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Difference between Supply and Demand of Land Consumption Function in Huadu District, Guangzhou City, China

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Abstract Ecological Footprint Method is introduced to define the range of biological resource consumption account and fossil energy consumption account. According to the relevant data of land use and ecological environment in Huadu District, Guangzhou City, Guangdong Province, China from the year 1990 to 2005, ecological footprint analysis method is used to research on the demand and supply of land consumption function of Huadu District, as well as the difference variation between supply and demand. Result shows that per capita ecological footprint and total ecological footprint have increased sharply from 1990 to 2005. Biological resource consumption has an absolute advantage of proportion compared with fossil energy. Growth speed of fossil energy footprint is faster than that of biological resource footprint. However, structure of total ecological footprint has not changed significantly. Demand of land consumption function is far beyond the ecological carrying capacity of Huadu District. But land use intensity has not exceeded the ecological threshold produced by supporting consumption function of land use system, indicating that ecological environment system is still relatively safe in Huadu District.

Key words Land consumption function; Ecological footprint; Ecological deficit; Ecological capacity; Huadu District, China

Ecological Footprint Method is a quantitative method developed in recent years, which measures the ecological sustainable development. It uses biophysical unit to measure the demand of a certain region for natural resources, as well as the ecological support for human survival, reproduction and economic activities provided by natural resources^[1–3]. As a sustainable assessment method of quantitative measurement, it has relatively more scientific and complete theoretical foundation, simplified index system, and methodological universality, which lead to widespread attention of the academic circle. Scholars have done a great deal of researches on the theories and methods and have applied them widely in different regions, spaces and social aspects^[4–15]. But when comparing the regional ecological carrying capacity with the ecological footprint, Ecological Footprint Method only pays attention to the land consumption functions that can be quantitatively and materially obtained, but seldom concerns about the land service functions that can hardly be quantified and expressed^[4–5]. Therefore, objectives used to measure the regional sustainable development should be reduced only to the supply and demand analysis of regional land consumption function. This not only can overcome the shortcomings in Ecological Footprint Method, but also can manifest the supply and demand of land consumption function to a large extent under the support of regional environment, which provides scientific basis for the regional government to develop feasible land-use policy.

Huadu District in Guangzhou City used to be a city at

county level administered by Guangzhou City. In June, 2000, Huadu District is directly governed by Guangzhou City, which is a typical outskirts of large city greatly affected by the central city. Research on the supply differences in land consumption function is undoubtedly typical, which is conducive to the regional future development and overall urban planning.

1 Data source and calculation method

World average yield, yield factor, equilibrium factor, energy conversion factor, global energy footprint and other indices used in this research are from relevant literatures and statistical sources of FAO^[12–15], which will not be described in detail. Data of various ecological footprint accounts are from 1999–2001 and 2003–2006 *Huadu Statistical Yearbook*, *The Fifty Years of Huadu* (1949–1998) and *The First National Economic Census Data Compilation*.

Calculation of ecological footprint is composed of energy consumption, biological resources consumption and trade adjustment. Among them, trade adjustment is not analyzed in this paper due to the lack of relevant data. Biological resources consumption account includes grain, vegetable, peanut, fruit, aquatic product, pork, beef, mutton, poultry and egg. And the consumption of timber is not analyzed in this paper due to the limited statistical data. Fossil energy consumption account includes coal, coke, gasoline, kerosene, diesel, fuel oil, liquefied petroleum gas and electricity.

2 Calculation result and analysis

2.1 Land consumption function demand in Huadu District from the year 1990 to 2005 Table 1 reports that per capita

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ecological footprint and total ecological footprint in Huadu District have increased rapidly from the year 1990 to 2005. And per capita ecological footprint has risen from 1.93 hectares in the

year 1990 to 2.88 hectares in 2005, an increase rate of 49.46%; while total ecological footprint has risen from 971 397.24 hectares to 1 817 675.12 hectares, up by 87.12%.

