ISSN 1 746-7233, England, UK
World Journal of Modelling and Simulation
Vol. 3 (2007) No. 1, pp. pp 10-19

Forecast model of ecological footprint and its application to county cycle economy*

Lihui Zhao , Jiuping Xu†

Uncertainty Decision-Making Laboratory
School of Business and Administration, Sichuan University, Chengdu 610064, P. R. CHINA

(*Received October 12 2005, Accepted May 1 2006*)

Abstract. In this research we concentrate on developing an ecological footprint model for county cycle economy research. We follow the tracks of consumption of energy and natural resources of the county, then change the consumption into the bio-productive area which supplies energy and natural resources. Through studying whether the demand of bio-productive area exceeds the available supply, we analyze the sustainability of the county cycle economy system. To forecast ecological footprint of the county, we combine the index of ecological footprint with the index of GDP by collecting data from thirty nations and areas in the whole world. Through this model and forecast, we get a series of results, which can provide scientific evidence to the cycle economy development in this area. In the meanwhile, we find a new point to set up three types of models which combine ecological footprint with GDP according to energy efficiency. And this is available to provide a new strategic idea for governments, businesses and other organizations to improve the economical and social construction.

Keywords: ecological footprint, sustainability, cycle economy

1 Introduction

The ecological footprint method is a bio-physical sustainable development evaluation method. It considers mankind and his development from a new view. The six assumptions of measuring ecological footprint which are defined by Dr Wackernagel[1–3] are as follows: 1) it is possible to follow the tracks of consumption of resources and wastes of mankind; 2) The resources and wastes can be measured by changing them into bio-productive area which is necessary to produce these resources and assimilate wastes; 3) Kinds of land which have biological productivity can be converted into standard hectare-global hectare, biological productivity per global hectare is equal to the average productivity of the global land this year; 4) Because the use of every kind of land is repellent, we can get the consumption demand of mankind by adding kinds of land; 5) The ecological service supply of nature can be expressed by bio-productive space denoted by global hectare; 6) The ecological footprint can exceed ecological carrying capacity. Through following the tracks of consumption of energy and natural resources of the county, then changing the consumption into the bio-productive area, the method gives a concise frame to calculate the globe, nation, area, family and people' utilization of nature asset. The ecological footprint method quantitatively judges whether the development of the area is in the scope of ecological carrying capacity and supplies scientific theory information for the sustainable development evaluation.

* This research was supported by the National Science Foundation for Distinguished Young Scholars, P. R. China (Grant No. 70425005) and the Teaching and Research Award Program for Outstanding Young Teachers in Higher Education Institutions of MOE of P. R. China (Grant No. 20023834-3).

† Corresponding author. Tel.:+86-28-85418522; Fax:+86-28-85400222.
E-mail address: xujiuping@openmba.com, zhaolihui-735@sina.com.

The research on ecological footprint can be traced back to the seventies of the 19th century which discussed extra shadow area needed by a city in the energy sense[4, 5], and analysed oceanic ecosystem area demanded by coastal fishery of Baltic Gotland[6]. Based on the research of predecessors above, some researchers brought up the concept of ecological footprint[7], then perfect it and developed it into the ecological footprint model. The concept of ecological footprint was introduced to China by these scholars in 1999, and there were some research results in 2000[8], then the scope was extended to all provinces and parts of cities, countries and towns. At present, the ecological footprint model methodically has compound, component and input-output methods. The compound method was raised in the 1990s[9], and it is suitable for the study of ecological footprint on the globe, nation and region level; The component method was posed in the 1998[10], and it is applicable to the study of ecological footprint for town,village,company, individuals and activity; The input-output method was put forward in 1998[11], then was improved by other scholars[12]. Recently some scholars also focus on the study of the input-output method, and published the research results in January of 2006[13]. Besides, because of the characteristic of being unfit for dynamic analysis for the ecological footprint model, researchers strengthen the time series research on the ecological footprint model[14].

Compared with other countries of the world, the research on the ecological footprint is relatively late in China. Although now the research has already involved the levels of nation, area and city, it mainly concentrates on the static comparative analysis of the ecological footprint on the national level; On the regional level, the research on the ecological footprint mostly adopts the compound method to measure the ecological footprint, and uses the productivity data of national average land to calculate the ecological carrying capacity. The ecological footprint model was applied to the globe since 1997 when some scholars submitted the report of the national ecological footprint which was entrusted and subsidized by the earth council[15–17]. The report of the national ecological footprint calculated the ecological footprint in 1993 of 52 countries in the world for the first time. These 52 countries have 80% of the population in the world and 95% of the world gross domestic product, and the impact on global sustainable development is very important.

