

A Coupling Study of Agricultural Carbon Emission, Water Resources and Economic Development in Heilongjiang Province

-- Supplemented By a Discussion from The Perspective of Kuznets Theory

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Abstract: Heilongjiang Province is a major agricultural province in China, and its agricultural water consumption will account for 88.6% of the province's water consumption in 2020. Based on the coupling effects of agricultural water resources, agricultural carbon emissions and agricultural economy, this paper calculates and finds the data of Heilongjiang Province from 2000 to 2019, and uses Kuznets model theory, literature reading method, systematic research method and geographical research as the theoretical basis. The negative problems of Heilongjiang Province's agriculture, such as weak level of sustainable development, unreasonable consumption of agricultural water resources, and poor sustainable and good development of environment and economy, are analyzed in depth. Finally, by analyzing the restrictive factors, the author puts forward the path and countermeasures of the corresponding coordinated economic development.

Keywords: Agriculture; Water resources; Carbon emissions; Economy.

1. Introduction

Water is the source of life and the key resource for the stable development of society. Global economic growth and population growth are increasing the demand for water. Although there are many freshwater lakes in China, the amount of fresh water available per capita is limited. Water shortage, pollution and other problems make it as valuable as non-renewable resources, and become the factors restricting China's economic growth.

By contrast, the world is under pressure to emit carbon. Economic growth, energy consumption and urbanization are associated with carbon dioxide emissions. In 2022, China's carbon dioxide emissions will be 11,477 million tons, down 0.2% from 2021. Carbon reduction by industry offsets the increase in carbon emissions from combustion.

Heilongjiang Province, located in the northeast of China, is an old industrial and agricultural province and an important economic development area in the early days of New China. With the development of social economy, the shortage of water resources has become the key factor restricting its development and the environmental short-board. Therefore, low-carbon agriculture and high-quality, sustainable development have become important tasks.

2. Literature Review

Many provinces in China have carried out carbon dioxide emission research, and analyzed the data for a period of years. Carbon emission formula decomposition based on the LMDI model, using publicly available data. The current method has the disadvantage of unexplained remaining terms, and the log-average exponential decomposition method has the

advantages of ease of use, applicability and interpretability. Although the domestic and foreign academic circles have made progress in the research on carbon emissions, there are still some deficiencies, such as the inconsistency of calculation methods and standards, which leads to inconsistent results and affects the practical value and interpretation. There is little literature on the combination of agricultural water resources consumption and agricultural carbon emissions.

3. Study Methods and Data Sources

3.1. Research method

In this paper, the economic development under the influence of the coupling relationship between water consumption and carbon emission generates Kuznets curve by data programming of R language program.

3.2. Data source

The data were selected from 2000-2020, agricultural carbon emission, agricultural economy and agricultural water resource usage in Heilongjiang Province. Through websites such as China Statistical Yearbook, Heilongjiang Bureau of Statistics, Heilongjiang Ministry of Water Resources, China-Carbon-Accounting-Database, etc. (Note: the statistical data of different websites are slightly different, which does not affect the study of this paper). Before sorting out the classification of carbon emissions in agriculture, the types and categories of carbon emissions in agriculture were analyzed through literature and data, and it was found that different scholars had no major differences in the classification of carbon emission sources (see Table 1).

Table 1. Classification of carbon emission sources by different scholars

Scholar	Carbon emission sources
Zhang Xiaoping	Fertilizer, pesticides, agricultural film, agricultural diesel, agricultural irrigation water, land ploughing
Bao Zhen	Fertilizer, pesticides, agricultural film, agricultural diesel, land ploughing, agricultural irrigation, straw
Tian Yun	Fertilizer, pesticides, agricultural film, agricultural diesel, agricultural irrigation electricity, rice field emissions, livestock enteric fermentation, manure management
MiSonghua	Input of industrial products such as fertilizers, pesticides, agricultural film, consumption of agricultural energy such as coal and diesel, emissions from rice cultivation, livestock intestinal fermentation, livestock manure management, straw burning
Yang Jun	Agricultural production input, energy consumption in agricultural production
Gao Biao	Fertilizer, pesticide, agricultural film, agricultural diesel, rural electricity
Zhu Zhicao	Agricultural land uses carbon emissions, rice fields, and livestock farming carbon emissions

