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Evaluation of Modern Agricultural Development Level in Huaibei Area of Anhui Province

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Abstract Based on the data of modern agricultural development level in Huaibei area, this paper made a comprehensive evaluation on the modern agricultural development of 6 cities in Huaibei area by Analytic Hierarchy Process (AHP). It analyzed the development trend and difference in the level of agricultural input, the level of agricultural output, the level of rural social development and the level of agricultural ecological security. The study shows that the overall level of modern agricultural development in Huaibei area is rising in the past 6 years, with the highest increase in Suzhou City, followed by Huainan City and Huaibei City, and the other cities ranking in the middle. In view of the problems in the process of modern agricultural development in Huaibei area, it came up with recommendations, including strengthening the land consolidation, transfer of agricultural population, improving the rural education and controlling the agricultural pollution.

Key words Modern agriculture, Development level, Evaluation, Huaibei area

1 Introduction

Developing the modern agriculture is an essential requirement for China to transform the economic development mode and build a moderately prosperous society in all respects. It is also the only way to promote the construction of beautiful countryside, improve the rural situation and raise the living standards of farmers. Modern agriculture is the new agricultural development mode that combines modern industries, scientific and technological achievements and scientific management methods with agricultural production. Different from the traditional agriculture, modern agriculture needs large volume of inputs of fine seeds, pesticides, chemical fertilizer, and machines, as well as commercial environment with larger agricultural product market and higher information accessibility. At present, China remains at the key stage of promoting synchronous "four modernizations". In order to keep coordination between modern agricultural development, industrialization, informationization, and urbanization, the key is to see clearly current situation of modern agricultural development, existing or possible problems in the process, and so as to come up with effective recommendations. In the *National Agricultural Modernization Plan (2016–2020)*, it set forth that by 2020, China's agricultural modernization should make substantial progress, national grain security realizes effective guarantee, the quality and efficiency of agricultural product supply system are significantly improved, agricultural international competitiveness is further strengthened, farmers' living conditions reach the moderately prosperous level, and beautiful and livable countryside construction reaches a new stage^[1]. The Huaibei Plain is a main grain producing area in China. Accelerating the agricultural modernization in this area will provide a

strong guarantee for the realization of the national strategic planning. Therefore, we analyzed the agricultural development level in Huaibei area, revealed its influence mechanism, analyzed how to raise the regional modern agricultural development level and consolidate the position of grain production bases. This is of great significance for guaranteeing China's grain security and promoting the implementation of central area rising strategy.

With many years of exploration in developing agricultural modernization with Chinese characteristics, the academic circle of China has been enriching and improving the evaluation of the modern agricultural development. For the construction of modern agricultural evaluation indicator system, Huang Zuhui and Lin Benxi, taking the resource utilization rate as the core, established a set of evaluation system with labor productivity, land output rate and resource utilization rate as the core^[2]. Based on the development of agricultural production, Yang Junzhong established an evaluation system with agricultural material and equipment, scientific and technological materials and personnel investment, industrialization and market-oriented level as the core^[3]. At the practical level, the scholars made optimization and combination of indicators in these two kinds of evaluation systems. Under the premise of improving the model flexibility and adaptation, they made the model application much simpler. Li Man, *et al.* established an evaluation system from agricultural material and equipment, agricultural output efficiency, agricultural economic structure, agricultural industrialized management, agricultural sustainable development, and rural social and economic development, and applied the evaluation system in the modern agricultural development evaluation of Zhulu County of Hebei Province^[4]. Qiuyuan *et al.* applied the similar evaluation system in the evaluation of modern agricultural development in Zigong City^[5]. Li Baoyu, Li Gang, and Gao Chunyu, *et al.* established an evaluation system from the agricultural

input, agricultural output, rural social development and sustainable development of agriculture and applied the evaluation system in the evaluation of modern agricultural development level of areas around the Bohai Sea^[6]. Jiang Heping, *et al.* applied similar evaluation system to evaluate the development of modern urban agriculture in Beijing^[7]. These studies provide rich theoretical basis and valuable research experience for China's agricultural modernization research.

Based on the field survey, with full reference to the existing research results, we established the modern agricultural evaluation indicator system for Huaibei area in 2010–2015, further evaluated the development of modern agriculture of Huaibei area in 2010–2015, and analyzed the development characteristics of all cities of Huaibei area. Besides, based on the resource endowment and socio-economic development characteristics of Huaibei area, according to the analysis results, we came up with pertinent modern agricultural development recommendations, in the hope of providing a scientific basis for the development of modern agriculture in Huaibei area.

