Modern Applied Science
www.ccsenet.org/journal.html
Vol. 3, No. 3
March 2009

The Regional Resource Supply and Environmental Capacity Analysis Based on the Ecological Footprint--a Case Study in Shijiazhuang of Hebei Province

Juanmin Cui (Corresponding author)
Chengde National Teachers College
Chengde 067000, China
E-mail: cuijuanmin@163.com

Baolin Yu
Hebei Institute of Land-Resources Using and Planning
Shijiazhuang 050051, China

Abstract

Based on the theory of ecological footprint this paper analyzed the ecological economic system in Shijiazhuang city in the view of demands of economic system to natural resource and supply of ecosystem for natural resources. Quantitative analysis of the ecosystem of Shijiazhuang city was attempted to estimate the status of sustainable development and give some insight into protection of the ecological environment of it and its province, Hebei province.

Keywords: Ecological footprint, Resource supply, Environmental capacity

1. Introduction

The term ecological footprint was first proposed by Rees and later refined by Wackernagel, a Canadian economist (1996) to describe quantitatively the use of natural resources by humans and their supply via nature to indicate regional sustainable development ability. Ecological footprint analysis compares human demand on nature with the biosphere's ability to regenerate resources and provide services. It does this by assessing the biologically productive land and marine area required to produce the resources a population consumes and absorb the corresponding waste, using prevailing technology. Footprint values at the end of a survey are categorized for biomass (food, fiber), build-up lands, water and energy and as well as the total footprint number of Earths needed to sustain the world's population at that level of consumption. This resource accounting is similar to life cycle analysis wherein the consumption of cropland, forestry, build-up land, water area, pastureland and ocean are converted into a normalized measure of land area called 'global hectares' (gha).Per capita ecological footprint (EF) is a means of comparing consumption and lifestyles, and checking this against nature's ability to provide for this consumption. The tool can inform policy by examining to what extent a nation uses more (or less) than is available within its territory, or to what extent the nation's lifestyle would be replicable worldwide. The higher the footprint is the more human demand.

Due to no conspicuous distinguish between "ecological capacity" and "environmental capacity " by our government and researchers all over the world, in view of the particularity and availability of the land resource, the ecological capacity in the present paper is environmental capacity.

2. Background introduction

Located in the vicinity of the North China Plain, Shijiazhuang, the capital of Hebei Province, neighbors Beijing and Tianjin in the north, Henshui city in the east, and lies against the continuous Taihang Mountain in the west and Xingtai city in the south. Covering an area of 15.8 thousand square kilometers (6100.4 square miles), it has 6 districts, 12 counties, 5 county-level cities and 1 national-level new and high-tech development zone under its prefecture. Shijiazhuang has a population of 9.395 million, 2.313 million of whom live in the urban area. Sitting in the central south of vast North China Plain, Shijiazhuang City is located at the longitude of 113°31′~115°29′, and the latitude of 37°26′~38°46′. Shijiazhuang City enjoys convenient transportation conditions, called as "a gate from south to north and the throat from Hebei to Shanxi" and "One of the cardinal foundation of pharmacy industry". Enveloped in the temperature continental monsoon climate, it's clearly distinguished between seasons with yearly average temperature of 13.3 centigrade, the coldest month of the year (January) at–2.9 centigrade, compared with the warmest (July) at 26.5 centigrade. The average precipitation is 534.6mm, sunshine hours more than 2513.9 hours. The city gross product increased from 78.1 billion yuan in 1997 to 178.6 billion yuan in 2005, and thus the city is during a mew period to adjust economic structure at present.

3. Analysis of resource supply and environmental capacity in 2005

3.1 Analysis of resource consumption

3.1.1 Biomass consumption

Biomass resource is categorized for farm, animals, water and forestry products, and each category has its small sort. Calculation of biomass productive area was adopted the average yield from the data of World and Agricultural Organization (FAO) of United Nations in 2003, which facilitate to the comparison with countries and regions. Biomass consumption of Shijiazhuang city in 2005 was converted into ecological arable land area which this consumption demands, and the data in detail was list in Table 1.

3.1.2 Energy consumption and built-up land

Energy balance accounts dealt with several kinds of energy as follows: raw coal, coke, gasoline, diesel and power according to the energy consumption data of Shijiazhuang city. Fuel consumption was converted into fossil energy yield land area, based on the the criterion of average calorific value per fossil energy yield land area in the world, and heat resulted from local energy consumption was converted into fossil land area. According to the land area derived from Shijiazhuang land census data in 2005, built-up land data and its area converted by power consumption was processed with results listed in Table 2 in detail.

