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Original Research Article

Evaluation of Green Production Efficiency of Grain in Huaihe Eco-economic Zone and Countermeasures Based on SBM-DEA

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Abstract: The article measured the green production efficiency of grain in 25 cities in the Huaihe Ecological Economic Belt from 2010 to 2020 based on the SBM -DEA model of non-expected output, and analyzed its evolution characteristics in two dimensions: time and space. The study found that the trend of grain green production efficiency in the Huaihe Ecological Economic Belt from 2010 to 2020 showed a slow increase in fluctuation, with 19 cities reaching the effective level of grain green production efficiency in 2020; at the same time, there was no obvious positive correlation between grain green production efficiency and economic development level, and cities with less developed economy also The cities with less developed economies can also optimise the green production efficiency of grain through such paths as large-scale production, optimising resource allocation andstrengthening the application of agricultural science and technology. In this regard, the Huaihe Ecological Economic Zone should strengthen the construction of high-standard farmland, improve the mechanism of green grain production and promote the reduction and increase of agricultural surface source pollution, so as to achieve a green transformation of grain production in the Huaihe Ecological Economic Zone.

Keywords: Green production efficiency of grain; SBM-DEA; Agricultural modernization.

1. Introduction

The international macroeconomic situation in 2021 is not optimistic. Under the background of huge pressure on the global food supply chain caused by geopolitical conflicts, frequent extreme weather and repeated COVID-19 epidemic, it is particularly important to ensure China's food security. In recent years, the problem of domestic grain production has gradually become prominent. Although China's grain production has steadily increased, the excessive loss of natural resources such as land and the destruction of the ecological environment have made it difficult to sustain the traditional grain production model of combining input, resources, and environment. At the same time, with the increasing population and the continuous urbanization process, there has been a decrease in arable land and an increase in food demand, resulting in a sustained increase in domestic food supply security pressure. As an important commodity grain base and an important fruit and vegetable production area in China, the Huaihe River Ecological Economic Belt has a relatively complete industrial system, obvious advantages in the food processing industry cluster, and is adjacent to economically developed areas such as the Yangtze River Delta. It is these natural advantages that make the Huaihe River Ecological Economic Belt one of the main grain production areas in China, and therefore it needs to take on the responsibility of ensuring national food security. However, considering the positive improvement and efficiency of China's grain production The transformation of green production requires a certain transformation in the grain production mode of the Huaihe River Ecological Economic Belt. Therefore, this article takes 25 prefecture level cities in the Huaihe River Ecological Economic Belt as the research object, calculates the green production efficiency of grain from 2010 to 2020, clarifies the spatiotemporal evolution characteristics of green production of grain in the Huaihe River Ecological Economic Belt in the past eleven years, and promotes the improvement of green production efficiency of grain in the Huaihe River Ecological Economic Belt.

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2. Literature Review

In terms of the research on the concept of green production of grain, scholars believe that in the 40 years since the reform and opening up, China's agricultural production methods urgently need to undergo green transformation, and the modernization of agriculture must be ecological, green, and low-carbon. Wang Cheng and Gao Hong-gui [1](2017) believe that the large-scale introduction of input factors such as pesticides, fertilizers, and agricultural plastic films since the reform and opening up directly affects the security of China's agricultural ecosystem. In the long run, the continuous improvement of China's grain production and quality also faces problems, and agricultural ecological security directly threatens food security. Yu Fawen and Lin Shan[2] (2022) believe that green food production under the background of carbon neutrality and carbon peak is conducive to actively promoting rural revitalization and rural ecological civilization construction. The establishment of the “dual carbon” goal points out a new direction for agricultural production and also puts forward new requirements for green agricultural production.

