Chapter 129
An Ecological Carrying Capacity Analysis of the Low-Carbon Economic Development of Downtown Leshan

Zhiyi Meng and Xiaotong Jian

Abstract Ecological footprint methodology is to quantitatively evaluate whether the development of a specific zone is within the range of its ecological carrying capacity by measuring the gap between the human ecological footprint and ecological carrying capacity, so as to provide a scientific basis for sustainable development of the assessed object. Analyzing the carrying capacity of the current environmental resources in downtown Leshan from the perspective of ecological footprint methodology, the paper concludes with the current conditions and features of the ecological supply and its demand, which provides an ecological and environmental basis for the urban planning of Leshan. Moreover, comparing Leshan with its neighboring areas as well as some more developed zones, the paper also finds out some specific approaches to optimizing its ecological carrying capacity.

Keywords Ecological footprint · Ecological supply · Ecological carrying capacity · Sustainable

129.1 Introduction

Eco-environmental protection is not only a great performance, but also a giant project, which is reactive power in the contemporary era and the benefit of future generation [10]. To made unremitting efforts to develop the ecological environmental protection is a succession and development of industriousness, an important part of maintaining sustainable development of economy, society and environment and are the base for fulfilling the concept of scientific development, building harmonious society and establishing economical society [3]. The ecological carrying capacity of a specific zone is the basis and premise of achieving regional economic development, society and environmental coordinated development, which provides an important basis for

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something, whether there is coordination between intense exploitation of economic and environmental carrying capacity [2]. Hence, in order to implement sustainable developmental strategy comprehensively, carry out the basic state policies of environmental protection, and strengthen outcomes of ecological construction [4], it is necessary that carrying capacity of eco-environments is evaluated and predicted effectively.

In recent years, in the light of the Scientific Outlook on Development, we can see a significant economic growth in downtown Leshan. For example, it contributes to businesses growth, urban sprawling and population growth. It is, however, inescapable that it is based on the utilization of resources in the ecological environment in downtown Leshan. At the same time, Leshan Giant Buddha which is the world heritage is located in middle district of Leshan [9]. It is obvious that it is able to increase the development of reliance on eco-environments. Therefore, when it comes to the future plan of the development of Leshan, We must also have a clear understanding of the current situation of ecological carrying capacity and calculate the ecological carrying capacity spatial, in order to offer a guidance of making a sustainable development plan in the future in downtown Leshan [6].

129.2 Modeling

At the present, the ecological footprint approach mainly includes synthetic method, component method, input-output analysis and so on. The synthetic method has been raised since the middle of 1990s. It applies to ecological footprint research at the region level and all over the world. On a national level, it concentrates on comparative static analysis; at a regional scale, synthetic method is mainly adopted in calculation of ecological footprint at present. When we calculate the ecosystem carrying capacity, we usually use the national productivity of land average data.

129.2.1 Model Description

Considering relationships among human and its development and ecological condition from a new prospective, ecological footprint methodology is a biophysical assessment method. Ecological footprint methodology is suggested to give an accounting of global, national, regional, and families and individuals of natural capital utilization for a concise framework, which is necessary to produce the resources and energy consumed in a region by tailing after region energy and resource consumption. Ecological footprint methodology is to quantitatively evaluate whether the development of a specific zone is within the range of its ecological carrying capacity by measuring the gap between the human ecological footprint and ecological carrying capacity, so as to provide a scientific basis for sustainable development of the assessed object.

In the process of calculating the carrying capacity of ecological, equivalence factors and yield factors variable is going to be frequently used [1]. The method assumes that the carrying capacity of ecological provided by two different kinds of can be substituted because of the different productivity in ecosystems. In this way, adopting equivalence factors can quantify the area ecosystems. It can be converted into area ecosystems with ecological average productivity. Thanks to yield factors, the productivity from different countries and regions can be expressed as the area of the ecological system with the global average ecological productivity.

Ecological Footprint Calculation is based on the following six assumptions [9]:

(1) It is possible that we can track most human society consumes resource and waste.
(2) Most of these resource and waste flow can be measured in accordance with the essential biological productive area of support for these flows.
(3) Various types of land can be converted into standard ha- Global hectares. one global hectares of biological production capacity is equal to the average productivity of the global land.
(4) The land use is repellent, so it can be summed up to be one of the human consumption demand.
(5) The supply of natural ecological services can also be expressed in the biological production space with the global hectares.
(6) Ecological footprint can exceed the biological carrying capacity.

