COAL RESOURCES CITIES' ECOLOGICAL FOOTPRINTS IN SHANXI PROVINCE FROM 1997 to 2005

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ABSTRACT

According to the ecological footprint model, this text calculates the ecological footprints of Datong, Yangquan, Jincheng, Shuozhou cities and so on which are coal resources cities in Shanxi province, and has carried on the comparison and the analysis in that foundation. The findings indicated that, during 1997~2005 years, these four cities all are at the unsustainable development state, and the average per capita ecological footprints and average per capita GDP grow continually, ten thousand Yuan GDP ecological footprints present the drop tendency continuously. As a whole, the sustainable development states of these four coal resources cities from 1997 to 2005 year are unoptimistic, and in that foundation the text proposes several methods of the sustainable development of these four cities in the future to choose.

Key words: Coal resources cities, Ecological footprint, Shanxi province.

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INTRODUCTION

Shanxi province, known as "home of coal" in the world, is extremely rich in coal resources. Almost 40% of the whole province, over the 94 countries (cities, districts), has a coal seam to scatter under the ground, and the preserving and owning coal resource has being 264,490,000,000 tons. Shanxi already becomes the base of resource and chemical industry that China government priority builds, and it has become one of the super-huge coal basis in the world. Among them, Datong, Yangquan, Jincheng and Shuozhou are representative coal resources cities of the whole nation country. According to the ecological footprint model, this text which is in the base of Shanxi Province statistics data from 1997 to 2005, calculates and analyses the ecological footprints of those four cities, and judges the sustainable development state, so some scientific advices for the sustainable development of the area can be provided

ECOLOGICAL FOOTPRINT MODEL

The ecological footprint (EF) provides an aggregate measure of human societies' pressure put on nature. It relates socio-economic metabolism to land use, one of the most dominant processes of society-nature interaction that contribute to environmental change[1,2]. The EF estimates people’s demand on the environment by measuring the amount of biologically productive land and water a population requires to produce the resources it consumes and to absorb the waster it generates. The ecological footprint model computation is based on 5 basic suppositions: (1) humanity may determine own consumption of the overwhelming majority resources and the quantity of the waste; (2) these resources and the waste can be transformed to the corresponding biologically productive land area; (3) each kind of land has the reprobation in the space, (4) As long as using the biologically productive forces to weigh the lands, lands of different regions may use the same unit to express; (5) the supplies ability of the ecology service of the natural system can compare to the total quantity of the natural system the human system demands. According to the difference of the productive forces, the computation of the EF mainly considers 6 kinds of biologically ecological land: fossil fuel land, cropland, forests, grazing land, built-up land and fishing grounds. They are the unified platform of the ecological footprint model. According to the supposition and the theory above, the technical route of the ecological footprint computation is: (1) division of consumption project and computation n of the average per capita ecological footprint of kinds of consumption project, the formula is $A_i = C_i / Y_i = (P_i + I_i - E_i)/(Y_i / N)$: In the formula, i for consumption project type; A_i for the Biologically productive area that average per capita holds converted by i kind of consumption project (average per capita ecological footprint component, hectare/capita); C_i For average per capita consumption quantity; of the i kind of consumption project. Y_i for world yearly average output that the biologically productive land produces the i kind of consumption project (kilogram/hectare); P_i for year productivity of i kind of consumption project; I_i for yearly import quantity of i kind of consumption project; E_i for yearly export quantity of i kind of consumption project; N for population. (2) the formula of average per capita ecological footprint is: $ef = \sum r_j A_i = \sum r_j (P_i + I_i - E_i)/(Y_i / N)$ In the formula, ef is the average per capita ecological footprint (hectare/capita); r_j For the balanced factor, the balanced factor transforms the different type of biologically productive land to the unified biologically productive land; A_i for the Biologically productive area that average per capita holds converted by kind of consumption project (average per capita ecological footprint component, hectare/capita); (3) computation of the average per capita ecology carrying capacity, the formula is $ec = a_j \times r_j \times y_j$: In the formula, ec is the average per capita ecology carrying capacity. a_j for the average per capita biologically productive area; r_j For balanced factor; y_j for the output factor, the output factor is the ratio of average productive forces of some national or local some type land and average productive forces of the world same type land [3] .

THE ECOLOGICAL FOOTPRINTS COMPUTATION OF FOUR COAL RESOURCES CITIES IN SHANXI PROVINCE

The EF computation

According to the ecological footprint model and taking the Shanxi Province 1997~2005 year statistical data as a data pool, this text calculates the EF of Datong, Yangquan, Jincheng, Shuozhou cities and so on which are coal resources cities in Shanxi province. Its ecological footprint computation is divided into 2 parts: Biological resources account, energy consumption account. It is necessary to point out that during the process of these cities ecological footprints computation, the computation defers to the material object consumption, and simultaneously aiming at the data origin situation of each city has made the suitable revision to the consumption quantity.

