Indexed in
Scopus Compendex and Geobase Elsevier,
Geo-Ref Information Services-USA, List B of Scientific
Journals, Poland, Directory of Research Journals

International Journal of Earth Sciences and Engineering

www.cafetinnova.org

ISSN 0974-5904, Volume 09, No. 06

December2016,P.P.2563-2567

The Carrying Capacity of Land Resources in the Beijing, Tianjin and Hebei Region Based on Scientific Urbanization Development

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Abstract: Land resources have become one of the “bottlenecks” of further promotion of urbanization in the Beijing, Tianjin and Hebei region. This paper analyzed the status of land resource development and exploitation in these regions, on whose basis an evaluation index system was established from the perspective of scientific urbanization development. By building up a land resource carrying capacity (LRCC) index model, we assessed the LRCC of Beijing municipality, Tianjin municipality, and all 11 prefecture-level cities in Hebei province. The evaluation results reflect noticeable region-varying LRCC differences. Therefore, regional resource characteristics should be based on in formulating scientific and reasonable land development and land use schemes as well as social-economic development strategies.

Keywords: *Scientific Urbanization Development; the Beijing-Tianjin-Hebei Region; Land Resource Carrying Capacity; Land Resource Carrying Capacity Index Model*

1. Introduction

Urbanization is the inevitable social-economic development trend in China with its great potential to boost domestic demands. Up to now, the Beijing-Tianjin-Hebei region has achieved initial progress in developing urbanization, and gradually enters the expressway of urbanization construction. This, however, exposes numerals problems such as the lagged urbanization level behind the level of economic development and industrialization [1], unbalanced development between large, medium and small cities, and inharmonies between urban development and resource guarantee [2]. Among them, land resources have become a “bottleneck” of further promotion of urbanization in the Beijing, Tianjin and Hebei region. Given this, it is a matter of great urgency to systematically study on LRCC which is aimed at accelerating the realization of scientific development of Beijing-Tianjin-Hebei urbanization.

LRCC is the maximum size and intensity of various human activities that the land resources can guarantee in certain social, ecologic and bio-environmental conditions at a given period and spatial area [3]. Xie Qianglian and Jiang Junyi (2009) used a state-space model to analyze different LRCCs in Changsha-Zhuzhou-Xiangtan urban agglomeration, and accordingly classified the then LRCCs into four kinds, i.e. load-bearing zone, mildly overloaded zone, intermediately overloaded zone and strongly overloaded zone [4]. In order to address the subjectivity and arbitrariness of assigning weights to LRCC evaluation indices, Jiang Qiuxiang et al. (2011) proposed the PSO-based projection pursuit aggression model [5]. Liu Chunyan and Feng Yanling (2012) adopted the mean-square-error decision analysis method to conduct a dynamic evaluation on LRCC in Jilin City [6]. In the same year, by establishing a TOPSIS model, Sun Yu et al. analyzed the spatial difference of comprehensive LRCC in Beijing-Tianjin-Hebei urban agglomeration [7,8]. As a follow-up research, Su Yu cooperated with Li Xingang in 2013 to undertake an OLS-GWR-based empirical analysis on comprehensive LRCC in urban China, with the Bohai Rim Megalopolis as an example. These research findings have laid foundation for promoting the scientific development of Beijing-Tianjin-Hebei urbanization and carrying out empirical research on LRCC.

2. Overview of the Beijing-Tianjin-Hebei region

The Beijing-Tianjin-Hebei region covers Beijing Municipality, Tianjin Municipality and Hebei Province made of 11 prefecture-level cities and 22 county-level cities. Beijing and Tianjin, as the core cities, serve for agglomeration and diffusion of production factors and commodity trade, and play an exemplary role in China’s new-type urbanization construction.

2.1 The development trend of Beijing-Tianjin-Hebei urbanization

In general, urbanization level is gauged by indicators of urbanization rate, i.e. the proportion of urban residents to total residents in a given region. We measured the urbanization level according to this index, and plotted the measurement data in Figure 1 as follows. Vertically, the development level of Beijing-Tianjin-Hebei urbanization is increasing year by year, which shows that the development of urbanization in the region has achieved certain results. However, horizontally, despite that the overall level of Beijing-Tianjin-Hebei urbanization slightly exceeds the national average level, the urbanization level in Hebei Province is significantly lower than it. Since 2005, the level of urbanization in Beijing has stabilized at above 83%, reaching 86.29% in 2013 after a nine-year slow growth. This is followed by Tianjin on its heels, and the gap is gradually closed with a higher growth rate than that of Beijing. By contrast, the urbanization level in Hebei Province is lagging far behind.