129.2.2 Index System

Footprint on biological index system is a unified whole, the selection of the index and the construction of the system should be able to reflect the connotation of sustainable development. It is generally to follow the following principles [5, 7, 8, 11]:

(1) Conciseness and scientific. Ecological occupancy index system must be built on the basis of science, which is clear and have a wide coverage. It can objectively reflect the regional resources and ecological sustainable development.
(2) Integrity and completeness. As a comprehensive indicator of the sustainable development of a region, ecological occupancy should reflect the main features and conditions of the evaluation from all angles.
(3) Dynamic and stability. Ecological occupancy index system should maintain the relative stability for a certain period of time. However, with the development of region, index system should be adjusted accordingly to adapt to changes in time and space of sensitivity. It can truly reflect a future development trend.

Based on the basic principle, shown in Fig. 129.1, a indicator of ecological occupation will be built.

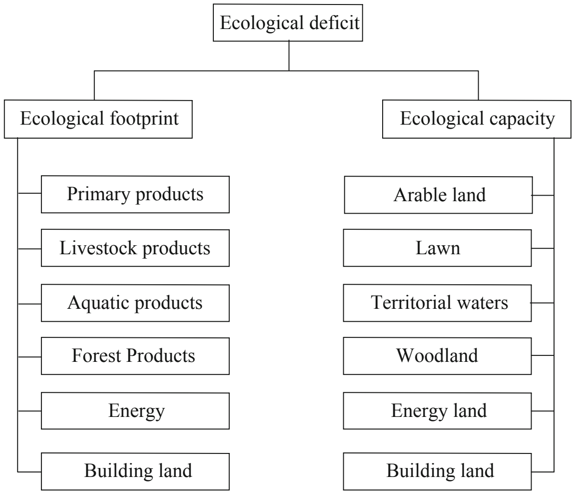

Fig. 129.1 The indicator system of ecological occupation

129.2.3 Data Source

The calculation data by model come from the urban statistical yearbook and relevant departments. After sorting the main life consumption and production consumption data in 2008, we are able to get available data.

129.2.4 The System of Equations

At present the distribution of biological resource usage is used more FAO in 1999 about biological resources of the world's average production so that the calculation results can be compared. It will provide the main consumption into consumer goods of biological production area formula is:

$$A_i = \frac{X_i}{\overline{Y}}, \tag{129.1}$$

where i is the type of consumer goods, A_i is the ith per capital biological-production areas which is converted by article of consumption, X_i is the ith per capital consumer, $\overline{Y}$ is the account average output of biology in the world.

Secondly, we need to calculate energy occupation. The calculation of energy is that the major energy consumer such as coal, petroleum, gas and hydropower may be changed into standard coal. The energy consumer may be changed into fossil fuel. The computational formula of the land area is:

$$X_i = \frac{A_i}{\overline{Y}}, \tag{129.2}$$

where X_i is the ith per capital ecological occupation, A_i is the ith per capital consumer, $\overline{Y}$ is the ith per capital energy average output rate.

All kinds of biology resources and the consumption of energy constitute gross ecological occupation. Formula is:

$$EF = N \times ef = N \times \sum (aa_i) = N \times \sum \left(\frac{C_i}{P_i} \right), \tag{129.3}$$

where i is the type of consumer goods and input, C_i is the ith per capital consumer, p_i is the ith average input ability of consumer, aa_i is the ith biological production area of the exchange of goods, N is the total population, ef is the ecological footprint per capital, EF is the total ecological footprint.

Judging from the bio-productive land types, the resource environmental bearing capacity (ecosystem carrying capacity) can be calculated in the circumstances, Formula is:

$$ec = a_i \times r_i \times y_i, i = 1, 2, 3, \ldots, \tag{129.4}$$

where ec is the ecological capability per capital, a_i is the bio-productive areas per capital, r_i is the balance factor and y_i is the yield factor.

The regional ecosystem's carrying capacity formula is:

$$EC = N \times (ec), \tag{129.5}$$

where EC is the regional ecosystem's carrying capacity and N is the total population.

129.3 Comprehensive Evaluation

Through the urban area in 2008 data collation, we can analysis whether ecological occupancy and ecological supply in urban areas is in a state of sustainable development.