2 Overview of the study area

The Huaibei Plain area includes 6 prefecture cities, namely, Huaibei, Bozhou, Fuyang, Bengbu, Huainan and Suzhou. The farmland area of Huaibei area accounted for 42.7% of the total farmland in Anhui Province. Huaibei area is the largest grain producing area of Anhui Province and also an important commodity grain production base of China. However, Huaibei area has problems of large rural population, low per capita resource, and underdeveloped economy. As of 2015, its rural population was 24.775 million, the per capita farmland was only 0.1 ha, the number of agricultural workers was 6.407 million, accounting for 45.9% of the total number of agricultural workers in Anhui Province. The conflict between population and farmland and the shortage of agricultural development resources was prominent. In 2014, the total agricultural output value was 106.98 billion yuan, accounting for 43.2% of Anhui Province, but much lower than the per capita GDP (18725.7 yuan/person) and lower than the average value of Anhui Province (34424.61 yuan/person). Apart from the above indicators, there are other factors restricting the development of modern agriculture, such as the low utilization efficiency of agricultural resources, backward rural social development, and constant deterioration of agro-ecological environment. To solve these problems, we should follow the principle of understanding current situations, exploring the root causes, and then coming up with the recommendations. The primary task is to make an objective analysis of current situation of modern agricultural development, and come up with pertinent recommendations based on the evaluation results.

3 Comprehensive evaluation of modern agricultural development in Huaibei area

There are significant differences in the economic development level

and resource endowment characteristics between different areas of China. The objective understanding of the current situations and problems of agricultural development is a prerequisite for working out pertinent measures. There, it is necessary to make evaluation of modern agricultural development level by quantitative analysis. Using the multiple indicator comprehensive evaluation method, based on the regional development characteristics, and taking into account the economic benefits of agricultural development, we discussed the social and ecological benefits of agricultural production security and agricultural development, in the hope of realizing the objective of accurately evaluating the modern agricultural development level of Huaibei area and coming up with pertinent recommendations.

3.1 Selection of evaluation indicators Different scholars established many evaluation indicator systems with high application from different points of view. On the basis of fully understanding the basic connotation, development characteristics and main tasks of modern agriculture, following the comprehensive, operable, regional comparable, and dynamic development principles, combined with the agricultural production characteristics of Huaibei plain area, we divided the modern agricultural evaluation indicator system into four levels (4 level I indicators), namely, agricultural input level, agricultural output level, rural social development level and agricultural ecological security level, and 12 level II indicators, the property and distribution of these indicators were listed in Table 1.

3.2 Determination of weight and standardized treatment of evaluation indicator In this study, we used Analytic Hierarchy Process (AHP) to determine the weight of the indicators, because this method has characteristics of integrating subjective and objective decision-making factors, and simple and flexible operation. The principle is to divide a complex problem into many sub-factors, so that the various sub-factors form interrelated hierarchical structure, and the importance of each sub-factor can be compared according to actual situation, and then comparison results can be substituted into the structure, and finally mathematical methods are used to calculate the weight of each indicator.

In this study, the evaluation indicator system we adopted is a multi-indicator evaluation system. If original values are directly used for analysis, the results will weaken the function of the indicators with lower values, so that the results may not objectively reflect the actual situation. In order to eliminate the difference between the different dimensions and orders of magnitude, we used the extreme value standardization method to make dimensionless treatment of the original data, the formula is as follows:

$$y_{ij} = \frac{x - \min x}{\max x - \min x} \quad (\text{Direct indicator})$$

$$y_{ij} = \frac{x - \max x}{\max x - \min x} \quad (\text{Inverse indicator})$$

3.3 Comprehensive evaluation value After determining the weight of each indicator and conducting standardized treatment, we carried out the weighted sum of each indicator, and obtained

the evaluation value of the modern agricultural development level of Huaibei area. The basic model is as follows:

$$Y = \sum_{k=1}^n f_k \sum_{i=1}^m w_{ki} c_{ki} (1 \leq k \leq n, 1 \leq i \leq m)$$