Because the ecological footprint model is easily understood and related directly with the global sustainable development, it receives extensive concerns of the research institutions such as relevant international body, government department, non-government organization and university, etc., and becomes the international important method estimating sustainable development.The ecological footprint has now been applied to measure the sustainability of many nations, cities and regions as well as for globe itself. And its applied field has been extended to land demand forecast, tourism sustainability measurement, environment impact assessment and so on[18–20].

The rest of the paper is organized as follows. In section 2, based on the nature of sustainable development, we construct a set of indexes system and put forward design principle. In the section 3, we analyse this county system and construct models of ecological footprint and biocapacity. In the section 4, we analyse the ecological footprint and biocapacity of this county through applying the models constructed in the section 3. In the following, in the section 5, we propose a forecast model of the ecological footprint on the basis of econometrics model and finally the conclusions have been made in section 6.

2 Preliminary concepts

The ecological footprint provides an excellent framework for measuring the extent (area) of humanity's appropriation of natural resources and services within the context of sustainability. Since its inception, there has been continuous valuable advances in footprinting[22–24]. Ecological carrying capacity, which is called biocapacity, is the maximum of utilization of resources and assimilation of wastes under the prerequisite of not damaging productivity and function of the ecosystem and guaranteeing to realize sustainable utilization[9]. In the course of calculating ecological carrying capacity, because there are great differences in the ecological production capacity of various kinds of bioproductive land among different countries or regions, the same types of areas of bioproductive land of different countries or regions need to weight to compares each other. The tap between one type area of bioproductive land in different countries or regions and the average yield of world is regarded as yield factor[9]. And yield factor is the rate between one type area of bioproductive land of one country or region and the same type land area of the world. The ecological carrying capacity in global average yield can be calculated by kinds of areas of bioproductive land multiplying corresponding equilibrium factor. At the same time, in term of WCED report, at least 12% of ecological capacity should be reserved for protection biodiversity[25]. To evaluate the sustainability of this region through comparing the balance between ecological footprint and ecological carrying capacity, we must construct a set of scientific index system according to government policy and local circumstance. We should define the construction principle of the index system to evaluate the county cycle system well with these indexes.

2.1 Construction principle

The index system of ecological footprint is a uniform whole, and the choosing of indexes and the construction of the system should reflect the intension of sustainable development, generally conform to the following principle:

(i) Concise and scientific. The index system of ecological footprint must be built on the basis of science, the concept of indexes is clear, the coverage rate is wide, and can reflect sustainable development capacity of regional resources and ecology.

(ii) Integerity and completeness. The ecological footprint which is regarded as a comprehensive index should reflect the main characteristics and states appraised from every point of view.

(iii) Dynamic and stability.The index system of ecological footprint should keep relative stability during a period of time, but with the regional development and change, the index system should also adjust to meet the change sensitiveness of time and space, and reflect the future trend truly.

2.2 Index system

According to the analysis above, from the viewpoint of regional sustainable development, we structure the index system of ecological footprint, see Fig. 1.