129.3.1 The Actual Calculation

Several biological resources occupy the calculation results are shown in Table 129.1.

The results of calculation of the energy occupancy in the city are shown in Table 129.2.

The city center of ecological footprint demand can be seen in Table 129.3.

Table 129.1 Calculation results of biological resources

Project classification	Consumption of city central district (t)	Average global output (kg × hm^{-2})	Total ecological occupancy (hm^{-2})	Ecological footprint per capital (hm^{-2} × cap^{-1})	Biological production
Agriculture products					
Rice	136086	2744	49594.02332	0.085509591	Cultivated land
Wheat	2337	2744	851.6763848	0.001468453	Cultivated land
Corn	10414.5	2744	3795.37172	0.006543947	Cultivated land
Peas and beans	3244.5	1856	1748.114224	0.003014084	Cultivated land
Root crops	16057.5	12067	1330.695285	0.002294373	Cultivated land
Oil	12690	1856	6837.284483	0.011788787	Cultivated land
Tobacco	120	1548	77.51937984	0.000133658	Cultivated land
Silkworm	769.5	1000	769.5	0.001326765	Cultivated land
Tea	499.5	1182	422.5888325	0.000728624	Cultivated land
Vegetables	309390	18000	17188.33333	0.029635977	Cultivated land
Sugar	1726.5	65204	26.47843691	0.000045654	Cultivated land
Livestock productivity yield					
Pork	48430.5	457	105974.8359	0.182720905	Grassland
Beef	1050	33	31818.18182	0.054860637	Grassland
Mutton	172.5	33	5227.272727	0.009012819	Grassland
Poultry	23046	457	50428.88403	0.08694905	Grassland
Eggs	35905.5	400	89763.75	0.154769889	Grassland
Aquatic products	16600	29	572413.7931	0.986950962	Grassland
Forest products production					
Nuts	177	3000	59	0.000101727	Woodland
Fruit	35934	3000	11978	0.020652365	Woodland

Table 129.2 The main energy consumption in the city and the per capital ecological occupancy

Fuel type	Consumption of city central district (ton)	Consumption per head ($10^3 \times cap^{-1}$)	Global average energy occupancy ($GJ \times hm^{-2}$)	Conversion factor ($GJ \times 103\,kg^{-1}$)	Per capital ecological footprint	Occupancy type
Raw coal	1038913.05	37.49875996	55	20.934	0.681795636	Fossil fuel
Gasoline	172214.95	12.80487565	93	43.124	0.137686835	Fossil fuel
Natural gas	44441.7	29.8312683	93	389.31	0.320766326	Fossil fuel
Power	137243.4	2.801745323	1000	11.84	0.002801745	Construction land

Table 129.3 Ecological footprint demand

Ecological occupancy demand			
Type ($hm^2 \times cap^{-1}$)	Demand area ($hm^2 \times cap^{-1}$)	Equivalent factor	Ecological occupancy
Cultivated land	0.142489914	2.8	0.398971759
Woodland	0.020754092	1.1	0.022829501
Grassland	0.4883133	0.5	0.24415665
Waters	0.986950962	0.2	0.197390192
Construction land	0.002801745	2.8	0.007844887
Fossil fuel	1.478066007	1.1	1.625872608
Total demand area			2.497065598

129.3.2 Conclusion Analysis

(1) Occupancy Ratio Analysis

According to Tables 129.1 and 129.2, we can calculate that Leshan the major living consumption and energy consumption ecological occupancy for 2.50 $hm^2 \times cap^{-1}$ in 2008. According to Table 129.3, the proportion of fossil fuels in central area is very large, accounting for more than 60 %.The proportion of water is only 20 %, which shows the proportion of ecological footprint's unbalance.

(2) Supply and Demand Balance Analysis

Through the comparison between Tables 129.3 and 129.4, we can see that the per capital account for $hm^2 \times cap^{-1}$ in 2008 in downtown Leshan, the per capital ecological consist of 2.06 $hm^2 \times cap^{-1}$ and 2 ratio of 1.3. It shows that City Central Ecological occupation is a little large. However, it can meet the basic needs of the occupation thanks to the strength of the city district ecological supply capacity, especially cultivated land has played a pillar role to. It should be noted that the city in 2008. Only thing to note here is that the total supply and demand has appeared the characteristics of the ecological deficit, that is to say, there is a imbalance. Therefore, we should pay more attention on this in the future development.

