Evaluation of the Level of Green Development Agriculture and Obstacles in Shandong Province

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ABSTRACT

Taking Shandong Province as the research object, 13 evaluation indexes were selected from three levels of efficient production, resource conservation and environmental protection to construct the evaluation index system of agriculture green development. The entropy weight method and obstacle degree model are used to analyse the level of agriculture green development and its obstacle factors in Shandong Province. The results show that the level of agriculture green development in Shandong Province from 2013 to 2023 generally shows a trend of change that first decreases and then increases, in which environmental protection is the main factor affecting the level of agriculture green development in Shandong Province. From the results of the barrier degree analysis, environmental protection has the strongest hindering effect on the green development of agriculture. For the sustainable and stable development of green agriculture, it is necessary to change the agriculture production mode, build a modernized agriculture production system, accelerate green technological innovation, maintain and build the ecological environment, and promote the synergistic development of the agriculture economy and the ecological environment in Shandong Province.

Keywords: green agriculture development, entropy weight method, obstacle degree, comprehensive evaluation

INTRODUCTION

Accelerating the green development of agriculture is an important initiative to implement China's new era of ecological civilization thinking, implement the new development concept and promote sustainable agriculture development [1]. Since 2012, the Chinese Government has attached great importance to the green development of agriculture and has promulgated and implemented a series of policy documents, with the “14th Five-Year Plan for National Green Agriculture Development” explicitly mentioning the need to accelerate the green development of agriculture [2]. The Opinions on Innovative Institutional Mechanisms to Promote Green Agriculture Development also indicate the need to promote the formation of a new pattern of green development [3][4].

At present, China's research on agriculture green development mainly focuses on the definition of concepts, the construction of evaluation indicators for agriculture green development, and comprehensive evaluation. Starting from the theory and connotation of agriculture green development and the status quo and performance measurement of agriculture green development in Jiangsu Province, the current problems and countermeasures of agriculture green development in Jiangsu Province are analyzed and put forward [5]. By constructing an

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evaluation index system for agriculture green development, the level, characteristics and regional differences of agriculture green development are evaluated and analyzed from the national and 30 provincial and regional scales [6]. The level of green development of agriculture in the middle reaches of the Yangtze River in China is categorized and analyzed, and the differences of the analyzed regions are examined and evaluated [7]. Based on the data of the three northeastern provinces of China, the time-series characteristics and regional differences of the green development level were analyzed by the entropy weight method [8].

However, there are still some limitations in the existing studies, such as the evaluation index system is not perfect, and there are fewer studies on Shandong Province. As a large agriculture and economic province in northern China, Shandong Province has experienced a series of problems such as inefficient use of resources and damage to the ecological environment in the process of accelerating urbanization [9].

RESEARCH METHODOLOGY

Entropy weight method is an objective weighting method, which can largely avoid the errors caused by subjective factors. So this research chooses to adopt entropy weight method to measure the development level of green agriculture [10]. The idea of the entropy weight method of evaluation is that the greater the difference in the value of the evaluation object in a certain indicator, the greater the weight value and the more important the object is [11]. According to the degree of variation of the indicators, the weight value of each indicator is calculated, which can provide a more reliable basis for the comprehensive evaluation of multiple indicators [12].

In this research, the entropy weight method is used to calculate the weights and scores of the indicators related to agriculture green development. It measures the level of green development of agriculture in Shandong Province and analyzes the obstacle factors of green development of agriculture through the obstacle degree model.

Entropy Weight Method

The first step, data standardization: for n samples, m indicators, x_{ij} is the original value of the j indicator of the i sample ($i = 1, 2, 3, \dots, n$; $j = 1, 2, 3, \dots, m$), and the standardization is carried out by using the method of extreme deviation.

Positive Indicator: $a_{ij} = \frac{x_{ij} - \min x_{ij}}{\max x_{ij} - \min x_{ij}}$

Negative Indicator: $a_{ij} = \frac{\max x_{ij} - x_{ij}}{\max x_{ij} - \min x_{ij}}$

When a 0 or 1 occurs after data normalization, it is necessary to pan the normalized data.

In the second step, the weight of the i sample value under the j indicator is calculated for that indicator:

$$p_{ij} = \frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}}$$

In the third step, the entropy value of the j indicator is calculated:

$$e_i = \frac{\sum_{i=1}^{n} p_{ij} \ln p_{ij}}{\ln n}$$

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In the fourth step, the weights of the indicators are determined:

$$w_j = \frac{1 - e_j}{\sum_{j=1}^{m}(1 - e_j)}$$

In the fifth step, a composite score for green agriculture development was calculated:

$$s_i = \sum_{j=1}^{m} w_j a_{ij}$$

Barrier Degree Modeling Analysis

The first step is to calculate the indicator deviation:

$$k_{ij} = 1 - a_{ij}$$

Factor contribution:

$$u_{ij} = w_j \times k_{ij}$$

Where k_{ij} reflects the gap between the specific indicator and the green agriculture development goal, and u_{ij} reflects the degree of influence of the specific indicator on the green agriculture development goal.