Table 1 Variation of ecological footprint in Huadu District from 1990 to 2005

Year	Biological resources consumption account		Fossil fuel consumption account		Total	
	Footprint per capita	Total footprint	Footprint per capita	Total footprint	Footprint per capita	Total footprint
1990	1.73	872 624.91	0.20	98 772.33	1.93	971 397.24
1991	1.55	791 868.18	0.19	97 505.74	1.75	889 373.92
1992	1.94	1 003 700.25	0.20	102 616.87	2.14	1 106 317.12
1993	2.35	1 243 519.20	0.20	108 153.02	2.55	1 351 672.22
1994	2.72	1 484 296.20	0.31	167 848.17	3.02	1 652 144.38
1995	2.69	1 499 025.42	0.59	327 888.04	3.27	1 826 913.46
1996	3.18	1 801 023.60	0.53	300 283.87	3.71	2 101 307.48
1997	2.63	1 528 873.84	0.49	284 902.47	3.12	1 813 776.31
1998	2.92	1 716 918.65	0.47	276 661.86	3.39	1 993 580.52
1999	3.04	1 806 992.54	0.62	369 957.57	3.66	2 176 950.10
2000	3.16	1 899 323.59	0.65	392 945.81	3.81	2 292 269.40
2001	2.83	1 712 553.76	0.58	349 712.27	3.41	2 062 266.03
2002	2.61	1 615 644.80	0.58	358 338.05	3.19	1 973 982.85
2003	2.35	1 460 857.97	0.67	413 097.82	3.02	1 873 955.78
2004	2.25	1 412 558.30	0.67	419 431.11	2.92	1 831 989.41
2005	2.28	1 436 619.45	0.60	381 056.37	2.88	1 817 675.82

According to the internal structure, proportion of biological resource consumption in total ecological footprint is relatively larger than the proportion of fossil energy consumption. According to the growth speed, biological resource consumption is different from the fossil energy consumption. In the years 1990–2005, both total and per capita ecological footprint, which are caused by human consumption of biological resources, grow slowly in Huadu District. Among them, total ecological footprint has increased from 872 624.91 hectares to 1 436 619.45 hectares, an annual increase of 1.68%. And per capita ecological footprint has risen from 1.73 hectares in 1990 to 2.28 hectares in 2005, up by 2.10% annually. At the same time, Huadu District has shown rapid increase in total and per capita ecological footprint caused by fossil energy consumption in the years 1990–2005, which has greatly supported the rapid growth of regional total and per capita ecological footprint. Total fossil energy footprint has enhanced by 285.79% from 98 772.33 hectares

in 1990 to 381 056.37 hectares in 2005, an annual increase of 19.05%. Percentage of fossil energy consumption footprint in total ecological footprint has risen from 10.17% in 1990 to 20.96% in 2005, increased by 10 percentage points. However, since the percentage of biological resource consumption footprint still plays a dominant role, difference in growth speed has not changed the structure of total ecological footprint significantly.

2.2 Consumption function supply of land in Huadu District from the year 1990 to 2005 Land consumption function supply in Huadu District has declined slowly due to the variation of land use structure. Total supply has reduced from 200 968.88 hectares in 1990 to 193 083.59 hectares in 2005, a decrease of 3.92%. Supply of per capita land consumption function has declined greatly due to the population growth in Huadu District. It has reduced from 0.40 hectare in 1990 to 0.31 hectare in 2005, a decrease of 23.25% (Table 2).

Table 2 Variation of ecological capacity in Huadu District from 1990 to 2005

Year	Ecological capacity of land use					Total ecological capacity	
	Cultivated land	Woodland	Grassland	Construction land	Water area	Total quantity	Per capita
1990	113 929.69	12 564.97	348.22	73 050.71	1 075.30	200 968.89	0.40
1995	87 428.01	8 657.80	621.84	75 498.41	1 944.19	174 150.24	0.31
2000	79 864.04	15 944.52	182.79	76 791.88	2 706.52	175 489.75	0.29
2005	75 051.21	8 480.17	254.53	106 287.37	3 010.30	193 083.59	0.31