Table 129.4 Ecological occupancy supply in Leshan

Per capital ecological footprint supply					
Type	Total area	Supply area ($hm^2 \times cap^{-1}$)	Equivalent factor	Yield factor	Ecological carrying capacity ($hm^2 \times cap^{-1}$)
Cultivated land	284925	0.491265246	2.8	1.66	2.283400864
Woodland	27819.8	0.047966661	1.1	0.91	0.048014628
Grassland	29163	0.050282595	0.5	0.19	0.004776847
Waters	1906.7	0.003287516	0.2	1	0.000657503
Construction land	261.27	0.000450479	2.8	1.66	0.002093829
Total supply area	–	–	–	–	2.33894367
Bio diversity conservation area	–	–	–	–	0.28067324
Total available space	–	–	–	–	2.05827043

Table 129.5 Comparison of ecological footprint, ecological carrying capacity

Type	City district	Sichuan province	Western 12 provinces	Eastern region	All the country	Global
Per capital ecological footprint	2.497065598	0.951	1.172	1.379	1.326	2.8
Per capital ecological supply	2.05827043	0.385	0.718	0.513	0.618	2
Per capital ecological deficit	−0.438795168	−0.566	−0.454	−0.843	−0.645	−0.8
Million GDP ecological footprint	1.335329197	2.141	2.721	1.306	2.038	–

(3) The Comparative Analysis

Comparison of ecological footprint, ecological carrying capacity and ecological footprint of 10000 yuan GDP in the city and other regions can be seen in Table 129.5.

In Table 129.5 we can see the per capital ecological footprint in Leshan is nearly 3 times than that in Sichuan province and is 2 times than the western, Eastern and the Whole country, while the ecological supply is about 7 times than that in Sichuan province, is about 3 times than that in the East and West. It is based on the above two point, the city's huge ecological footprint can be barely supported, so that the ecological deficit are in a relatively low level.

Million GDP ecological footprint reflects the use efficiency of regional resources. We can use the total ecological footprint and the GDP value of the year, the ecological footprint of GDP was 1.36 per year in 2008. The resource utilization efficiency was similar with that of the eastern region, which was better than other parts of Sichuan province and the West.

129.4 Policy Suggestion

Based on the above results, we are trying to find out the cause of the "ecological deficit", and analysis the ecological problems in the economic development of the city in the future. Moreover, we would like to put forward countermeasures. We hope to lay a foundation for the urban construction of low carbon demonstration pilot area and the harmonious and sustainable development of the city in the future.

129.4.1 Possible Reasons

(1) The large consumption of Fossil energy account for the majority of the total ecological footprint. This is closely related to the rapid development of economy in the city as well as a large amount of the consumption of fossil energy. It is based on energy structure of coal-dominating. With the expediting of urbanization and industrialization, coal resources consumption are increasingly growing.
(2) There exists ecological space in downtown Leshan the problems of single supply type and limited total size. In the downtown district, ecological space types are mainly cultivated land, moreover, grassland, water area, the supply of land for construction space is very limited.
(3) Being an ecological fragile, the area of soil erosion of a thousand mountain areas cover 348.83 sq × km, which accounts for 41.72 % of the land area. The average soil erosion loss reaches 2646.43 ton/km^2. The annual average amount of soil erosion is 92.29 m tones.

129.4.2 Feasible Solutions

(1) We must pursue comprehensive, balanced and sustainable ecological development, which contributes to the industrialize and ecologicalize as well as economic and environmental coordinative development. Take full account of the regional society, economic and resources as well as environmental coordinated development in order to promote the development of urban and rural areas harmony between man and nature, so as to achieve economic, social and environmental benefits of the "win-win".

(2) Improving the ecological carrying capacity

Firstly, it is necessary to strengthen the investment in ecological environment construction and management. Secondly, in no cases, should we neglect the importance of implementing Natural Forest Conservation Programme Improve and increase the artificial forest area. Thirdly, It is essential to increase production output of natural resources per unit area, use the existing stock of resources efficiently. Last but not least, we should focus on human resource development and technology investment.

