Evaluation on the Development of Agricultural Circular Economy in Hunan Province

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Abstract By using conceptual model of BPEIR (Behavior – Pressure – Effect – Impact – Response) and Delphi method, we establish the evaluation index system of agricultural circular economy including four indices, namely index of socio-economic development, index of reducing input of resources, index of recycling of resources and index of safety of environment and resources. We conduct comprehensive evaluation on developmental level of agricultural circular economy from 1998 to 2007 in Hunan Province. The analysis results show that the agricultural circular economy of Hunan Province from 1998 to 2007, on the whole, has the tendency of development with annual growth rate of 1.89%. The annual decrease rate of recycling of resources and reducing input of resources from 1999 to 2003 is 25% and 11% respectively, which has become the main factor impeding development of agricultural circular economy. After the year 2003, it is mainly reducing input of resources.

Key words Agricultural circular economy, Comprehensive evaluation, Hunan Province, China

Agricultural circular economy is good circular system of self-accumulation and self-development integrating growing, breeding and processing, agriculture, science and education, and production, provision and marketing, which applies the concept of circular economy to system of agricultural economic development so as to reduce the input amount of resources and material and waste emission in the process of agricultural production[1]. It is a new economic form of realizing agricultural sustainable development by optimization of agricultural structure, recycling and high-efficiency use of resources and ecological protection. The traditional mode of agricultural production makes the problems confronted by Hunan which is as China's big agricultural province, increasingly critical, such as environment pollution, ecological damage and resources depletion. Therefore, conducting comprehensive evaluation on the status of development of agricultural circular economy in Hunan is basic work of realizing sustainable agricultural development in Hunan.

1 Establishment of evaluation index system

By using conceptual model of BPEIR (Behavior – Pressure – Effect – Impact – Response) which is established by Maqi Fang[2], Delphi method, and AHP method (Analytic Hierarchy Process)[3], we conduct comprehensive analysis and quantitative evaluation on the level of economic development of Hunan agricultural circular economy, and conduct analysis on factors impeding development of Hunan agricultural circular economy according to the results of evaluation.

1.1 Selection of evaluation index According to the conceptual connotation of agricultural circular economy, we can conduct quantitative evaluation on level of development of agricultural circular economy from 4 aspects, namely socio-economic development, reducing input of resources, recycling of resources and safety of environment and resources[4,5]. By drawing on previous research results, according to the regional characteristics and data availability in Hunan Province, we establish the following index system: in terms of socio-economic development, we select 5 indices, namely agricultural GDP, per capita net income of farmers, per capita grain output, output rate of farmland, and commercialization rate of livestock products; in terms of reducing input of resources, we select 5 indices, namely the total horsepower of farm machinery, use degree of fertilizer, agricultural labor forces, rural power utilization amount and agricultural water use amount; in terms of recycling of resources, we select 5 indices, namely multiple crop index, pesticide use level, use level of agricultural film, effective use coefficient of fertilizer, and industrial wastewater discharge rate of reaching the standard; in terms of safety of environment and resources, we select 5 indices, namely forest coverage rate, effective irrigation rate, per capita farmland, and total discharge of industrial wastewater (Table 1).

1.2 Determining of index weight Based on Delphi method, this research uses AHP method to assign weight to the evaluation index[6]. The calculation result can be seen in Table 1.

1.3 Standardization of evaluation index data Using the following method to standardize the raw data:

Positive index (the bigger the index, the better):

$$X'_{ij} = X_{ij} / X_i \quad (1)$$

Negative index (the smaller the index, the better):

$$X'_{ij} = X_i / X_{ij} \quad (2)$$

In the form, X'_{ij} is the standardized value of an index; X'_{ij} is original value of an index; X_i is the original value of the ith in-

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dex of the development of circular economy in Hunan Province in 1998.

1.4 Index of comprehensive evaluation To fully understand the Hunan agricultural development of circular economy, we need to conduct comprehensive assessment on agricultural circular economy in Hunan, and the calculation model is as follows (form 3).

