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Research on Comprehensive Carrying Capacity of Beijing-Tianjin-Hebei Region Based on State-space Method

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ABSTRACT

Based on state-space method and component analysis, this paper builds a comprehensive evaluation system of carrying capacity for the Beijing-Tianjin-Hebei region from four aspects, namely economy, environment, ecology and energy. The results show that the comprehensive carrying capacity in this region gradually rises in recent years and the economic carrying capacity plays an important role in this situation. Ecological and environmental carrying capacity are gradually enhanced but still affected by water shortages. The energy carrying capacity of this region is low, which is the major factor restricting its sustainable development. Based on the empirical results, following policy suggestions should be adopted: Firstly, local government should accelerate technological progress, promoting the optimization and upgrading of industrial structure; Secondly, the contradiction between supply and demand of water resource should be solved gradually; thirdly, government should develop recycling economy, realizing the coordinated development of economy and environment; last but not least, saving energy and improving energy efficiency.

Keywords: comprehensive carrying capacity, state-space method, component analysis, Beijing-Tianjin-Hebei region

1. Introduction

With the rapid development of China's industrialization and urbanization since entering the twenty-first century, the carrying capacity of resource and environment in most regions of China is facing enormous challenges from its unceasingly expanding population and scale, such as the most representative Beijing-Tianjin-Hebei (BTH) region which is the political and cultural center as well as the important economic center in China, as shown in Fig.1. In national "Eleventh Five-Year" plan of China, BTH metropolitan region is proposed to be built as the "the third pole" of China economy growth. Currently, it is the key period of accelerating the adjustment of industrial structure, promoting the construction of industrial integration within the region and enhancing the international influence for BTH region. However, the rapid development of its economy has caused population expansion, traffic congestion, serious environment pollution and continued deterioration of ecological environment. In 2012, the State Council of China clearly defined 47 cities as the main areas of prevention and control of atmospheric pollution, in which BTH region includes 6. This highlights the serious environmental problem in BTH region. Thus, it is necessary to study the carrying capacity of this region for promoting the sustainable development of regional economy.

Fig.1. Map of BTH region

Regional comprehensive carrying capacity was referred to the ability of the regional resources and environment to carry the total population and economy development, under the conditions of ensuring rational exploitation and usage of resources and the benign cycle of ecological environment in a certain period of time, defined by Stephen (1975) and Mao et al. (2001). Studies on regional carrying capacity in environment, resources and ecological aspects have been conducted by many scholars. Slesser (1990) proposed the ECCO to calculate the new resources and environmental carrying capacity in 1990, which comprehensively considered the relationships among population, resources, environment and development, put energy as the conversion standard and established a system dynamic model to determine the long-term development goals of regional optimization scheme. Lv (2008) selected the land, water resources, transportation and environmental as carrying capacity indexes of Zhongyuan city agglomeration, established an evaluation indexes system. Ou (2009) analyzed the comprehensive carrying capacity of seven cities such as Changsha, Zhu Zhou and Xiang Tan using multi indexes comprehensive analysis and mean square deviation decision method. Xu (2009) established a complete index system to research the environmental carrying capacity of Fujian province by using the state space method. Zhu (2010) researched the ecological environment carrying capacity of Haihe River. Qin (2011) constructed the evaluation index system based on resource, environment, social, economy. Fan (2013) selected the indexes of land, environment and water resources of the Yellow River Delta urban agglomeration to establish a comprehensive carrying capacity evaluation index system, finding that the water resources carrying capacity was the key factor of influencing the carrying capacity of the Yellow River Delta through. Wang (2014) combined the AHP method with pressure-state-response model to analyze ecological environment carrying capacity of Shandong Peninsula.