① Carrying out the construction of agricultural modernization. To begin with, it is necessary to strengthen basic farmland construction, adjust industrial structure as well as promote the transformation from traditional agriculture to modern agriculture. Still, we should implement protective farming strictly and make control of non-agricultural occupation of farmland. What is more, it is important for us to establish compensation mechanism for farmland, increase land consolidation efforts to ensure that the basic farmland is not reduced and invariably use as well as invariant mass in order to lay a foundation for agricultural modernization.

② Promoting ecological restoration. It is essential to promote natural forest protection, forest, soil erosion, field protection, land remediation and other ecological restoration planning,improve the implementation of green channel along the Yangtze River protection forest, landscape greening, habitat forest and other projects. In addition, there is no deny that we would like to build a system including green landscape, large green, green corridor, and green space to improve the ecological carrying capacity.

(3) Reduce the ecological footprint

① setting up resource economizing type society. It is necessary to establish a resource-saving society production and consumption system in order to control population growth as well as reasonable planning and urban and rural development, and reduce the occupation demand and accelerate industrial restructuring, What is more, we should pay more attention to promote industrial upgrading and transformation as well as adhere to the line of technological content, good economic benefits, low resource consumption, environmental pollution and human resource advantages.

② Popularization of new energy use. City center can use solar energy industry to develop solar energy industry, we can use both new alternative energy and agricultural resources. Biogas fermentation raw material is adequate. It is suitable for developing a broad region of methane and improving the rural biogas farmers' popularization rate. Furthermore, I would like to talk about the fact that the importance of accelerating the construction of urban living sewage and reliving sewage treatment.

③ Waste disposal On the foundation of garbage classification, we can sort garbage into plastics, paper, cloth and other organic matter, in addition, we can also sort garbage into scrap iron and steel, copper, aluminum and other metals, glass, nonferrous metals which can be composted, other screening and other inorganic compounds. On the one hand, waste paper recycling can be used as reworked plastics fee. On the other hand, it can be also changed into fuel oil or petroleum gas to use as energy.

④ Strengthen the supervision on the ecological environment of resource development activities and construction projects. To control unreasonable resource development as one of the priority we should strengthen the protection of water, land, forests and other natural resources.

129.5 Conclusion

As we all know, ecological footprint methodology is to quantitatively evaluate whether the development of a specific zone is within the range of its ecological carrying capacity by measuring the gap between the human ecological footprint and ecological carrying capacity, so as to provide a scientific basis for sustainable development of the assessed object.

In this study, analyzing the carrying capacity of the current environmental resources in downtown Leshan from the perspective of ecological footprint methodology, the paper concludes with the current conditions and features of the ecological supply and its demand, which provides an ecological and environmental basis for the urban planning of Leshan. Besides, comparing Leshan with its neighboring areas as well as some more developed zones, the paper also finds out some specific approaches to optimizing its ecological carrying capacity.

References

1. Byron C, Link J et al (2011) Calculating ecological carrying capacity of shellfish aquaculture using mass-balance modeling: Narragansett Bay, Rhode Island. Ecol Model 222(10):1743–1755
2. Chen Y, Ye Z, Zheng X (2010) On harmonious development between regional floating population and social economy. Contemp Econ Manag
3. Chu C, Meng H (2006) Ecology migration and sustainable development of economy in inner mongolia autonomous region. Res Agric Modernization 2:005
4. Guo X (2003) Essects and solutions of market subject's craying for profits on sustainable development strategy. J Nanjing Inst Technol
5. Jones EM, Doblin MA et al (2015) Assessing and evaluating the ocean-colour footprint of a regional observing system. J Mar Syst 143:49–61
6. Liu D, Feng Z et al (2011) Spatial patterns of ecological carrying capacity supply-demand balance in China at county level. J Geogr Sci 21(5):833–844
7. Naval J, Farrés J (2010) Systems biology footprint. Nutrafoods 9(3):31–35
8. Wei H, Hu E (2011) Dynamic analysis of ecological footprint of biological resource: a case study of the "two circles" in Hubei province. China Popul Resour Environ 21:167–174 (in Chinese)
9. Xu Z, Zhang ZQ et al (2003) Ecological footprint calculation and development capacity analysis of China in 1999. Chin J Appl Ecol 14(2):280–285
10. Zheng M (2011) Resources and eco-environmental protection of salt lakes in China. Environ Earth Sci 64(6):1537–1546
11. Zhou P, Liu G (2009) The change in values for ecological footprint indices following land-use change in a loess plateau watershed in China. Environ Earth Sci 59(3):529–536