Table 1 The comprehensive evaluation index system and weight of agricultural circular economy of Hunan Province

Classified index B	Separate index C	Weight of index	Explanation of index
Socio-economic development B_1	C_1 Agricultural GDP // $\times 10^8$ yuan	0.09	Agricultural GDP
	C_2 Per capita net income of farmers yuan/people	0.42	Total per capita net income of farmers-Per capita expenditure
	C_3 Per capita grain output // kg/people	0.26	Grain output/Total population
	C_4 Output rate of farmland // yuan/m^2	0.16	Agricultural output value/Farmland area
	C_5 Commercialization rate of livestock products // yuan/t	0.06	Output value of animal husbandry/Meat output
Reducing input of resources B_2	C_6 The total horsepower of farm machinery kW	0.06	The total horsepower of farm machinery of agriculture, forestry and animal husbandry
	C_7 Use degree of fertilizer // kg/hm^2	0.42	Use amount of fertilizer/Agricultural planting area
	C_8 Agricultural labor forces // $\times 10^4$	0.26	Labor forces who are engaged in agriculture, fishing, forestry and animal husbandry
	C_9 Rural power utilization amount // $\times 10^4$ kW · h	0.10	Power utilization of agricultural production and life
	C_{10} Agricultural water use amount // m^3	0.16	Agricultural water use amount/Agricultural GDP
Recycling of resources B_3	C_{11} Multiple crop index // %	0.42	Agricultural crops area/Farmland area
	C_{12} Pesticide use level // kg/hm^2	0.26	Pesticide use amount/Agricultural planting area
	C_{13} Use level of agricultural film // kg/hm^2	0.16	Use amount of agricultural film/Agricultural planting area
	C_{14} Effective use coefficient of fertilizer yuan/kg	0.06	Agricultural output value/Use amount of fertilizer
	C_{15} Industrial wastewater discharge rate of reaching the standard // %	0.10	Discharge of industrial wastewater up to the discharge standard/Total discharge of industrial wastewater
Safety of environment and resources B_4	C_{16} Forest coverage rate // %	0.47	Forest land area/Total area of land
	C_{17} Effective irrigation rate // %	0.10	Effective irrigation area/Farmland area
	C_{18} Per capita farmland // m^2/people	0.16	Farmland area/Total population
	C_{19} Total discharge of industrial wastewater $\times 10^4$ m^3	0.28	Total discharge of industrial wastewater

$$Z = \sum_{i=1}^{4} \left(\sum_{j=1}^{n} X_j \times W_j \right) \times R_i \quad (3)$$

In the form, X_j is the standardized value of the jth separate index subordinate to the ith classified index; W_j is the corresponding weight of the jth separate index subordinate to the ith classified index; R_j is the weight of the ith classified index; Z is comprehensive evaluation index of development of agricultural circular economy; $\sum_{j=1}^{n} X_j W_j$ is value of all classified evaluation indices.

2 Evaluation results and analysis

2.1 Analysis of comprehensive evaluation index After collecting historical data, we calculate comprehensive evaluation regarding development of Hunan agricultural circular economy, according to the aforesaid method (Fig. 1). We can find that from 1998 to 2007, nearly 10 years, the development of Hunan agricultural circular economy can be divided into three stages. At the first stage (1998 – 1999), it is a rising stage, and the growth rate of developmental level of agricultural circular economy reaches 7.69%. In this period, socio-economic development, reducing input of resources, recycling of resources and safety of environment and resources all grow rapidly, which promotes the great development of agricultural circular economy; at the second stage (1999 – 2003), it is a decline stage, and the average annual decline rate of developmental level of agricultural circular economy is 9.90%. Reducing input of resources and recycling of resources become the main factors impeding development of agricultural circular economy, with the average annual decline rate of 25% and 11% respectively; at the third stage (2003 – 2007), it is an upswing stage. Since 2003, due to the rapid growth of socio-economic development and safety of environment and resources, and the change of recycling of resources from negative growth to positive growth, the developmental level of agricultural circular economy tends to rise, with average annual growth rate of 13.33%. In addition, on the whole, during nearly 10 years, the developmental level of agricultural circular economy in Hunan tends to rise slowly, with average annual growth rate of 1.89%.