Continuation table 1

Scholar	Carbon emission sources
Wu Xianrong	Agricultural materials, rice cultivation, land ploughing, animal breeding
Zhang Guangsheng	Nitrogen fertilizer application, agricultural chemicals implied carbon, agricultural fossil energy combustion, indirect emission of agricultural electricity consumption, rice cultivation, animal intestinal fermentation, and fecal management
Li Bo	Chemical fertilizer, pesticide, agricultural film, agricultural machinery application, agricultural soil tillage, agricultural irrigation power consumption, agricultural straw burning

Summarize scholars' classification and views on agricultural carbon emission sources, and determine the final agricultural carbon emission sources based on geographical characteristics, so as to provide a basis for subsequent calculation. This paper discusses the relationship between

carbon emissions and economic development, simplifies the classification of carbon emission sources in agriculture, forestry, livestock and fishery (see Table 2), and puts forward development suggestions.

Table 2. Classification of carbon emission sources in agriculture, forestry, livestock and fisheries

Sort	Carbon emission sources					
<i>Agriculture</i>	Chemical fertilizer	Pesticide	Agricultural film	Irrigate	Diesel oil	Turn over
<i>Forestry</i>			Device application			
<i>Animal husbandry</i>		Livestock breeding			Manure disposal	
<i>Fishery industry</i>			Ships diesel			

4. Analyse

4.1. Data analysis

(1) The proportion of agricultural economy is gradually increasing. Due to the good development situation of agricultural economy in Heilongjiang Province, the collation of the collected data shows that since 2000, the proportion of

agricultural economy in the province's economy has basically increased year by year (see Figure 1).

(2) The overall use of agricultural water resources has gradually increased, and the proportion of total water resources use has also increased year by year (see Figure 2). After searching the data, it was found that in 2020, agricultural water consumption reached 27.148 billion, accounting for 88.6% of the province.

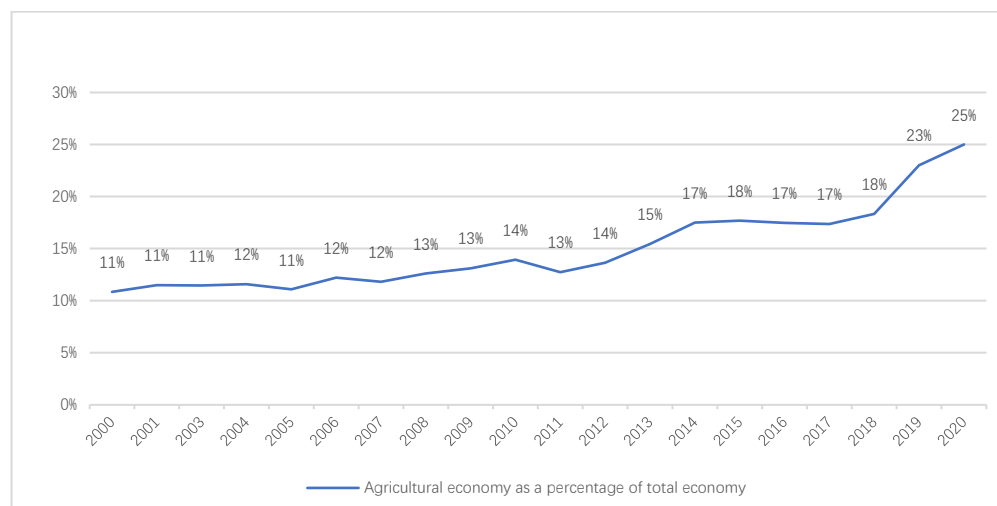


Figure 1. The percentage of the agricultural economy in the total economy

(3) The proportion of carbon emissions fluctuated slightly in each year, maintaining around 1.5% (see Figure 3-3). Although the overall share of agricultural carbon emissions

in China is not high, with the gradual progress of the goal of "carbon neutrality by 2060", the agricultural sector must play a greater role in reducing emissions.

