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Calculation and Analysis of Ecological Footprint in Hefei City during the Period 2005 – 2010

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Abstract This paper carries out calculation and analysis of various kinds of ecological footprint and 10^4 yuan GDP in Hefei City during the period 2005 – 2010, and the results show that in recent years, the industrial economic development in Hefei City is accelerated, people's living standards are improved, and the momentum of urbanization is gathered. At the same time, as the resource utilization rate is increased year by year, the city's economic development has already begun to be resource-intensive.

Key words Hefei City, Per capita ecological footprint, GDP, Ecological footprint per 10^4 yuan GDP

Ecological footprint, also known as ecological appropriation, is a measure of human demand on the Earth's ecosystems. The ecological footprint method was proposed by two Canadian ecological economists Wackernagel and Riss William in the 1990s. Many research institutions, community groups, government departments, international organizations, *etc.* have attached great importance to the ecological footprint method. Along with the deepening of research and development, the current ecological footprint method has reached an unprecedented breadth and depth, ranging from the researches on a global scale to the researches a small field. For example, it is applied to the study of agricultural products. The ecological footprint method uses a number of indicators concerning land area to signify the effects of human economic and social activities on the ecological environment, to provide scientific basis and strategic guidance for the mankind to rationally use natural resources and achieve sustainable development from a brand-new perspective^[1]. As the capital city of Anhui Province, Hefei has gained momentum of urban construction in recent years. With the accelerated pace of urban construction, the urban ecological environment becomes an important issue, and this paper carries out calculation and analysis of ecological footprint in Hefei City during the period 2005 – 2010, to provided the basic data for the ecological environment construction in Hefei City.

1 Overview of the study area

Hefei ($31^{\circ}52'$, $117^{\circ}17'E$) is the capital and largest city of Anhui Province in Eastern China. It is the political, economic, and cultural centre of Anhui. Located in the central portion of the province, it borders Huainan to the north, Chuzhou to the northeast, Chaohu to the southeast and Lu'an to the west. Hefei has an area of $11\,323\text{ km}^2$ ($4\,372\text{ sq mi}$) and, as of 2010 Census, a population

of 7 457 027 inhabitants. Its built-up area ("metro") is home to 3 352 076 inhabitants encompassing all urban districts.

The topography in the whole city is divided into three major types: hill, downland and plain. The areas along southern Yuan-dong Mountain have a relatively high altitude, and most of the remaining areas are low and short downland. In 2011, the administrative division of Hefei was adjusted, and the new Hefei administers four districts (Yaohai, Luyang, Shushan, Baohe), one prefecture-level city (Chaohu) and four counties (Changfeng, Feidong, Feixi, Lujiang).

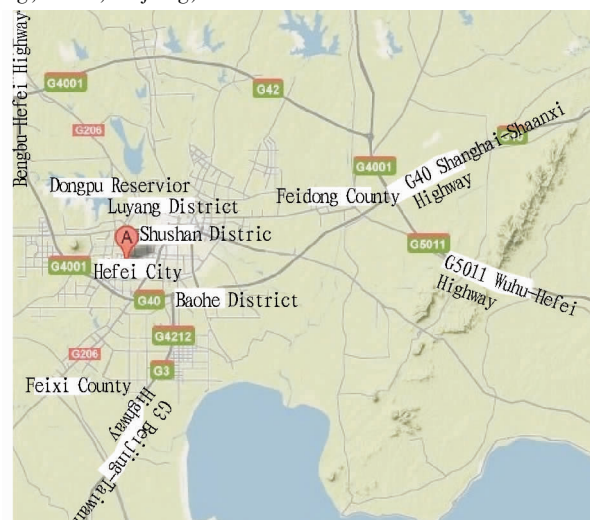


Fig.1 Topographic map of Hefei City

2 Calculation and analysis of ecological footprint in Hefei City during the period 2005 – 2010

2.1 Data processing This paper uses ecological footprint calculation model, 10^4 yuan GDP ecological footprint and other methods to process the data, according to the data from *Statistical Yearbook*.

2.1.1 Ecological footprint calculation model. Ecological footprint calculation is carried out based on certain assumptions:

(i) The amount of energy consumed by human, the amount

of resources and the amount of waste can be estimated;

(ii) The amount estimated can be calculated, and the calculation is carried out by converting the amount into bio-productive land area^[2].

Meanwhile, according to the hypothesis of mutual spatial exclusion, all kinds of bio-productive land can be aggregated^[3].

The mathematical model for calculating ecological footprint^[4]:

2.1.2 Ecological footprint per 10^4 yuan GDP^[5]. Gross domestic product (GDP) is the market value of all officially recognized final goods and services produced within a country in a given period of time.