Table 1 Modern agricultural development indicator system and its weight

Level I indicator	Level II indicator	Unit	Auxiliary indicator	Nature	Weight	
					Level I indicator	Level II indicator
Agricultural input level	Effective irrigation rate	%	Effective irrigation area and farmland area	Direct indicator	0.3334	0.1036
	Agricultural machinery power input per unit area of farmland	w/ha	Total power of agricultural machinery and farmland area	Direct indicator		0.0653
	Per capita farmland	ha/person	Farmland area and number of people engaged in agriculture	Direct indicator		0.1645
Agricultural output level	Grain yield per unit area of farmland	t/ha	Total grain yield and farmland area	Direct indicator	0.3333	0.0667
	Labor productivity	10 ⁴ yuan/person	Total agricultural output value and number of people engaged in agriculture	Direct indicator		0.1333
	Land output rate	10 ⁴ yuan/ha	Total output value of agriculture and farmland area	Direct indicator		0.1333
Rural social development level	Urbanization level	%	–	Direct indicator	0.1667	0.0741
	Percentage of food expenditure of rural family	%	Food consumption expenditure and total expenditure of rural family	Inverse indicator		0.0185
	Net income of farmers	10 ⁴ yuan	–	Direct indicator		0.0741
Agricultural ecological security level	Forest coverage	%	–	Direct indicator	0.1666	0.0238
	Application of chemical fertilizer per unit area	t/ha	Application of chemical fertilizer and farmland area	Inverse indicator		0.0714
	Application of pesticide per unit area	t/ha	Application of pesticide and farmland area	Inverse indicator		0.0714

4 Analysis of evaluation results

4.1 Data source The data used in this study mainly came from the *Statistical Yearbook of Anhui Province (2011–2016)*, the land use change survey data provided by the department of land and natural resources, as well as the statistics in government website of cities in Huaibei area.

4.2 Comprehensive evaluation of modern agricultural development in Huaibei area By comparing the data in 2010–2015, we found that, except Huainan City had significant low evaluation value due to the adjustment of administrative division (Shou County was included into Huainan City from Lu'an City), the overall level of modern agricultural development in Huaibei area was increasing year by year (as shown in Fig. 1). By the end of 2015, the ranking of modern agricultural development level in Huaibei area was Suzhou City, Bengbu City, Huainan City, Bozhou City, Fuyang City and Huaibei City, among which Suzhou City had the fastest development, increasing by 16.76% compared with the evaluation value in the beginning year. In addition, the comprehensive evaluation value of modern agriculture in Bozhou, Bengbu and Fuyang in 2015 was significantly higher than that in 2010, which was 12.88%, 12.01% and 10.03% respectively. The growth rate of Huaibei and Huainan was lower, but the results indicated that the gap with the Level I areas was not big.

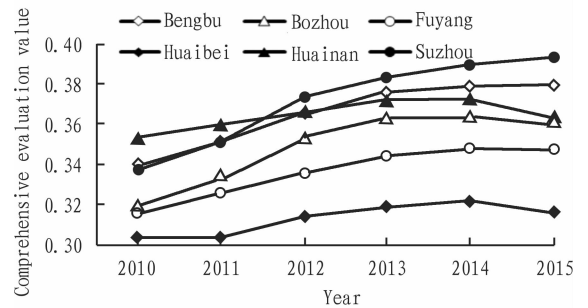


Fig. 1 Comparison of comprehensive evaluation value for modern agricultural development of 6 cities in Huaibei area

According to the division of agricultural modernization process by research results of other scholars^[8], the modern agricultural development level of Huaibei area still remained at the starting stage. In other words, modern factors exerted certain effect on promoting agricultural development, chemical fertilizer, fine seed and other factors of production have been integrated into the agricultural system, but the agricultural market was not developed, the agricultural mechanization rate and scientific and cultural level of agricultural producers were relatively low, all these factors still constrained further development of modern agriculture^[9].

(i) The evaluation results of agricultural input level in Huaibei area are shown in Fig. 2. In 2010–2015, the agricultural in-

put level of 6 cities in Huaibei area was relatively stable situation. In 6 cities, Huaibei City had the best irrigation base, the highest rate of agricultural mechanization, highest per capita farmland, so it ranked the first in 6 the past 6 years. However, in recent years, due to the number of people engaged in agriculture returned to increase, the agricultural input level of Huaibei City declined; Suzhou City and Bozhou City ranked the second and third position, but the growth rate was obvious, reflected in the specific indicators, the two cities had significant increase in the effective irrigation rate, and the farmland area per capita and agricultural machinery power input per unit area of farmland growth rate also ranked the first; Bengbu, Huainan, and Fuyang was the lowest in the agricultural input level, these three cities had relatively stable agricultural input, but the data comparison showed that their agricultural input level was also rising.