In terms of research on the current situation of green food production, Bai Yan-tao and Tan Xue-liang[3] (2021) believe that ensuring food security while prioritizing ecology requires improving agricultural green production efficiency. They used the SBM-DEA model with unexpected output to calculate the agricultural green production efficiency of the Chengdu Chongqing urban agglomeration and found that developing the rural economy, adjusting the agricultural industry structure, and narrowing the urban-rural income gap will significantly improve agricultural green production efficiency, Therefore, policy recommendations are proposed to strengthen regional agricultural production cooperation and interaction, as well as to strengthen agricultural science and technology research and application. Wang Shu-hong and Yang Zhi-hai[4] (2020) used the GML index to calculate the green all factor production index of grain in 27 provinces and cities in China from 1991 to 2016. They found that although the green all factor production efficiency of grain in most provinces and cities showed an increasing trend, it was still in a low efficiency range. At the same time, there were also serious regional imbalances in the green all factor production efficiency of grain in China, including the main sales areas of grain The green production efficiency of grain in the production and sales balance zone is significantly lower than that in the main production zone. In addition, strengthening fiscal support for agriculture can effectively improve the overall green production efficiency of grain. Based on this, it is proposed to strengthen the promotion of agricultural mechanization, promote the transformation of the management mode of the grain industry towards intensification, organization, specialization, and socialization, and appropriately increase the level of agricultural financial support.

In terms of research on evaluation tools for green production of grain, Wei Qi, Zhang Bin, and Jin Shu-qin[5] (2018) selected 14 evaluation indicators from four perspectives: resource conservation, environmental friendliness, ecological sustainability, and high quality and efficiency to construct the Green Development Index of China's agriculture. This provides a quantitative evaluation basis for the horizontal and vertical comparison of the green development level of agriculture in the country and 31 provinces and cities, To provide scientific management tools for promoting the green transformation of agriculture. Yan Xing, Luo Yi, and others[6] (2022) used a three-stage DEA model with the addition of SBM model to calculate the efficiency of high-quality development in Shaanxi's manufacturing industry. They believe that this model can effectively solve the efficiency calculation problem of unexpected output in output, compensate for the shortcomings of traditional three-stage DEA models such as input and output Slacks, and avoid the influence of random factors and external environment, So as to more accurately reflect the efficiency level of high-quality development of Shaanxi's manufacturing industry. Sun Cai-zhi, Ma Qi-fei et al[7]. (2018) measured the green efficiency of water resources in 31 provinces and cities in China from 2000 to 2014 based on the SBM-DEA model of unexpected output, and constructed a cross period productivity index using the Malmquist total factor productivity index model to decompose the total factor productivity of water resource green efficiency.

The theoretical and practical experience of the above-mentioned scholars provide an important theoretical and methodological basis for this study. In view of this, this article first measures the green production efficiency of grain in various regions within the Huaihe River Ecological Economic Belt, and then analyzes the spatiotemporal evolution trend of green production efficiency of grain in the Huaihe River Ecological Economic Belt through horizontal and vertical comparisons. Based on this, problems are identified and targeted suggestions are proposed.

3. Calculation and Spatiotemporal Evolution Characteristics of Green Productivity of Grain in the Huaihe River Ecological Economic Belt

3.1 Research Methods and Data Sources

Data Envelopment Analysis (DEA) is an efficiency evaluation method developed by Charles et al. based on the theory of non parametric analysis. The advantage of DEA is that it can simultaneously handle multiple input and output indicators, so it is widely used in efficiency evaluation of different topics. The principle of DEA is mainly to project the DMU onto the front surface while keeping the input and output of the decision-making unit (DMU) unchanged. The distance between the DMU and the front surface can be used to evaluate their efficiency. When using traditional DEA to measure the efficiency of green food production, the output variables only consider economic benefits, namely the total agricultural output value, without taking into account the adverse effects of unexpected outputs such as agricultural pollutant emissions and carbon emissions. This is inconsistent with the actual agricultural production process in the context of ecological agriculture and low-carbon development, and the issue of input and output relaxation is also ignored, Thus, there is a certain error between the calculated green production efficiency of grain and the actual value. Therefore, we adopt Tone's non radial and non angular SBM model based on Slacks to make the measurement of green production efficiency of grain more accurate. The formula is as follows:

$$\theta = \min \frac{1-\frac{1}{N}\sum_{n=1}^{N} S_n^x / x_{k'n}^{t'}}{1+\frac{1}{M+1}\left(\sum_{m=1}^{M} S_m^y / y_{k'm}^{t'} + \sum_{i=1}^{I} S_i^b / b_{k'i}^{t'}\right)}$$

$$s.t. \sum_{t=1}^{T}\sum_{k=1}^{K} \lambda_k^t x_{kn}^t + S_n^x = x_{k'n}^{t'}, n=1,\cdots,N$$

$$\sum_{t=1}^{T}\sum_{k=1}^{K} \lambda_k^t y_{km}^t - S_m^y = y_{k'm}^{t'}, m=1,\cdots,M$$

$$\sum_{t=1}^{T}\sum_{k=1}^{K} \lambda_k^t b_{ki}^t + S_i^b = b_{k'i}^{t'}, i=1,\cdots,I$$

$$\lambda_k^t \geq 0, S_n^x \geq 0, S_m^y \geq 0, S_i^b \geq 0, k=1,\cdots,K$$

In the formula, θ , N , M , I represents the efficiency value of green production of grain, the number of input indicators for green production of grain, the expected output indicators for green production of grain, and the number of unexpected output indicators for green production of grain; x, y, b is a relaxation vector, representing input, expected output, and unexpected output, respectively; S_n^x , S_i^b represents the redundant values of input and unexpected output indicators, respectively; S_m^y represents the shortfall in the expected output of green grain production. $\left(x_{k'n}^{t'}, y_{k'm}^{t'}, b_{k'i}^{t'}\right)$ is the input-output value, corresponding to the k' th decision-making unit in period t , and λ_k^t is the corresponding weight. θ strictly monotonically decreases with respect to S_n^x , S_m^y , and S_i^b , and the value range of the objective function θ is (0,1); When θ =1, it means $S_n^x = S_m^y = S_i^b = 0$, indicating that the evaluated DMU is efficient and there is no redundancy or deficiency in input-output; When θ <1, it indicates that the evaluated DMU is DEA invalid and there is an efficiency loss. It is necessary to optimize the input-output quantity of green grain production to optimize the efficiency level.

3.2 Indicator Selection and Explanation

In order to measure the green production efficiency of grain in the four provinces and twenty-five cities of the Huaihe River Ecological Economic Belt, it is necessary to calculate various input indicators, expected output indicators, and unexpected output indicators in the grain production process. This article refers to the research methods of Li Wenqi and Li Bo, and selects 8 indicators from three dimensions of labor force, land, and agricultural modernization level as the main input indicators for agricultural green production. The agricultural gross domestic product is selected as the expected output indicator for food green production, and 3 indicators are selected from two dimensions of agricultural carbon emissions and pollutant emissions as the unexpected output indicators for agricultural green production, The specific indicators and their calculations are shown in Table 1.

Table 1 Calculation indicators for green production efficiency of grain.

Indicators	Specific indicator names	Calculation method
Input indicators	Labor input	Employees in the primary industry (total agricultural output value/total primary industry output value)
	Land investment	Agricultural planting area
	Fertilizer input	Fertilizer application amount
	Pesticide input	Pesticide usage
	Agricultural film input	Agricultural film usage
	Mechanical investment	Total power of agricultural machinery
	Water conservancy investment	Effective irrigation area
	Animal husbandry investment	Number of large livestock at the end of the year
Expected output indicators	Total agricultural output value	Total agricultural output value
Unexpected output indicators	Agricultural carbon emissions	Chemical fertilizer×0.8956kg/kg + Pesticide×4.9341 kg/kg +Agricultural film ×5. 18 kg/kg + Agricultural irrigation×20. 476 kg/Hectare
	Pollutant emissions	Loss of nitrogen and phosphorus from fertilizers
		Residual amount of agricultural film