Ecological footprint per 10^4 yuan GDP reflects the rate of resource utilization of biologically productive area in one region, and it is calculated using the total demand of regional ecological footprint in a period to be divided by the GDP in the same period. If the ecological footprint per 10^4 yuan GDP is larger, the rate of resource utilization will be lower, and if the ecological footprint per 10^4 yuan GDP is smaller, the rate of resource utilization will be higher.

2.2 Analysis results

2.2.1 Ecological footprint analysis. In the analysis of ecological footprint, this paper divides the ecological needs into six categories, and it is calculated in accordance with the above calculation method and Hefei Yearbook^[6-11].

And the yield factor is calculated through the average yield of all kinds of productive land in the world during the period 2005 – 2010 from International Statistical Yearbook^[12] and the yield of various types of productive land in Hefei City during the period 2005 – 2010 from Hefei Statistical Yearbook. Due to data limitations, the production capacity of grassland is calculated using the national average production capacity. The annual yield factors in Hefei City are obtained (Table 1).

Table 1 Various land yield factors in Hefei City during the period 2005 – 2010

Year	Farmland	Woodland	Grassland	Fossil energy land	Water area	Construction land
2005	1.53	0.83	0.38	0	1	1.38
2006	1.56	0.83	0.38	0	1	1.38
2007	1.572	0.83	0.38	0	1	1.38
2008	1.6	0.83	0.38	0	1	1.38
2009	1.61	0.83	0.38	0	1	1.38
2010	1.61	0.83	0.38	0	1	1.38

(i) Ecological footprint of arable land. As can be seen from Fig. 2, the per capita ecological footprint of arable land in Hefei City was steadily increased from 2005 to 2010, basically from 0.456 777 101 hectares in 2005 to 0.588 442 711 hectares in 2010, showing a rising trend, except a small trough in 2007 (0.440 368 656 hectares), but there is little change in this upward trend, indicating that the basic needs of the people in Hefei experience little change.

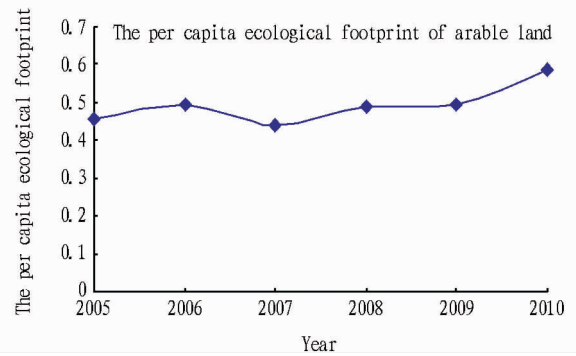


Fig. 2 The per capita ecological footprint of arable land in Hefei City

(ii) Ecological footprint of water area. As can be seen from Fig. 3, the ecological footprint of water area in Hefei City changed little, from 0.176 008 hectares in 2005 to 0.171247 hectares in 2010, indicating that the Hefei people's consumption of aquatic products basically experienced no change during these six years.

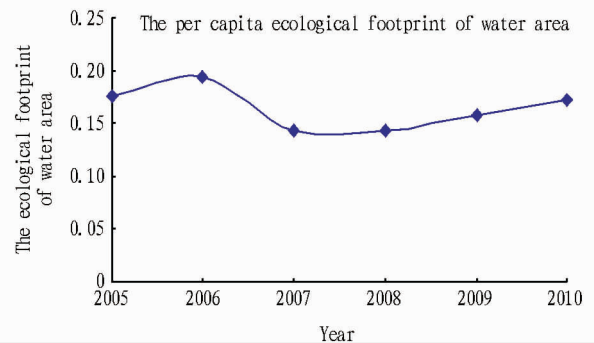


Fig. 3 The per capita ecological footprint of water area in Hefei City

(iii) Ecological footprint of grassland. As can be seen from Fig. 4, the per capita ecological footprint of grassland in Hefei City changed from 0.469 886 493 hectares in 2005 to 0.519 911 917 hectares in 2010, showing an overall upward trend, with obvious changes. The demand for pasture reflects the demand for beef, mutton and dairy products in the life consumption structure. With the growing demand for meat and milk in the life, it also reflects the improvement of people's living standards. It is closely related to the improvement of people's living standards in Hefei City.

(iv) Ecological footprint of woodland. As can be seen from Fig. 5, the per capita ecological footprint of woodland in Hefei City basically experienced no change during the period 2005 – 2009, but it increased from the former 0.003 235 hectares to 0.013 28 hectares in 2010, with substantial changes, which is related to the demand for forest products and the market price adjustment.