The biological resources consumption is mainly divided into several big kinds such as agricultural product, the animal product and so on. Moreover each big kind is equipped with some segmentation. In the concrete computation of biological resources productive area conversion it is used that the world average output material of biological resources. Of UN Food and Agriculture Organization in 1993 Taking Jincheng city in 2004 as the example, computed result of biological resources account is shown in Table 1.

Table 1.: computed result of Jincheng biological resources account in 2004.

Biological item	Consumption per capital (kg/cap)	Global equilibrium output (kg/hm^2)	Cropland (m^2/cap)	Grazing land (m^2/人)	Fishing land (m^2/cap)	Forests land (m^2/cap)
Foodstuff	364.25	2744.00	1327.454			
Cotton	0.32	1000.00	3.250			
Oil-bearing crops	6.52	2333.00	27.939			
Vegetables	133.38	30444.00	43.812			
Fruit	22.40	22422.00	9.990			
Beef and mutton	4.69	33.00		1419.778		
Pig	22.38	457.33	489.288			
Fowl	11.09	784.00	141.443			
Breasts	2.12	502.00		42.296		
Fishing	0.19	29.00			65.517	
Wool	0.25	15.00		167.190		
Wood	0.28	1990				3.967
Total			2043.176	1629.264	65.517	3.967

Energy consumption accounts on the base of data are processed into several kinds as follows: raw coal, coke, natural gas, gasoline, electric power and so on. Taking the average calorific capacity of the world unit fossil fuel productive land as the standard, the quantity of heat of the local energy consumption is converted to certain fossil fuel land. This energy consumption is transformed to fossil energy land area. During the reckoning of these four cities, according to the global average land productive rate which Wackernagel and others determine. For example: the global average land productive rate of coal, petroleum, and natural gas are respectively 55GJ/hm^2, 71GJ/hm^2, and 93GJ/hm^2. Still taking 2004 Jincheng as the example, the computed result of ecological footprint in 2004 is shown in table 2.

The computation of ecological footprint balance

Ecological footprint balance uses in finally calculating the local ecological footprint and the ecology carrying capacity. It is divided into the demand chart and supplies chart, so both of them can be contrasted. The balance table transforms the obtained land area, which is calculated by the biological resources and the energy consumption account for the global comparable biologically productive area. To delivers the factor and the balanced factor estimated data, according to the national ecological footprint calculation data of china in 1996 of “Redefining Progress” in 2000.Take Jincheng balance computation in 2004 as the example, as is shown in Table 3.

Table 2.: The computed result of Jincheng energy consumption account.

Energy item	Global average energy footprint (GJ/hm^2)	Transformity (GJ/t)	Consumption	EF per capita ($m^2 \cdot cap^{-1}$)	Land item
Coal (10000ton)	55	20.934	1392.1	24116.37	Fossil fuel land
Electric (100 million kwh)	1000	0.0083 GJ/KWh	61.37	231.8308	Built-up land
Coke (10000ton)	55	28.4	198.43	4675.19	Fossil fuel land
Petroleum (ton)	93	43.124	57900	122.1372	Fossil fuel land
Kerosene (ton)	93	43.124	1217	2.568	Fossil fuel land
diesel oil (ton)	93	42.71	138600	289.7636	Fossil fuel land

Table 3.: Jincheng in 2004 ecological footprint balance.

Category	Demand			Supply		
	Total hm^2/cap	Equivalence factor	Equivalent Total hm^2/cap	Yield factor	Regional area hm^2/cap	Yield adjusted equiv area hm^2/cap
Fossil fuel	2.920346	1.1	2.534087	0.61	0	0
Cropland	0.204318	2.9	0.592521	1.82	0.084650803	0.45
Grazing	0.162926	0.6	0.097756	0.94	0.020003018	0.02
Forests	0.000139	1.1	0.000156	0.61	0.159104287	0.16
Built-up	0.023183	2.9	0.031085	1.82	0.016939875	0.03
Fishing	0.006552	0.2	0.00131	1	0.005783237	0.00
Total used hm^2/cap			3.971199	Total existing hm^2/cap		0.66
				12% for biodiversity		0.584555
				Ecological deficit hm^2/cap		3.39

THE COMPUTED RESULT OF FOUR CITIES AND THE CONTRAST ANALYSIS

The dynamic change tendency of average per capita ecological footprints of 4 coal resources cities

According to the computational method above, the article has carried on the reckoning, of ecological footprints of Datong, Yangquan, Shuozhou, which are compared to Jincheng, the result has been as follows:

