Research on the Industrial Ecologicalization in Yunnan Province

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Abstract By using ecological carrying capacity, ecological footprint method and shift-share analysis and the data from *Yunnan Statistical Yearbook* and *China Statistical Yearbook*, the status quo of industrial ecologicalization development in Yunnan Province is analyzed from the aspects of consumption of resources and environment, production technology and industrial pollution and industrial structure. The results show that the economic growth in Yunnan Province is based on the huge consumption of resources; the consumption of natural environment has surpassed its carrying capacity; the production technology is relatively backward and the comprehensive use efficiency of the "three wastes" is low; the solid waste emission of the ten thousand GDP far exceeds the average level of the whole county; the total emissions of industrial waste gas and domestic sewage are increasing; the efficiency of industrial structure is bad. On the strength of the analysis, the relevant measures on ecological industrial development in Yunnan Province is put forward, covering strengthening the awareness of saving resources and protecting environment; establishing energy-saving type national economy and social system; actively adjusting industrial structure; strengthening ecological construction of the three major industries.

Key words Industry, Industrial ecologicalization, Countermeasures, Yunnan Province, China

Nowadays, the industrial ecologicalization has become popular in the world economic development. Industrial ecologicalization is to incorporate the industrial activities, which are the main content of the material production process, with the huge ecological system; put the consumption of natural resources and effects on environment caused by industrial activities into whole material and energy exchange process of the big ecological system, so as to realize the virtuous circle and sustainable development of ecological system[1]. The marketed feature of ecological industry is the low consumption and high use rate of natural resources and the low emission of wastes, as well as solve the conflicts among environment, resources and development[2]. Since the reform and opening up, the social economy of Yunnan Province has been developing rapidly and the per capital GDP has increased from 226 yuan in 1978 to 7 833 yuan in 2005. But the economic growth mode of Yunnan Province is at the expenses of huge amount of resource consumption, waste emission and low efficient use of natural resources, which cause the environmental pollution, ecological degradation and the conflicts between people and environment. How to ensure the sustainable use of natural resources and promote the sustainable development of social economy has become a major issue faced by Yunnan Province in the process of economic and social development. The research on the industrial ecologicalization of Yunnan Province is of great significance to the sustainable development of social economy and ecological environment.

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1 Research method and data source

1.1 Research method

1.1.1 The ecological carrying capacity model and ecological footprint model. The research chooses "ecological carrying capacity" to measure the ecological support capacity[3], "ecological footprint"[4] to measure ecological consumption and "ecological deficit and reserve" to measure the sustainable status.

Ecological carrying capacity is the self-remaining and self-adjusting capability of ecological system, the tolerance capability of environment and sub-system of environment and the social economy strength and the number of people with certain economic level it maintained[3]. The equation of ecological carrying capacity EC is:

$$EC = N \cdot ec \quad (1)$$

In the formula, $ec = a_j \cdot r_j \cdot y_j$; a_j is the per capital biologically productive area; r_j is equivalence factor; y_j is yield factor; N is the number of people.

Ecological footprint is also called ecological occupation, ecological mark, and ecological foot-print and so on. Ecological footprint is defined as follows. The ecological footprint of any people (a person, a city or a country) refers to all the resources consumed by producing all the people and the biologically productive areas (including land and water) needed for all the wastes produced by receiving all the people. The equation is as follows:

$$A_i = C_i / Y_i \quad (2)$$

$$EF = N \cdot ef = N \cdot (\Sigma r_j A_i) \quad (3)$$

In the formula, i is the sort of consumption items; $j = 1, 2, 3, \cdots, 6$; A_i is the per capital biologically productive land of the *i sort of consumption item* (hm^2/people); C_i is the per capital consumption of the *i sort of consumption item* (kg/people) Y_i is the annual (world) average yield of the i sort of consumption item produced by ecologically productive land (kg/hm^2); EF is

the whole ecological footprint in a region(hm^2); N is the number of people; ef is per capital average ecological footprint (hm^2/people); r_j is equivalence factor[4].