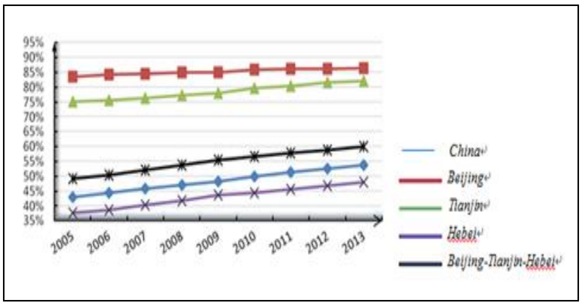

Figure 1: *Comparison of urbanization development trend*

As shown in Figure 1, there is extreme imbalance between urbanization levels in different parts of the Beijing-Tianjin-Hebei region. Specifically speaking, the urbanization levels of Beijing and Tianjin keep pace with each other and attract resources spontaneously, while Hebei province performs poorer and poorer as a comparison. In addition, by constructing Binhai New District, Tianjin adopted the pragmatic approach to implement its strategy of developing as the economic center city in northern China. As a result, polarization was enhanced in this municipality. The function, technology and industry in downtown Beijing began to spread to the surrounding areas. For Hebei province, due to limited economic radiation to the surrounding cities, it is difficult for central cities to share the development achievements with the peripheral zones.

The concept of urbanization has transcended population migration from rural to urban areas, but essentially covers the subsequent update of ancillary resource facilities. There is no doubt that population aggregation is effectively done in Beijing and Tianjin. Nevertheless, with population migration, the carrying capacity of resource facilities in the two municipalities, especially of land resources, is approaching the limit. Beijing and Tianjin have faced serious problems like traffic jam and housing shortage caused by overpopulation and non-renewable land resources. They are deeply rooted in the limitation of land resource carrying capacity such that the occurrence is inevitable once the threshold value is exceeded. In view of this, the promotion of Beijing-Tianjin-Hebei urbanization development must be reasonably planned under the premise of LRCC, with diversion of overloaded land resources.

2.2 The utilization of land resources in Beijing, Tianjin and Hebei

According to the China Statistical Yearbook data, the past five years witnessed nearly unchanged urban areas in Beijing, Tianjin and Hebei, which were respective 12,187, 2,334, and 6,478 square km in 2013. This shows that the total supply of land resources in Beijing-Tianjin-Hebei region is relatively abundant. However, with the increasingly upward urbanization level of Beijing and Tianjin, demands grow for land use, and urban built-up area continues to expand (Fig. 2). This is particularly noticeable in Tianjin, with a 49.4% rise in 2013 built-up area (747 square km) compared to that in 2014. Hebei followed, with an increase of 43.19% over the same period.

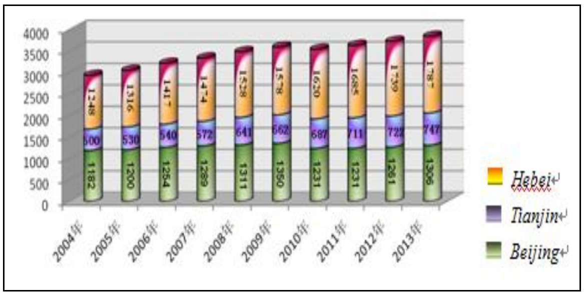

Figure 2: *Changes of built-up areas in the Beijing-Tianjin-Hebei region (Km^2)*

Apart from the limitation of land resources unused, problems arising from land resources for agricultural or construction uses become noticeable with respect to locally deteriorated ecological environment, degraded arable land, and poor quality and limited amount of undeveloped area. On the basis of scientific evaluation of land resources carrying capacity, it has been an important basis for the further development of urbanization in Beijing, Tianjin and Hebei by remedying the developed land resources, tapping their potential and rationally exploiting unused land resources.

3. Evaluation of Beijing-Tianjin-Hebei LRCC

The upper limit or threshold for land resource carrying capacity, as it exists, is linked to the certain level of production technology. The urbanization process is bound to be blocked once LRCC reaches its threshold value along with the declination of production technology. Therefore, LRCC is the prerequisite for the promotion of Beijing-Tianjin-Hebei urbanization. In this paper, 13 municipal districts in Beijing-Tianjin-Hebei region are taken as the basic unit to study the LRCC of the region, in an attempt to provide some technical support for the development of Beijing-Tianjin-Hebei urbanization.