From the view of the internal structure, cultivated land and other low intensity land-use type has changed rapidly into the high intensity construction land, which is the main reason for the total supply reduction of land consumption function in recent years. Among them, total supply has reduced from 113 929.69 hectares in 1990 to 75 051.21 hectares in 2005. And its percentage in total land consumption function has decreased by 17.82% from 56.69% in 1990 to 38.87% in 2005. And consumption function supply of construction land has risen from

73 050.71 hectares in 1990 to 106 287.37 hectares in 2005. Its percentage in total land consumption function has increased from 36.35% in 1990 to 55.05% in 2005, an increase of 18.7%. Besides, woodland, grassland, water area and other land use consumption function supply have also fluctuated during this period. Woodland has declined from 12 564.97 hectares in 1990 to 8 480.17 hectares in 2005, a decrease of 32.50%; grassland has reduced from 348.22 hectares in 1990 to 254.53 hectares in 2005, a decrease of 26.90%; water area

has increased from 1075.29 hectares in 1990 to 3 010.30 hectares in 2005, an increase of 179.95%. Since their proportions in total supply are relatively small, impact of these land use types on total amount is not great.

Conversion of land consumption function structure caused by the conversion of land use structure has brought certain threat to the ecological stability of land use system. According to the principles of system theory, entropy can be used to reflect the system stability and the order degree. Information entropy of system, which is close to 0, indicates a stable system. Bigger entropy value leads to greater disturbance degree and more unstable system. Therefore, calculating the information entropy of ecological footprint structure can reflect the ecological stability of land ecosystem. Hence, the equation of information entropy is:

$$H = - \sum_{i=1}^n P_i \ln P_i,$$

where P_i is the percentage of the i th land type in total ecological footprint. According to the above equation, information entropy from supply system of land consumption function in Huadu District are 0.90, 0.93, 1.01 and 0.91 in the years 1990, 1995, 2000 and 2005, respectively.

Calculation result indicates that information entropy from supply system of land consumption function has shown certain increase in Huadu District in the years 1990–2005. Information entropy has risen from 0.90 in 1990 to 0.91 in 2005 along with certain fluctuation. This indicates that in the past 15 years, rapid socio-economic development and increasing ecological footprint demand have greater impact on the supply system of land consumption function supported by ecological environment, which has affected the system ecological safety to a certain extent. But the range of fluctuation is small in general and the supply system is still stable at present.

2.3 Supply and demand difference of land consumption function in Huadu District Table 3 reports the supply and demand difference of land consumption function in Huadu District in the years 1990–2005.

Table 3 Calculation of ecological deficit in Huadu District from 1990 to 2005 hm^2

Year	Ecological footprint demand/supply	Ecological deficit per capita	Total quantity of ecological deficit
1990	4.83	1.53	770 428.36
1995	10.49	2.96	1 652 763.21
2000	13.06	3.52	2 116 779.65
2005	9.41	2.58	1 624 592.23

Table 3 shows that there is a strong upward trend in the demand-supply ratio of ecological footprint, ecological deficit per capita and total quantity of ecological deficit in Huadu District from 1990 to 2005. Demand-supply ratio of ecological footprint has enlarged from 1:4.83 in 1990 to 1:13.06 in the year 2000, showing a rapid increasing trend. Then, it slows down in the years 2000–2005 but is still as high as 1:9.41. Total quantity of ecological deficit has enhanced from 770 428.36 hectares in 1990 to 2 116 779.65 hectares in the year 2000, up by 1.75 times. In the year 2005, it declines

slightly to 1 624 592.23 hectares, increased by 1.11 times compared with that in the year 1990. Ecological deficit per capita has increased from 1.53 hectares in 1990 to 2.58 hectares in 2005, up by 0.68 time. It reaches to 3.52 hectares in the year 2000, increasing by 1.3 times compared with that in the year 1990.