3.2 Trade adjustment of Ecological footprint calculation

Calculation of ecological footprint indices demands for net consumption, and thus trade adjustment should be taken into account in the expenditure of biomass and energy, namely calculating the ecological footprint of biomass consumption, energy consumption, net expenditure of the population in regions. Due to no access to detail external trade information from regions, trade adjustment of import and export was not considered in the present paper.

3.3 Per capita ecological footprint demand

The results of ecological footprint of Shijiazhuang city in 2005 were list in Table 3.

3.4 Environmental capacity calculation

Equivalence factors were selected from the reports of ecological footprint all over the world. When yield land area of Shijiazhuang city was converted into comparable biology yield land area, equivalence factors of arable land, grassland, forestry land, water area and built-up land were limited by data. Then we multiplied the corresponding equivalence factor by present physical spatial areas—arable land, grassland, forestry land, water area and built-up land. 'Yield factor' selected in the paper was once used to calculate Chinese ecological footprint by Wackernagel (1996) and the average yield factor applied was 1.66, 0.19, 0.91, 1 and 1.66 respectively. At the same time, based on the proposal by World Commission on Environment and Development (WCED), 12% of the biologically productive land area should be taken away from ecological footprint to protect biodiversity (Wackernagel, 2000, PP. 21-42, Lenzen, 2001, PP. 229-255, Xu, 2007, PP. 56-57). Available environmental capacity of Shijiazhuang city was listed in Talbe 4.

3.5 Analysis of resource carrying capacity and environmental capacity

Consequence of ecological footprint was composed of its demand and available ecological yield land area, namely environmental capacity.

4. Conclusions and proposals

According to the analysis above, per capita ecological footprint demand, environmental capacity and ecological deficit of Shijiazhuang city in 2005 were 2.7159 hm^2, 0.3899 hm^2 and 2.326 hm^2, respectively. Those numbers were far higher than ecological deficit in China.(According to "Report on sustainable development of domestic land resource in China (2004) " compiled by Land Resource Information Centre in China, per capita ecological footprint increased during the period of 1978~2003, and amounted to 0.890 hm^2 in 2003). The ecological deficit indicated that Shijiazhuang city was in a situation of unsustainable development.

According to per capita ecological footprint demand structure, there was conspicuous discrepancy between the structures of productive land supply and social economy development demand in ecological economy system of Shijiazhuang city, which was mainly ascribed to no preservation of CO_2 absorption land and failure service for fossil fuel demand. Per capita ecological footprint of built-up land was 0.0022 hm^2, while that of ecological supply was

0.0899 hm^2 which was 0.0877 hm^2 higher than demand with surplus supply. Meanwhile, there was great discrepancy between the demand and supply of arable land and forestry land. Demand of arable and forestry land was 0.8061 hm^2 and 0.5761 hm^2 while supply was 0.2947 hm^2 and 0.0583 hm^2, respectively. Per capita supply of built-up land exceeded ecological demand. Moreover, according to planning revision of land utilization, more and more cropland was occupied, especially for arable land. Demand of grassland and water area was 1.0008 hm^2 and 0.0217 hm^2 while supply was 0 hm^2 and 0.0002 hm^2, respectively. This acute discrepancy was attributed to the calculation and analysis based on the conversion of average level of the world, however, it was not necessarily the case in fact. Local stockbreeding industries rely on not only the natural grassland, but mainly feedstuff which resulted from development of feedstuff through internal structure adjustment of agriculture and establishing of professional livestock farm. Annual pork products from farmers rank the top in the region, not totally provided by grassland. Based on less invalidity of the serious imbalance of local demand and supply proportion, aquatic product doesn't rely on large amount of water area but intensive artificial propagation, and thus improving the resource utilization could solve the supply deficiency problem of water area.

According to the supply structure of the resource carrying area, per capita footprint of arable land was attained to 0.2947 hm^2 accounting for 5.58%. In addition, in order to protecting biodiversity 12% of the biologically productive land area was not retained. Taken together, natural ecological system degraded, configuration of land utilization was unreasonable and configuration of ecological spatial category for local population consumption was somehow single in Shijiazhuang city.

Without reducing the standard of living, the ecological deficit mainly ascribed to excess utilization of natural resource could be ameliorated by the following measures:

1) Alter consumption manners of produce and life, establish resource-economizing consumption system of social production.

2) Based on the development of science and technology, adopt new technology and improve per capita yield of natural resource.

3) Utilize the present resource efficiently.

4) Import inadequate resource from other regions to balance ecological footprint.

References

Lenzen, M., Murray, S.A. (2001). A modified ecological footprint method and its application to Australia. *Ecological economics*, 37(2):229-255.

Wackernagel, M., David, Y. (2000). Footprints for sustainability: The next steps. *Environment, development and sustainability*, (2):21-42.

