Yield of Agricultural Eco-economic System in Dongting Rim

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Abstract To analyze the efficiency of the agro-ecosystem of Dongting Rim in Hunan Province, this paper adopted the emergy theory to study the agricultural output of this region during 2001 to 2010. The results showed that the value of regional agricultural emergy output increased by 44.68% to (6.50 E) sej, but lower than the growth of non-agricultural industry output. Compared with 2001, the emergy output of planting industry was (4.10E) sej in 2010 which occupied 63.09% of the total agricultural emergy output and got an increase of 2.93 percentage points, while the emergy output of stock farming got a decrease of 2.87 percentage points. The growth of fishery emergy output was not in conformity with the characteristics of Dongting Rim in Hunan. From the contrast between emergy output and economic output, we could find that the economic return ratio of planting industry and fishery industry were lower than those of forestry industry and stock farming industry, which indicated that it is necessary to improve the economic benefits of planting industry and fishery industry which were the traditional industries with advantages of the Dongting Rim in Hunan.

Key words Dongting Rim, Agricultural eco-economic system, Emergy yield, Economic output, Structural adjustment

1 Introduction

Hunan Dongting Rim is a major agricultural main producing area in Hunan Province and even the whole country. From 2011, the Hunan provincial government decided to strengthen the construction of Dongting Rim Ecological Economic Zone, and endeavor to make Dongting Lake area into the national strategic level. In late 2011, the formulation of Dongting Lake Ecological Economic Zone Development Plan was carried out. The data from Hunan Statistical Yearbook 2011 show that the area of Hunan Dongting Rim accounts for 20% of land area of Hunan Province; the permanent population accounts for 24.69% of the province's total population; GDP accounts for 21.89% of the provincial GDP, and agricultural output value accounts for 31.47% of that of the province. So, from area, population, agricultural output value and other indicators, Dongting Rim is an important area worthy of further research for Hunan's economic and social development, the construction of new industrialization, agricultural modernization, new urbanization, informatization, resource-conserving and environmentally friendly strategy, and solving issues concerning agriculture, countryside and farmers. In this study, we use the theoretical methods of emergy to analyze the emergy yield of agricultural eco-economic system in Hunan Dongting Rim during the period 2001 - 2010, and compare it with the agricultural economic output to analyze the characteristics and development trend of agricultural output, to provide new ideas for the industrial structural adjustment of agricultural eco-economic system in Hunan Dongting Rim.

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2 Literature review

2.1 Theory of emergy With the thorough implementation of the concept of sustainable development worldwide, people have a new understanding of the relationship between socio-economic development and environment. Energy can be used to express and understand the relationship between life and the environment, between human socio-economic development and nature. However, different types of energy have different qualities, and it is difficult to directly compare them; the general energy units can not compare and measure the relationship between socio-economic development and environment[1-2]. Many of the theories and methods can not effectively solve the energy comparison between different systems. The founding of emergy theory makes the energy research develop into emergy research, achieving a major leap in terms of theory and methods[3]. It provides a common scale to measure and compare various types of energy, for the quantitative analysis of the real value of social and economic activities and the relationship between socio-economic development and environment. Emergy analysis provides a more direct way to quantify the system's various inputs and outputs[4]. And rigorous economic analysis can not measure the value of ecosystem services[5]. Currently, the emergy theory and analysis have made many pioneering achievements[6-8], and there are hundreds of published books on emergy study, involving ecosystems, alternative technologies, information, species, environmental impact, nation, causation in the history and other research fields[9], some of which are applied to agricultural production systems[10-12]. It has scientific research methods and extensive application prospects of interdisciplinary research, so the theory becomes a widely used analysis paradigm with obvious advantages and effects. Lan Shengfang is a famous scholar studying and using emergy theory at home, who introduces the international relevant theories, methods and results on emergy

to China; his monograph emergy Analysis of Eco-economic System[13] makes a further comprehensive and systematic introduction of emergy analysis theory, making an important contribution to the Chinese theory and practice on emergy. Subsequently, more scholars on ecology, economics and other aspects in China began to participate in the emergy theory research. Currently, domestic scholars mainly apply emergy theory to farmland (farming) ecosystems, some specific ecosystems, economic systems, natural-social-economic complex ecosystem, emergy theory and methods and other fields. And they have made many important research results. For the research of Hunan's agricultural ecosystems, Zhou Jian, *et al*[14] uses emergy theory to conduct quantitative research on Hunan's overall ecological and economic system in 2004, and put forth the corresponding measures for the sustainable development of eco-economic system in Hunan Province. Zou Jinling, *et al*[15] make a quantitative analysis of the total emergy input during the development of the agricultural economy in Huaihua City in 2005, and the results show that the calculated growth results of the traditional agricultural GDP are too high in Huaihua City. Zhu Yulin, *et al*[16] use emergy theory to conduct research from the perspective of sustainable development, and believe that Hunan's agricultural ecosystem has the obvious characteristics of high consumption and extensive development.