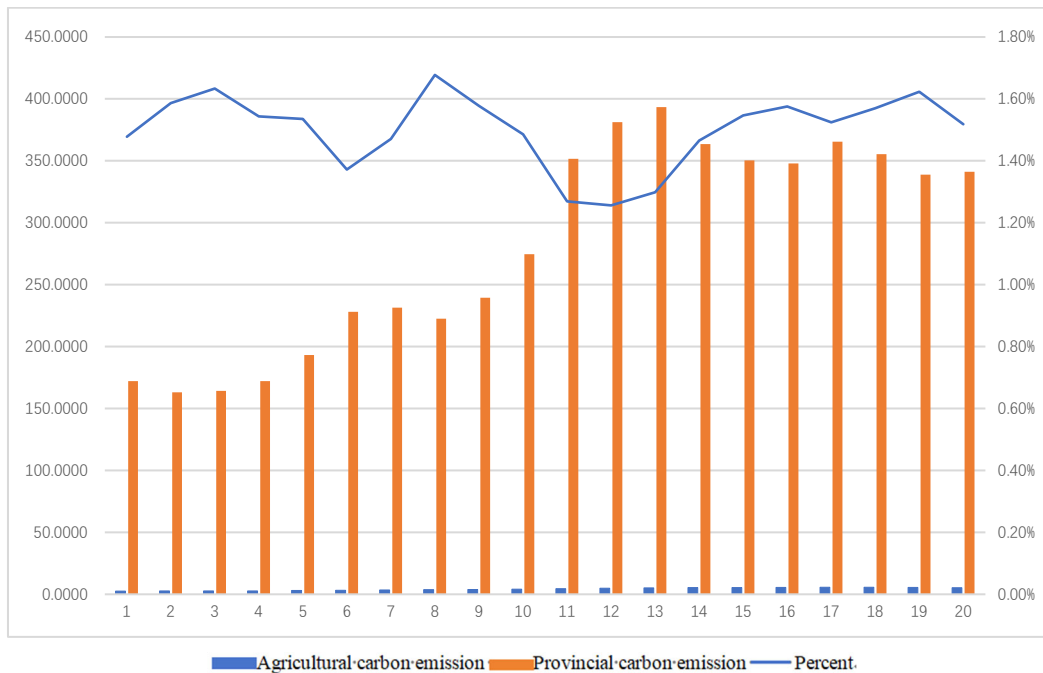


Figure 2. Analysis of agricultural carbon emissions

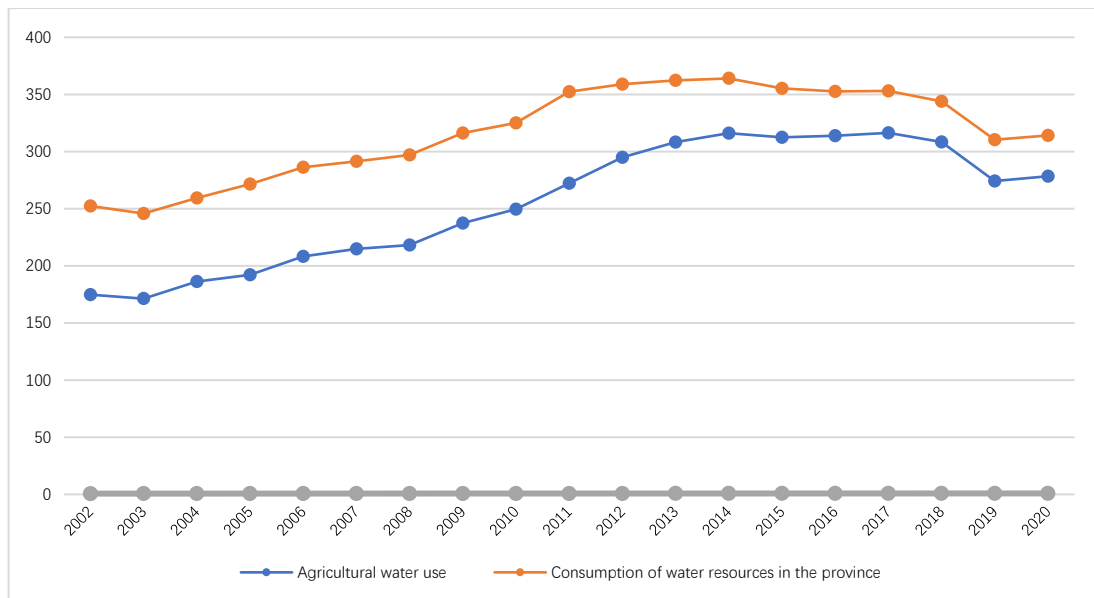


Figure 3-2. Comparative analysis of water resources usage

4.2. Spatial analysis

4.2.1. Geographical analysis

Heilongjiang Province is located in the extreme northeast of China, spanning 43°26' -53°33' north latitude and 121°11' -135°05' east longitude. Its landform is characterized by "five mountains, one water, one grass and three fields", which belongs to the temperate continental monsoon climate, with long cold winter and short warm summer. The province is one of the three famous black soil belts in the world, and the agricultural land area accounts for 83.5% of the province.

Heilongjiang Province is rich in water resources, including the Heilongjiang, Nenjiang, Ussuri, Songhua and Suifenhe rivers, as well as more than 640 lakes and 630 reservoirs.

Precipitation is mainly concentrated in June to September, accounting for 60%-80% of the total annual precipitation, and the average annual precipitation is 400-1000 mm, providing a good environment for biological growth.

4.2.2. Soil analysis

Groundwater in Heilongjiang is one of the important water sources for agricultural irrigation, and some cities rely on groundwater to irrigate agriculture, such as Daqing, Jiamusi, Qiqihar and so on. Groundwater is one of the important water sources for agricultural irrigation, but these areas have been over-exploited, resulting in groundwater depletion and water level decline, this situation urgently needs to be changed, and in serious cases, it will form a large area of the drop funnel.

5. Kuznets Curve Analysis

5.1. The Kuznets curve

Simon Smith Kuznets proposed the hypothesis of an inverted U-shaped curve between economic development and income inequality. He believes that industrialization and urbanization drive economic growth, and the distribution gap will change. Limited by data and models, he used a binary structure for his research. Kuznets argues that "creation" and "destruction" in economic development alter social and economic structures and affect income distribution. Comparing data across countries shows that income inequality begins, then levels off, and eventually becomes equal when the economy is fully developed.

5.2. Water-Carbon curve