In the second step, the barrier degree of level 2 indicator is calculated:

$$I_{ij} = \frac{u_{ij}}{\sum_{j=1}^{m} u_{ij}}$$

Level 1 Indicator Barrier Degree:

$$N_i = \sum I_{ij}$$

The obstacle degree of each indicator can be calculated according to the formula of Eq. The larger the value, the greater the resistance of the indicator to the realization of green agriculture development in Shandong Province.

Indicator Selection and Data Sources

Based on the main indicators in the National Agricultural Green Development Plan for the 14th Five-Year Plan promulgated and implemented by the State in 2021, combined with the China Agricultural Green Development Report, and with reference to existing studies [10][11][12]. In this research, 13 evaluation indicators are selected from three levels of efficient production, resource conservation and environmental protection to construct the evaluation index system of agriculture green development. This research takes Shandong Province as the research object, and the research period is 2013-2023, considering the availability and continuity of data. The data in this research are mainly from the 2013-2023 Shandong Statistical Yearbook, China Statistical Yearbook, and statistics from the Department of Agriculture and Rural Affairs of Shandong Province. Some missing data are supplemented by linear interpolation. Using the standardized data, the weights of the indicators were calculated by entropy weighting method, as shown in Table 1.

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Table. 1 Evaluation Indicator System for Agriculture Green Development in Shandong Province

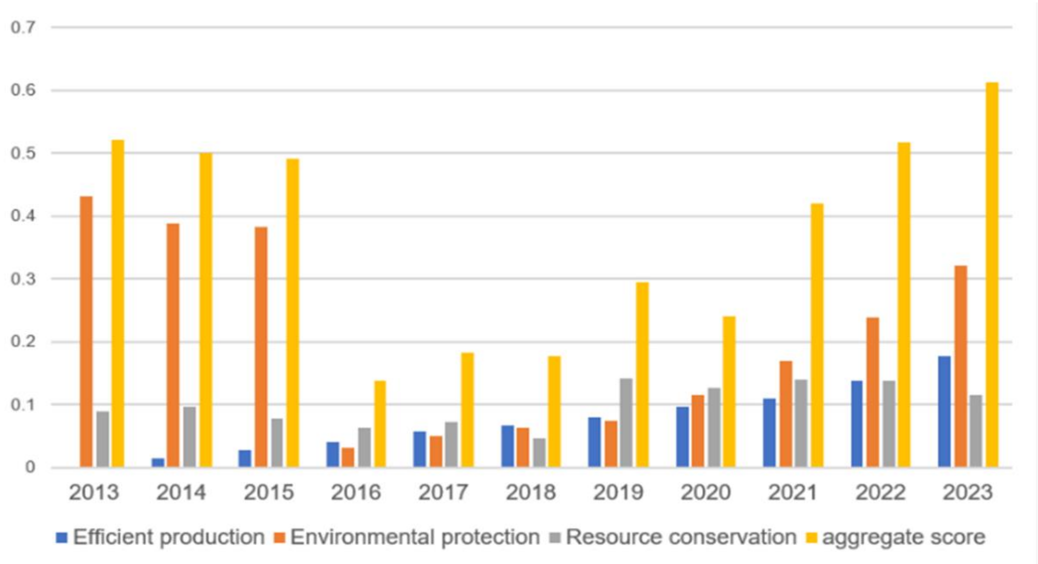
Firstly indicator	Secondary Indicator	Explanation of indicators	Indicator attributes	Weight
Efficient production	Rural disposable income	Rural disposable income	+	0.0423
	labor productivity	Gross output/primary sector employees	+	0.0617
	Land productivity	Gross value of production/area sown under crops	+	0.0414
Resource conservation	Percentage of area under water-saving irrigation	Water-saving irrigated area/cultivated area	-	0.0438
	Cropland recovery index	Crop sown area/cultivated area	-	0.0314
	Total power per unit of sown area	Total power of agriculture machinery/area sown with crops	-	0.0458
	Percentage of fiscal expenditure on agriculture	Agriculture, forestry and water expenditure/general public budget expenditure	-	0.0408
Environmental protection	Fertilizer intensity	Fertilizer application/area sown to crops	-	0.1101
	Pesticide application intensity	Pesticide application/area sown to crops	-	0.1032
	Film application intensity	Amount of agriculture film applied/area sown to crops	-	0.0214
	Percentage of area under soil erosion control	Soil erosion control area/land area	+	0.0404
	Percentage of wetland area	Wetland area/national land area	+	0.266
	Percentage of area of nature reserves	Area of nature reserves/national territory	+	0.0207

RESULTS

Comprehensive analysis

No more than 3 levels of headings should be used. All headings must be in 10pt font. Every word in a heading must be capitalized entropy weight method is used to measure the comprehensive score of the level of green development of agriculture in Shandong Province between 2013-2023, and the results are shown in Figure 1.