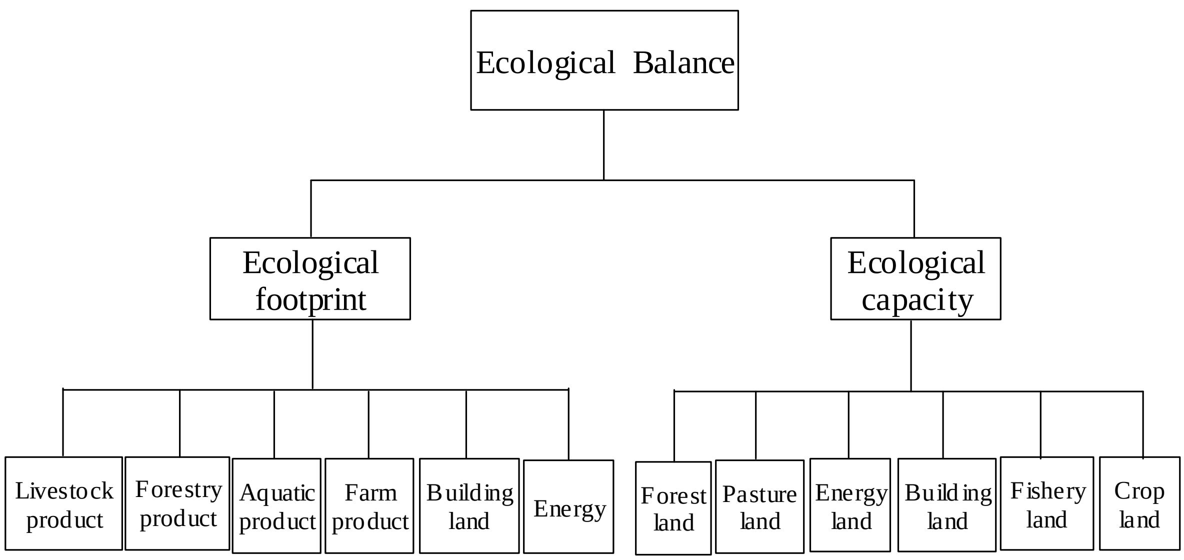

Fig. 1. index system of ecological footprint

3 Ecological footprint modelling

By adopting the popular ecological goal measure method–ecological footprint model since the middle period of 1990s[7], we calculate the ecological footprint of this county. Then we measure the current bio-capacity of resources and environment according to the existing bioproductive land of this area. Finally we judge whether the ecological appropriation is in the range of the ecological carrying capacity in this county by comparing the ecological appropriation with the ecological carrying capacity of the area.

3.1 Structure of ecological footprint model

Firstly we calculate the appropriation of biological resources in the county. We adopt the globe average yield of biological resources of Food and Agriculture Organization of the United Nations in 1999 to measure the use of biologic resources in the county (in order to make the result comparable), then change the main consumptions of the area in 2005 into bioproductive area which is necessary to produce these resources, the formula is as follows:

$$A_i = \frac{X_i}{\overline{Y}} \tag{1}$$

where: i represents the type of consumption; A_i is regarded as per-capita bioproductive area of consumption items; X_i is considered as per-capita consumption amount of consumption items. $\overline{Y}$ is deemed the globe average yield of i kinds of biological resources.

In the following, we calculate the use of energy of the area. Firstly we summarize the main categories of energy consumption: coal, coke, petrol, kerosene, diesel oil, petroleum gas, heavy oil, water and electricity, etc., to raw coal, petroleum, natural gas, water and electricity then change them into coal equivalent. Next, convert the energy consumptions into the fossil fuel. The formula which is used to calculate the areas of land production is as follows:

$$X_i = \frac{A_i}{B_i} \tag{2}$$

where: X_i: per-capita ecological appropiation amount of the i kind of energy (ha.cap^{-1}); A_i: per-capita consumption amount of the i kind of energy (GJ/kg); B_i: average yearly output rate of the world (GT.ha.cap^{-1}).

Variety of consumptions of biological resources and energy constitute the ecological footprint, the formula is as follows:

$$EF = N \times ef = N \times \sum (aa_i) = N \times \sum (\frac{C_i}{P_i}) \tag{3}$$

where: i: the types of goods-consuming and input; C_i: per-capita consumption amount of the i kind of goods; P_i: average production capacity of the i kind of goods; aa_i: bioproductive area of the i kind of goods; N: population; ef: per-capita ecological footprint; EF: total ecological footprint.

3.2 Structure of ecological carrying capacity model

According to current the areas of bioproductive land, we calculate the ecological carrying capacity, the formula of ecological carrying capacity is as follows:

$$ec = a_i \times r_i \times y_i \quad i = 1, 2, 3 \cdots \tag{4}$$

where: ec: per-capita ecological carrying capacity (hectare/capita); a_i: per-capita bioproductive area; r_i: equilibrium factor; y_i: yield factor.

The formula of total ecological carrying capacity is as follows:

$$EC = N \times (ec) \tag{5}$$

where: ec: per-capita ecological carrying capacity; N: population.

4 Application to county cycle economy system

Utilizing the data from the county's Statistical Yearbook of 2005, we get some results of use of biological resources of the county, See Tab. 1 and Tab. 2. The demand of ecological footprint is 7.1228 ha.cap^{-1}. We use the globe average output of biological resources of Food and Agriculture Organization of the United Nations in 1999 and global yield factor and equilibrium factor[26] to measure the conversion of productive area of biological resources. The proportion of ecological footprint of biological resources of the county is uneven. We get the ecological carrying capacity of this county in 2005, See Tab. 3. Per-capita ecological carrying capacity of this area is 3.1042 ha.cap^{-1} which is showed in Tab. 3.