2.2 Study of agricultural and ecological development in the Dongting Lake area Liu Xinping, *et al*[17] expound the characteristics of resources and environment in the Dongting Lake area, analyze the regional eco-economic issues concerning agricultural development, and set forth the strategy and approach for comprehensive agricultural development. According to the characteristics of Dongting Lake, He Jianlin, *et al*[18] analyze the impact of the construction of the Three Gorges Project on Dongting Lake, and analyze the evolution trends of agricultural production conditions in the Dongting Lake area after the construction of the dam. Zhang Xi[19] analyzes the ecological characteristics of agricultural operation in the Dongting Lake area, and believes that it is necessary to choose the path of agricultural operation in the Dongting Lake area, under the principles of not only developing agricultural economy, but also maintaining the ecological balance. Peng Peiqin *et al*[20] propose the sustainable agricultural development mode of embankment agriculture based on the existing experience. Yang Xinrong[21] holds that accelerating the comprehensive management of agriculture and the development of efficient ecological agriculture in the Dongting Lake area, has become a top priority of economic revitalization in the area. Xu Lianfang, *et al*[22] use AHP, GIS technology and "agro-ecological insecurity index", to carry out a comprehensive evaluation of agricultural ecological security in the Dongting Lake area, and the results show that the declining lake's flood storage function, increased threat of floods, serious soil erosion and deteriorating environmental pollution are the main problems facing the agricultural ecological security in the Dongting Lake area. Dong Lisan[23] believes that the lake area is greatly influenced by the mechanical changes in the newcomers, thereby affecting the agricultural development process; the changes of villages and towns in the lake area, are closely linked to agricultural economic development in the lake area, and these places are gradually developed into small cities, collecting and distributing centers of agricultural and sideline products, and thus developed into larger cities; the development of transport industry is closely related to the ups and downs of agricultural production. Li Mingxian[24] proposes constructing large-scale and high-standard national modern agriculture demonstration zone playing a leading role in the Dongting Lake area, which is conducive to promoting the transformation of agricultural development pattern, and of great significance to regional food security, Hunan's food security, and even national food security. Liao Yi *et al*[25] take the variables of total power of agricultural machinery, crop acreage, machine-ploughed area and application rate of chemical fertilizer to build multiple linear regression model, and analyze the factors influencing total agricultural output value in the Dongting Lake area during the period 1986 – 2008; the results show that for each additional percentage point in total power of agricultural machinery, machine-ploughed area and application rate of chemical fertilizer, the agricultural output value will be increased by 1.17%, 0.83%, 0.40%, respectively, while the crop acreage has no obvious impact on the agricultural production in the lake area. From the above literature review, it can be found that the scholars have carried out in-depth study of agricultural development and ecological construction in the Dongting Rim with their own particular emphases. However, these studies fail to effectively combine ecology with economy closely in Dongting Rim, and they do not truly reflect the relationship between the ecological and economic values.

3 The study areas, research methods and data

3.1 The study areas Geographically, the Dongting Lake area crosses Hunan Province and Hubei Province. According to Dongting Lake Ecological Economic Zone Development Plan, Hunan section of Dongting Lake includes Yiyang City (Ziyang District, Heshan District, Nan County, Datonghu District, Taojiang County, Anhua County and Yuanjiang City), Yueyang City (Yueyanglou District, Yunxi District, Yueyang County, Huarong County, Xiangyin County, Pingjiang County, Miluo City and Linxiang City), Changde City (Wuling District, Dingcheng District, Anxiang County, Hanshou County, Li County, Linli County, Taoyuan County, Shimen County and Jinshi City), and Changsha City (Wangcheng District); Hubei section of Dongting Lake includes Jingzhou City (Shashi District, Jingzhou District, Honghu City, Jiangling County, Shishou City, Jianli County, Songzi City and Gong'an County). The main study areas are the areas under the jurisdiction of Dongting Rim, namely Yiyang City, Yueyang City, Changde City, and Wangcheng District of Changsha City.

