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Assessment on the Eco-environment and the Land Use Based on the Ecosystem Service Value

—A Case of Guangdong Province, China

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Abstract Based on the previous research and the 1996 and 2008 land use change survey, land use type of Guangdong Province is divided into 10 types of farmland, garden plot, woodland, grassland, residential points and other construction sites, traffic and transmission land, land for water conservancy facilities, wetland, water area, and land hard to be utilized. Then, area change and annual changing rate of land use type in Guangdong Province are calculated by the analysis method of land use change. Based on this, ecosystem service value assessment method is used to discuss the variation of ecosystem service value in Guangdong Province. Result shows that ecosystem service value of land use shows a decreasing trend in Guangdong Province, having reduced from 635 036 billion yuan in the year 1996 to 632 394 billion yuan in the year 2008. Ecosystem service value has reduced by 2 642 billion yuan, a reduction rate of only 0.416 1%. Farmland, woodland, grassland, wetland, land for water conservancy facilities, and unused land have all reduced. But garden plot, traffic and transmission land, water area, and residential point and other construction site have increased. The major characteristics of land use change the years 1996–2008 in Guangdong Province are the internal adjustment of agricultural structure and the increase of construction land. Land use change and adjustment direction are basically rational and the ecological environment is stable.

Key words Land-use change, Ecosystem service value, Guangdong Province, China

Ecosystem service refers to the conditions and processes that can meet and maintain human needs provided by natural ecosystem and its species. Ouyang Zhiyun, Wang Rusong *et al.* summarized the conception of ecosystem service, that is, the natural environmental conditions and utility for the subsistence of the mankind formed and maintained by ecosystem and ecological process^[1–3]. Land use/ land cover change determines the service function of ecosystem through changing the structure and function of ecosystem^[4–6]. Quantitative evaluation on the land use result based on ecosystem service value is of great significance to master the ecological benefits of land use, to make land use policy, to scientifically prepare the land use overall plan, to optimize land use structure and layout, and to realize the sustainable use of land resources.

1 General situation of the research area

Guangdong Province is located in the southern China, connecting the South China Sea in the south, Guangxi Autonomous Region in the west, Hunan and Jiangxi Provinces in the north, and Fujiang Province in the east. Hainan Province and Leizhou Peninsula in southwest Guangdong are located in the two sides of the Qiongzhou Strait. Guangdong Province (20°07′–25°31′N, 109°26′–117°20′E) currently has jurisdiction over 21 prefecture-level cities, 33 county-level cities, 43 counties, 3 autonomous counties, 42 municipal districts, and 1 588 towns (villages). In the year 1996, total population of the whole province is 69 610 thousand with 30.6% urbanization level, 651 914 million yuan GDP, per capita GDP of 9 365

yuan, population density of 384 people per square kilogram on average. In the year 2008, population of Guangdong Province reaches 95 440 thousand, with 63.4% urbanization level, population density of 526 people per square kilogram on average, 3 569 646 million yuan GDP, and per capita GDP of 374 010 thousand yuan, which has basically reached the level of moderately developed countries.

2 Data source and research method

2.1 Data source and treatment method Data are from the 1996 and 2008 land use change survey^[7–8]. In the undigested change data, area of island and island beach is 11 333.26 hectares. According to the characteristics of ecosystem and land cover of land use type, statistic analysis on the three grades of land types combining with the meaning of land cover and the actual situation in Guangdong Province. Land use type of Guangdong Province is divided into 10 types of farmland, garden plot, woodland, grassland, residential points and other construction sites, traffic and transmission land, land for water conservancy facilities, wetland, water area, and land hard to be utilized. According to the actual situation of Guangdong Province, equivalent factor table of unit ecosystem service value is adjusted based on the research results of Gao Di *et al.*^[9–10]. In the table, woodland corresponds with forest; garden plot is the mean value of forest and grassland; and value of construction land is 0. Average yield of rice in Guangdong Province in the years 1996–2008 is taken as the reference unit yield; and national average market price in the years 1996–2008 is taken as the reference of unit grain price. Based on this, considering that the economic value of ecological system with no human input is 1/7 of the food production service value

of current per unit area of farmland, it is concluded that economic value of farmland natural grain yield is about 1 958.52 yuan per hectare in Guangdong Province^[11], which is taken as the benchmark unit price of different ecosystem service values.