Ecological deficit and reserve refers to the difference between ecological carrying capacity and ecological footprint. The equation is as follows:

Ecological deficit = Ecological carrying capacity (EC) – Ecological footprint(EF) (4)

When ecological carrying capacity is larger than ecological footprint, the ecological reserve will appear, and then the economic development is in harmony with environment, and then the development is sustainable; whereas, the development is unsustainable.

1.1.2 Shift-share analysis. The shift-share analysis is chosen to analyze the benefit status of industrial structure in Yunnan Province. The shift-share analysis is to take the regional economic change as a dynamic process; take the economic development of the very region and the nation as the reference frame and divide the changes of region economy within a certain region into three components, that are shift component, structure deviation component and competitive deviation component, so as to explain the causes of regional economic development and recession; judge the regional economic structure and self competitiveness; find out the industrial sectors with relative competitive advantages in the region, and then the reasonable direction of future economic development and the principles of industrial structural adjustment can be defined[5]. The equation is[6]:

$$G_j = N_j + P_j + D_j \quad (5)$$

In the equation, $N_j = [(E_t - E_0)/E_0] \times E_{j0}$; $P_j = \sum[(E_{it}/E_{i0}) - (E_t/E_0)] \times E_{ij0}$; $D_j = \sum[E_{ijt} - (E_{it}/E_{i0}) \times E_{ij0}]$. G_j, N_j, P_j, D_j represent the increment of regional total output, shared increment, structural increment, transferred increment respectively; E_t and E_0 represent the total output of the sample region at the 0 time period and t time period respectively; E_{j0} and E_{jt} represent the total output of the j region in the 0 time period and t time period respectively; E_{ij0} and E_{ijt} represent the total output of i industry in j region at the time period of 0 and t respectively.

The research takes the year of 2000 as the base period, 2005 as the trial period and GDP of the whole nation in 2000 and the GDP of Yunnan Province in 2005, the GDP from the primary, secondary and tertiary industry and the GDP of the agriculture, forestry, animal husbandry, and fishery as the basic data to calculate.

1.2 Data source The research data mainly comes from *Yunnan Statistical Yearbook* from 1978 to 2005[7], the *China Statistical Yearbook* in 2005[8], and the bulletin of GDP energy consumption issued over the years by the National Statistics Bureau.

2 Results and analysis

2.1 The status quo of ecological environmental consumption consumed by industry According to the data from the years 1978 to 2005, and by using the equations from(1) to (4), the ecological carrying capacity, ecological footprint and ecological deficit and reserve(Table 1)[9].

Table 1 Per capita ecological carrying capacity, ecological footprint and ecological deficit and reserve of Yunnan Province from 1978 to 2005 hm^2

Year	Per capita ecological footprint	Per capita ecological carrying capacity	Ecological deficit and reserve	Year	Per capita ecological footprint	Per capita ecological carrying capacity	Ecological deficit and reserve
1978	0.621	1.369	0.748	1992	0.976	1.003	0.027
1979	0.595	1.272	0.677	1993	1.009	0.988	−0.021
1980	0.599	1.266	0.667	1994	1.045	0.975	−0.070
1981	0.627	1.248	0.621	1995	1.149	0.958	−0.191
1982	0.665	1.224	0.559	1996	1.235	0.953	−0.282
1983	0.697	1.206	0.509	1997	1.366	0.944	−0.422
1984	0.748	0.974	0.226	1998	1.420	0.984	−0.436
1985	0.748	0.956	0.208	1999	1.463	0.933	−0.530
1986	0.720	0.962	0.242	2000	1.525	1.058	−0.467
1987	0.744	1.003	0.259	2001	1.564	1.044	−0.520
1988	0.822	1.060	0.238	2002	1.688	1.016	−0.672
1989	0.845	1.044	0.199	2003	1.748	0.997	−0.751
1990	0.902	1.021	0.119	2004	1.814	0.739	−1.075
1991	0.940	1.015	0.075	2005	1.952	0.896	−1.056