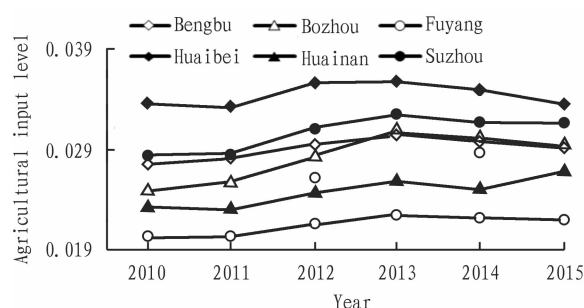


Fig. 2 Comparison of agricultural input level of 6 cities in Huaibei area

(ii) The evaluation results of agricultural output level in Huaibei area are shown in Fig. 3. Except Huainan City, the agricultural output level of other 5 cities in Huaibei area had increased, of which the largest increase was Suzhou City with labor productivity and land output rate in 2015 increasing by 95.2% and 60.0% compared with that in 2010, ranking the first in 6 cities, followed by Bengbu, Huainan, Bozhou, Fuyang and Huaibei. Bengbu, Bozhou, and Fuyang had a substantial growth in the grain yield per unit area, labor productivity and land output rate, while Huaibei City although had grain yield per unit area close to these three cities, other two indicators had obviously lower growth rate, Huainan City had lower data compared with the initial year due to the adjustment of administrative divisions.

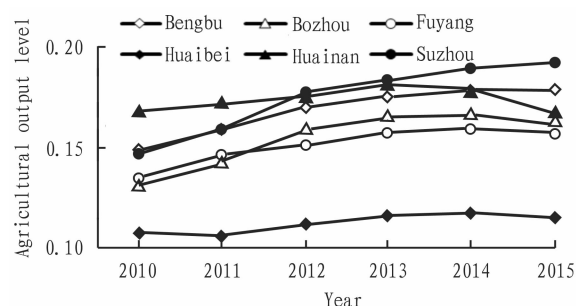


Fig. 3 Comparison of agricultural output level of 6 cities in Huaibei area

(iii) The evaluation results of rural social development level

in Huaibei area are shown in Fig. 4. Different from the above-mentioned two indicators, the 6 cities in Huaibei area had relatively consistent rural social development level, and the difference between the cities was also small, with the ranking as follows: Bengbu City, Huaibei City, Huainan City, Suzhou City, Bozhou City and Fuyang City. At the indicator level, except the level of urbanization having steady development, Bengbu, Bozhou, and Fuyang realized doubled per capita net income in 2015 compared with the year 2010, Huaibei, Suzhou, and Huainan were close to this goal, which is favorable for attracting farmers to pay more attention to agricultural land management and lay a certain foundation for the development of modern agriculture.

