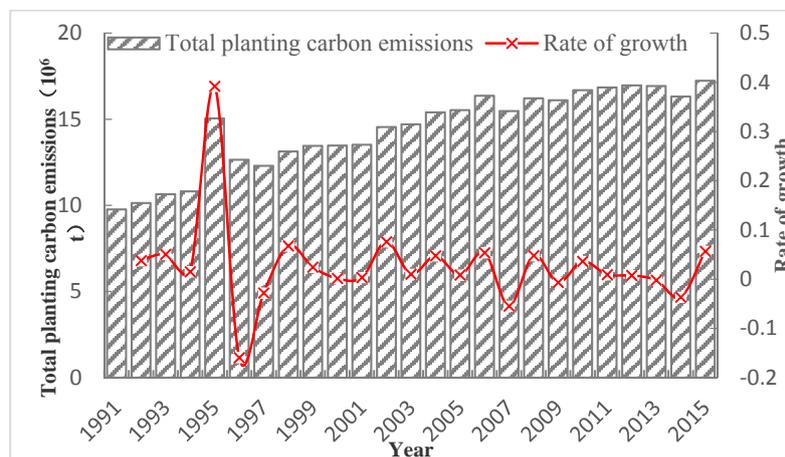


Figure 1. CO₂ emission from crops in Henan province over the period 1991–2015.

It can be seen from Figure 1 and Figure 2 that the greenhouse gas emissions from agricultural land and paddy fields account for 81.07% and 18.93% of the total greenhouse gas emissions, respectively. Among them, the contribution of agricultural land to the total greenhouse gas emissions in the crop industry. At the same time, the proportion of greenhouse gases produced by rice fields is declining, and the proportion of greenhouse gas emissions from agricultural land has increased.

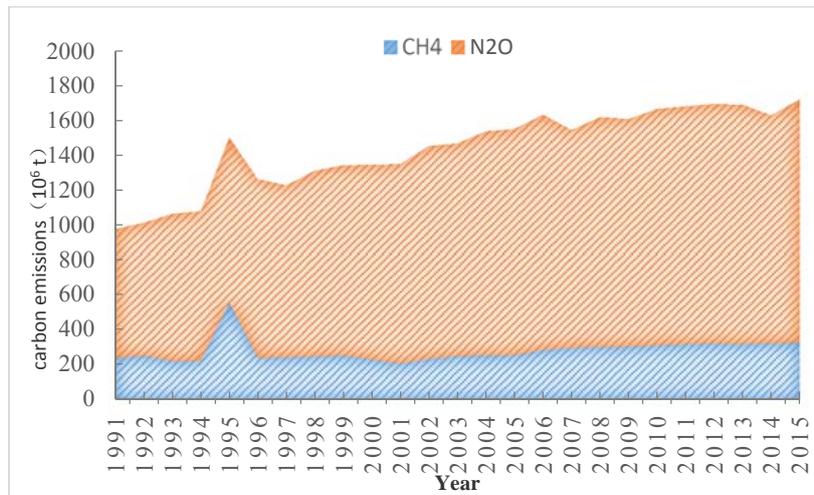


Figure 2. Crop farming carbon emissions from CH₄ and N₂O in Henan Province from 1991 to 2015.

3.2. Carbon intensity

As can be seen from Figure 3, between 1991 and 2015, the overall carbon emission intensity showed a downward trend, from 0.26kg/yuan to 0.107kg/yuan. Before 2003, the carbon emission intensity was higher than 0.2kg/yuan. The carbon emission intensity of crop production in 2003-2015 was greatly reduced, mainly due to the Central No. 1 document issued in 2004. The main objective of the document is to increase farmers' income (9).