Table 1. Main consumption and per-capita ecological footprint of the county in 2005

items	average yield of world $kg.ha^{-1}$	consumption of county 10^3kg	total ecological footprints ha	per-capita ecological footprint $ha.cap^{-1}$	biological productive area type
Wheat	2744	64971	23.67747813	0.027116	Crop land
Potato	2500	7863	3.1452	0.003602	Crop land
Rice	2744	177170	64.56632653	0.073942	Crop land
Corn	2744	32587	11.87572886	0.0136	Crop land
Sweet potato	12067	9983	0.827297588	0.000947	Crop land
Oil	1856	36237	19.52424569	0.022359	Crop land
Tea	1182	195	0.164974619	0.000189	Crop land
Candy	1800	2231	1.239444444	0.001419	Crop land
Pork	457	49067	107.3676149	0.122959	Pasture land
Beef	33	2246	68.06060606	0.077944	Pasture land
Mutton	33	1350	40.90909091	0.04685	Pasture land
Milk	457	2444	5.347921225	0.006125	Pasture land
Egg	400	23488	58.72	0.067247	Pasture land
Bancoul nut	1600	333	0.208125	0.000238	Forest land
Palm sheet	2000	274	0.137	0.000157	Forest land
Walnut	3000	919	0.306333333	0.000351	Forest land
Garden fruit	3500	27720	7.92	0.00907	Forest land
Aquatic product	29	10200	351.7241379	0.402799	Fisheries land
Construction	1000	2017700	2017.7	2.310696	Built-up land

Table 2. Demand of ecological footprint of the county

types	demand of per-capita ecological footprint		
	demand area	equilibrium factor ($ha.cap^{-1}$)	ecological footprint($ha.cap^{-1}$)
Crop land	0.143175327	2.8	0.4009
Pasture land	0.321123721	0.5	0.1605
Forest land	0.009816146	1.1	0.0108
Fisheries land	0.402799059	0.2	0.0805
Built-up land	2.31069629	2.8	6.4699
Total demand area			7.1228

Table 3. Supply of ecological biocapacity of the county

types	supply of per-capita ecological biocapacity			
	supply area ($ha.cap^{-1}$)	equilibrium factor	yield factor	ecological carrying capacity ($ha.cap^{-1}$)
Crop land	0.671504	2.8	1.66	3.121149
Pasture land	0.064778	0.5	0.74	0.023968
Forest land	0.319343	1.1	0.91	0.319662
Fisheries land	0.041913	0.2	1	0.008383
Built-up land	0.011693	2.8	1.66	0.054347
	Total supply area			3.5275
	Area of bio-diversity protection(12%)			0.4233
	Total available area of ecological space			3.1042

4.1 Assessment of results

Judging from the demand and supply of per-capita ecological footprint, the non-harmonious characteristic of total support and demand is obvious, and the ecological deficit exists seriously. In 2005 per-capita ecological footprint of the area (7.1228 ha. cap^{-1}) is 2.2945686 times of per-capita ecological supply (3.1042 $ha.cap^{-1}$), so the ecological deficit has appeared. The result shows that the demand of productive land of this county exceeds its supply capacity and the contradiction between the demand and the supply is serious. Moreover, the result reveals that the present ecological situation is severe. From Tab. 4, we can find that the

Table 4. Compare this county with other areas

types	county	province	west	east	nation	world
per-capita ecological footprint/(ha.cap^{-1})	7.1228	0.951	1.172	1.379	1.326	2.8
per-capita ecological supply/(ha.cap^{-1})	3.1042	0.385	0.718	0.513	0.681	2.0
per-capita ecological balance/(ha.cap^{-1})	-2.29	-0.566	-0.454	-0.843	-0.645	-0.8

per-capita ecological footprint of the county is 5.371644 times of the globe and is higher than other areas; It is 416% more than the eastern area; It is 507% more than the western area; It is 649% more than the province. The per-capita ecological deficit of the county is more serious than other areas above. Though the per-capita ecological supply of the county is more than other areas above, the per-capita ecological footprint of the county is also more than other areas above.

5 Ecological footprint forecast modelling

Because ecological footprint model is a static and instantaneous index, it assumes that population, and technology, consumption level of materials do not change, the ecological footprint model only assess the current situation. It is unable to reflect the population growth, technological progress and impact of social economic development on ecological footprint, and lacks the prediction function of the future development trend. The ecological footprint model has neglected such important factors as economy, society, technology, consumers' characteristic causing the ecological environment pressure. Therefore, to reflect the state of sustainable development synthetically and strengthen the prediction function of the ecological footprint model, we attempt to combine the index of ecological footprint with economic indicator GDP so as to offer the economic plan, development strategy and environmental protection of nations and areas more scientific, comprehensive and truer reference basis.