Then, benchmark unit price is multiplied by equivalent factor table, the result of which is the ecosystem service value of the unit area land use type in Guangdong Province (Table 1).

Table 1 Ecosystem service value of the unit area land use type in Guangdong Province

yuan/hm²

Ecosystem service function	Farmland	Garden plot	Woodland	Grassland	Wetland	Water area	Land hard to be utilized
Gas regulation	979.26	4 210.82	6 854.82	1 566.82	3 525.34	0	0
Climate regulation	1 743.08	3 525.34	5 288.00	1 762.67	33 490.69	900.92	0
Water conservation	1 175.11	3 917.04	6 267.26	1 566.82	30 357.06	39 914.64	58.76
Soil formation and protection	2 859.44	5 728.67	7 638.23	3 819.11	3 349.07	19.59	39.17
Waste disposal	3 211.97	2 565.66	2 565.66	2 565.66	35 605.89	35 605.89	19.59
Biodiversity protection	1 390.55	4 259.78	6 384.78	2 134.79	4 896.30	4 876.71	665.90
Food production	1 958.52	391.70	195.85	587.56	587.56	195.85	19.59
Raw materials production	195.85	2 595.04	5 092.15	97.93	137.10	19.59	0
Recreational culture	19.59	1 292.62	2 506.91	78.34	10 869.79	8 499.98	19.59
Total	13 533.37	28 486.67	42 793.66	14 179.68	122 818.79	90 033.16	822.58

2.2 Analysis method of land use change Dynamic degree of single land use type can quantitatively describe the quantity change of a given land use type in a given period of time. Its equation is

$$K = (U_b - U_a) / U_a T^{-1} \times 100\%, \quad (1)$$

where K is the dynamic degree of a given land use type within the studied time period, U_a and U_b are the quantities of a given land use type in the beginning and the end of study period, respectively, T is the period of study time, and K is the annual changing rate of a given land use type when the period of T is calculated by years.

2.3 Evaluation method of ecosystem service value Calculation equation of ecosystem service value is

$$ESV = \sum (P_i \times L_i), \quad (2)$$

$$ESV_i = (P_{ai} \times L_i), \quad (3)$$

where ESV is the total ecosystem service value in research region (yuan), P_i is the ecosystem service value of the i th land

use type with P_i as the unit area (yuan/hm²), L_i is the area of land use type in research region, and ESV_i is the ecosystem single service value in research region (yuan).

3 Result and analysis

3.1 Analysis of land use change According to the data in Table 1 and the area of land use type, Table 2 reports the annual changing rate and area change of land use type in Guangdong Province in the years 1996 – 2008 based on equation (1). Due to the land reclamation in recent years, total land area in the year 2008 has increased by 6 030.84 hectares compared with that in the year 1996. To make the data more comparable, water area in the year 1996 is the difference value between the actual value in 1996 and the changing value in the second stage.

Table 2 Annual changing rate and area change of land use type in Guangdong Province in the years 1996 – 2008

Land use type	Area//hm ²		Change of area//hm ²	Change rate//%	Annual changing rate//%
	1996	2008			
Farmland	3 500 073.86	3 069 170.48	-430 903.38	-12.31	-0.95
Garden plot	789 574.30	1 007 520.78	217 946.48	27.60	2.12
Woodland	10 322 988.48	10 127 846.00	-195 142.48	-1.89	-0.15
Grassland	602 618.99	589 675.71	-12 943.28	-2.15	-0.17
Residential point and other construction site	1 195 478.81	1 518 310.23	322 831.43	27.00	2.08
Traffic and transmission land	78 419.63	121 482.87	43 063.24	54.91	4.22
Land for water conservancy facilities	164 347.70	162 263.29	-2 084.41	-1.27	-0.10
Wetland	285 823.51	250 626.06	-35 197.45	-12.31	-0.95
Water area	884 655.29	994 081.00	109 425.71	12.37	0.95
Land hard to be utilized	145 951.86	128 956.01	-16 995.85	-11.64	-0.90
Total	17 969 932.43	17 969 932.43			