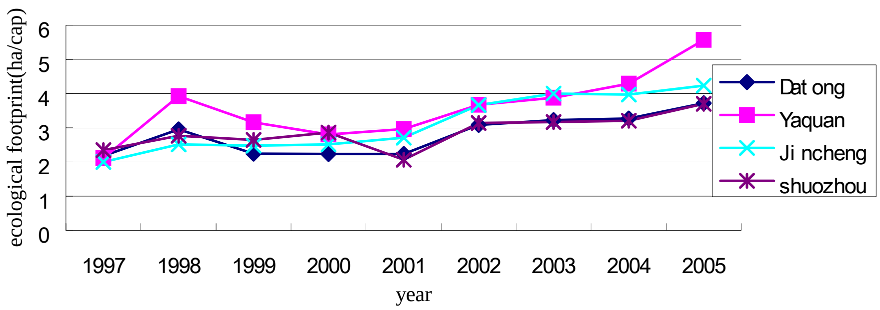

Figure1.: The dynamic change tendency of average per capita ecological footprints of 4 coal resources cities.

The dynamic change tendency of average per capita ecological footprints of 4 coal resources cities as a whole assumes growing tendency (shown in Figure 1) with steady steps, manifesting recent years the biological productive area which are needed by average per capita to maintain resources consumption and the waste absorbability increases unceasingly. Among them, the absolute value of ecological footprint in Yangquan is big and the growth is quick, from 2.18 hm^2/capita in 1997 to 5.57 hm^2/capita in 2005, increasing by 2.63 times; Next is Jincheng, by 2.12 times; Shuozhou and Datong's ecological footprints grows relatively gently. Shuozhou increases from 2.35 hm^2/capita to 3.7 hm^2/capita, by 1.55 times, Datong increases from 2.18 hm^2/capita to 3.72 hm^2/capita, by 1.72 times.

Analysis of ecological footprint land type classification

According to the ecological footprint demand structure in the four cities (analysis of ecological footprint land type classification), the fossil fuel occupied with the place demand 70% of the complete space, but the main consumable of the fossil fuel with the place is coal, occupying to 80%, of energy demand footprint, which accounts the important reason of the ecological deficit is the primarily energy consumption of coal, this is owing to itself energy resources specially the rich of coal resources as well as the energy densification industrial base construction ,which reflects these four cities social economy development rely on excessively the consumption of natural capital storage quantity, enlarging the pressure ,to the natural ecosystem .and restricting the sustainable development of the cities.

Taking Datong as the example (Figure 2), during the 9 years from 1997 to 2005, the constitution proportion of variant types land of the average per capita ecological footprint is quite stable, changing not obviously. The fossil fuel land, occupies the biggest proportion, approximately composing 70%. Next is cropland, approximately composing 20%, but other several kinds of land type accounts for the proportion to be extremely few, some for 1%, some does not. The quickest grow are the fossil fuel land and the built-up land, which concerns with the cities economical development as well as the increase of the coal mining quantity and the demand.

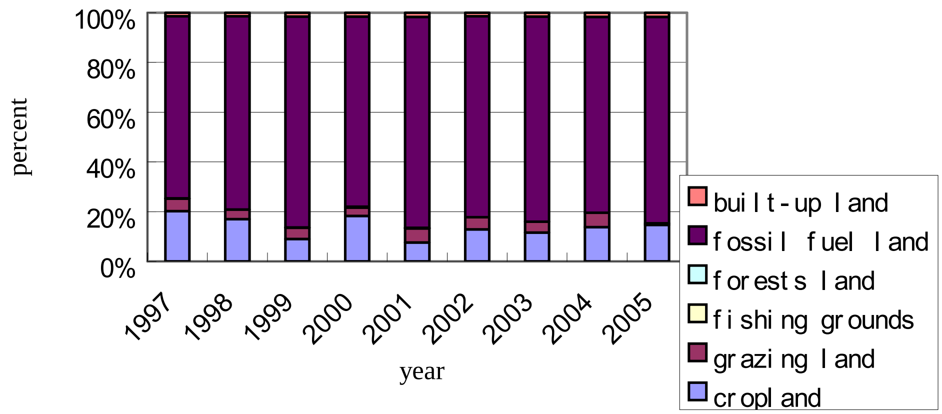

Figure 2.: Different type biology production configuration land accounts for the proportion in the total average per capita ecological footprint constitution (Datong city).

Analysis of four cities ecological deficits

Datong, Yangquan, Jincheng and Shuozhou all have the quite big ecological deficits, and these four coal resources cities are being at the unsustainable ecology condition as a whole, the average per capita ecological footprints is 3 to 12 times of the ecology carrying capacity which are provided by each city. According to "strong sustainable", the developments of these urban are not sustainable. In 2004, all of these four cities average per capita ecological footprints are higher than the average per capita ecology carrying capacity, producing the ecological deficit. Their ecological deficit is respectively: 2.55hectare/capita, 3.88hectare/capita, 3.39hectare/capital, and 1.95hectare/capita. Moreover, according to the research of XUZhongmin[5], ZhangFang[8] as well as ChengQiuji[9] and others people, average per capita ecological footprint of national average level in 2003 was 1.547 hectares and the average per capita ecological deficit was 0.817 hectare. In 2004, average per capita ecological footprints and the ecological deficit of the main coal productive area respectively are 1.43 hectare and 0.793 hectare, But the ecological footprints and the ecological deficits of these four coal resources cities all are higher than China's average level and also higher than the level of Shanxi Province as well as the main coal productive area in 2004.

