Study on The Influencing Factors of Agricultural Carbon Emission in Sichuan Based on LMDI Decomposition Technology

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Abstract. With the increasing climate change, all professions and trades of life in society are facing the requirements of emission reduction and quality improvement. In the context of the “Belt and Road”, China's opening pattern has changed from being the first one in the east to paying equal attention to both East and West. Sichuan agriculture is facing great development opportunities in energy saving emission reduction and low carbon development. This paper uses LMDI decomposition technology as the main research method. By studying the three influencing factors, such as total emission, emission intensity and regional space, this paper analyses the key factors that affect the agricultural carbon emissions in Sichuan, so as to help Sichuan seize the development opportunity of “Belt and Road”.

1 Introduction

In 2016, countries around the world signed the Paris Accord to control the rise of global average temperature. Under the skeleton frame of the treaty, the Chinese government has proposed a series of emission reduction measures aimed at reducing China's total carbon emissions and the intensity of carbon emissions.

At the same time, the strategy of "one belt and one road" with the theme of "open development" will enable China's western region to enhance its position in the strategy of opening to the outside world. According to the statistical annual report of Sichuan provincial government in 2018, Sichuan, only 10% of the total output value is generated by 30% of the employed population. Therefore, how to improve production efficiency and reduce carbon emissions is a topic worthy of attention in the future. From the perspective of factor-driven, this paper uses 16-year agricultural carbon emission data of Sichuan to analyse the key factors affecting carbon emissions, so as to promote agricultural quality and efficiency in Sichuan.

Reviewing the relevant literature, in the aspect of carbon emission efficiency research, Wan [1] and others used the SBM model and the ML index to measure the carbon emission efficiency of three public transportation modes in Beijing. Zhao [2] and others used the decoupling index and LMDI decomposition technology to divide the driving factors of greenhouse gas emissions in Hong Kong, and provided guidance for Hong Kong's emission reduction work in the future. Xu [3] and others used the LMDI model to measure the agricultural carbon emission efficiency of Jilin Province. In summary, the main research focus is on the industrial field, and the research results on carbon emissions in Sichuan are relatively few. Therefore, this paper uses LMDI model to analyse the factors affecting agricultural carbon emissions in Sichuan in the past 16 years, in order to find the key factors.
affecting agricultural carbon emissions and promote the work of energy conservation and emission reduction.

2 Introduction to research areas and research methods

2.1 Overview of the study area
Sichuan Province is located in Western China. In 2018, Sichuan's first output value was 442.67 billion yuan. This paper will examine in detail the impact of chemical fertilizers, pesticides, agricultural film, agricultural machinery, land tillage and irrigation on carbon emissions in the process of agricultural production in Sichuan Province. Since the agricultural production in Sichuan is still dominated by the "family" mode of production, this paper speculates that the main sources of agricultural carbon emissions in Sichuan Province are chemical fertilizers and agricultural film. Policy and natural disaster factors will also be taken into account.

2.2 Introduction to research methods

2.2.1 Construction of Agricultural Carbon Emission Indicator System. According to the 16 years of agricultural development in Sichuan from 2000 to 2015, the following models were constructed for carbon emissions from fertilizers, pesticides, agricultural film, land tillage, irrigation, and agricultural machinery:

\[ C_t = E_1 + E_2 + E_3 + E_4 + E_5 + E_6 = A \times G_1 + B \times G_2 + C \times G_3 + D \times G_4 + E \times G_5 + F \times G_6 \]  

(1)

In the formula, \( C_t \) represents the total amount of carbon emissions, \( E_1 \) represents the carbon emissions from agricultural fertilizers, \( E_2 \) represents the carbon emissions from pesticides, \( E_3 \) represents the carbon emissions from agricultural film, and \( E_4 \) represents the carbon emissions from land tillage, \( E_5 \) represents the carbon emissions from irrigation, and \( E_6 \) represents the carbon emissions from the use of diesel in agricultural machinery. \( G_1, G_2, G_3, G_4, G_5 \) and \( G_6 \) represent the use data of fertilizers, pesticides, agricultural film, land tillage, irrigation and agricultural machinery, respectively, \( A, B, C, D, E, F \) represent the corresponding carbon Emission factor.