It can be seen from Table 1 that the per capital ecological carrying capacity declines annually, while the per capital ecological footprint increases annually. Since 1993, the ecology in Yunnan Province has made a loss of 0.021 hm^2 per capital, and the whole country has lost 80.234×10^4 hm^2, and the loss was expanding. In 2005, the per capital loss was 1.056 hm^2, and the loss of the whole was $4\ 701 \times 10^4$ hm^2, 59 times more than that in 1993. It can be seen that, from the perspective of the whole nation, since 1993, the development of Yunnan Province has begun to make up for the sufficient of ecological carrying capacity on the costs of natural resources to occupy the rapid development of economy. It was an unsustainable model of development. The development illustrated that the effect caused by the economic activities in Yunnan Province has been far beyond the ecological carrying capacity. The over dependence of Yunnan economic development on natural resources is the main reason that caused ecological deficit. It is obvious that from 1978 to 2005, the ecological footprint consumption of ten thousand yuan GDP has shown the decreased trend, but comparing with that of the whole nation, the consumption was high. For example, in 2000, the ecological footprint of ten thousand yuan GDP of the nation was 1.82 hm^2[10], but in Yunnan Prov-

ince the figure was 3.288 51 hm^2, which was 1.8 times more than that of the whole nation. The researches showed that since 1999, the per capital ecological footprint in Yunnan Province has surpassed that of the nation.

2.2 The status quo of resource consumption According to the prediction of Yunnan Economic Research Institute, in 1990, the rate of resource consumption to output in Yunnan Province was 1:1.3, which indicates that the economic growth in Yunnan Province is based on the expenses of resource consumption[11]. Taking the energy consumption as an example, in recent years, due to the proper implementation of energy-saving measures, the energy consumption of each ten thousand GDP has decreased obviously. The economic growth and energy saving of Yunnan Province go in accordance with the environmental Kuznets curve , and it stays in the right half of the "U" type. But comparing with the national energy saving level, the energy consumption of per 0.1 billion outputs is higher (Table 2). In 2005, the energy consumption of per unit GDP is 1.73 tce/ $\times 10^4$ yuan, ranks the tenth of the national level; the energy consumption of per unit industrial added value 3.55 tce/ $\times 10^4$ yuan, ranks the ninth of the whole nation(Table 3) . Each item of energy consumption in Yunnan Province is higher than that of the average level of the nation, and the elastic coefficient of energy consumption shows wave-shaped annual growth. At present, the raw materials and water resources consumed by per unit GDP of Yunnan Province are higher than that of the national average level. The energy consumption in the heavy industry with large scale, extractive industry and raw material industry account for 60% of the total consumption and that in the energy-based enterprises is higher[12].

Table 2 Comparison of the energy consumption per 10 000 yuan GDP between Yunnan Province and Whole China from 2000 to 2005

tce/ $\times 10^4$ yuan

Region	2000	2001	2002	2003	2004	2005
The Whole China	1.46	1.40	1.42	1.50	1.40	1.22
Yunnan Province	1.72	1.75	1.79	1.74	1.69	1.73

Table 3 Comparison of various energy consumption per 10 000 yuan GDP between Yunnan Province and the Whole China in 2005

Region	Energy consumption of per unit GDP tce/ $\times 10^4$ yuan	Electric consumption per unit GDP (kW·h)/ $\times 10^4$ yuan	Energy consumption per unit industrial added value tce/ $\times 10^4$ yuan
Whole China	1.22	1 358.5	2.59
Yunnan Province	1.73	1 604.6	3.55