Dongting Rim has a subtropical monsoon climate, with mild climate and abundant rainfall; the annual average temperature is 16.4 – 17℃, the frost-free period is 258 to 275 d and the annual precipitation is 1300 – 1700 mm. The good weather conditions

suitable for crop growth, coupled with developed river net, fertile soil, and abundant natural resources in the lake area, make Dongting Rim become one of the major grain production bases, one of important domestic bases of pig, rapeseed oil, reeds, cotton, ramie and other commodities, and freshwater fishing base.

3.2 Research methods and data This study uses emergy theory and related methods to calculate the output of agricultural eco-economic system in Hunan Dongting Rim, namely to convert the agricultural output within the area into the emergy of solar energy that can be compared. The data in this article are mainly from Hunan Statistical Yearbook (2001 – 2011)[26], Hunan Yearbook (2001 – 2011)[27], namely the statistics since the Tenth Five-Year Plan period; another data are from Statistical Yearbook of Changde, Yiyang and Yueyang. There are many varieties yielded by agricultural eco-economic system in Hunan Dongting Rim, but the data on some small varieties are incomplete and inaccessible, such as honey, walnuts, rabbit, etc., with little impact on the output results. Therefore, this study does not to consider these small varieties. In addition, this study uses the energy conversion coefficient and calculation methods of Luo Shiming[28] and Agro-technical Economics Manual[29], and adopts the latest global emergy basis, emergy conversion rate and calculation method[30].

4 Results and analysis

4.1 Emergy yield results According to the above method and statistical data, the calculation results of emergy output of agricultural eco-economic system of Dongting Rim in Hunan Province during the period 2001 – 2010 are shown in Table 1. The energy conversion coefficient and energy conversion rate during the study period remain unchanged, so emergy yield actually reflects the yield of agricultural material object of this eco-economic system.

Table 1 Emergy output of agricultural eco-economic system of Dongting Rim in Hunan Province during the period 2001 – 2010 Unit : sej/yr