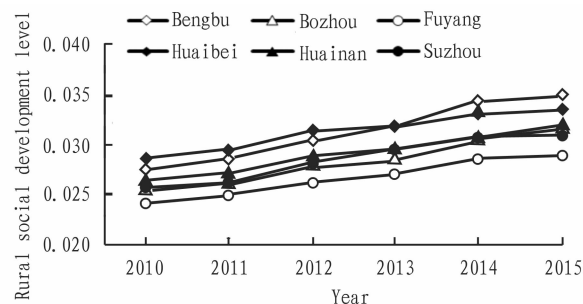


Fig. 4 Comparison of rural social development level of 6 cities in Huaibei area

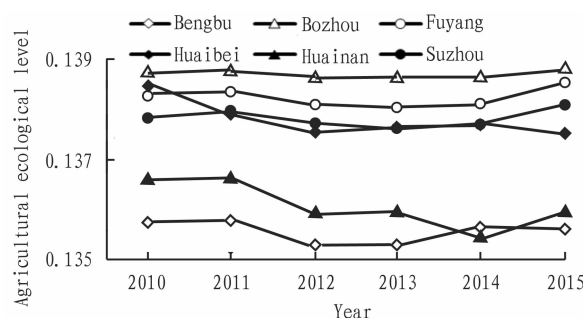


Fig. 5 Comparison of agricultural ecological level of 6 cities in Huaibei area

(iv) The evaluation results of agricultural ecological security level in Huaibei area are shown in Fig. 5. From comparison of the data of the past 6 years, we can see that the ecological agriculture security has gradually attracted the attention of cities in Huaibei area in recent years. Apart from increasing the forest coverage, all cities also slowed down the growth rate of pesticide and chemical fertilizer. Therefore, there was the tendency of decline first and then rise. Among the 6 cities, Bozhou City had the best agricultural ecological status, which should give the main credit to its lower pesticide and fertilizer application. Fuyang, Suzhou, and Huaibei followed Bozhou City closely, of which Fuyang and Suzhou had obvious rising trend, while Huaibei City had a significant decline in recent years. Then it was Huainan City and Bengbu City. Huainan City had the decline in forest coverage due to the adjustment of administrative divisions, and the application of pesticide and chemical fertilizer per unit area had been high all the time, so there was a clear decline trend. Although ranking the last position, Bengbu paid attention to controlling the application of pesticide and chemi-

cal fertilizer, so its forest coverage rate showed a considerable increase and the rising trend was also the most significant.

4.3 Existing problems in modern agricultural development of Huaibei area

Based on the above evaluation results, we found that Huaibei area has made considerable achievements in the development of modern agriculture, especially in the effective irrigation area and grain yield per unit area, indicating that Huaibei area has made great achievements in large scale comprehensive land consolidation construction projects. However, there are still following problems in the development of modern agriculture. (i) The base number of agricultural transfer population is too large, especially in Fuyang, Bozhou, and Suzhou cities. This not only restricts the scale operation of agriculture, but also makes the intensive use of resources lose the foundation. (ii) The agricultural economic output is relatively low, especially in Huaibei City. Although the grain yield is high, the low level of labor productivity and land output rate is not favorable for the formation of modern agricultural system. Therefore, in the process of modern agricultural development, it is required to pay close attention to how to improve the quality of agricultural products, how to extend the agricultural industry chain, and how to improve the economic structure of agriculture. (iii) Agricultural ecological problem is increasingly serious, especially in Bengbu and Huainan. The food security is inseparable from farmland health. Without excellent agricultural ecological environment, there will be no farmland health. Therefore, how to eliminate the negative effects of oil-based agriculture at the same time of increasing the yield of agricultural products is also a key issue in the process of modern agricultural development.

In addition to the above problems, we also found that the level of agricultural science and technology in Huaibei area was low, mainly reflected in the poor level of agricultural equipment, the low penetration rate of agricultural science and technology, the imperfect agricultural science and technology extension system and low cultural quality of people engaged in agriculture. Science and technology is the source power of modern agricultural development. In order to smoothly promote the modern agricultural construction, it is necessary to build excellent agricultural scientific research and education environment.

5 Recommendations for modern agricultural development of Huaibei area

5.1 Strengthening the land consolidation project and achieving the four in one of quantity, quality, landscape, and ecology

In the face of large population but little land, and the pressure of insufficient farmland, the strategy of modern agricultural development of Huaibei area should be placed on developing the land conservation technology. In the past few years, through vigorously carrying out land consolidation project, Huaibei area effectively increased the grain yield per unit area of farmland and realized the objective of saving farmland. In accordance with the requirements of beautiful countryside construction, it is required to improve the traditional land consolidation model and improve the environmental aesthetic effect and land rehabilitation^[10]. Firstly,

it is recommended to change the thought of land consolidation, properly treat the relationship between short-term and long-term, fully respect the intention of farmers, increase the farmland area and the integrated production capacity of farmland, and also improve the rural production and living conditions. Secondly, the competent authorities should give full play to the leading role in the construction of the project. Before the construction, it is recommended to make full demonstration of the nature and scope of projects. In the process of construction, they should play the role of organization and supervision. After the completion of construction, it is recommended to reinforce the acceptance, combine landscape ecological evaluation and soil health assessment, explore the establishment of appropriate land consolidation evaluation mechanism, and objectively understand the consolidation effect. Finally, we should give full play to the role of land consolidation platform, and combine existing rural land system reform, integrated urban and rural development, and ecological construction.