Wackernagel, M., Rees, W. (1996). *Our Ecological Footprint: Reducing human impact on the earth*. Gabriola Island: New Society publishers.

Xu, Y. (2007). Dynamic analysis of sustainable development in Sichuan province based on the ecological footprint. *Journal of China west normal University(Natural science)*, (2):56-57.

Table 1. Biomass accounts of Shijiazhuang city

Category	Total average product (kg/hm^2)	Biomass(t)	Ecological footprint (hm^2)	Per capita ecological footprint (hm^2/cap)	Land category	Total population (million)
Farm product				0.2879		
cereal	2744	4824262	1758112.9738	0.1897	Arable land	92.7
Oil	1856	238671	128594.2888	0.0139	Arable land	92.7
Cotton	429	17529	40860.1399	0.0044	Arable land	92.7
Vegetable and melon	18000	13338048	741002.6667	0.0799	Arable land	92.7
Animal product				2.0015		
Meat	74	1072719	14496202.7027	1.5638	Grassland	92.7
Milk	502	740108	1474318.7251	0.1590	Grassland	92.7
Poultry egg	400	1033251	2583127.5000	0.2787	Grassland	92.7
Aquatic product	29	29232	1008000.0000	0.1087	Water area	92.7
Forestry product				0.5237		
Fruit	3500	1725579	493022.5714	0.0532	Forest land	92.7
Dry fruit	3000	22239	7413.0000	0.0008	Forest land	92.7
Pricky-ash	1600	3098	1936.2500	0.0002	Forest land	92.7
Other forestry product	1.99	8662	4352763.8191	0.4696	Forest land	92.7

Table 2. Energy account of Shijiazhuang city

Category	Global average energy footprint (GJ/ hm^2)	Conversion coefficient (GJ/t)	Consumption (t)	Consumption (GJ)	Ecological footprint (hm^2)	Per capita footprint (hm^2/cap)	Yield land category
Energy						0.2809	
Raw coal	55	20.934	5856765	122605518.5100	2229191.2456	0.2405	Fossil energy land
Cork	55	28.470	392259	11167613.7300	203047.5224	0.0219	Fossil energy land
Gassoline	93	43.124	215579	9296628.7960	99963.7505	0.0108	Fossil energy land
Diesel	93	42.705	155611	6645367.7550	71455.5673	0.0077	Fossil energy land
Power	1000	11.840	628170 (10^4kw.h)	7437532.8000	7437.5328	0.0008	Built-up land

Table 3. Per capita ecological footprint of Shijiazhuang city

Land category	Primary per capita ecological footprint (hm^2/cap)	Equivalence factor	Per capita ecological footprint after balance (hm^2/cap)
Arable land	0.2879	2.8	0.8061
Grassland	2.0015	0.5	1.0008
Forest land	0.5237	1.1	0.5761
Fossil energy land	0.2809	1.1	0.3090
Built-up land	0.0008	2.8	0.0022
Water area	0.1087	0.2	0.0217
Per capita ecological footprint demand			2.7159

Table 4. Environmental capacity of Shijiazhuang city

Land category	Total area (hm^2)	Per capita area (hm^2/cap)	Yield factor	Equivalence factor	Per capita area after balance (hm^2/cap)
Arable land	587688.97	0.0634	1.66	2.8	0.2947
Grassland	0	0.0000	0.19	0.5	0.0000
Forestry land	539671	0.0582	0.91	1.1	0.0583
CO_2 absorption	0	0.0000	0	1.1	0.0000
Built-up land	179205.95	0.0193	1.66	2.8	0.0899
Water area	11567	0.0012	1.00	0.2	0.0002
Total supply area					0.4430
Biodiversity protection12%					0.0532
Per capita environmental capacity					0.3899

Table 5. Ecological footprint and environmental capacity of Shijiazhuang city

Ecological footprint demand		Ecological footprint supply		Discrepancy between supply and demand (hm^2/cap)
Land category	Per capita ecological footprint (hm^2/cap)	Land category	Per capita environmental capacity (hm^2/cap)	
Arable land	0.8061	Arable land	0.2947	0.5114
Grassland	1.0008	Grassland	0.0000	1.0008
Forestry land	0.5761	Forestry land	0.0583	0.5178
Fossil energy land	0.3090	CO_2 absorption	0.0000	0.3090
Built-up land	0.0022	Built-up land	0.0899	-0.0877
Water area	0.0217	Water area	0.0002	0.0215
Per capita ecological footprint demand	2.7159	Total supply area	0.4430	
		Biodiversity protection12%	0.0532	
		Per capita environmental capacity	0.3899	
		Per capita ecological deficit		2.3260