3.1 Establishment of the evaluation index system

During the process of urbanization development accompanied by the continuous influx of rural people, in addition to basic living needs, land resources are expected more to satisfy the requirements of people participating in social economic activities and enjoying high quality urban lives. The major contributing factors include economic and technological advance, enlarged social development scales, and ecological environmental protection. Therefore, the focus of LRCC studies cannot be limited to the number of people that fit in an area, but must take into account the scale of social development that the land resources can support, economic and technological levels as well as the degree of ecological environmental protection.

Given this, this paper constructs the evaluation index system of LRCC on three aspects, i.e. population carrying capacity, socio-economic development carrying capacity and ecological environment carrying capacity. First of all, referring to the results of previous studies, we sort the evaluation indices appearing in relevant literatures in the last decade according into the said three indices. Then, all indicators belonging to the same index are ordered according to their frequencies, and the top ten indicators are selected as standbys. Finally, with the selected indicators in each category as independent variables, we conduct multiple regression analysis and correlation analysis on their corresponding carrying capacity indices as dependent variables, so that sifting qualified indicators that represent carrying capacities. The statistical analysis results are listed in Table 1.

Table 1: *The evaluation index system of Beijing-Tianjin-Hebei LRCC*

Index type	Basic index	Index calculation (for city-governed district)
Population carrying capacity (C_P)	Land area per capita	Land area/permanent population
	Floor area per capita	Floor area/ permanent population
	Road area per capita	Road area/permanent population
	Built-up area per capita	Built-up area/ permanent population
	Arable area per capita	Year-end arable area/ permanent population
Social-economic carrying capacity (C_S)	Area of land for construction use per capita	Referring to statistic data
	The ratio of land for industrial use	Gross area of land for industrial use/area of land for construction use
	Working population per area	Working population/built-up area
	GDP per area	GDP/land area
	Added value of the second and tertiary industries per area	Added value of the second and tertiary industries/land area
Bio-environment carrying capacity (C_E)	Green coverage rate for built-up areas	Green area in built-up areas/built-up area
	Forest land coverage rate	A_{for}×(closed forest land area + shrubland area + open forest land area + the rest of forest land area)/ national territorial area
	Centralized treatment rate of urban wastewater	Referring to statistic data
	Innocent treatment rate of urban garbage	Referring to statistic data

Note: The selection criteria for these basic indicators are: 1. the significance level is over 90%; and 2. be in positive proportion to the bearing capacity.

A_{for}: The normalized coefficient of forest coverage rate, equal to 113.39 in this paper as the reference value recommended for ecological functional areas.

3.2 Evaluation model construction

3.2.1 Determination of the standard values of evaluation indices

In this paper, multivariate regression analysis is adopted to determine the standard values of the three indicators: carrying capacity of population (C_P), carrying capacity of social and economic development (C_S) and ecological carrying capacity (C_E). We use population carrying capacity (C_P) as an example to illustrate the determination process:

First, a multiple linear regression model $C_P = \alpha_0 + \alpha_1 P_1 + \alpha_2 P_2 + \alpha_3 P_3 + \alpha_4 P_4 + \alpha_5 P_5 + \mu$ is established. The regression analysis is carried out with the 2005-2013 panel data of the aforementioned 13 municipal districts as the data samples, and the regression coefficients are accordingly obtained and marked as α_1、α_2、α_3、α_4、α_5。

Then, each basic index is given weight according to these regression coefficients, i.e. the weight of P_1 index $w_1 = \alpha_1 / (\alpha_1 + \alpha_2 + \alpha_3 + \alpha_4 + \alpha_5)$.

Finally, the weighted average value of each index is calculated as the standard value of population carrying capacity (C_P).

3.2.2 Evaluation model construction

In order to reveal the degree of LRCC in the Beijing-Tianjin-Hebei region, we choose the 2013 new-type urbanization development demonstration zone —— Langfang Longhe Hi-tech Industrial Development Zone as the frame of reference to construct the corresponding Land Resource Carrying Capacity Index (LCI) model. C_P is taken as the example, and the corresponding index calculation formula is:

$$LCI_P = (C_P - LC_P) / LC_P$$

Where LCI_P is the index of population carrying capacity; C_P refers to the population carrying capacity of a certain area in 2013; LC_P is given as the 2013 population carrying capacity (Note: In order to ensure the comparability of indicators, this index is calculated according to the aforementioned method).