5.1 Econometric model

Econometrics has already been widely applied in reality as the effective tool studying the development trend of regional economy and analysing economic structure. Econometric model is a subject of expressing the economic relation by means of mathematics, and it has the functions of structure analysis, economic forecasting and analysis guidance to regional economy[27–29]. To anlyse the structure of this county cycle economy system, demonstrate its development policy and predict its economic development trend, we use the econometric model to analyse and predict GDP, population and per-capita GDP of this county according to its historical materials and the current development situation. All statistical parameters are compiled in Tab. 5. The data come from the county's Statistical Yearbook from 1995 to 2005. Except for the unit of x_5 is yuan/person and the unit of x_6 is person, the units of the remain are ten thousand yuan. The models based on the econometric model are as follows:

(1) GDP: $x_1 = x_2 + x_3 + x_4$;

(2) Per capita GDP: $x_5 = \dfrac{x_1}{x_6}$;

(3) population: $x_6 = -6243670 + 3.709 \times x_5 + 3517.121 \times time$ R^2=0.903 $F = 16.079$

5.2 Economy forecast for county system

A county area is a complex and huge system, and its development has the extremely complicated dynamic characteristic. We construct economic models by econometrics to describe operation behavior of the economic course, predict economic systems and evaluate policy. According to the economic models built, based on 20 billion yuan of accumulative total amount of the fixed assets of the county from 2006 to 2010, we make the prediction to the economy and population in the county. See the predictions in Tab. 6 and the trends of predictions from Fig. 2 to Fig. 4. We make the data of 2006 as initial data, initial time equals to 0 namely. And we make year as time unit. In the tables, all prices are current.

Table 5. parameters

Year	x_1	x_2	x_3	x_4	x_5	x_6
	GDP	GDP of first industry	GDP of second industry	GDP of third industry	Per capita GDP	population
1995	333872.0	85286.00	152311.8	96274.11	4099.00	814596.5
1996	401634.4	102441.0	174643.3	124550.1	5093.00	788660.0
1997	444574.3	109589.0	186011.9	148973.4	5645.00	787614.0
1998	470455.3	109921.0	186015.8	174518.4	5942.00	791749.0
1999	505665.9	111722.0	198839.5	195104.4	6342.00	797357.0
2000	528173.3	106846.5	211933.3	209393.5	6401.00	825133.0
2001	574144.4	103453.9	232328.2	238362.3	6840.00	839400.0
2002	633763.2	110367.0	258887.9	264508.3	7708.00	822221.0
2003	727909.1	125831.0	296164.1	305914.1	8891.00	818676.0
2004	852602.0	151648.0	359290.0	341664.0	10261.00	830955.0
2005	992500.0	166400.0	441300.0	384800.0	11851.00	873200.0

Table 6. Economy predictions

Year	GDP	Per capita GDP	population
	ten thousand yuan	yuan/person	ten thousand person
2006	1043490	11926.3	87.4946
2007	56849.3	13741.4	87.6696
2008	63671.2	15619.8	87.8450
2009	71311.7	17730.7	88.0207
2010	132569	21055	88.2583