Items	Conversion rate of emergy	Emergy output									
		2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Total emergy output		4.49E+22	4.17E+22	4.44E+22	5.03E+22	5.30E+22	5.60E+22	5.82E+22	5.54E+22	6.25E+22	6.50E+22
Farming		2.70E+22	2.28E+22	2.49E+22	2.99E+22	3.03E+22	3.25E+22	3.37E+22	3.32E+22	3.95E+22	4.10E+22
Cereals	8.30E+04	8.76E+21	8.27E+21	8.35E+21	1.06E+22	1.11E+22	1.17E+22	1.20E+22	1.18E+22	1.27E+22	1.27E+22
Soybean	8.30E+04	1.18E+20	1.23E+20	1.23E+20	1.24E+20	1.22E+20	1.18E+20	1.24E+20	6.45E+19	8.89E+19	8.33E+19
Potato	8.30E+04	3.28E+20	3.76E+20	3.73E+20	3.68E+20	3.60E+20	3.83E+20	4.19E+20	1.84E+20	2.65E+20	2.61E+20
Cotton	1.90E+06	6.05E+20	4.92E+20	5.91E+20	6.29E+20	5.68E+20	6.39E+20	7.65E+20	8.16E+20	7.99E+20	9.18E+20
Oil crops	6.90E+05	1.64E+22	1.27E+22	1.45E+22	1.72E+22	1.70E+22	1.85E+22	1.91E+22	1.90E+22	2.42E+22	2.56E+22
Hibiscus cannabinus	8.30E+04	2.33E+18	5.57E+18	4.90E+18	7.43E+17	5.41E+17	5.41E+17	5.48E+17	6.28E+17	5.48E+17	5.49E+17
Ramie	8.30E+04	1.15E+20	1.63E+20	1.59E+20	1.52E+20	1.66E+20	1.76E+20	1.73E+20	1.37E+20	1.57E+20	7.81E+19
Tobacco	2.70E+04	2.80E+17	2.96E+17	3.41E+17	3.32E+17	3.83E+17	4.12E+17	3.87E+17	1.79E+17	3.21E+17	2.91E+17
Tea	2.00E+05	8.95E+19	9.53E+19	9.32E+19	1.02E+20	1.05E+20	1.09E+20	1.26E+20	1.28E+20	1.39E+20	1.62E+20
Citrus	5.30E+05	6.18E+20	5.50E+20	6.94E+20	7.72E+20	7.82E+20	9.69E+20	9.92E+20	1.09E+21	1.14E+21	1.21E+21
Animal husbandry		9.33E+21	9.82E+21	9.97E+21	1.05E+22	1.13E+22	1.16E+22	1.20E+22	1.08E+22	1.12E+22	1.16E+22
Pork	1.70E+06	8.25E+21	8.68E+21	8.79E+21	9.24E+21	9.92E+21	1.01E+22	1.05E+22	9.71E+21	1.01E+22	1.03E+22
Beef	4.00E+06	6.73E+20	7.15E+20	7.36E+20	8.03E+20	8.80E+20	9.84E+20	1.01E+21	7.14E+20	7.64E+20	8.91E+20
Lamb	2.00E+06	4.01E+20	4.34E+20	4.52E+20	4.67E+20	5.03E+20	5.13E+20	5.28E+20	3.76E+20	3.61E+20	3.77E+20
Forestry		9.67E+20	9.90E+20	8.35E+20	5.49E+20	1.34E+21	1.06E+21	1.07E+21	1.09E+21	9.63E+20	1.13E+21
Timber	4.40E+04	3.53E+20	3.18E+20	4.46E+20	8.28E+19	7.12E+20	6.00E+20	6.77E+20	6.49E+20	4.97E+20	6.70E+20
Bamboo	4.40E+04	3.95E+20	4.43E+20	1.59E+20	2.41E+20	4.23E+20	2.22E+20	1.31E+20	1.15E+20	1.69E+20	1.97E+20
Camellia seed	8.60E+04	1.25E+20	1.31E+20	1.26E+20	1.10E+20	1.05E+20	1.56E+20	1.57E+20	1.95E+20	1.60E+20	1.57E+20
Tung tree seeds	6.90E+05	7.51E+19	7.39E+19	8.59E+19	9.40E+19	7.00E+19	6.22E+19	6.30E+19	6.49E+19	3.68E+19	4.07E+19
Turpentine	8.60E+04	4.28E+18	4.90E+18	3.76E+18	2.70E+18	2.00E+18	2.58E+18	1.85E+18	6.04E+18	6.35E+18	1.55E+18
Chestnut	8.60E+04	8.20E+18	1.22E+19	1.09E+19	1.53E+19	1.16E+19	1.64E+19	3.11E+19	2.85E+19	4.82E+19	3.90E+19
Dried bamboo shoots	8.60E+04	5.99E+18	6.71E+18	2.46E+18	2.46E+18	2.03E+19	2.84E+18	6.53E+18	2.97E+19	4.52E+19	2.91E+19
Fishery		7.60E+21	8.12E+21	8.61E+21	9.25E+21	1.01E+22	1.08E+22	1.14E+22	1.03E+22	1.09E+22	1.12E+22
Aquatic products	2.00E+06	7.60E+21	8.12E+21	8.61E+21	9.25E+21	1.01E+22	1.08E+22	1.14E+22	1.03E+22	1.09E+22	1.12E+22

Note: The data are calculated based on the statistics from *Hunan Statistical Yearbook* (2001 – 2011), and *Hunan Yearbook* (2001 – 2011); in accordance with caliber of *Hunan Statistical Yearbook*, food includes rice, wheat, potatoes, cereals (such as maize), soybeans *etc.*

4.2 Result analysis

4.2.1 Total emergy yield. As can be seen from Fig. 1, the total emergy yield of agriculture in this eco-economic system shows a rising trend, increasing from 4.49E + 22 sej in 2001 to 6.50E + 22 sej in 2010, an increase of 44.68%. During this decade, to achieve the average annual compound growth rate of 3.76% was very rare. During this period, the industrialization and urbanization in Hunan Province were accelerated (not just the transfer of rural surplus labor force, but also the transfer of more agricultural young labor to non-agricultural industries), and achieving this growth rate is mainly driven by the policy. First, the government paid more attention to the position of agriculture and food security,