5.2 Promoting the transfer of agricultural population and cultivating a new type of agricultural management

To realize agricultural development, in addition to improving the productivity of farmland, it is also necessary to constantly open up the agricultural market. According to historical experience, we can easily find that the social supply capacity of farmers per capita is usually accompanied with the increase in production capacity and economic level. For Huaibei area with large population, promoting the agricultural scale management is a most suitable path for developing the modern agriculture. Therefore, we should take promoting the transfer of agricultural population as the precondition for modern agricultural development, while cultivating new agricultural management entities is a fundamental path. The specific approach is as follows. (i) It is recommended to further speed up the reform of household registration system, relax restrictions on household registration, and provide a driving force for transfer of dense agricultural population areas, and accelerate the formulation of policy of compensated adjustment of land-related indicators, and provide space for population flow-in area. (ii) It is recommended to promote healthy circulation of rural contracted land, and legally recognize contractual right of farmers on the basis of completing land right, ensure land-expropriated farmers can enjoy reasonable land security within the contractual period, and realize assets value of agricultural land, so as to provide assets guarantee for development and expansion of new agricultural management entities. (iii) It is recommended to set up a series of support and supervision measures for new agricultural management entities, and carry out monitoring of land use purpose and management level and strictly forbid non-agricultural use of agricultural land at the same time of providing subsidies, finance, insurance, and facility land.

5.3 Improving the rural education environment and increasing the conversion rate of agricultural scientific and technological achievements

In modern agriculture, the importance of science and technology as a productive force is getting higher and higher, while education continues to undertake the spread and transformation of scientific and technological achievements. For the Huaibei area, education is not only a key way to develop new technologies and apply new achievements, but also an important

means to help low-income people to get rid of poverty, and also a great force for turning the population burden into the personnel advantage in future. Therefore, it is recommended to make efforts from exogenous and endogenous aspects.

The main exogenous goal is to take the agricultural technology extension system as the gripper, break through the traditional agricultural management way through the pilot demonstration, popularization and application process, so that agricultural operators accept the high intensification and high scientific and technological content from the concept. The realization approaches mainly rely on building scientific and technological extension team and establishing county-level agricultural science and technology experimental station. The works mainly include research and development, assessment and extension of breeding, high yield, soil improvement, fertilizer, pest control, fertilizer and pesticide application, and increase in the agricultural scientific and technological conversion rate, to provide comprehensive, systematic and integrated services for agricultural production^[11]. In this way, agricultural operators can truly understand the important role of science and technology for agricultural development and change their passive action to active acceptance, accordingly promoting the improvement of rural educational environment.

The main endogenous goal is to improve and strengthen the rural education and training system, comprehensively enhance the scientific and cultural quality of farmers by increasing the investment in basic education and vocational education of rural areas, cultivate farmers to be technical personnel, and comprehensively reduce the difficulty in conversion of agricultural scientific and technological achievements. The realization approach mainly relies on expanding the coverage of the educated population, as well as innovative ways of education. Apart from guaranteeing minors accepting elementary education, it is required to make effort to encourage individuals or economic organizations with intention of agricultural production and operation to receive training and education. It is recommended to propagate policies and typical experience with the aid of new media and provide teaching in accordance with differences of objects. In this way, it is feasible to effectively improve the cultural quality of agricultural workers, stimulate the endogenous force and spontaneously look for suitable scientific and technological achievements and apply them in actual production.

5.4 Controlling the agricultural non-point source pollution and reducing the ecological risk of agricultural development

Agricultural non-point source pollution refers to the agricultural production process of pollutants through rainfall and surface runoff. At present, agricultural non-point source pollution has become one of the main causes of water pollution in China, accounting for 45%–55% of the total pollution, and China's agricultural non-point source pollution is mainly due to high volume and improper application of fertilizer and pesticide, and water loss and soil erosion. In recent years, although the agricultural ecology in Huaibei area has been improved, the agricultural ecological risk faced by the development of agriculture still can not be neglected. The problem of pollution of pesticide and fertilizer is more and more serious.

Thus, effectively control of agricultural non-point source pollution is of great significance for sustainable development of modern agriculture in Huaibei area. In this situation, it is recommended to establish the farmland health "physical examination" project, establish land health file, make clear the soil nutrient and organic matter stock volume, lay a certain foundation for scientific application of fertilizer, and take effective measures for farmland with low fertility to restore the production capacity^[12]. Besides, it is recommended to integrate with the *Rehabilitation Plan for Farmland, Grassland, Rivers, and Lakes (2016–2030)* issued by the State Council, popularize technologies of straw returning to field, reduce pollutants from the source, rehabilitate and improve rural pool and dyke systems in Huaibei area, so as to control the spread of non-point source pollution, and build the artificial wetland through building vegetation filtration belt, to establish an ecological barrier with characteristics of Huaibei area.

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