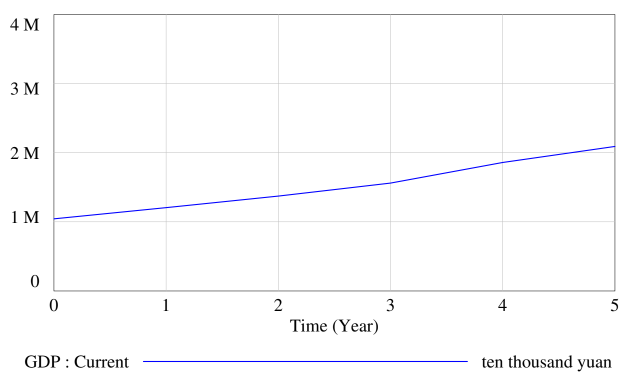

Fig. 2. GDP

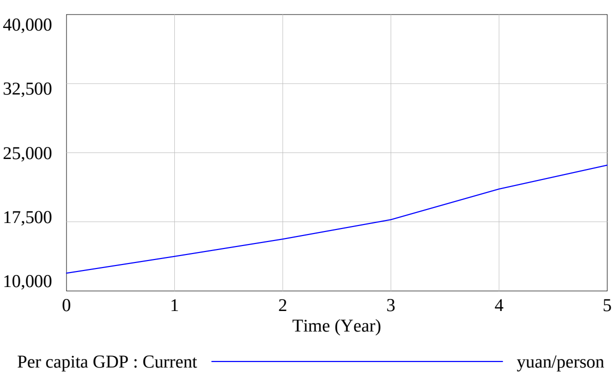

Fig. 3. Per capita GDP

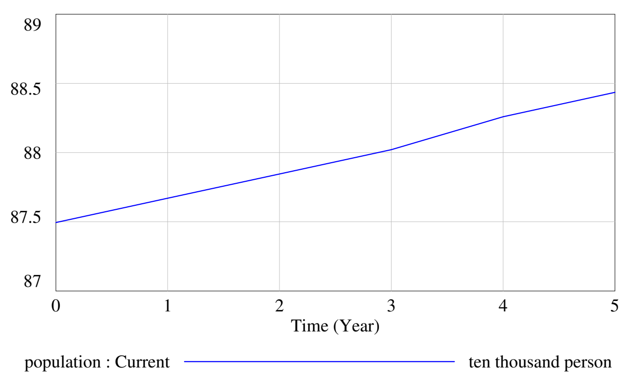

Fig. 4. population

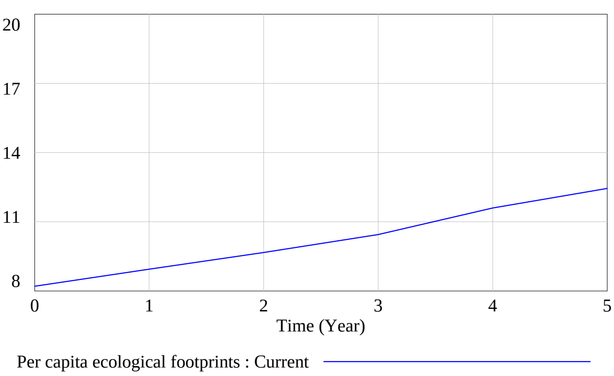

Fig. 5. Per capita ecological footprint

5.3 Forecast model of ecological footprint

Based on the analysis above, through collecting data of 34 nations and areas, we build three types of forecast models of ecological footprint according to energy efficiency, GDP per unit of energy use namely, which reflect the different relations between per-capita GDP and per-capita ecological footprint because of different energy efficiency. The models are separately forecast model of ecological footprint of low energy consumption, forecast model of ecological footprint of middle energy consumption and forecast model of ecological footprint of high energy consumption. According to historical materials and empirical data, we think energy efficiency between 0 and 15 as high energy consumption, between 15 and 25 as middle energy consumption, more than 25 as low energy consumption. By using statistical data, we firstly build the relations between per-capita GDP and per-capita ecological footprint, then analyse the current energy consumption of the county, finally adopt the corresponding forecast model to predict and analyse the ecological footprint of the county. All statistical parameters are compiled in Tab. 7. The data come from the International Statistical Yearbook 1998[21] and the website (http://rprogress.org/resource).

Table 7.

Nation	X	Y	Z
	Per capita GDP	Per capita ecological footprint	GDP per Unit of Energy Use
	dollar/person	ha/per capita	dollar per kg of coal equivalent
Egypt	790	1.5	1.1
Russia	2240	4.7	3.8
China	620	1.5	6.3
Czech	3870	4.1	7.2
Venezueal	3020	4.3	7.2
Jordan	1510	1.7	7.7
Poland	2790	4	7.8
India	340	1	8.7
South Africa	3160	3.1	10.5
Malaysia	3890	3.1	13.4
Pakistan	460	1	13.5
Turkey	1820	2.1	15.2
Nigeria	260	1	15.3
Canada	19380	7.4	17.5
Zndonesia	980	1.4	17.5
Mexico	3320	2.6	19.1
Thailand	2740	2	21.4
Philippine	1050	1.7	22.3
Korea	9700	3.8	23.5
Bangladesh	240	0.6	24.0
Australia	18720	10	24.1
America	26980	10.9	24.7
New Zealand	14340	8.2	25.8
Singapore	26730	6.2	30.5
Holland	24000	5.9	32.0
England	18700	4.9	34.6
Argentina	8030	3.5	36.5
Brazil	3640	3.8	40.0
Israel	15920	3.7	40.6
Spain	13580	4.1	42.8
France	24990	5.4	45.9
Italy	19020	4.4	46.3
Germany	27510	4.8	48.8
Japan	39640	4.7	77.9

We get the models for per-capita ecological footprint as:

(1) Per-capita ecological footprint of high energy consumption: $Y = \frac{e^{-3.612}}{X^{0.609}}$

$R^2 = 0.854 \qquad F = 52.718;$

(2) Per-capita ecological footprints of middle energy consumption: $Y = \frac{e^{-3.453}}{X^{0.56}}$