and increased financial input to agricultural production; second, the government let go of the grain purchase price, so that the price difference between agricultural and industrial goods was narrowed; third, the government abolished agricultural taxes, and increased agricultural subsidies. These policies largely stabilize and promote agricultural production. From the inside of agriculture, farming, animal husbandry, forestry and fishery all experienced a certain level of positive growth during the study period (see Table 1 and Fig. 1). It can also be found from Fig. 1 that there were fluctuations in total emergy yield of agriculture in some years, such 2002 and 2008, and the decline in emergy yield in 2008 was mainly caused by the impact of financial crisis on all industries. However, after 1 year of adjustment or so, it rebounded. During the study period, the growth rate of farming was 51.71%, and farming was one growing fastest in the four sub-industries, increasing from 2.70E+22 sej in 2001 to 4.10E+22 sej in 2010; the growth rate of fishery was 47.92%, increasing from 7.60E+21sej in 2001 to 1.12E+22 sej in 2010, also higher than the growth rate of agriculture as a whole; although the emergy yield of animal husbandry and forestry achieved positive growth, the growth rate (24.50% and 17.38%) was lower than the growth rate of agriculture as a whole. There are a variety of reasons for such imbalance in the growth rate, but it is mainly from policy factors. For example, liberalization and steady growth of food purchase price, remission of agricultural tax, and a variety of agricultural subsidies, played a stabilizing and facilitating role for farming development. And based on ecological protection reasons, the policy also encouraged the development of forestry. But for reasons of ecological protection areas, the felling of forest products was regulated, that is, more forestry output was not reflected in the year. Therefore, this emergy yield calculated based on the amount of forest harvesting has some limitations. However, for Dongting Rim primary based on farming, animal husbandry and fishery, this method of calculation does not lead to large deviation. In addition, the emergy yield of animal husbandry is close to that of fishery, nearly showing a state of overlap in Fig. 1.

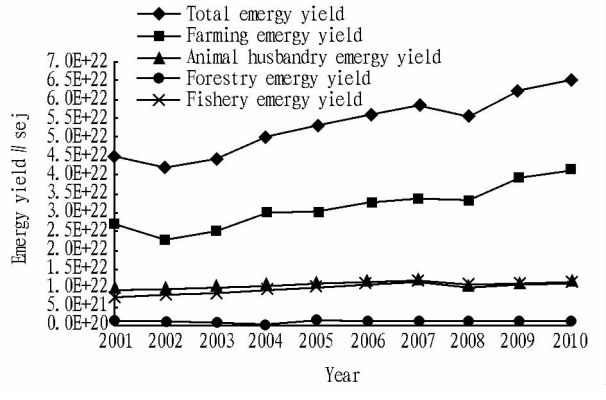

Fig. 1 Total emergy yield of agricultural eco-economic system of Dongting Rim in Hunan Province

4.2.2 Emergy yield structure. It can be inferred from the above analysis that due to the different growth rates, since 2001, the proportion of emergy yield of farming, animal husbandry and forestry and fishery to agricultural emergy yield has experienced certain changes. Fig. 2 shows the changes in the proportion of emergy yield of these four industries to total agricultural emergy yield. The proportion of farming increased from 61.16% in 2001 to 63.09% in 2010, an increase of nearly 3 percentage points; the proportion of fishery increased from 16.92% in 2001 to 17.30% in 2010, an increase of nearly 0.42 percentage points; animal husbandry and forestry showed varying degrees of decline, from 20.76% to 17.87% and from 2.15% to 1.75%, a decrease of 2.89 percentage points and 0.40 percentage points, respectively. Therefore, during the study period, the growth rate of ratio of emergy yield of various industries to total agricultural emergy yield is as follows: farming (4.86%), fisheries (2.24%), livestock (−13.95%) and forestry (−18.87%). It is consistent with the growth rate of total industrial emergy yield analyzed above. There are many reasons for the above emergy yield structure, and the policy factors are most important. Dongting Rim is regarded as China's major grain production base, whose basic function is to provide grain and oil. Thus, the policy measures must first ensure the steady growth of the grain and oil output. A large number of rural labor forces are transferred to non-agricultural industries, but the aforementioned policy has played an important role in stabilizing the grain and oil production. During the study period, in terms of both total production and proportion, the fishery ranked second, but this increase was somewhat unexpected, because there are some factors affecting fishery production: continuing decline of Dongting Lake water area; straight discharge of industrial waste water without purification, and a lot of schistosomiasis snail drugs which can affect fishery production; fish migration channels blocked by the embankment blocking the lake and river; excessive fishing so that some rare species almost extinct. Another important reason is the slight rise in the overall price of fishery. In addition, since 2001, the prices of grass carp and other major varieties have risen less than 20%, well below the rise of grain and pork prices. Over the same period, the rise of prices of livestock products such as pork is mostly offset by higher feed prices, and the sharp fluctuations in pork prices do not bring benefits to farming households. Therefore, the growth rate of emergy yield of animal husbandry and its proportion are also not in line with expectations, and the proportion falls by 2.89 percentage points.