2.3 The emission of production industry and industrial waste The chemical industry, building materials industry, electric industry and light industry of Yunnan Province lay in the backward level of the country and the metallurgy is close to or stay at the advanced level of the whole nation[13], but its industrial added-value rate, interest rate of industrial output and some other performance indicators are all lower than the national average level, which indicates that the overall industrial level of Yunnan Province is low and the industrial production still lays in the extensive state; the deep-processing capability of the basic raw material industries is weak and the added-value is low. From 1996 to 2005, the industrial waste gas, released by the production technology process, accounts for 50% of the total volume of waste gas emission. The township enterprises are mainly middle-and-small-enterprises with low technology and backward environmental handling facilities. Agricultural irrigation facilities are backward, mechanization level is low and cultivation is on steep slopes, deforestation and soil erosion lead to the grave desertification; improper use of fertilizer leads to the sealing of soil and the drop of fertility. The relevant investigation shows that 50% of the nitrogen and phosphorous, which lead to the water nutrition enrichment, come from the fertilizer. The biggest pollution source of Dianchi Lake is the residual of fertilizer and pesticide in the river basin[13]. In Yunnan Province, the volume of fertilizer use was increasing, from 1.12 million t in 2000 to 1.427 t in 2005. There are few cycling economic sectors in Yunnan Province, although the total value of the comprehensive use of "three wastes" was increasing gradually, from 1996 to 2004, the per capital output of the comprehensive use of "three wastes" in Yunnan Province is lower than that of the average level of China. But the discharge of solid waste of billion GDP always far outstrips the average level of the whole China. In 1997, it was 12.7 times higher than that of the whole China, which was the maximum value; in 2004, it was 1.4 times higher than that of the whole China, which is the minimum value. Besides, the amount of per capital waste water discharge increases annually. From the perspective of the total amount, the discharge of industrial waste gas and waste water is increasing year by year.

2.4 The status quo of industrial structural interests According to the original data and by using the shift-share analysis, the increment of the structural interests of the three industries in Yunnan Province (Table 3) and the increment of the structural interests of agricultural inner structure (Table 4) can be calculated.

It can be seen from Table 3, the three industries of Yunnan Province share a large part of increment. It indicates that economy of Yunnan Province has obtained larger increase based on the national average speed. From the viewpoint of the total transfer increment, the value is negative in Yunnan Province, which implies that Yuan Province does not have so much resource transfer, economic activities is inactive and the economic growth in Yunnan Province is lower than the national average level. In terms of structural increment, the value of the primary industry is negative, which shows that it is not the rapid growth sector; the total structural increment is negative, which shows that the industrial structural interest is low. In the location increment, the values of the primary and the secondary industries are all negative,which demonstrate that the two industries do not have the location advantage. The value of the tertiary industry is positive, which indicates that the tertiary has the location advantages, the tourism in particular.

It can be seen from Table 4 that, the total structural increment is negative, which indicates the unreasonable industrial structure and low efficiency. The location increment of forestry and fishery is negative, which shows that it has certain location advantage. But the total location increment of agriculture is negative, which indicates that the whole agriculture in Yunnan

Province does not have the location advantage.

Table 4 Interest increment of three industrial structures in Yunnan Province $\times 10^8$ yuan

Industry	Shared increment	Structural increment	Location increment	Transfer increment	Increment of the total output value
The primary industry	368.77	−121.15	−27.72	−148.87	219.90
The secondary industry	712.81	55.17	−161.53	−106.36	606.45
The tertiary industry	571.14	19.18	100.58	119.76	690.90
Total	1 652.72	−46.81	−88.67	−135.47	1 517.25

Table 5 Benefit increment of agricultural industrial structure in Yunnan Province $\times 10^8$ yuan

Agricultural industry	Shared increment	Structural increment	Location increment	Transfer increment	Increment of the total output value
Plantation	155.63	−45.26	−33.69	−78.95	76.68
Forestry	18.6	−1.95	16.27	14.32	32.92
Animal husbandry	75.31	28.02	1.37	29.39	104.70
Fishery	4.94	−0.87	1.53	0.66	5.60
Total	254.48	−20.06	−14.52	−34.58	219.90

As far as the analysis above, it can be seen that the economic growth of Yunnan Province is based on the huge consumption of resources; the consumption on natural environment has surpassed its carrying capacity; the production technology is backward and the comprehensive use of "three wastes" is low; the discharge of solid waste of ten thousand yuan GDP has far surpassed the average level of the whole nation and the total volume of industrial waste gas and domestic waste water is increasing; industrial structural benefit is poor and the competitiveness is weak.