2.2 Analysis of reason

2.2.1 Index of socio-economic development. Fig. 2 shows

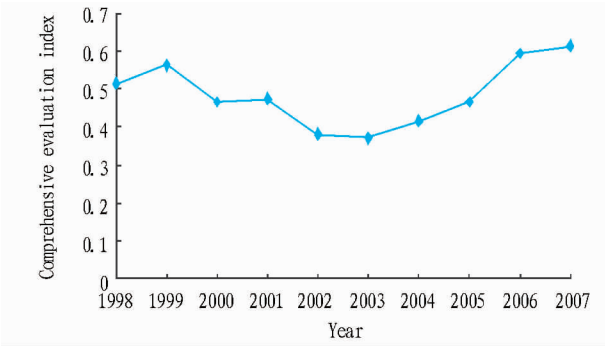

Fig. 1 Result of comprehensive evaluation of development of agricultural circular economy of Hunan Province

that the evaluation index of socio-economic development, on the whole, tends to rise, with average annual growth rate of 12%, much higher than the overall agricultural development rate of 1.89% of agricultural circular economy, and especially after 2003, the average annual growth rate is up to 48%. This will promote rapid development of the agricultural circular economy.

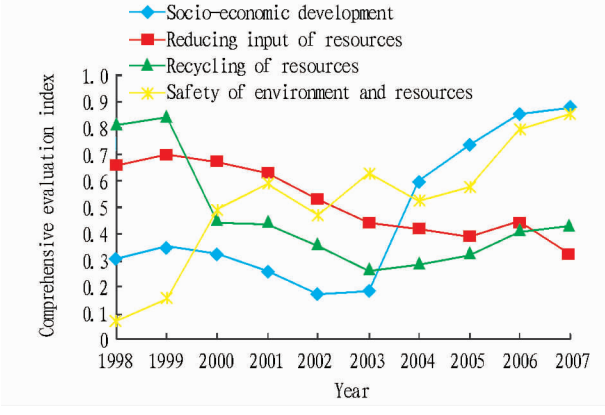

Fig. 2 Classified evaluation indices of development of agricultural circular economy of Hunan Province

2.2.2 Index of safety of environment and resources. In recent years, the awareness of environmental protection of resident increases and the government also adopted a series of measures in order to protect the environment and promote sustainable development of agriculture. During this period, the index of safety of environment and resources, on the whole, shows an upward trend, with average annual growth rate of 31%, 16 times the rate of development of agricultural circular economy. Safety of resources and environment has become the positive factor promoting rapid and dramatic development of agricultural circular economy in Hunan.

2.2.3 Index of reducing input of resources. Study finds that being that people's awareness of resource conservation is weak and they are impacted by traditional modes of agricultural production, the index of reducing input of resources decreases year by year, except that of 1999. The index of reducing input of resources decreased from 0.70 in 1999 to 0.31 in 2007, with average annual decline rate of 8%, 1% bigger than average annual decline rate of the index of recycling of resources. The index of reducing input of resources has become the principal factor impeding development of agricultural circular economy in Hunan.

2.2.4 Index of recycling of resources. Long-term traditional mode of agricultural economic development makes people form the habit of "mass production, mass consumption, and mass waste", coupled with backward effective use of resources recycling technologies, which ultimately leads to the low efficient use rate of resources and low level of recycling. Fig. 2 shows that the index of recycling of resources decreased greatly from 1999 to 2003, with average annual decline rate of 7%. Although after 2003, the index of recycling of resources changes from fall to rise, its growth rate is slow, so the index of recycling of resources has become the second biggest factor impeding development of agricultural circular economy in Hunan.