The non expected output indicators in Table 1 mainly refer to the research methods of scholars such as Li Bo for measuring agricultural carbon emissions. Based on the availability of data, the four main sources of agricultural carbon emissions are calculated, including: (1) carbon emissions from pesticide sources, which is the sum of indirect carbon emissions caused by pesticide production and direct carbon emissions caused by pesticide use. According to ORNL data, Its carbon emission coefficient is 4.934kg•kg^{-1}; (2) The carbon emissions from fertilizer sources are equal to the sum of indirect carbon emissions caused by the fertilizer production process and direct carbon emissions caused by the use process. According to ORNL data, its carbon emission coefficient is 0.895kg•kg^{-1}; (3) The carbon emissions from agricultural plastic film sources are equal to the sum of indirect carbon emissions caused by the agricultural film production process and direct carbon emissions caused by the use process. According to IREEA data, its carbon emission coefficient is 5.18kg•kg^{-1}; (4) The carbon emissions from agricultural irrigation sources are relatively high, and the large amount of electricity consumed by agricultural irrigation requires indirect consumption of fossil fuels, resulting in indirect carbon emissions. According to data from the School of Biology and Technology at China Agricultural University, the carbon emission coefficient is 25kg•kg^{-1}. The emission of pollutants in unexpected output indicators is mainly caused by agricultural non-point source pollution, with nitrogen and phosphorus loss in fertilizers and residual agricultural film as the main factors. Fertilizer nitrogen and phosphorus loss=nitrogen fertilizer application amount × Nitrogen fertilizer loss coefficient + phosphorus fertilizer application amount × The coefficient of phosphorus fertilizer loss, corresponding to the fertilizer loss coefficient in the semi humid plain area of the Yellow River, Huai River, and Hai River in the First National Pollution Source Census: Handbook of Fertilizer Loss Coefficient for Agricultural Pollution Sources: 0.950% for nitrogen fertilizer and 0.375% for phosphorus fertilizer; The residual amount of agricultural film is calculated by multiplying the amount of agricultural plastic film used by the residual rate of agricultural film. This coefficient is derived from the 19.2% residual rate of agricultural film in the semi humid plain area of the Yellow, Huai, and Hai Seas in the First National Pollution Source Census: Handbook of Residual Factors of Agricultural Film.

This article selects agricultural input and output data from 25 cities in four provinces of the Huaihe River Ecological Economic Belt from 2010 to 2020 to calculate the efficiency of green food production. The data used is sourced from the Statistical Yearbooks of each province and city, and some missing data is supplemented using interpolation and ratio methods.

4. Result Analysis

This article is based on panel data on the green production of grain in the Huaihe River Ecological Economic Belt from 2010 to 2020. The super efficiency SBM-DEA model is used to calculate the green production efficiency of grain in 25 cities in the Huaihe River Ecological Economic Belt. The time trend chart of green production efficiency of grain in the Huaihe River Ecological Economic Belt (Figure 1) and the mean chart of each city (Figure 2) are drawn, and the green production efficiency of grain in each city is divided into five horizontal intervals (Table 2), This article presents the division results for 2010, 2015, and 2020 to illustrate the spatiotemporal pattern changes in the green production efficiency of grain in various cities in the Huaihe River Ecological Economic Belt in the past 11 years.