4.2.3 Emergy yield of major agricultural products. It can be found from Fig. 3 that the single varieties with the proportion of emergy yield more than 5% in this agricultural eco-economic system only include cereal, oilseed, pork and aquatic products. In 2001, it accounted for 91.28% and this proportion was increased to 92.12% in 2010. Therefore, the degree of concentration of agriculture emergy yield in this region is very high.

From the ratio of emergy yield of the above four varieties to total emergy yield, oilseed always remains high, and the growth of farming emergy yield is mainly from oilseed. Other three varieties increased significantly in 2002, and the percentage of oilseed ex-

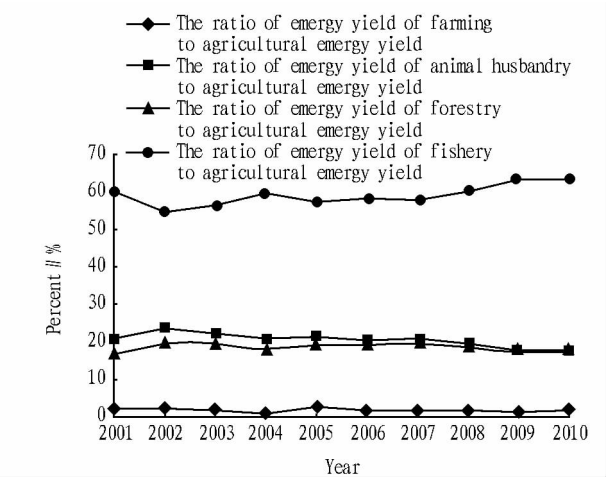

Fig. 2 The emergy yield structure of agricultural eco-economic system in Hunan Dongting Rim

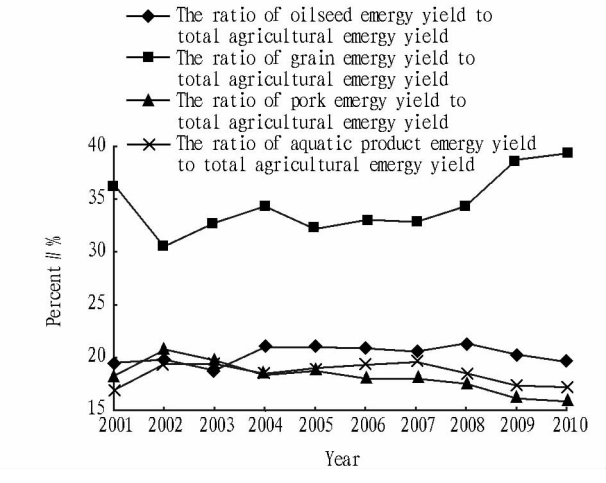

Fig. 3 The ratio of major agricultural products' emergy yield to the total emergy yield of agricultural eco-economic system of Dongting Rim in Hunan Province

perienced a substantial decline in 2002, followed by an upward trend in 2010 reaching 39.34%. During the study period, the ratio on cereal was close to 20%; the ratio on aquatic products increased by 0.38 percent, 17.30% in 2010; the ratio on pork fell by 3.45 percentage points, 15.92% in 2010.

5 Comparison between emergy yield and economic output of agricultural eco-economic system in Hunan Dongting Rim

5.1 The growth rate of agricultural yield is lower than that of non-agricultural industries In 2010, the emergy yield of agricultural eco-economic system in Hunan Dongting Rim increased by 44.68% over 2001. According to the economic data of Hunan Statistical Yearbook in the same period, the total agricultural output of this eco-economic system increased 149.46%. Emergy reflects the total yield of material unrelated to price factors within a system, measured by the standard units, so the growth rate of material reflected by emergy is much lower than that of economic output based on price calculation. Difference between the two reflects the magnitude of price changes over the same period. Therefore, the agricultural price index rose by 72.42% over the same period. The total output of the whole society in Hunan Dongting Rim based on currency accounting over the same period grew by 264.33%, and excluding the price rise factors, the growth rate of material output is about 1.5 times. This rate is much higher than the growth rate of agricultural material based on emergy (44.68%). It also reflects that in the process of accelerated industrialization, the growth rate of agricultural output is lower than that of non-agricultural industries in Hunan Dongting Rim, which leads to the dwindling share of the primary industry in the national economy.

5.2 The economic benefits of traditional competitive industries are not obvious From the perspectives of emergy accounting and economic accounting, Table 2 calculates the changes in the proportion of each industry within agriculture during the study period. Fig. 4 shows the trends of changes in the ratio of output value of agricultural industries to total agricultural output value during the study period (Fig. 2 reflects the ratio of emergy of agricultural industries to total agricultural emergy). From Table 2, Fig. 2, 4, we can find that there is a big difference in the two kinds of calculation results.