Calculation result of ecological footprint in other cities by Professor William and his research group shows that almost all cities have much larger ecological footprint than their own administrative area; and ecological footprint in developed cities are even several times, or more than ten times, of their own area^[12]. In the year 2003, demand-supply ratios of per capita ecological footprint in Beijing, Shanghai and Wuhan are as high as 106.50, 10.15 and 8.62, respectively. In the year 2005, demand-supply ratio of per capita ecological footprint in Huadu District is 9.41, which is lower than those of Guangzhou City in the year 2000 and Shanghai in the year 2003, and belongs to a relatively lower ratio of city in the same period among the same development level of regions. Land use intensity in Huadu District has not exceeded the ecological environment threshold produced by the consumption function of land use system.

3 Conclusion and discussion

(1) Per capita and total ecological footprint in Huadu District have shown the trend of rapid growth from the year 1990 to 2005. According to the structure, proportion of biological resource consumption in total ecological footprint is larger than that of fossil energy. Although growth of fossil energy footprint is far faster than that of biological resource footprint, structure of total ecological footprint has changed significantly.

(2) There is a strong upward trend in the demand-supply ratio of ecological footprint, ecological deficit per capita and total quantity of ecological deficit in Huadu District from 1990 to 2005. However, information entropy of land consumption function supply system has not changed significantly and land use system is still relatively stable. This indicates that demand of land consumption function in Huadu District has far exceeded its ecological carrying capacity in the past 15 years. But the ecological environment system is still relatively safe in Huadu District.

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there are usually some misunderstandings about these relationships. Without correct understanding of these relationships, performance of land circulation would be affected, which may even lead to a series of contradictions and problems that affect the economic development and social stability.

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农村土地流转中的十大关系探讨

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摘要 探讨了土地流转的十大关系。其中, 在农户与政府关系中指出, 由于农民在土地流转中往往没有话语权, 提出应以农民为土地流转的主体, 政府只应履行其服务和监管职能; 在土地所有权和承包经营权关系中, 侧重于探讨土地承包经营权的流转, 并指出土地流转的客体就是—定期限的土地承包经营权; 在土地流转和深化改革关系中指出, 土地流转只是发展规模经营和深化农村改革的一个途径, 只有大力发展二、三产业、加快农村剩余劳动力转移, 才能加快土地流转; 在土地流转和土地改革中指出, 现阶段我国不适于进行新土改; 在附期限的土地承包与承包制、私有制关系中指出, 承包制、私有制不适合我国国情, 应该继续坚持附期限的土地承包方式; 在土地流转与经济发张关系中指出, 土地流转是自然过程, 不应带有强制性, 否则将不利于农村经济的发展; 在企业与农户关系中指出, 土地流转应在农户之间进行, 公司和企业可以参与其中; 在土地流转与农业经营绩效关系中指出, 土地流转应因地制宜; 在土地流转与土地兼并、流失关系中指出, 土地流转必须坚持合法原则, 规模经营必须坚持适度原则, 防止土地流失到少数人手中; 在小农经济和农业现代化关系中指出, 小农经济的家庭经济模式未必成为农业现代化的障碍。

关键词 土地流转; 承包制; 制度变迁

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广州市花都区土地消费性功能供需差异研究

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摘要 简述了生态足迹方法, 对生物资源消费帐户和化石能源消费帐户的涵盖范围进行了界定。根据1990~2005年广东省广州市花都区土地利用及生态环境的相关数据, 利用生态足迹分析方法, 研究了广州市花都区土地消费性功能的需求、供给及供需差异变化情况。结果表明, 1990~2005年, 人均生态足迹与生态足迹总量均呈迅速增长的趋势, 生物资源消费所占比例较化石能源存在绝对优势, 化石能源足迹增长速度快于生物资源足迹, 但生态足迹总量的结构并未发生明显变化; 花都区土地消费性功能的需求远远超出了该区的生态承载力, 但其土地利用强度并未超出支撑土地利用系统消费性功能持续产出的生态环境阈值, 从而说明花都区生态环境系统仍然是比较安全的。

关键词 关键词 花都区; 土地消费性功能; 生态足迹; 生态赤字; 生态承载力