Table 2 shows that the land use status has changed greatly in Guangdong Province in the years 1996 – 2008. Farmland, woodland, grassland, land for water conservancy facilities, wetland, and unused land have all reduced. But garden plot, traffic and transmission land, water area, and residential point and other construction site have increased. Among the land types with area reduction, farmland takes the first place, a decrease of 430 903.38 hectares, followed by woodland, a de-

crease of 195 142.48 hectares. Among the land types with area increase, residential point and other construction site take the first place, an increase of 322 831.43 hectares, followed by garden plot, an increase of 217 946.48 hectares. Water area has increased by 109 425.71 hectares, taking the third place.

3.2 Variation analysis of total ecosystem service value According to the data in Table 1 and 2, total ecosystem service value of land use in Guangdong Province in the years 1996 –

2008 can be calculated (Table 3) based on equation (2).

Table 3 Change of total ecosystem service value of land use in Guangdong Province in the years 1996 –2008

Land use type	ESV per unit area ESV//yuan/hm ²	ESV// × 10 ⁸ yuan		Change of ESV // × 10 ⁸ yuan	Change rate of ESV//%
		1996	2008		
Farmland	13 533.37	473.68	415.36	-58.32	-12.311 3
Garden plot	28 486.67	224.92	287.01	62.09	27.603 0
Woodland	42 793.66	4 417.58	4 334.08	-83.51	-1.890 4
Grassland	14 179.68	85.45	83.61	-1.84	-2.147 8
Wetland	122 818.79	351.04	307.82	-43.23	-12.314 4
Water area	90 033.16	796.48	895.00	98.52	12.369 3
Land hard to be utilized	822.58	1.20	1.06	-0.14	-11.644 8
Total	312 667.93	6 350.36	6 323.94	-26.42	-0.416 1

Table 3 reports that *ESV* of Guangdong Province has decreased from 635 036 million yuan in the year 1996 to 632 394 million yuan in the year 2008. Ecosystem service value has reduced by 2 642 million yuan, a reduction rate of only 0.416 1%. Among all the land use types, only the *ESV* values of garden plot and water area have increased by 6 209 million and 9 852 million, accounting for 38.69% and 61.34% of the total increased area, respectively. *ESV* of woodland has the maximum decrease of 8 351 million yuan, accounting for 44.65% of the total reduction area. *ESV* of farmland has also reduced by 5 832 million yuan, occupying 31.18%. *ESV* of wetland has decreased by 4 323 million yuan, accounting for 23.11%. And *ESV* of the grassland and the land hard to be utilized have reduced by 184 million and 14 million yuan, respectively. The major reasons for the *ESV* reduction of Guangdong

Province are economic development and urban expansion, which requires more construction land and reduces the area of farmland and garden plot around the city. Woodland with higher *ESV* is turned into farmland and garden plot with lower *ESV*, because farmers plant fruit trees for economic development and governments develop garden and hill land to obtain additional farmland to ensure the total dynamic balance of farmland. However, internal adjustment of agricultural structure, such as turning farmland into water area, has maintain the stable state of ecological environment and the *ESV* in Guangdong Province has reduced only a little.

3.3 Variation analysis of single ecosystem service value

According to the data in Table 1 and 2, single ecosystem service value of land use in Guangdong Province in the years 1996 –2008 can be calculated (Table 4) based on equation (3).