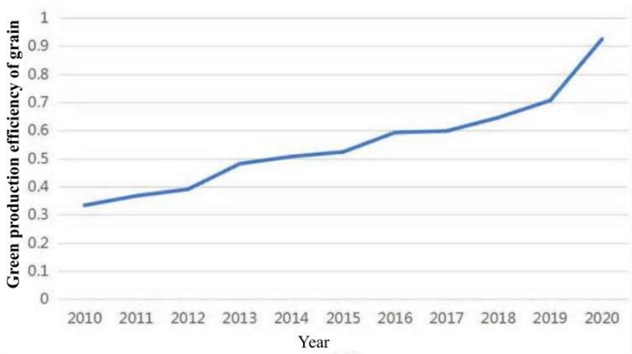

Figure 1 Time trend of green production efficiency of grain in the Huaihe river ecological economic belt.

(1) The change trend of green production efficiency of grain in the Huaihe River Ecological Economic Belt from 2010 to 2020 shows a slow upward trend in fluctuations, and is divided into four stages: the stable upward stage from 2010 to 2012, 2013 to 2015, 2016 to 2019, and the rapid upward stage from 2019 to 2020. The significant improvement in the green production efficiency of grain in the Huaihe River Ecological Economic Belt in 2012 may be due to the gradual implementation of comprehensive rural environmental improvement actions throughout the country. With the development of urbanization and urban-rural integration, some rural environmental improvement has been integrated into the urban governance system. At the same time, the process of industrialization and agricultural modernization has also promoted the transformation of green grain production, But at that time, the serious pollution caused by livestock and poultry farming and the quality and safety issues of agricultural products were the stumbling blocks that hindered the significant improvement of green food production efficiency. The 2015 Central Economic Work Conference and the Central Rural Work Conference both made the green transformation of grain production an important content, emphasizing the protection of arable land resources from both quantity and quality aspects, while paying attention to the utilization efficiency of water resources and arable land resources. They also introduced a series of supporting

policies for the green transformation and development models of grain production, such as ecological agriculture, becoming an important force in promoting the green transformation and development of grain production, This has a significant promoting effect on the improvement of grain production efficiency in 2016. The rapid improvement in green production efficiency of grain in the Huaihe River Ecological Economic Belt in 2020 may be due to the central government increasing investment in agriculture and rural areas, enhancing the comprehensive production capacity of agriculture, and promoting high-quality development of grain production. Among them, the subsidy funds for farmland construction reached 69.5 billion yuan, strengthening high standard farmland construction, and accelerating the improvement of agricultural production conditions. The balance of agricultural loans reached nearly 4 billion yuan by the end of 2020, an increase of 10.7% compared to the previous year, The rapid growth of agricultural and rural investment has led to a 30.87% increase in the green production efficiency of grain in the Huaihe River Ecological Economic Belt in 2020 compared to 2019. (Figure 2)

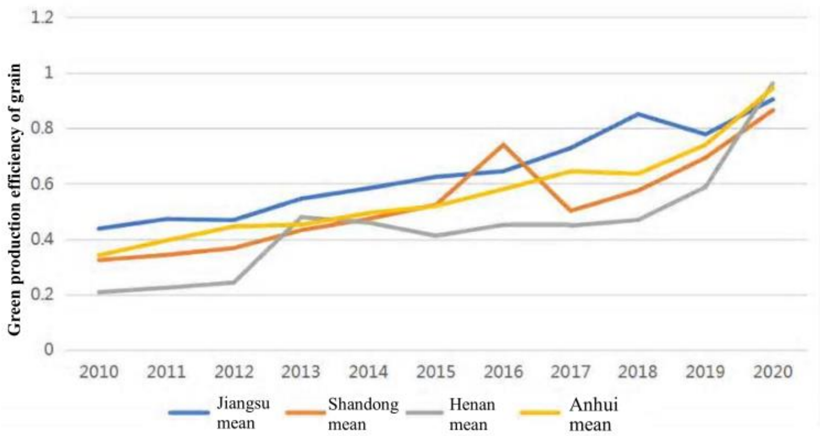

Figure 2 Time trend of green production efficiency of grain in various provinces of the Huaihe river ecological economic belt.