(v) Ecological footprint of construction land. As can be seen from Fig. 6, the per capita ecological footprint of construction land in Hefei City experienced a substantial increase in 2010, indicating that with the constant acceleration of urbanization in Hefei City and increasing urban area, and the ecological footprint of construction land is also increased constantly.

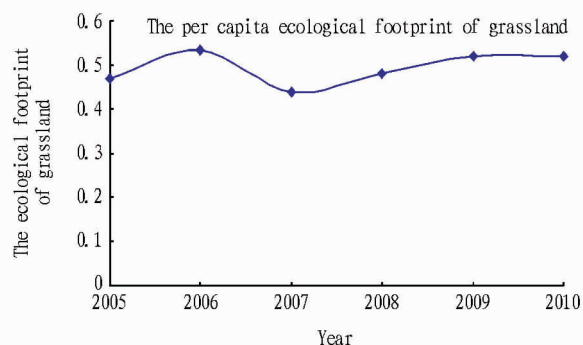


Fig. 4 The per capita ecological footprint of grassland in Hefei City

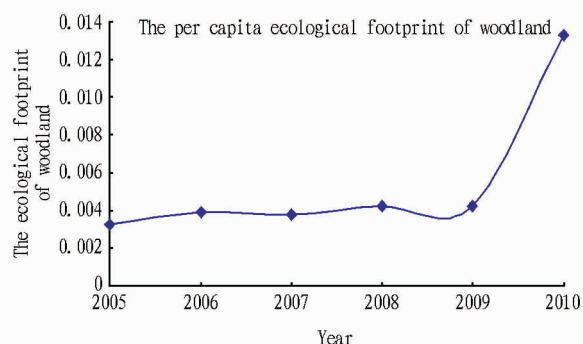


Fig. 5 The per capita ecological footprint of woodland in Hefei City

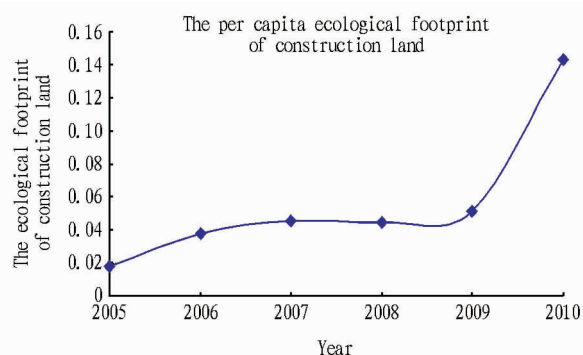


Fig. 6 The per capita ecological footprint of construction land in Hefei City

(vi) Ecological footprint of fossil energy land. As can be seen from Fig. 7, the per capita ecological footprint of fossil energy land in Hefei City showed a steady overall upward trend during these six years, indicating that the industrial consumption in Hefei City was steadily increased during the period 2005 – 2010, and the industrial economy was developed steadily.

(vii) The proportional distribution of six types of ecological footprint. All kinds of ecological footprint during the period 2005 – 2010 are aggregated and then averaged. Through mutual comparison, the proportional distribution in Fig. 8 is derived:

As can be seen from Fig. 8, the contribution of ecological footprint in Hefei City during the period 2005 – 2010 was mainly based on arable land, accounting for 30% of the total ecological

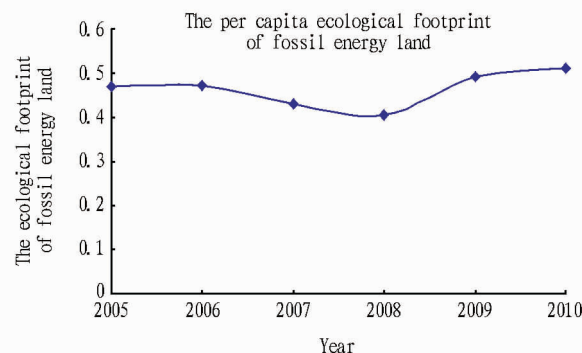


Fig. 7 The per capita ecological footprint of fossil energy land in Hefei City

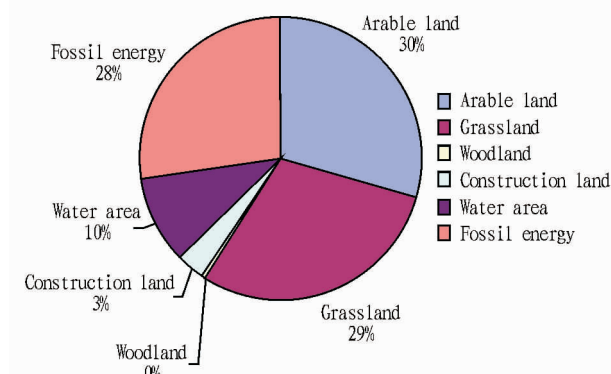


Fig. 8 The proportional distribution of six types of ecological footprint in Hefei City

needs; the ecological footprint proportion of grassland was 29% , indicating that people's living standards in Hefei City were improved continuously; fossil energy land was second only to grassland, accounting for 28% of the total, which was inseparable with the development of the industrial economy in Hefei City in recent years.