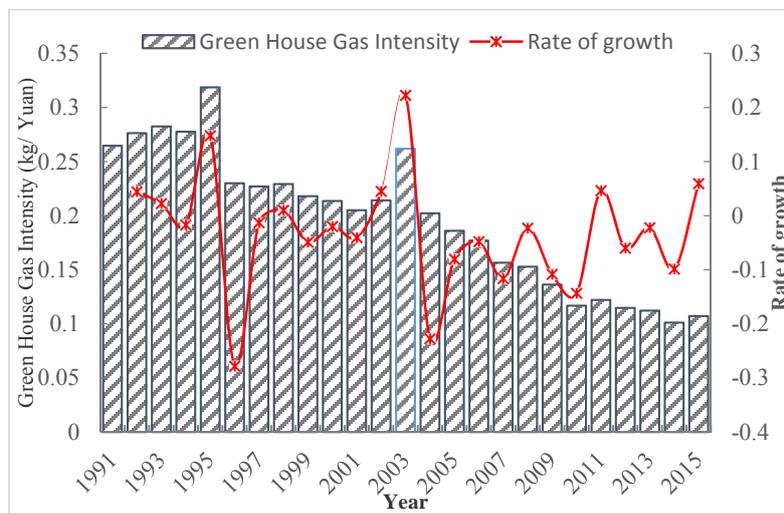


Figure 3. Temporal trends of CO₂ emission intensity over the period 1991–2015.

The trend of unit grain carbon emission intensity in Henan Province is not large. Compared with 1991, the carbon intensity per unit of grain decreased from 0.32kg/kg to 0.28kg/kg, a decrease of 12.5%, and the annual average decline rate was 0.5% (Fig.4). As can be seen from the chart, from 2003 to 2007, the intensity of carbon emissions per unit grain in Henan Province has continued to decrease, although the decline has been high and low, but the overall decline has been very large. The decline exceeded the total decline of 1991 to 2015, reaching 2%.

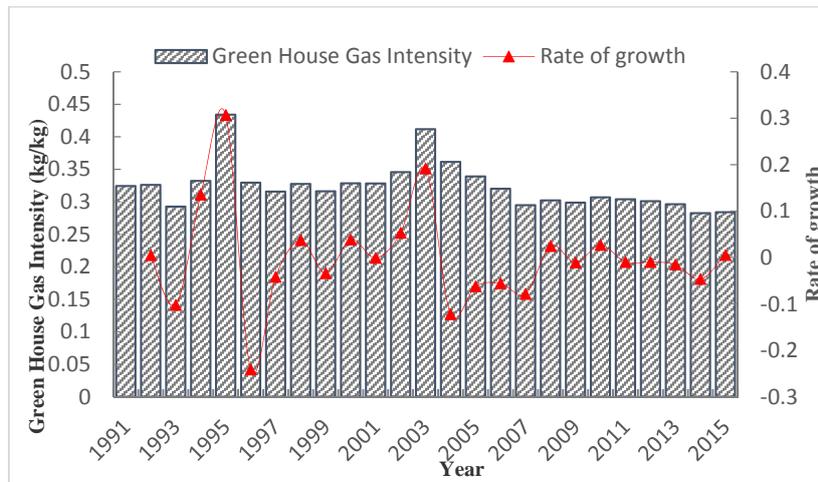


Figure 4. Temporal trends of grain production over the period 1991–2015.

3.3. *Driving factors*

Based on the LMDI model, combined with the planting industry and carbon emission data of Henan Province, the results of decomposition analysis of the factors affecting planting carbon emissions in Henan Province from 1991 to 2015 are calculated. It can be seen from Table 5 that from 1991 to 2015, the most important factors influencing the increase of carbon emissions in crop production in Henan Province were the economic level of the crop industry and the labor force, with a contribution of 20.60 million tons and 1.046 million tons, respectively. The productivity of the planting industry and the scale of the industrial structure have inhibited the increase of carbon emissions to a certain extent, and the contribution to carbon emission reduction is 11.88 million tons and 2.29 million tons respectively.