Table 2 Division of green production efficiency interval for Huaihe river ecological economy large grain.

interval	Year 2010	Year 2015	Year 2020
$0 \le eff < 0.2$	Luohe, Pingdingshan		
$0.2 \le eff < 0.4$	Xuzhou, Lianyungang, Huai'an, Suqian, Yancheng, Heze, Linyi, Shangqiu, Xinyang, Zhoukou, Zhumadian, Bengbu, Chuzhou, Fuyang, Huaibei, Huainan, Lu'an, Suzhou	Heze, Luohe, Pingdingshan, Shangqiu, Zhumadian, Huainan	Heze
$0.4 \le eff < 0.6$	Taizhou, Jining, Zaozhuang, Bozhou	Xuzhou, Huai'an, Yancheng, Linyi, Zhoukou, Bengbu, Bozhou, Chuzhou, Huaibei, Lu'an, Suzhou	Yancheng, Zhoukou, Huainan
$0.6 \le eff < 0.9$		Lianyungang, Suqian, Taizhou, Jining, Zaozhuang, Xinyang, Fuyang	Huai'an and Suzhou
$1 \le eff$	Yangzhou	Yangzhou, Heze	Xuzhou, Lianyungang, Suqian, Yangzhou, Taizhou, Jining, Linyi, Zaozhuang, Luohe, Pingdingshan, Shangqiu, Xinyang, Zhumadian, Bengbu, Bozhou, Chuzhou, Fuyang, Huaibei, Lu'an

From a provincial perspective, the green production efficiency of grain in the four provinces of the Huaihe River Ecological Economic Belt has shown a fluctuating upward trend. Compared to other regions, Jiangsu Province started relatively high, with a green production efficiency of over 0.4 in 2010. From 2010 to 2018, the green production efficiency of grain in Jiangsu Province steadily increased, but slightly decreased in 2019; Except for the decrease in green production efficiency of grain in 2017, Shandong Province has shown an upward trend in all other years; Henan Province saw a significant increase in the efficiency of green grain production in 2013, followed by relatively stable development, with growth rates increasing again in 2019 and 2020; The green production efficiency of grain in Anhui Province has steadily increased from 2010 to 2020, with a more significant increase in 2019 and 2020.

From Figure 3, it can be seen that on average, all 25 cities in the Huaihe River Ecological Economic Belt are inefficient areas for green food production. This indicates that the foundation of green food production in the Huaihe River Ecological Economic Belt is weak, and the overall level is relatively low. There is still a long way to go to achieve the goal of coordinated development of agricultural economic benefits, ecological green, and low-carbon. Horizontally, Zhoukou, Zhumadian, Shangqiu, Pingdingshan, and Heze all have an average efficiency of less than 0.4 in green grain production, making them cities with relatively low efficiency in green grain production. The top three regions with green grain production efficiency are Yangzhou, Xinyang, and Jining, all of which have an average efficiency of over 0.7, making them cities with relatively high efficiency in green grain production. As economically underdeveloped cities, Yangzhou, Xinyang, and Jining have higher green grain production efficiency than other more developed cities. This indicates that there is no significant positive correlation between green grain production efficiency and economic development level. Economically underdeveloped cities can also improve green grain production efficiency through large-scale production, optimized resource allocation, and enhanced agricultural technology application level.