| Carbon source          | Carbon emission coefficient | Source of literature |
|------------------------|-----------------------------|---------------------|
| fertilizer             | 0.8965 kg*kg-1              | ORNL                |
| pesticide              | 4.9341 kg*kg-1              | ORNL                |
| Agricultural film      | 5.18 kg*kg-1                | Yun Tian [4]        |
| Land tillage           | 312.6 kg*hm-2               | Xianchao Zhao [5]   |
| irrigation             | 266.48 kg*hm-2              | West[6]             |
| agricultural machine   | 0.18 kg*hm-1                | Qiaoyu Zhu [7]      |

2.2.2 Model method. LMDI decomposition technology is an exponential decomposition method which can decompose target variables without producing residual values. His basic idea is to decompose the change of target variable into several sub-variables, so as to achieve the purpose of driving factor analysis. This paper uses LMDI decomposition technology to decompose agricultural carbon emissions from four dimensions: intensity, agricultural industry effect, scale effect of agricultural output value and rural population effect. Decompose according to kaya identity.
\[ C_t = \frac{C_t}{PGDP} * \frac{PGDP}{AGDP} * \frac{AGDP}{P} = AI * BI * CI * DI \] (2)

In the formula, PGDP is the output value of agriculture (planting), AGDP is the total output value of agriculture, forestry, fishery and animal husbandry, P is the rural labor force population, AI is \( \frac{C_{total}}{PGDP} \), and BI is \( \frac{AGDP}{P} \). CI stands for \( \frac{AGDP}{P} \), DI stands for P.

Take a logarithmic relationship on both sides of formula (2), there is

\[ \ln C = \ln AI + \ln BI + \ln CI + \ln DI \] (3)

Decomposition of Formula (3) by LMDI Decomposition Technique

\[ \Delta C = \Delta AI + \Delta BI + \Delta CI + \Delta DI \] (4)

from that we get:

\[ \Delta AI = \sum \frac{CT-\text{CO}}{\ln (AI_{\text{T}}/AI_{0})} \] (5)
\[ \Delta BI = \sum \frac{CT-\text{CO}}{\ln (BI_{\text{T}}/BI_{0})} \] (6)
\[ \Delta CI = \sum \frac{CT-\text{CO}}{\ln (CI_{\text{T}}/CI_{0})} \] (7)
\[ \Delta DI = \sum \frac{CT-\text{CO}}{\ln (DI_{\text{T}}/DI_{0})} \] (8)

In the formula, T represents the target year and 0 represents the base year. \( \Delta AI, \Delta BI, \Delta CI, \Delta DI \) they represent the contribution of carbon emission intensity, agricultural industry effect, scale effect of agricultural output value and rural population effect to rural carbon emission.

3 Example analyses

This paper analyses the data obtained from Sichuan Statistical Yearbook, Sichuan Government Annual Work Report and National Rural Census Bulletin of Sichuan Statistical Bureau.

3.1 Characteristics of changes in total carbon emissions

It can be seen that Sichuan’s agricultural carbon emissions have been declining continuously in the past 16 years. The total amount has dropped from 3.562 million tons in 2000 to 2.811 million tons in 2015, a decrease of 20.84%. In terms of categories, the total carbon emissions from fertilizers decreased by 330,000 tons, down by 14.90%. The total carbon emissions from pesticides increased by about 10,000 tons, but based on the 16-year perspective analysis, there was no significant change in the total amount of pesticides, but simply fluctuated around the 2000 base year emissions. The total carbon emissions of agricultural film decreased by about 300,000 tons, or about 45.10%. Changes in carbon emissions from land tillage and irrigation are similar to changes in carbon emissions from pesticides, both of which fluctuate around the 2000 baseline year. Finally, the carbon emissions from agricultural machinery fell by about 100,000 tons, down 36.65%. Therefore, from the total amount, the reduction of agricultural carbon emissions in Sichuan from 2000 to 2015 is mainly due to the reduction of carbon emissions from fertilizers, agricultural film and agricultural machinery. From the perspective of emission reduction ratio, the top three contributions are agricultural film, agricultural machinery and fertilizer.