As the China's political and cultural center, BTH region has caused many scholars' attention to carry the research on its carrying capacity. Feng (2006) quantitatively analyzed water resources carrying capacity of population and economic development scale in Beijing-Tianjin-Hebei region in different years using "carrying population" method, results showed that the water resources could not support the existing level of economic development in accordance with the well-off standard of living at this stage. Bi (2011) constructed 22 core indexes by using the state space method and ecological footprint method to analyze the resources and environment carrying capacity of Beijing-Tianjin-Hebei area, pointed out that restricting factors of the regional resources and environment carrying capacity, and put forward related suggestions based on this research. Sun (2012) used TOPSIS model to calculate the comprehensive land carrying capacity of BTH urban agglomeration, analyzed its spatial difference and imbalance, gave the ranking of the 10 cities and the "short board bearing capacity" in this region, put forward their own development strategy. Peng (2014) studied the comprehensive carrying capacity of land resources of BTH region by using AHP method, finding that the carrying capacity among different spaces was quite different. Based on the previous studies, it's found that most are remained in a qualitative or quantitative analysis of the current situation by a single element, few studies making a comprehensive and regional comparison in the time dimension. As a result, a comprehensive, dynamic and longitudinal evaluation is more scientific and reasonable. Based on these, this paper tries to evaluate the carrying capacity of BTH region comprehensively, dynamically and longitudinally.

As a political and cultural center, BTH region plays a leading role in China's economy. Although some scholars in China have studied the carrying capacity of this region, comprehensive researches are still scarce for providing scientific basis for the coordinated development of this region. In view of this point, this paper comprehensively constructs a scientific index system considering factors from economy, environment, ecology and energy, to draw the potential and restrictive factors of this region for more practical policies. The rest of the paper is organized as follows. Section 2 introduces the methodology of this paper. In Section 3, we discuss the results and finally, we conclude this study in section 4.

2. Methodology

This paper is based on the model of the state-space method and principal component analysis method to quantify the regional carrying capacity of BTH region. The aim of this paper is to better measure the difference between actual value and ideal carrying capacity value and to provide guidance for the development of BTH region by using the state space model. The principal component analysis is a better solution to choose the weights among the evaluation index in the paper.

2.1 Framework of research

In this paper, the state space-model principal component analysis are described firstly; Then Stress indexes and sustainable indexes are selected based on our analysis; Thirdly, weights of each index are chose by principal component analysis and raw data is processed. Finally we calculate the final status of the region's carrying capacity. The framework of this paper is shown in Fig.2.

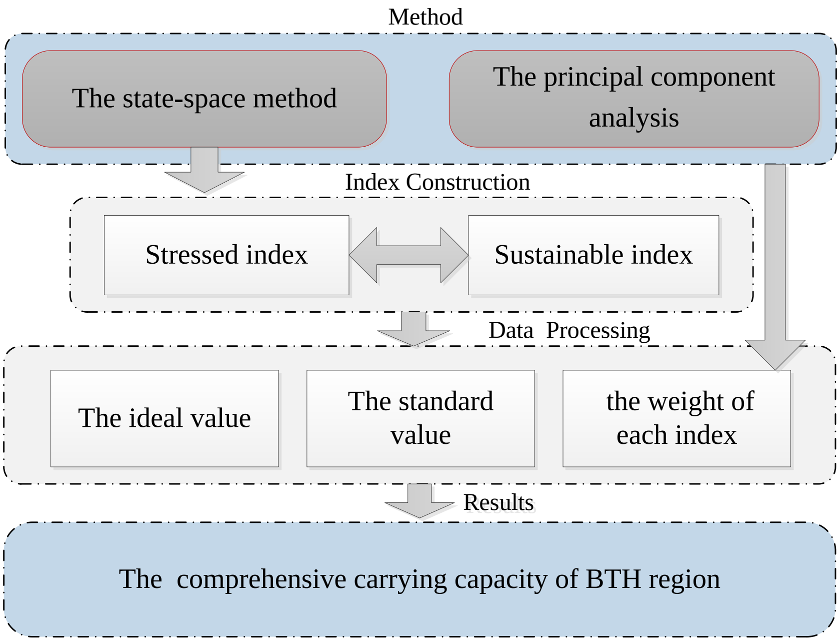

Fig.2. Framework of calculation and analysis

2.2 Model description

2.2.1 State-space model

The state-space model quantitatively describes the state of the system in Euclidean geometry space, which is commonly used to measure the carrying capacity of one region (Mao et al. 2001). It is usually composed by the three-dimensional axes which represent the state vector of various elements in space region, and the value of regional carrying capacity can be showed by the vector model formed by the origin in the state space with the point of system state. The mathematical expression of the regional carrying capacity is as follows,

$$RCC = |M| = \sqrt{\sum_{i=1}^{n} x_{ir}^2} \tag{1}$$

RCC (Regional Carrying Capacity) is the value of regional carrying capacity. In this paper, |M| is the length of vector which begins at origin and ends at the point in the State-space, namely the value of the regional carrying capacity; x_{ir} (i= 1, 2… n) is the state space value when the human activities, the resource and environment are in the ideal condition. When the human activities and the elements of resource and environment are taken into account, the weight axis will change. The mathematical expression of the regional carrying capacity is:

$$RCC = |M| = \sqrt{\sum_{i=1}^{n} \omega_i x_{ir}^2} \tag{2}$$

In this formula, ω_1 is the weight of the x_{ir} .