Figure 4-1 shows the relationship between agricultural water use (horizontal axis) and agricultural carbon emissions (vertical axis). The increase in water use leads to a corresponding increase in carbon emissions, mainly due to the respiration of crops, forest crops, fertilizer use and agricultural modernization machinery. From 2000 to 2020, agricultural water use increased from 2,032 thousand hectares to 6171 thousand hectares, while agricultural water carbon emissions increased from 540,000 tons to 1.64 million tons. Over the same period, crop acreage and crop carbon emissions also increased. The carbon emission in rice production is mainly from greenhouse gases, in which CH₄ is the dominant form of carbon emission, which is the key to emission reduction.

5.3. Carbon-Economic curve

The horizontal axis represents agricultural carbon emissions and the vertical axis represents the agricultural economy. With the increase of agricultural carbon emissions, the agricultural economy has grown rapidly. Although this Kuznets curve does not fit the traditional definition, the flatness at its end may indicate a downward trend. Over time, the agricultural economy may reach saturation and decline as carbon emissions grow, or continue to rise. Historically, a slowdown is more likely. For example, the economic development of Europe during the Industrial Revolution led to serious environmental problems that threatened human life and made people realize that the environment and the economy need to be balanced. Similarly, "environment-economy" coordinated development has been attached importance, emphasizing sustainable development and low-carbon development, and achieving environmentally friendly economic development.

5.4. Water-Economy curve

The relationship between agricultural water use (horizontal axis) and agricultural economy (vertical axis) shows an ascending and descending curve, similar to the environmental Kuznets curve. The use of water resources can promote agricultural development and produce economic benefits, but irrational use can lead to waste and economic stagnation. In Heilongjiang, the proportion of agricultural irrigation water is high but the efficiency is low, which is affected by many factors. The lack of water-saving consciousness, the lack of regulations and the unreasonable pricing of water resources lead to the waste of water resources. Technical deficiencies in industrial and urban water use also affect water scarcity. The water quality in Heilongjiang Province continues to

deteriorate, and some water bodies have lost their function.