According to the efficiency of resources and calculation of ten thousand Yuan GDP of these four cities ecological footprints, obviously, the bigger the demand of ten thousand Yuan GDP footprints are, the lower the efficiency of resources are. Otherwise, the efficiency of resources is higher. In 2003 the footprints of our country average ten thousand Yuan GDP was 1.8 hm^2, which was higher than the developed country as well as the world average level, reflecting the low, and efficiency in using our countries resources. Ten thousand Yuan GDP ecological footprints of Datong, Jincheng, Yangquan, Shuozhou all the four cities are higher than the national level. Yangquan had achieved 5.13 hectares in 1998, higher than the national level by far, which reflected the efficiency of using resources in these four coal resources cities are extremely low, and still was one kind of sustainable development condition that was at the high consumption, the low benefit taking loss of the natural ecology as the price .The economical development still was the extension economy growth way. But through analyzing the development trend of these four cities ten thousand Yuan GDP ecological footprints value from 1997 to 2005, this term value from 1997 to 2005,years has the drop tendency, but this tendency was not obvious, this reflects in certain extent these four coal resources cities have the tendency to transform to the developing model of the intensive type, saving type, but the change is slight and the degree of transformation was insufficient, so the space also exists to enhance the efficiency of use the resources. To save the resources and to realize the sustainable development need further diligent hard-working and enhancement.

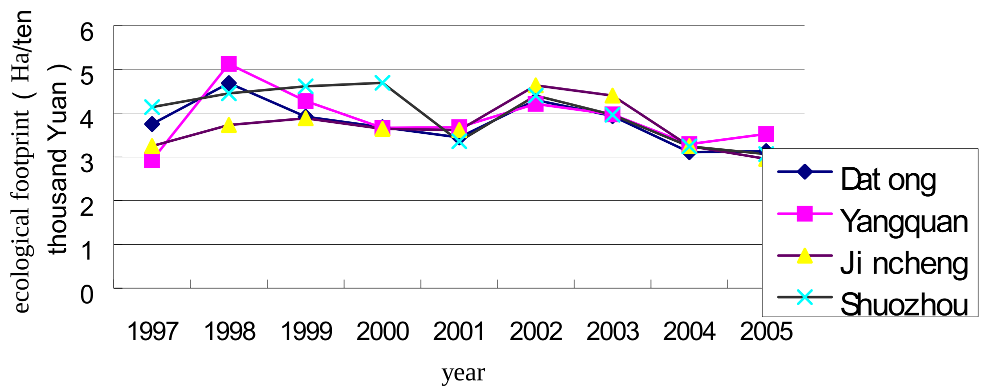

Figure 3.: Four coal resources cities ten thousand Yuan GDP ecological footprints compares

CONCLUSIONS

According to the basic principle of the ecological footprint model, this article carries on the computation and the analysis of ecological footprints and the ecological carrying capacity of Datong, Yangquan, Jincheng, and Shuozhou, which are important coal resources cities in Shanxi Province. The findings indicate that these four cities are at one kind of unsustainable development state. Simultaneously the ecological footprints value of ten thousand Yuan GDP of these four cities are relatively high, which reflects the low, efficiency of using resources.

In order to reduce the average per capita ecological footprint as well as the ecological deficit, and to reduce the influence of the humanity to the ecological environment, regarding to these four coal resources cities, following several measures may be taken:

(1) We should enhance the land resource management. In recent years the actual utilization land area, specially the cropland, of these cities have the reduced tendency, therefore the plan and the development of the not using land need to be strengthened, simultaneously arrangement and duplicate ploughs of the land have to come into being. We should increase the land reserve resources, strengthen the saving land opinion, enhance cropland protection and the basic farmland construction, enhance the management of built-up land, and simultaneously maintain the demand of the economic built-up land.

(2) We should change the production method of the society and the consumption method of the humanity living, realize the transformation from the industry civilization consumption pattern to the ecology civilized pattern, establish social product system of the resource conservation pattern and the reasonable health consumption pattern.

(3) We should absorb the more effective development experience through each measure from the developed area, display the region superiority of energy heavy chemical industry base, and carry on the industrial structure adjustment. We should use and introduce the new technology to lengthen the industrial chain, gradually change the economy growth pattern of resources consumption and enhance the efficiency of using the resources.

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