Table 4 Single ecosystem service value of land use in Guangdong Province in the years 1996 –2008

Ecosystem service function	1996		2008		1996 –2008	
	ESV _i × 10 ⁸ yuan	Proportion %	ESV _i × 10 ⁸ yuan	Proportion %	Change of ESV _i // × 10 ⁸ yuan	Change rate of proportion//%
Gas regulation	794.66	12.513 7	784.80	12.410 0	-9.86	-0.828 5
Climate regulation	749.04	11.795 2	727.86	11.509 7	- 21.18	-2.421 2
Water conservation	1 168.43	18.399 4	1192.45	18.856 1	24.02	2.482 4
Soil formation and protection	966.63	15.221 6	950.23	15.025 8	-16.40	-1.285 9
Waste disposal	829.78	13.066 7	842.62	13.324 3	12.84	1.971 5
Biodiversity protection	812.38	12.792 6	806.43	12.752 1	-5.94	-0.316 9
Food production	98.84	1.556 5	90.80	1.435 8	-8.04	-7.750 1
Raw materials production	554.16	8.726 5	549.00	8.681 3	-5.16	-0.518 0
Recreational culture	376.44	5.927 9	379.75	6.004 9	3.30	1.298 8
Total	6 350.36	100	6 323.94	100	-26.42	0

Table 4 reports that the change trend of single ecosystem service value of land use in Guangdong Province is as follows: ecosystem service values of the gas regulation, climate regulation, soil formation and protection, biodiversity protection, food production, raw materials production, and recreational culture show different degrees of reduction; but the ecosystem service values of the water conservation and waste disposal increase due to the rise of water area.

4 Conclusion and discussion

4.1 Conclusion In the years 1996 –2008, areas of different land use types have changed greatly in Guangdong Province. Farmland, woodland, grassland, land for water conservancy facilities, wetland, and unused land have all reduced. But gar-

den plot, traffic and transmission land, water area, and residential point and other construction site have increased. The major characteristics of land use change in Guangdong Province are the internal adjustment of agricultural structure and the increase of construction land. Except the garden plot and water area, ecosystem service values of other five non-constructive land types show different levels of reduction. Among them, farmland, woodland and wetland have the maximum reduction of values. All the 9 single ecosystem service values have reduced except the water conservation and waste disposal. Among them, ecosystem service values of climate regulation and soil formation and protection show the maximum reduction. In Guangdong Province, the entire system is stable and land

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peasant households participating in training in the peasant households should participating in training, which mainly considers the distribution and equity. The equation is

$$PR = M/OM, \quad (13)$$

where PR is the participation degree, M is the sample size of peasant households participating in training, OM is the number of peasant households should participating in training, including the sum of peasant households participating in training, the peasant households who would like to participate in training but have not heard the news, the peasant households who have some restrictions but have no opportunity to participate in training.

3 Discussion

According to the problem of the lack of farmers' training evaluation index system in China at present, an evaluation index system with better pertinency is established. At the same time, farmers' training is evaluated from three aspects of demand, process and effect. And training effect is comprehensively and systematically reflected in order to improve the training plan and management level based on science. This evaluation index system is simple and practicable, has strong operability, and is more suitable for micro-level. It includes the evaluation of training programs in certain scale with the objective of increasing farmers' income and technical level in rural areas. However, framework of this index system still belongs to exploratory or experimental research, offering a basic evaluation index in embryo. This index system aims to further strengthen the local governments' importance understanding of farmers' training, to improve the quality of training, to evaluate the train-

ing scientifically and rationally, to make training and training evaluation more systemic, scientific and operational, to improve the farmers' cultural knowledge and science and technology, and to avoid the training and training evaluation to become a mere formality.

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use change has no significant impact on ecosystem at present.

4.2 Discussion Calculation of the ecosystem service value in Guangdong Province is only a preliminary estimation. And evaluation on the function and value of personalized service in Guangdong Province is based on the data in two time periods, which is not comprehensive enough and can not analyze the environmental benefit of land use dynamic change. Due to the complexity of ecosystem service, accounting method still needs to be improved and evaluation on ecological environment of land use dynamic change remains to be further studied.

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