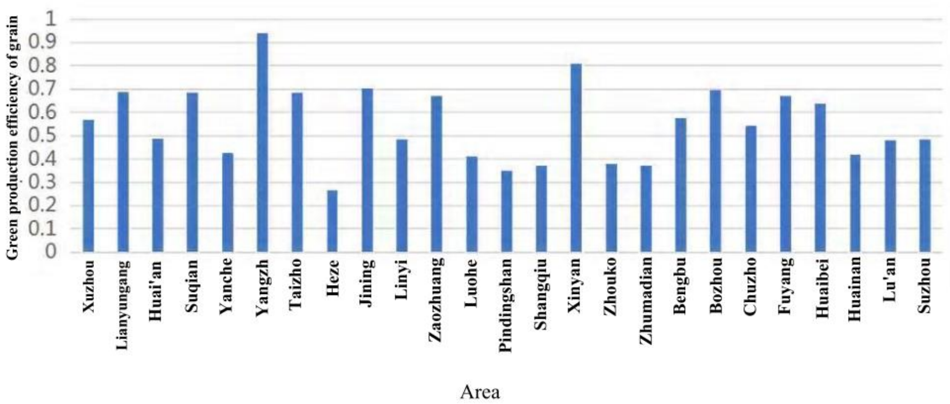

Figure 3 Annual average efficiency of green grain production in 25 cities in the Huaihe river ecological economic belt.

(3) From a temporal and spatial perspective, in 2010, among the 25 cities in the Huaihe River Ecological Economic Belt, only Yangzhou had a green production efficiency of over 1 for grain, mostly concentrated between 0.2 and 0.4. In addition, the green production efficiency of grain in Luohe and Pingdingshan was lower than 0.2, indicating that the grain production conditions in the region were relatively backward and agricultural pollution problems were more serious in 2010. By 2015, there was still only one city in Yangzhou in the region with a green food production efficiency greater than 1, indicating that Yangzhou was not blindly pursuing economic benefits, but rather a coordinated development of economy and environment; Although the green production efficiency of grain in other cities has not reached an effective level, compared to 2010, there are still many cities with higher levels of efficiency. For example, the green production efficiency of grain in Taizhou, Jining, and Zaozhuang all exceeds 0.6, which is close to the effective green production efficiency of grain; In 2010, the grain production efficiency of Luohe and Pingdingshan cities, which were less than 0.2, reached an efficiency range of 0.2 to 0.4 in 2015. In 2020, the green productivity of grain in the Huaihe River Ecological Economic Belt significantly improved, with 19 cities achieving effective green production efficiency. It can be seen that most cities in the Huaihe River Ecological Economic Belt have been transitioning towards green and low-carbon grain production in the past 11 years, with significant results. Currently, most cities have achieved effective green production efficiency of grain; In 2020, the five cities of Yancheng, Zhoukou, Huainan, Huai'an,

and Suzhou also reached 0.4 or above, with Huai'an and Suzhou reaching 0.6 or above, which is close to the effective green production efficiency of grain; Meanwhile, we have noticed that the green production efficiency of grain in Heze was between 0.2 and 0.4 in 2010, 2015, and 2020. It can be seen that there has been no significant effect on the green production of grain in the past 11 years. Through the analysis of the input and output indicators of grain production in Heze in 2010, 2015, and 2020, we found that labor and land input in Heze ranked among the top in the Huaihe River ecological and economic belt, However, its total agricultural output value does not reach the expected level. Compared with Fuyang, which has similar initial conditions, the labor and land input values of the two are similar in 2020, and the green production efficiency of grain is also between 0.2 and 0.4; In 2015, the green production efficiency of grain in Fuyang increased to 0.6. Comparing the input and output indicators of the two, it can be seen that the labor input and land input of the two are still at a similar level. In 2015, the inputs of fertilizers, pesticides, and agricultural films in Fuyang were significantly lower than those in Heze. Although the total agricultural output value of Fuyang was slightly lower than that in Heze, its agricultural carbon emissions, nitrogen and phosphorus loss from fertilizers The unexpected output data such as agricultural film residue were 22.01%, 63.84%, and 16.05% lower than those in Heze, respectively, resulting in a significant increase in the green production efficiency of grain in Fuyang in 2015 compared to Heze; In 2020, labor input in Fuyang significantly decreased, with only about 60% of labor input in Heze and nearly 20% decrease in land input. The input of fertilizers, pesticides, and agricultural films remained at a relatively low level, but the total agricultural output reached 91.42% of Heze's total agricultural output. At the same time, unexpected outputs such as agricultural carbon emissions, nitrogen and phosphorus loss from chemical fertilizers, and residual agricultural films accounted for 78.26%, 41.43%, and 89.31% of Heze's total agricultural output, Thus, the green production efficiency of grain in Fuyang has reached an effective level. In addition, through the analysis of input and output index data of cities with slow growth such as Bengbu, Xuzhou, and Lu'an, it can be seen that while reducing labor input, increasing investment in agricultural machinery, expanding effective irrigation area, and reducing inputs such as fertilizers, pesticides, and agricultural films, the total agricultural output value can steadily increase while reducing input. The corresponding reduction in input also reduces the unexpected output, namely agricultural carbon emissions, brought about by it The loss of nitrogen and phosphorus from fertilizers and the residual amount of agricultural film decrease accordingly. (Table 2)