Fig. 1 Composite score for level-1 indicator indicators, 2013-2023



Analyzing Table 2 shows that the level of agriculture green development in Shandong Province shows a general trend of decreasing and then increasing. According to the annual mean and standard deviation of the first-level indicators, environmental protection is the highest among the three first-level indicators, followed by efficient production and resource conservation.

Table. 2 Annual mean and standard deviation scores for level 1 indicators

Name	**Efficient production**	**Environmental protection**	**Resource conservation**	**Aggregate score**
average value	0.0733	0.2053	0.1004	0.3813
standard deviation	0.0507	0.1449	0.0308	0.1552

As shown in Fig. 1, in terms of Efficient production, there is a steady upward trend from 2013 to 2023, with an average value of 0.0733 and an average annual growth rate of 30.91%. With the continuous improvement of rural infrastructure, the optimization of agriculture production conditions, and the introduction of various policies to help and benefit farmers, labour productivity and land productivity have been effectively enhanced, so the efficiency of agriculture output has been improved [13]. However, the urban-rural gap, the shortage of agriculture labor, and crude agriculture production methods have not yet been resolved, as the promotion of a green level of agriculture development has not been obvious. It is therefore necessary to continue to strengthen financial support for the rural and peasant sectors and to continue to optimize agriculture production conditions [14].

The environmental protection indicator as a whole shows a trend of first decline and then increase. And it continued to decline between 2013-2016, which is due to the lack of environmental protection concept and protection awareness in the early period, the untimely implementation of soil erosion control work, and the lack of effective means to protect the wetland. With the promotion of ecological civilization construction, the concept of green development is deeply rooted in people's hearts, and people gradually realize the importance of the harmonious development of man and nature, economy and society. Shandong Province is actively promoting the process of ecological environmental protection during 2017-2023, carrying out emission reduction of major pollutants such as air pollution, water pollution and soil pollution, and scientifically and rationally using fertilizers, pesticides and other agriculture production materials [15]. At the same time, a pollution monitoring system has been established to scientifically and effectively manage agriculture surface source pollution, so the rate of increase of environmentally friendly indicators has gradually accelerated [16].

In terms of resource conservation, it is consistently below the 0.1 level line from 2013-2018, with a significant increase in 2021, but after 2022 the resource efficiency indicator again shows a slow downward trend. This is mainly due to the traditional crude agriculture production methods in Shandong Province before 2018, resulting in low agriculture production efficiency, inefficient irrigation, high energy consumption production operations phenomenon. 2019 after the gradual rise, on the one hand, because Shandong Province has increased policy support, objectively mobilized the enthusiasm of farmers to grow food, and improved labor productivity [17]. On the other hand, due to the rapid promotion of agriculture technology, Shandong Province continues to promote the propagation of water-saving irrigation technology, agriculture machinery and equipment, and closely integrates advanced agriculture technology with actual production activities, which greatly improves the utilization efficiency of agriculture resources [18].

Analysis of obstacle factors

In order to identify the factors hindering the green development of agriculture in Shandong, this study used the barrier degree model to calculate the barrier degree of each indicator layer to the level of green development of agriculture in Shandong province from 2013 to 2023, as shown in Figure 2. In terms of the ranking of the average barrier mean of the level 1 indicators, environmental protection is the highest among the 3 level 1 indicators (0.4004), followed by resource conservation (0.2420) and efficient production (0.1266).