R^2=0.951 $\qquad F = 194.559;$

(3) Per-capita ecological footprints of low energy consumption: $Y = \frac{e^{-0.371}}{X^{0.194}}$

R^2=0.847 $\qquad F = 17.974$

5.4 Per-capita ecological footprint forecast for county cycle economy system

According to the statistical data of the county, we get that GDP per unit of energy use is 4.219 dollar per kg of coal equivalent in 2005. Because GDP per unit of energy use of this county is between 0 and 15, we adopt the forecast model of ecological footprint of high energy consumption to predict per-capita ecological footprint of this county. See the predictions in Tab. 8 and the trends of predictions from Fig. 5. We make the data of 2006 as initial data, initial time equals to 0 namely. And we make year as time unit.

Table 8. Per-capita ecological footprint predictions

Year	Per capita ecological footprint
	ha/per capita
2006	8.20201
2007	8.941064
2008	9.66666
2009	10.44245
2010	11.59449

6 Analysis and policy

(1) According to the results and analysis above, if the county still adopt present production and consumption pattern, industrial structure shape, the per-capita ecological footprint will increase from 7.1228 to 11.59449 when per-capita GDP grows from 11851 yuan of 2005 to 21022 yuan of 2010, its economy development is at the cost of excessively depredating natural resources.

(2) The supply type of ecological space in the county is single, the total supply is very limited. Because of the special characteristics of the county, the supply types of ecological space are mainly forest land and farm land, but grass land and water area are seldom. With excess reclamation of farm land, serious soil erosion and inferior land quality, the improvement of total supply has been limited.

(3) The industries of the county is mainly high energy consumption, and the population is relatively small, so the index of per capita seems to be huge.

(4) People oriented, establish overall, coordinate, sustainable ecological development view. Change these imbalances of areas, towns and economic society development to promote an coordinated development in economic society.

(5) Improve ecological carrying capacity. The county should catch the favorable opportunity of the national policy of developing western regions, and strengthen the investment management of constructions of ecological environment, strengthen comprehensive administration of soil erosion, improvement of artificial pastures, ecological water infrastructure construction to improve production capacity of land. On the premise of not reducing people's living standard, the county should adopt the new and advanced technology to improve the production output of per unit area of natural resources.

(6) Reduce ecological footprint. Change people's production and life consumption patterns and establish the social production and consumption system of resources economizing. Control population growth, reduce the demand of ecological footprint, shorten the ecological deficit. The county lies in the industries stage of

intensive resources, and resources are intensive and technologies are low, which gives rise to the demand increase of natural resources. Therefore, it is urgent to accelerate the changing of assets and technologies.

(7) Solve the population of overloading of the ecosystem through many channels. Develop the third industry actively; Organize the export of labour services to solve peasants' excessive dependence on farm land; Advance the urbanization process of the small and medium-sized cities actively to absorb more surplus rural labor forces; In the area where the ecological condition worsens extremely, carry on the ecological immigrant step by step according to the local financial resources.

7 Conclusions

In this paper, we have developed the evaluation and forecast models of ecological footprint to make some studies of county cycle economy. Through following the tracks of consumption of energy and natural resources of the county and studying whether the demand of bio-productive area exceeds the available supply, we analyze the sustainability of the county cycle economy system. Because the index of ecological footprint is static and unable to reflect the population growth, technological progress and impact of social economic development on ecological footprint,we attempt to combine the index of ecological footprint with economic indicator GDP to reflect the state of sustainable development synthetically and strengthen the prediction study of the ecological footprint model. Through the analysis of the result, the course and the significance of cycle economy are clear. It may help the government to establish the policies and offer the development strategy related to cycle economy development much more effectively.

The forecast model of ecological footprint with Econometrics constructed in this paper is valuable for solving some problems and measuring the sustainability state of the county in a certain. But except this method, to evaluate the sustainability state scientifically and comprehensively, it is necessary to combine the indexes of economy, society and environment with the index of ecological footprint. And more further research still needs to be conducted.

References

[1] M. Wackernagel, C. Monfreda, D. Moran, et al. National Footprint and Biocapacity Accounts 2005:The underlying calculation method *Global Footprint Network*, Oakland, CA, USA, 2005.

[2] M. Wackernagel, N. B. Schulz, D. Deumling, et al. Tracking the ecological overshoot of the human economy *Proceedings of the National Academy of Sciences of the United States of America*, 2002, **(14)** 99: 9266-9267

[3] M. Wackernagel, C. Monfreda, D. Moran, et al. National Footprint and Biocapacity Accounts 2004:The underlying calculation method *Global Footprint Network*, Oakland, CA, USA, 2004.