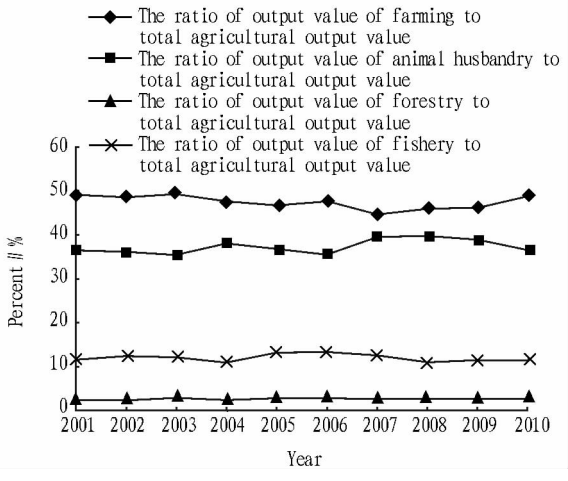

Fig. 4 The ratio of output value of industries within agriculture to total agricultural output value in Hunan Dongting Rim

5.2.1 From the perspective of emergy accounting. In the late period, there are changes in the proportion to some extent, and during the study period, farming accounts for about 60%. From the perspective of economic accounting, in the late period, the magnitude of change in the proportion is smaller than the magnitude of change in emergy accounting, and there is no industry with proportion more than 50%.

5.2.2 From the comparison between emergy yield and economic output. It can be found that farming emergy accounts for about 60%, but the economic value accounts for less than 50%, indicating that the farming output is "worthless", and fishery is also similar. The share of forestry and animal husbandry emergy is less than the share of economic value, indicating that the output of the

two industries is "valuable", belonging to the industry with high yield. From the ratio based on emergy accounting and economic accounting (B/A in Table 2), farming ratio and fishing ratio are far smaller than 1, while forestry ratio and animal husbandry ratio are far bigger than 1. The emergy yield of animal husbandry in 2010 dropped by 3 percentage points over 2001, but the economic output basically remained unchanged, indicating that the relative price increased, ie the B/A value increased.

Table 2 Emergy accounting and economic accounting of agricultural eco-economic system in Hunan Dongting Rim and the comparative analysis between the two

Accounting items		2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Emergy accounting (A)	Farming ratio	60.16	54.64	56.21	59.59	57.14	58.15	57.82	60.00	63.13	63.09
	Animal husbandry ratio	20.76	23.54	22.49	20.92	21.34	20.68	20.69	19.50	17.94	17.87
	Forestry ratio	2.15	2.37	1.88	1.09	2.54	1.90	1.83	1.96	1.54	1.75
	Fishery ratio	16.92	19.46	19.42	18.40	18.98	19.27	19.65	18.54	17.39	17.30
Economic accounting(B)	Farming ratio	49.40	48.69	49.35	47.93	46.90	47.96	44.80	46.06	46.31	48.89
	Animal husbandry ratio	36.70	36.29	35.41	38.06	37.03	35.57	39.71	40.10	39.18	36.57
	Forestry ratio	2.29	2.52	3.04	2.75	2.95	2.90	2.77	2.60	2.71	2.72
	Fishery ratio	11.60	12.49	12.21	11.26	13.12	13.57	12.73	11.25	11.80	11.82
B/A	Farming	0.82	0.89	0.88	0.80	0.82	0.82	0.77	0.77	0.73	0.77
	Animal husbandry	1.77	1.54	1.57	1.82	1.74	1.72	1.92	2.06	2.18	2.05
	Forestry	1.07	1.06	1.61	2.52	1.16	1.53	1.51	1.32	1.76	1.56
	Fishery	0.69	0.64	0.63	0.61	0.69	0.70	0.65	0.61	0.68	0.68

5.2.3 More importantly, from the ratio of based on emergy accounting and economic accounting (B/A). Farming is in the trend of "devaluation", and its ratio decreases, indicating that the prices of farming output are in a relatively unfavorable position in the whole national economic price system. The prices of fishery output are in a stable state, while the output of forestry and animal husbandry shows a trend of "appreciation", because B/A value shows a rising trend. Therefore, the traditional competitive industries, farming and fishery, in agricultural eco-economic system of Hunan Dongting Rim, do not continue to play to their strengths.