2.2.2 Principal component analysis

Principal component analysis is mathematically defined as an orthogonal linear transformation used for the dimension reduction that transforms the data to a new coordinate system such that the greatest variance by some projection of the data comes to lie on the first coordinate, the second greatest variance on the second coordinate, and so on. (Jolliffe, 2002). The principal component analysis can be simply stated as follows: using a orthogonal transform, we turned the original random vector containing the related partial vector:

$$X = (x_1, x_2, x_3, ..., x_P)^T \tag{3}$$

Into the new random variables：

$$U = (u_1, u_2, u_3, ..., u_P)^T \tag{4}$$

Make it points to where the sample points spread the farthest p orthogonal direction, then we reduce the dimension of multi-dimensional variables system, and make it transformed into a lower dimensional variables system by a higher precision. (Wang , 2004; Gao,2005; Qin,2003.)

The characteristic equation is the main mathematical tool to calculate the main component of variables. Solving the characteristic equation of observation variable correlation matrix, we get p characteristic values and the corresponding p characteristic vector. Then we rank the p characteristic values from the bigger to the smaller, representing the variance of the observed variables explained by the p principal components. And the principal component is a linear combination of the observed variables; the weight of the linear combination is the elements in the corresponding unit characteristic vector (Liu, 2015).

2.3 Model setting for this paper

2.3.1 Indicator analysis

To accurately measure the comprehensive carrying capacity in a certain region, we must establish a set of index system which can effectively reflect the state of the regional system. According to the scientific, comprehensive, actionable and concise principle, following the sustainable development index system of Chinese Academy of Sciences, this paper chooses 23 indictors combining the economic, environment, ecology and energy development state in BTH, which are targeted and easy to measure. At the same time, for the convenience of comparison in each category, indicators are divided into the stress indexes and sustainable indexes. The value of stress indexes is better when it is less and the carrying capacity is in the negative correlation. While the value of sustainable indexes is better when it is more and the carrying capacity is in the positive correlation. The index system is shown in Tab.1. In view of the availability of data, based on comprehensive carrying capacity, this paper constructed two levels in index system. There are 4 primary level indexes, namely the ecological carrying capacity, environmental carrying capacity, economic carrying capacity and energy carrying capacity, which include 23 secondary level indexes under the primary level.

When originally constructing the index system, more indexes are considered to enrich the evaluation, such as factors related to biodiversity, ecosystem services and renewable energy (refers to Cong, Smith, et al. 2014; Cong, Hedlund. et al. 2014; Cong, 2013; Cong and Shen, 2014). Nevertheless, for the lack of data of some indicators, 23 secondary indicators are selected at last based on the operable principle, shown in Tab.1.

Table 1 The evaluation index system of regional comprehensive carrying capacity

Primary index	Second level index	
	Stress index	Sustainable index
Ecological carrying capacity	Water consumption per ten thousand yuan GDP ($m^3/10^4$yuan); Per capita water resources consumption (m^3/person)	Per capita water resources reserves （ m^3/person）; Area of cultivated land of average per capita （ hm^2/person）
Environmental carrying capacity	The amount of generated air pollution per ten thousand yuan GDP ($m^3/10^4$ yuan); The amount of generated solid waste per ten thousand yuan GDP ($t/10^4$ yuan); The CO_2 emission intensity ($t/10^4$ yuan); The SO_2 emission intensity （ $t/10^4$ yuan）	The rate of industrial wastewater treatment（%）; The proportion of environmental protection investment accounted for GDP (%); Comprehensive utilization rate of industrial solid waste（%）
Economic carrying capacity	The proportion of high energy consuming industry (%); The proportion of the secondary industry (%); The Engel's coefficient (rural) (%)	The urbanization rate（%）; Per capita GDP (ten thousand yuan/ person); The proportion of the tertiary industry (%); The proportion of high-tech industry（%）
Energy carrying capacity	Energy intensity（Tons of standard coal /10^4 yuan）;Electricity intensity（kwh/ 10^4 yuan）	The per capita coal mines (t/person ）; The per capita oil reserves (t/person）; The per capita coal reserves（ t/person ）