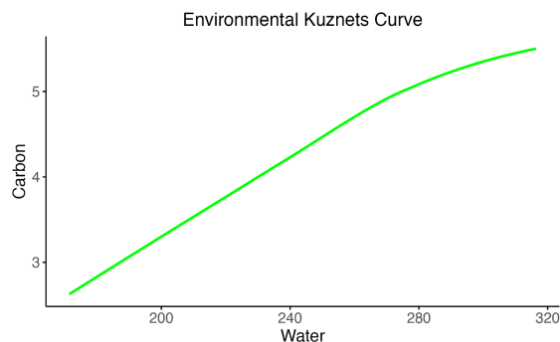


Figure 3. Water-Carbon curve

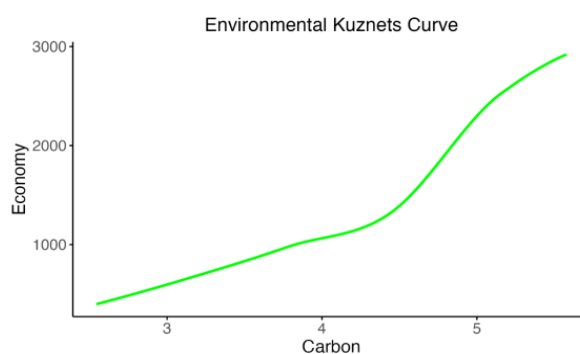


Figure 4. Carbon-Economic curve

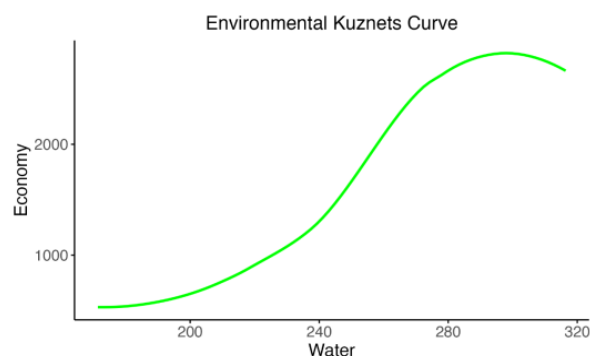


Figure 5. Water-Economy curve

6. Conclusion and Suggestion

6.1. Conclusion

(1) From 2000 to 2019, the proportion of agricultural carbon emissions and the proportion of agricultural economic output in Heilongjiang Province increased, showing a good development trend. Despite the increase in carbon emissions, the economy is still developing well, showing the characteristics of "high emissions and high sinks". During this period, Heilongjiang actively formulated policies to ensure proper support.

(2) There is a correlation between agricultural carbon emissions and water resources consumption in Heilongjiang Province. The increase of agricultural water consumption will lead to the increase of agricultural carbon emissions, which will further promote economic growth. Agricultural mechanization, fertilizer, irrigation, electricity, etc. have a large impact on agricultural carbon emissions, indicating that these energy sources and variables are crucial in economic development.

(3) Geographical factors affect economic development in

Heilongjiang. The northern neighbor of the Greater Khingan Mountains is abundant in precipitation but the terrain is not suitable for large-scale agricultural production, and the actual grain output is relatively low.

6.2. Suggestion

Based on the economic development of Heilongjiang Province and the research of this paper, the following suggestions are put forward:

(1) Optimize agricultural production methods, increase policy-guided mechanization, green energy, and reduce greenhouse gas emissions. Optimize agricultural resources, promote the use of clean energy, improve equipment automation and digitization, reduce energy consumption, reduce pollution. The government should formulate differentiated policies and provide practical help according to regional agricultural characteristics.

(2) Vigorously develop water-saving technologies and innovate agricultural water use and water-saving methods. It is an inevitable trend in the future to improve the efficiency of agricultural water supply and strengthen the intelligent and intelligent development.

(3) Optimize regional differentiated production. Songnen Plain and other areas are rich in water resources and can develop large-scale agricultural production. In the northern region, irrigation should not be developed, and natural precipitation utilization and yield improvement should be strengthened. We will adjust the structure of water resources and strengthen supply to promote sustainable and healthy agriculture.

(4) Increase irrigation and water conservancy projects. Affected by the typhoon, Heilongjiang Province suffered floods and heavy losses. Flood and drought prevention and response measures should be taken to reduce the damage in a timely manner. Protect water sources and black land, avoid pollution and damage, and ensure the green and healthy development of grain.

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