3.2 Carbon emission intensity changes and their characteristics

This study divides the total agricultural carbon emissions by the total agricultural output to produce the carbon emission intensity per unit output value. The total output value of agriculture is 100 million yuan, and the unit of carbon emissions is 10,000 tons, so it is simplified to (t/million). (Y standards for year/C standards for Carbon intensity /RG standards for rate of growth)
From Table 3, we can see that the carbon emissions per unit of agricultural output in Sichuan are gradually decreasing, which has dropped from 0.453 to 0.084. Among them, in the five years from 2007 to 2012, the decline rate was more than 2 digits, while in the two years of 2014 and 2015 the emission reduction rate slowed down or even rebounded.

### 3.3 Analysis of Agricultural Carbon Emission Structure

It can be seen from Figure 1 that the agricultural carbon emissions in Sichuan showed a significant decline during the period from 2000 to 2015. It can be inferred that the conversion of farmland to forestry project in Sichuan have played a role. Especially during the five years from 2008 to 2012. The agricultural emission reduction has increased. Due to the 2008 earthquake, the production and life in parts of western Sichuan were damaged. The timely recovery has reduced the carbon emissions of agriculture, but with the recovery of production and life after the earthquake, the agricultural carbon emissions in Sichuan have increased slightly. In terms of categories, since Sichuan is located in the hilly area of southwest China, large-scale irrigation and agricultural planting cannot be realized. Therefore, agricultural machinery and irrigation produce less carbon emissions. For governments, they can take measures to reduce the use of pesticides, agricultural films and fertilizers.

![Figure 1 Agricultural carbon emission structure chart of Sichuan from 2000 to 2015](image)

### 3.4 Analysis of factors affecting carbon emissions

According to the calculation of formula (5) to formula (8), we can see that table (4) shows that carbon emission intensity and regional population effect have a positive correlation with carbon emissions, and vice versa. Considering the impact of the 2008 Wenchuan earthquake on production and life in Sichuan, the overall level of agricultural carbon emissions in Sichuan showed a downward trend, the rural economic growth and agricultural carbon emissions showed a certain degree of “decoupling”. Therefore, Sichuan should continue this development trend and promote the further modernization of Sichuan agriculture. (AI is $\frac{C_{total}}{PGDP}$, and BI is $\frac{PGDP}{AGDP}$, CI stands for $\frac{AGDP}{P}$, DI stands for P,Y is year)
Table 3 Influencing Factors of Carbon Emission Intensity in Sichuan from 2000 to 2015

| Y  | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | 13 | 14 | 15 | Total |
|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|-------|
| A  | 0.2| 83 | 0  | 92 | 69 | 22 | 83 | 17 | 40 | 13 | 92 | 21 | 46 | 48 | 12   | 0.07  |
| B  | 79 | 70 | 73 | 88 | 45 | 0  | 92 | 3.2| 11.5| 2.6| 47 | 2 | 1.0 | 10.0| 6.0 | 0.0  |
| C  | 0.4| 1  | 2  | 7  | 3  | 0  | 15.84| 7 | 0.7 | 15.5| 8.7 | 6 | 9  | 25.108| 25.  |
| D  | 0.0| 0  | 0  | -  | -  | -  | 0  | -  | -  | -  | 0.1| 0.2| 2  | 4  | 9.2 | 16.  |
| I  | 2  | 35 | 61 | 06 | 10 | 05 | 8  | 37 | 49 | 55 | 1  | 0  | 59 | 70 | 2   | 3    |

4 Conclusion
The government can improve farmers' awareness of environmental protection through training seminars, and enhance the efficiency of farmers using chemical fertilizers, pesticides and agricultural film, thereby reducing the production of carbon emissions.

The core of the development strategy of "Belt and Road" is not only "Introduction" but also "Going out". Sichuan can accumulate experience and develop technology in low-carbon agriculture, actively explore the construction of agricultural carbon emissions trading system, and actively integrate into the "one belt and one way" development strategy, and make due contributions to cope with climate change.

At the same time, due to the limitation of accessible data, this paper does not take the burning of crop straw and rural garbage into account, so researchers will continue to pay attention to rural environmental issues in future research.

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