2.3.2 The ideal value and the factor weight

1） The ideal value

This paper takes the deviation between the real value of regional carrying capacity and the ideal value of regional carrying capacity as the basis of quantitative description, therefore the selection of ideal value of regional carrying capacity is very important. Methods to determine the regional comprehensive carrying capacity of the ideal value include questionnaire, the index method and so on. Considering the comparability and feasibility, the ideal value of stress indexes are selected from the last 1/3 samples' value in China in 2011, while that of the sustainable indexes are selected from the top 1/3 samples' value (Xu et al. 2009).

2）The standard value

During the analysis of comprehensive carrying capacity of BTH region, the raw data need to be standardized after completing data collection, for the selected indexes have different dimensions and they are unable to compare. The Standardized data processing can be carried out in accordance with two methods: one is based on the statistical method, which means, the original data of single index value minus the average value and then divide the standard deviation, getting the standard value. Another one is directly dealing with the single index according to the ideal value as a reference. The second method is adopted to standardize the data from 2005 to 2011 in this paper. The standard value of stress index is the ratio between ideal value and realistic value, while that of the sustainable index is on the contrary.

3）Selection of index weight

In the analysis of the carrying capacity of the BTH region, another key point is to select the index weight, which is also defined as the “Contribution degree” in this paper. Researching on the multi index comprehensive evaluation system, scholars in the past often used subjective or objective method to determine the index weight. The subjective method is based on the degree of importance by evaluators. The objective method determines the index weight according to the degree of relationship between the various indicators. The main objective method is the entropy method, principal component analysis and so on. Because of disputes in the entropy method, this article uses the principal component analysis to determine the weights of indexes, and related steps are as follows:

（1）Calculating the normalized sample matrix R, and getting the R of the eigenvalues λ_i and eigenvectors L_i.

（2）Calculating the variance contribution rate, and determining the number of principal components. Ranking the eigenvalues according to the size and the variance contribution rate of principal component z_j, $e_j = \lambda_j \Big/ \sum_{i=1}^{n} \lambda_i$, and $l_p = \sum_{j=1}^{p} \lambda_j \Big/ \sum_{i=1}^{n} \lambda_i$ is the cumulative contribution rate by principal component z_1, $z_2 \ldots z_p$ (p<n). The variance contribution rate means the contribution of index in the system. We usually choose the cumulative contribution rate is more than 85% of the former P principal components to conduct comprehensive evaluation.

（3）Determining the weight of each index and the principal component. The normalized value of contribution matrix $L_p = (L_1, L_2 \ldots\ldots L_n)$ of each index is the corresponding index weight; the normalized contribution rate is the weight of each index, that is $z_j = \lambda_j \Big/ \sum_{j=1}^{p} \lambda_j$.

2.3.3 Comprehensive carrying capacity calculating

After determining the weight of each index, the pressed index and sustainable index are as follows:

For stress index: $RCS_i^* = RCC_i / RCS_i$

For sustainable index: $RCS_j^* = RCS_j / RCC_j$

In the formula, RCC_i (i = 1 , 2 , …, n) is the ideal index value of type i , RCS_j (j= 1 , 2 , …, n) is the real index value of type j.

The ideal carrying capacity is 1, and the real carrying capacity is: $M = \sqrt{\sum_{i,j=1}^{n} \omega_{i,j} \left(RCS_{i,j}^* \right)^2}$

The bigger the M value is, the higher the carrying capacity is.

2.4 Data Sources

The data used in this paper are from China Statistical Yearbook (2006-2012), China Energy Statistical Yearbook (2006-2012), Beijing Statistical Yearbook (2012), Hebei Economic Yearbook (2012), Tianjin Statistical Yearbook (2012), and other relatively data in environmental bulletin of Beijing, Tianjin, Hebei province in 2012.