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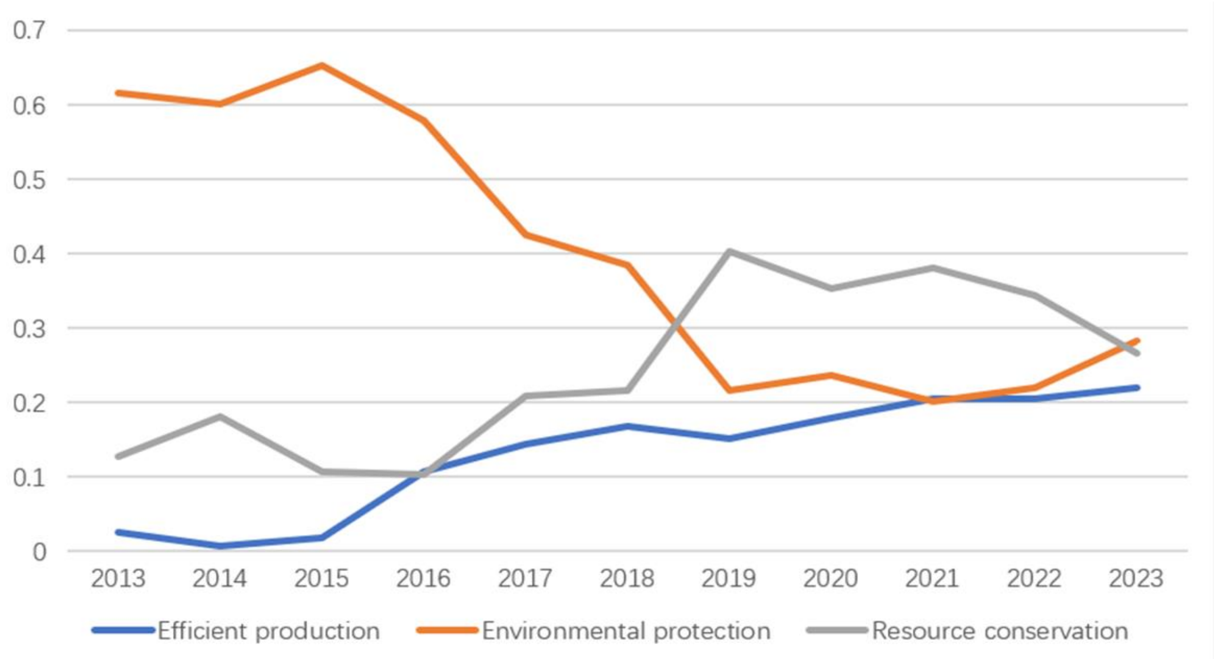
Fig. 1 Level 1 Indicator Barrier of Green Development Level of Agriculture in Shandong, 2013-2023



Efficient production obstacle degree scores are the lowest, and the results indicate a strong supportive role for agriculture green development. In recent years, Shandong Province has continued to promote high-standard farmland projects, the quality of arable land has been continuously improved, the conditions for mechanized operations and drainage and irrigation have been effectively improved, further promoting farmers' income and agriculture efficiency, and the efficiency of agriculture production and land productivity have both risen steadily. With the promulgation of various government policies to benefit and assist agriculture, the disposable income of rural residents has been rising, and the enthusiasm for agriculture production has increased significantly, adding new impetus to the green development of agriculture [19].

The environmental protection barrier degree shows some degree of influence, with overall levels lower than the environmental protection indicator. Shandong Province has always been a large agriculture province in China, rich in agriculture production resources, crop sowing area as well as the number of agriculture laborers is large, the conversion of agriculture waste into usable resources, reducing agriculture production costs while improving the efficiency of resource utilization [20].

Environmental issues are an important factor affecting the green development of agriculture in Shandong Province. In the early stages, Shandong Province's agriculture production infrastructure was relatively backward, and farmers' excessive use of chemical fertilizers and pesticides often occurred, causing great damage to the ecological environment, coupled with a lack of environmental awareness among rural residents [21]. In summary, Combined with Figure 2 obstacle degree scores. It can be seen that environmental protection and resource conservation are important obstacles affecting the green development of agriculture in Shandong Province, and environmental protection has become the most important factor hindering its development.

DISCUSSION

(1) From the score of the level of green development of agriculture, the overall situation shows a trend of change that first decreases and then rises, and there is an upward development trend in each level of indicators, with a large change in the environmentally friendly indicators and a relatively small increase in the resource conservation and output efficiency indicators. (2) From the obstacle degree score, environmental protection is the main factor hindering the level of green development of agriculture in Shandong Province, in which the intensity of pesticide and agricultural film application per unit of arable land area has a prominent role in hindering. The second is resource conservation, in which the cropland replanting index and the total power of

agricultural machinery per unit of cropland area are the main obstacle factors; Efficient production plays a positive supportive role, and the ecological resources and environment are still the key factors restricting the green development of agriculture in Shandong Province.

CONCLUSION

(1) Promoting green agriculture development and building a modernized agriculture production system. Implementing the concepts of green agricultural development and high-quality development, fully integrating all types of resources, and promoting the construction of a modernized agricultural production and management system. In the course of agricultural production, we have abandoned high-emission and high-pollution production methods, reduced unnecessary inputs of chemical fertilizers, pesticides and agricultural films, and realized green production and management methods. (2) Maintaining and building the ecological environment. Accelerating the development of ecological agriculture, facility agriculture, green agriculture, recycling agriculture and other new forms of modernized agro-industry, and promoting the synergistic development of the agricultural economy and ecological environment in Shandong Province.

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