3 Conclusion

Firstly, the developmental level of Hunan agricultural circular economy, on the whole, tended to rise from 1998 to 2007, with average annual growth rate of 1.89%. It can be divided into three stages generally. At the first stage (1998 – 1999), due to the positive role of socio-economic development, reducing input of resources, recycling of resources and safety of environment and resources, the development of agricultural circular economy in Hunan is rapid; at the second stage (1999 – 2003), it is a decline stage. During this period, the reducing input of resources and recycling of resources with average annual decline rate of 25% and 11% respectively make developmental level of agricultural circular economy fall year by year; at the third stage (2003 – 2007), it is an upswing stage. Due to the rapid growth of socio-economic and safety of environment and resources, coupled with the change of recycling of resources from negative growth to positive growth, the agricultural circular economic development level changes from fall to rise. In a nutshell, Hunan agricultural circular economy develops for the better.

Secondly, in the light of development of 4 chains of agricultural production, the evaluation index of socio-economic development and the index of safety of environment and resources, on the whole, tend to rise rapidly, with annual growth rate of 12% and 31% respectively, far higher than the rate of agricultural circular economic development. The evaluation index of socio-economic development and the index of safety of environment and resources have the positive factors promoting development of agricultural circular economy and people's life standard in Hunan Province, and play the significant role in promoting development of agricultural circular economy; the developmental level of recycling of resources, on the whole, is low, and it declined year by year from 1999 to 2003, with average annual decline rate of 7%. But after the year 2003, the index of recycling of resources changes from negative growth to positive change, with growth rate of 14%. The index of recycling of resources is developing for the better; the index of reducing input of resources has a tendency of decline after the year 1999, with average annual decline rate of 9%, which has become the most principal factor that puts sand in the wheels of development of agricultural circular economy in Hunan Province.

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ucts. Except for the competitive advantages of resources endowment, irrigation degree and road construction level in Guangxi are both far higher than the national level. The improved irrigation facilities, and highway, railroad, shipping and other transportation facilities can promote the sales of agricultural products, improve the living conditions of farmers, and enhance the extension of characteristic agricultural industry chain in Guangxi Zhuang Autonomous Region.

According to the competitive disadvantages, a stable growth mechanism of the investment in agricultural science and technology has not yet formed in Guangxi. And there is a serious shortage in the overall investment. The Three Funds allocated by the provincial government is far lower than the national average. And the proportion and total amount the Three Funds allocated by the provincial government for agricultural scientific research are also the lowest in China. Agricultural research investment intensity of Guangxi is lower than the national level and the average value of the research investment intensity of all industries in the whole region. Financial expenditure on agriculture and the national financial investment are both lower than other provinces. Moreover, cultural quality of agricultural labor forces in Guangxi is generally poor. For instance, among the people at the age of six and above, proportions of people graduated from primary school and middle school are the highest, which are both higher than 80%. And most of these people live in rural areas. At the same time, mechanization level of Guangxi is far lower than the national level, which leads to the competitive disadvantages in the agricultural scale management in Guangxi. Although the agricultural industrialization leading enterprises and the peasant specialized cooperatives have developed rapidly in recent years, their qualities are poor and the scale of leading enterprises is small. For instance, there are only 7 enterprises having more than 1 billion yuan of annual sales volume. And peasant specialized cooperatives have the disadvantages of funds shortage, loan difficulties, small scale, relatively low organization degree, few management talents, and highly irregular internal management.

Therefore, in order to enhance the competitiveness of characteristic agriculture, Guangxi Zhuang Autonomous Region of China should, on the one hand, improve its irrigation facilities, and highway, railroad, and shipping facilities, strengthen the competitive advantages in cane, jute and kenaf, mulberry cocoon, turpentine and other agricultural and forest products. On the other hand, Guangxi should form a growth mechanism for the agricultural science and technology investment, increase the total investment quantity, reinforce the technical training and overall quality training of agricultural labor forces by the mode of agricultural extension, support the agricultural industrialization leading enterprises and the peasant specialized cooperatives from the aspects of finance and taxation, and expand the scale and improve the quality of agricultural industrialization leading enterprises and the peasant specialized cooperatives.

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