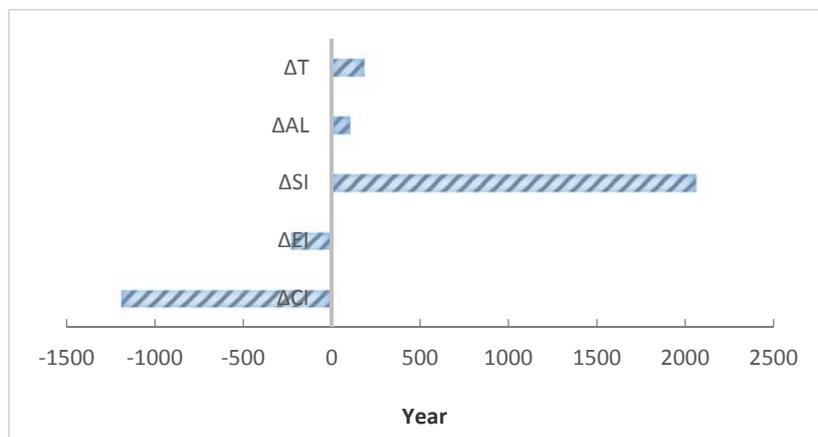


Figure 5. The contribution of CO₂ emission between 1991 and 2015.

From 1991 to 2015, the contribution of the economic level of planting industry to the carbon emissions of planting industry in Henan Province reached 20.60 million tons, which was mainly due to the expansion of planting production and the substantial increase in agricultural production (2). The contribution of crop industry structure factors to the carbon emissions of planting industry shows a dynamic trend. It shows that the agricultural industrial structure in Henan Province has been changing and adjusting, and the proportion of crop farming in agriculture, forestry, animal husbandry and fishery is unstable(10). The contribution reached 11.88 million tons. In recent years, the improvement of planting production efficiency in Henan Province has effectively curbed agricultural carbon emissions, and the efficiency of planting resource utilization is also an important measure to effectively reduce

carbon emissions in the future (11). The impact of labor factors on the carbon emissions of crops in Henan Province is a continuous promotion. The carbon emissions under this factor have continued to increase over the past 25 years, which means that Henan Province should liberate labor and improve labor efficiency (12).

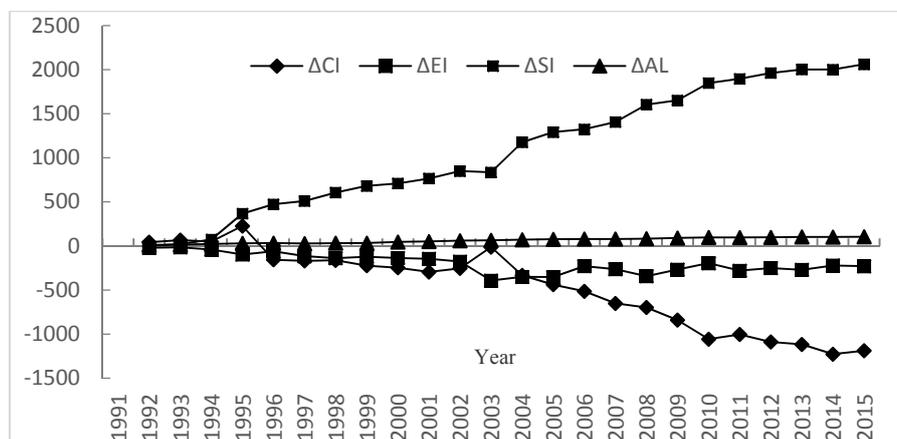


Figure 6. Annual variation in the contributions of the efficiency, structure, economy and labor.

4. Conclusion

The total carbon emissions of crops in Henan Province from 1991 to 2015 showed an overall upward trend, from 9.7651 million tons of CO₂-eq in 1991 to 17.235 million tons of CO₂-eq in 2015. The dominant position in greenhouse gas production in Henan Province is N₂O for agricultural land, followed by rice field CH₄. Compared with 1991, in 2015, the carbon emission intensity of unit GDP in Henan Province decreased by 59.52%, and the carbon emission intensity per unit of grain output decreased by 12.34%. LMDI analysis shows that the most important factors affecting the increase of carbon emissions in crop production in Henan Province are the agricultural economic level and industrial structure. The productivity and production structure of crop production have inhibited the increase of carbon emissions to some extent. This indicates that in the future, the carbon emission reduction work of crop production in Henan Province can focus on industrial structure and production efficiency, and adjust the optimal industrial structure, reduce agricultural carbon emissions, and moderately increase the special agricultural industry with better carbon absorption performance.

Acknowledgments

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