[4] E. P. Odum. Ecology: The link between the natural and social sciences. New York:Holt-Saunders, 1975.

[5] E. P. Odum. Ecology and our endangered life-support system. Sunderland: Sinauer Associates, 1989.

[6] A. M. Jasson, J. Zucchetto. Energy, economic and ecological relationship for Gotland, Sweden: A regional system study. *Swedish Natural Science Research Council*, 1978: Ecological Bulletins 28.

[7] W. E. Rees, M. Wackernagel. Urban ecological footprint:Why cites cannot be sustainable and why they are a key to sustainability *Environmental ImPact Assessment Review*, 1996: 224-248.

[8] Z. M. Xu, Z. Q. Zhang, G. D. Cheng. Concept and calculation model of ecological footprint *Ecological Economics*, 2000, **(5)**: 8-10 (in Chinese)

[9] M. Wackernagel, L. Onisto, Bellop, et al. National natural capital accounting with the ecological footprint concept *Ecological Economics*, 1999, **(3)** 29: 375-390

[10] C. Simmons, K. Lewis, J. Barrett. Two feet two approaches: a component based model of ecological footprint *Ecological Economics*, 2000, **(3)** 32: 375-380

[11] K. B. Bicknell, R. J. Ball, R. Cullen, et al. New methodology for the ecological footprint with an application to New Zealand economy *Ecological Economics*, 1998, **(2)** 27: 146-160

[12] G. Strassert. Physical input-output accounting and analysis: new perspectives. *13th International Conference on input-output Techniques*, 2000, 21-25 August, Macerata, Italy.

[13] T. Wiedmann, J. Minx, J. Barrett, M. Wackernagel. Allocating ecological footprint to final consumption categories with input-output analysis *Ecological Economics*, 2006, **(1)** 56: 28-48

[14] M. Wackernagel, W. Rees. Our Ecological footPrmt: Reducing Human Impact on the Earth. Gabriola Island, New Society Publishers, BC, 1996.

[15] M. Wackernagel, L. Onisto, L. Callejas, et al. Our Ecological footprint of nations: How much nature do they use? How much nature do they have? Commissioned by the Earth Council for the Rio+5 Forum. *Toronto:International Council for Local Environmental Initiatives*, 1997: 4-12.
[16] M. Wackernagel, C. Monfreda, D. Deumling. The Living Planet Report 2002. *World Wild Fund for Nature Inernational*, Grand, Switzerland, 2002.
[17] J. Loh, M. Wackernagel. The Living Planet Report 2004. *World Wild Fund for Nature Inernational*, Grand, Switzerland, 2004.
[18] C. Hunter, J. Shaw. The ecological footprint as a key indicator of sustainable tourism. *Tourism Management*, 2004,**(28)**: 46-57
[19] G. Hughes. Environmental indicators. *Annals of Tourism Research*, 2002, **(2)** 29: 457-477
[20] G. Hughes. Sustainable tourism and the touristic ecological footprint. *Environment, Department and Sustainability*, 2002, **(1)** 4: 7-20
[21] H. Liu. International Statistical Yearbook. China Statistics Press, Beijing, 1998 (in Chinese).
[22] N. Chambers, C. Simmons, M. Wackernagel. Sharing Nature's interst: Using Ecological Footprints as an indicator of Sustainability. EarthScan. UK, 2000.
[23] Ferguson, R. B. Andrew. The logical foundation of ecological footprints. *Environment, Department and Sustainability*, 1999: 149-156
[24] J. C. J. M. van den Bergh, H. Verbruggen. Spatial sustainability, trade and indicators: an evaluation of the ecological footprint. *Ecological Economics*, 1999, **(1)** 29: 61-72
[25] M. Wackernagel, M. Chad, K. H. Erb. Ecological footprint time series of Austria, the Philippines, and South Korea for 1961-1999: Comparing the conventional approach to actual land area. *Land Use Policy*, 2004, **(3)** 21: 261-269
[26] J. Venetoulis, J. Talberth. Sustainality indicators Program. *Ecological footprint of Nations 2005 UPDATE*, 2005.
[27] M. V. Pazarlioglu et al. Using econometric modelling to predict demand for fluid and farm milk: A case study from Turkey. *Food Quality and Preference*, 2006, **(18)** : 416-424
[28] S. Pazarlioglu. An econometric analysis of energy consumption in Nepal. *Energy Policy*, 2006, **(35)** : 350-361
[29] J. M. Wooldridge. Introductory econometrics (2nd Ed.), USA, 2002.