6 Conclusions

In this study, using the emergy theory, we calculate the agricultural output of agricultural eco-economic system in Hunan Dongting Rim. The results show that the emergy yield of agriculture in this region grows to some extent, but considering economic output accounting and deducting the price factors, the growth rate of agricultural output is slower than that of output of non-agricultural industries (or national economy). This partly reflects that during the acceleration of industrialization in Hunan Dongting Rim, the growth rate of agriculture is slower than that of national economy, which leads to the continuous decline in its share in the national economy. In terms of both total production and proportion, the fishery ranks second, but this increase is somewhat unexpected, because there are some factors affecting fishery production; the concentration of agricultural emergy yield is very high, mainly concentrated in cereal, oilseed , pork and aquatic products. From comparison between emergy yield and economic output of agricultural eco-economic system in Hunan Dongting Rim, the emergy of farming and fishery occupies a high proportion, but the economic value occupies a low proportion; the emergy of forestry and animal husbandry occupies a low proportion, but the economic value occupies a high proportion. This shows that the economic rate of return of farming and fishery is lower than that of forestry and animal husbandry. Especially from the ratio of the proportion based on economic accounting and emergy accounting, farming and fishery are the "devaluation" industry, while the output of forestry and animal husbandry shows a trend of "appreciation".

Through the study, it is found that there are certain differences between the emergy yield and the economic output of this agricultural eco-economic system. Emergy yield reflects the real objective output of agricultural ecosystem in this region, and economic output based on emergy yield reflects the status of agriculture in the national economy, which is closely related to the entire economic and social system. Therefore, emergy yield illustrates the actual development of agricultural output of agricultural eco-economic system in Hunan Dongting Rim (including the total amount and structure), and the economic output to a certain extent explains the reason for changes in the output structure of agriculture in this region. Through the comparative analysis of emergy yield and economic output, this study effectively reveals the development characteristics and trend of agricultural output of agricultural eco-economic system in Hunan Dongting Rim.

7 Discussions

Hunan Dongting Rim is regarded as the main producing area of grain, oil and aquatic products, and agricultural eco-economic system is of great significance to Hunan's economic and social development, construction of "four modernizations and two types", "Four Hunans", and solving the issues concerning agriculture, countryside and farmers. However, this study finds that in the process of industrialization, the agricultural output growth rate of agricultural eco-economic system in Hunan Dongting Rim is much lower than the growth rate of non-agricultural industries, unable to maintain the traditional agricultural comparative advantage. The reason is that the low efficiency of ecological output of agriculture is very low, and the economic benefits are not obvious, making Hunan Dongting Rim pays more attention to the development of non-agricultural industries. How to effectively promote the agricultural ecological output and economic output of agricultural eco-e-

conomic system in Hunan Dongting Rim, and achieve the optimization and adjustment of agricultural structure, is a problem that this system needs to carefully address. This study suggests that based on food security, economic development, ecological protection and other objectives, the industrial structural adjustment of agricultural eco-economic system and the improvement of output efficiency in Hunan Dongting Rim need to consider the following aspects:

(i) How to promote the development of grain and oil, aquaculture and other traditional industries? There is a need to continue to improve the purchase price of farming products, especially grain, so that the yield of farming is gradually increased, to stabilize the enthusiasm of farmers to grow grain; increase farming subsidies, and bridge the price gap between agricultural and industrial products; encourage the paid circulation of land, and encourage the scale operation of farming; strengthen the governance of the lake area, improve the structure of aquatic products, and increase the added value of aquatic products.

(ii) How to promote diversified operation of agriculture, and focus on the development of animal husbandry and other industries with obvious economic benefits? It is necessary to guide and support the large-scale characteristic industries, and diversified production; pay attention to market signals, and guide farmers to avoid the risk of price fluctuations in meat.

(iii) How to build the interest compensation mechanism in the major grain producing areas, to restore and maintain the advantages of the traditional industries and their role in national economic development, and ensure national food security? It is necessary to establish the interest compensation mechanism in the major grain producing areas. On the one hand, it can help to protect the farmers' agricultural production income in Hunan Dongting Rim; one the other hand, it can also help to increase investment in the infrastructure of agricultural production, and improve the level of agricultural mechanization within the region, to provide better hardware facility for food production. Of course, under the strong force of market mechanism, it needs some effective policy measures and adequate government financial resources, in order to effectively reverse the current production situation of neglecting agriculture (especially farming) in agricultural eco-economic system of Hunan Dongting Rim.

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