According to the LCI values, LRCC in different regions can be divided into five levels: surplus, slightly surplus, basically balanced, just overloaded and overloaded. Table 2 lists the specific evaluation criteria.

Table 2: *LCI-based classification of LRCC evaluation criteria [9]*

LCI / Grade	<-0.65	-0.65~-0.95	-0.95~-0.05	0.05~0.35	>0.35
LRCC	Overloaded	Just overloaded	Basically balanced	Slightly surplus	Surplus

3.3 Evaluation result analysis

According to the LCI model, we undertake a systematic assessment on the 2013 LRCCs of 13 municipal districts in the Beijing-Tianjin-Hebei region, and the result is shown in Figure 3.

Area	population	Social-economic development	Ecological environment LRCC
Beijing	overloaded	just overloaded	overloaded
Tianjin	just overloaded	basically balanced	just overloaded
Shijiazhuang	just overloaded	slightly surplus	overloaded
Tangshan	basically balanced	basically balanced	just overloaded
Qinhuangdao	slightly surplus	surplus	slightly surplus
Langfang	basically balanced	slightly surplus	basically balanced
Baoding	just overloaded	slightly surplus	overloaded
Xingtai	slightly surplus	slightly surplus	just overloaded
Handan	overloaded	basically balanced	just overloaded
Cangzhou	slightly surplus	surplus	slightly surplus
Hengshui	surplus	surplus	overloaded
Chengde	slightly surplus	slightly surplus	surplus
Zhangjiakou	surplus	slightly surplus	surplus

Figure 3: *The assessment result of the 2013 $LRCC_s$ of 13 municipal districts in the Beijing-Tianjin-Hebei region*

Overloaded" or "just overloaded" indicates that the LRCC in the region has exceeded the ideal value and should be diverted or improved; a region whose LRCC is "slightly surplus" or "surplus" is a recommended capable area to bear the diverted load from other regions because its LRCC has not reached the ideal value.

The figure shows that LRCC in Beijing and Tianjin have approached the limit, and part of the area is overloaded. Most areas in Hebei province have huge C_P potentials, except for Handan city with overloaded C_P and Shijiazhuang and Baoding with just overloaded C_P whose rates of natural increase should therefore be controlled; in terms of C_S, the growth space for all districts is large except for Tangshan and Handan with basically balanced C_S; this phenomenon reflects the current low-level economic development in this province and that the land resources in Hebei can strongly support higher-level economic growth; nevertheless, a majority of areas in Hebei province is overloaded in C_E, which indicates the gravely substandard ecological environment construction in this area.

4. Conclusions and Suggestions

$LRCC_s$ in the Beijing-Tianjin-Hebei region are diversified and unevenly distributed. In order to optimize land resource utilization and improve LRCC, it is a must to introduce or attract other resources in the region so that all resources can match and be allocated towards Pareto optimization. In this way, the Beijing-Tianjin-Hebei region can be driven to achieve scientific urbanization development.

First, it is true that LRCC cannot be lifted limitlessly due to its inherent attributes. Nevertheless, by expanding the green area to a reasonable extent, the ecological environment quality can be improved, and thus the ecological environment carrying capacity will be lifted; by increasing the area ratio of land for squares and roads and promoting construction of traffic infrastructure, the existing traffic network can be optimized so that easing the traffic pressure; In addition, the transformation of land use can help further tap the potential of land resources and improve the carrying capacity of land resources [10,11].

Second, once the regional LRCC reaches the critical state, a crisis early warning mechanism should be set up to monitor LRCC against the state of seriously overloaded. For overloaded areas, in addition to self-optimization, such measures as population diversion and industry shift to areas of surplus LRCC is considerable. The implementation of the above devisal rests more on the full play of market laws than on government policies. Realization of industrial strategic shift and resource allocation optimization should be done via market mechanism.

5. Acknowledgements

This paper by the funding of The National Development and Reform Commission CDM project <<Low Carbon City Pilot Project of Qinhuangdao>> (2012093); This article is one of the research results of social science fund project of Hebei province in 2016 <<The Beijing-Tianjin-Hebei Support Area Ecological Research of Ecological Environment>> (HB16YJ088); At the same time, This article is one of the research results of social science fund project of Hebei province in 2016 <<Based on the comprehensive carrying capacity of Hebei province urbanization path selection of the Beijing-Tianjin-Hebei region>> (HB16GL096)

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