The water area, construction land and woodland ranking in the last three places have a small proportion, but from the development of single one, the momentum of growth is significant, especially for construction land and woodland, which is related to the acceleration of the urbanization process in Hefei City in recent years.

(viii) Analysis of total ecological footprint in Hefei City during the period 2005 – 2010. On the basis of analyzing the above types of ecological footprint, this paper carries out an overall analysis of changes in the ecological footprint in Hefei City (Fig. 9). As can be seen from Fig. 9, during the period 2005 – 2010, the per capita total ecological footprint in Hefei City basically showed an upward trend, except a decrease in 2007.

Among the six indicators in 2007, apart from construction land with increase in the per capita ecological footprint, the other five indicators declined, indicating that the per capita ecological footprint of construction land had a small proportion, but it showed an upward trend in these six years, reflecting the steady development of urban construction in Hefei.

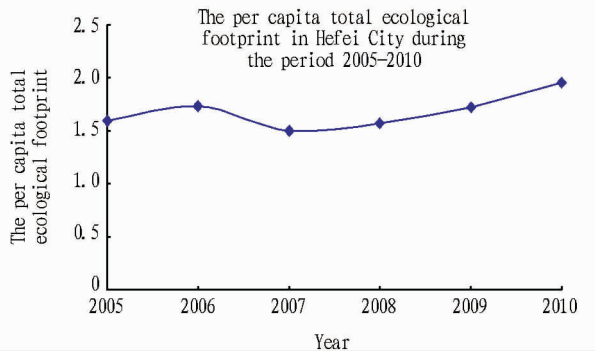


Fig. 9 The per capita total ecological footprint in Hefei City during the period 2005 – 2010

2.2.2 Analysis of ecological footprint per 10^4 yuan GDP. As can be seen from Table 2, the ecological footprint per 10^4 yuan GDP showed a gradually decreasing trend from 2005 to 2010, and the rate of reduction was obvious, from 0.774 268 019 $\text{hm}^2/10^4$ yuan in 2005 to 0.355 574 433 $\text{hm}^2/10^4$ yuan in 2010, indicating that the efficiency of resource utilization in Hefei City was increased year by year.

Due to the promotion of recycling economy and saving economy in recent years, the rate of resource utilization in Hefei City has been improved to some extent, and the city's economic development has already begun to be resource-intensive.

Table 2 The per capita ecological footprint and footprint per 10^4 yuan GDP in Hefei City during the period 2005 – 2010

Year	Per capita ecological footprint $\text{hm}^2/\text{person}$	Per capita GDP 10^4 yuan/person	Footprint per 10^4 yuan GDP $\text{hm}^2/10^4$ yuan
2005	1.591 895 048	2.056	0.774 268 019
2006	1.732 506 179	2.423	0.715 025 249
2007	1.498 739 06	2.9545	0.507 273 332
2008	1.564 395	3.6802	0.425 084 235
2009	1.715 614	4.2981	0.399 156 371
2010	1.947 765 628	5.4778	0.355 574 433

3 Conclusions

(i) Based on the analysis of six types of ecological footprint during the period 2005 – 2010, the per capita ecological footprint of arable land basically shows a steady rising trend; the per capita eco-

logical footprint of water area is basically unchanged; the per capita ecological footprint of grassland shows an overall upward trend; the per capita ecological footprint of woodland is basically unchanged; the per capita ecological footprint of construction land is increased substantially; the per capita ecological footprint of fossil energy land shows an overall upward trend. It indicates that in recent years, the industrial economic development in Hefei City is accelerated, people's living standards are improved, and the momentum of urbanization is gathered.

(ii) Based on the analysis of the ecological footprint per 10^4 yuan GDP during the period 2005 – 2010, the ecological footprint per 10^4 yuan GDP decreased from 0.774268019 $\text{hm}^2/10^4$ yuan in 2005 to 0.355574433 $\text{hm}^2/10^4$ yuan in 2010, reducing by more than two times, indicating that the rate of resource utilization in Hefei City is increased year by year, and the city's economic development has already begun to be resource-intensive.

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