5. Policy Recommendations

From the above analysis, it can be seen that the green production efficiency of grain in the Huaihe River Ecological Economic Belt is slowly increasing in fluctuations, with 19 cities achieving effective levels of green production efficiency of grain in 2020; At the same time, there is no significant positive correlation between the efficiency of green food production and the level of economic development. Economically underdeveloped cities can also optimize the efficiency of green food production through paths such as large-scale production, optimized resource allocation, and strengthened agricultural technology application.

5.1 Carry Out High Standard Farmland Construction

High standard farmland can help optimize the efficiency of rural farmland utilization, restore farmland production capacity, solve the problems of extensive development and low utilization efficiency of traditional land, and improve the ability to resist and prevent land disasters in the context of frequent extreme weather, ensuring high and stable food supply. Give full play to the role of fiscal investment in promoting the construction of high standard farmland, establish a sound financial support system for high standard farmland, and strengthen the financing and expansion mechanism for stable growth. Improve the level of transformation and application of agricultural scientific and technological achievements, support the green transformation of grain production with technology, promote the transformation of high standard farmland to agricultural modernization, and enhance the green efficiency of grain production.

5.2 Reducing and Increasing Agricultural Non-Point Source Pollution

In the past, food production relied too heavily on agricultural chemical inputs. Although the agricultural ecological environment has improved since the battle against pollution, the stock of non-point source pollutants continues to increase. Therefore, scientifically planning agricultural chemical inputs and improving agricultural production efficiency are important ways to solve the problem of green food production efficiency. On the one hand, it is necessary to establish fertilizer and pesticide application plans and standards based on different soil conditions in different regions. On the other hand, it is necessary to strengthen the transformation of scientific research achievements, improve the efficiency of nitrogen and phosphorus fertilizer utilization in agricultural products, and promote soil testing and formula fertilization technology. In addition, it is necessary to address agricultural non-point source pollution caused by agricultural chemical inputs and waste from the source, explore and try agricultural waste resource utilization models, and reduce secondary pollution.

5.3 Improve the Mechanism for Green Grain Production

One is to establish a sound ecological detection mechanism for the grain production environment, utilizing modern information technologies such as agricultural drones and big data to dynamically monitor the grain production environment, especially the soil environment, collect physical and chemical data during the grain production process, and provide decision-making basis for agricultural ecological governance plans and green grain production. The second is to establish a sound incentive system for technological innovation in grain production, focusing on ecological, environmental protection, and “dual carbon” goals, accelerate the research and promotion of green grain production technologies, formulate corresponding incentive and constraint systems, assist technological innovation, and improve the efficiency of green grain production. The third is to strengthen the mechanism for discovering the value of green agricultural products, thereby stimulating the enthusiasm of grain production entities for green production. On the one hand, establish a pricing system for ecological agricultural products, providing scientific value evaluation basis for high-quality ecological agricultural products to achieve preferential transactions. On the other hand, strengthen the supervision of the ecological agricultural product market, provide guarantees for the standardized development of the agricultural product market, and prevent the phenomenon of bad coins driving out good coins.

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