3 Countermeasures and suggestions

3.1 Enhancing the awareness of energy-saving and environmental protection and establishing the energy-saving national economic and social system The overall energy-saving and environmental protection awareness of people in Yunnan Province is backward. Some government officials still think that GDP is unalterable quota and environment is soft quota or zone quota[14]. In terms of attracting investment, they often introduce into enterprises with high pollution. The extensive economic growth pattern, which is high consumption, low quality, low output and based on the expenses of resource and environment, goes against the future development of Yunnan Province. Since 1993, the economic growth of Yunnan Province has surpassed the carrying capacity of ecological environment and the economic growth has gravely threatened the ecological security. Ecological security is the "bottom line" of ecological carrying capacity. If the ecological security goes beyond the threshold, it will collapse[15]. Therefore, the government and the masses should increase their awareness of ecological security; strengthen promotion on it; enhance the environmental protection awareness of regional people; establish the energy-saving national economy and social system and perfect and seriously implement the relevant laws and regulations on environmental protection.

3.2 Adjusting industrial structure actively and strengthening the ecological construction of the three industries The industrial structural benefits of Yunnan Province is low, so it should actively adjust its industrial structure; optimize and upgrade industrial structure; fully display its advantages and improve the structure benefit.

3.2.1 Establishing eco-industrial zone. The industrial evaluation of Yunnan Province is in the stage of "secondary industry, tertiary industry primary industry", so it should positively accelerate the industrial process; increase the input of science and technology; adopt high-tech technology and carry out clean production in the industries and enterprises. For example, the relevant departments should replace the high-consumption, heavy-pollution and low-benefit equipment with low-consumption, light-pollution and high-benefit equipment; positively strengthen the development and utilization of green technology; improve the production technology; reorganize the enterprises with green technology and eliminate the pollution in the end. The relevant departments should intensify the management of the enterprises; reduce the consumption; reduce pollution and positively explore the non-pollution and no-pollution clean products to replace the heavy pollution products. The government should establish the eco-industrial zone according the local conditions to improve the economic benefit. Besides, the government should actively develop the market-centered industry; fully make use of domestic and foreign resources; decrease the proportion of resource-based industry and alleviate the pressure of environment.

3.2.2 Developing ecological agriculture. The agricultural structure of Yunnan Province is unreasonable and the benefit of it is low. Yunnan Province is a mountainous province with dense population and limited land. The area of mountainous areas accounts for 94% of the total area, but the plantation takes a large proportion, which leads to the structural dislocation of agricultural industrial structure and land resource structure, so the government should develop agriculture according to the local situation; adjust agricultural structure; optimize the combination of agricultural natural resources and develop ecological agriculture so as to realize the sustainable development of agriculture.

3.2.3 Enforcing the ecological construction of the tertiary industry. The proportion of the total value of the tertiary industry

in the gross national economy is increasing, and the environmental problems caused by the rapid development of it, especially, commerce, food and restaurant service industry, real estate, transportation and tourism, become more and more serious. For example, at present, the total discharge of domestic sewage has surpassed the total volume of industrial waste water discharge. It can be seen that the environmental pollution problem of the tertiary industry has become another environmental pollution that can not be ignored after the industrial pollution, so it is urgent to strengthen the ecological construction of the tertiary industry.

3.2.4 Actively developing recycling economy. From the perspective of industrial ecologicalization, the sector of recycling economy is the decomposer of the whole industrial ecological system. In the industrial ecological economic development, there is no decomposer (such as waste recycling companies, resource recycling companies and so on) to handle, transfer and reuse the by-products and wastes caused by industrial enterprises and companies. Therefore, the recycling and reuse of waste materials in the production process should be strengthened to realize the reuse of waste materials in the enterprises and change the wastes to resource, and then promote the more harmonious relations between industrial production and the environment.

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the rural development and minimizing the gap between urban and rural areas are important historical issues of constructing the new socialist countryside and the harmonious socialist society.

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