3. Results and discussion

3.1 Current situation of BTH region

The BTH region is an area of about 120 thousand square kilometers, and its total population is 107.70 million which mainly includes Beijing, Tianjin and Tangshan, Shijiazhuang, Qinhuangdao, Langfang, Baoding, Cangzhou, Zhangjiakou and Chengde of Hebei province. The economy of this region develops rapidly, whose total GDP was 2088.7 billion in 2005, and by 2012 the regional GDP reached 5734.8 billion, with the average annual economic growth rate more than 10%, higher than China's average level.

The economy of BTH region is mainly supported by the secondary and tertiary industry which account for more than 90% on its total GDP. Noteworthy, the proportion of its tertiary industry has reached to more than 50% in 2010, which means the tertiary industry occupies a dominant position in this region. The energy consumption in BTH region has increased year by year since 2005, as shown in Fig.3, which brings a great challenge to the development of regional economy. However, the region's energy efficiency is gradually improved, with energy intensity decreased from 1.4 tce /10^4 yuan in 2005 to 1.04 tce /10^4 yuan in 2012 and electricity intensity has been lower than 0.2 kWh /10^4 yuan, reflecting the level of energy utilization technologies has been improved. Elasticity of energy and electricity consumption is also gradually declining, showing that GDP growth is higher than its energy consumption growth rate.

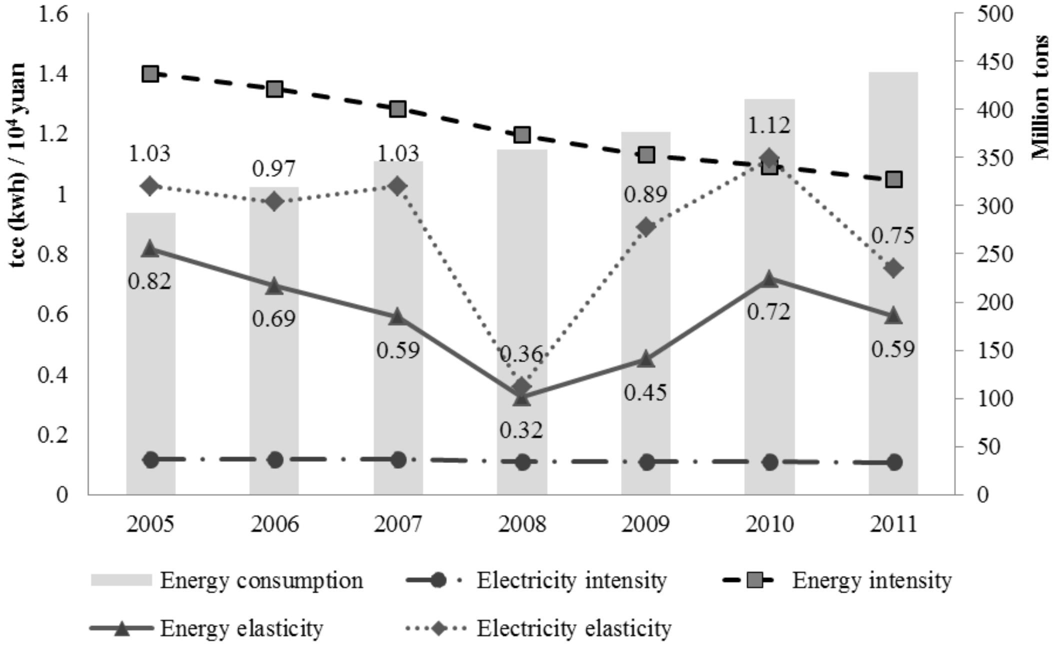

Fig.3. Indicators of energy consumption in BTH region

Water resources of BTH are scarce, with per capita capacity of 187.8 m^3 in 2011, less than 20% of international water resources per capita capacity, which restricts the region’s sustainable development. Along with the industrialization especially the agglomeration of heavy chemical industry and the rapid development of this region, more and more people come here, which brings huge pressure to the region’s environment, resource and ecology. Carrying capacity of this region is facing enormous challenges.

3.2 Analysis of comprehensive carrying capacity in BTH region

The comprehensive carrying capacity and the contribution degree of the four second carrying capacity from 2005 to 2011 in BTH area are calculated, as shown in Fig.4. As it is can be obtained from the evaluation results, the comprehensive carrying capacity value in 2005 is 0.82, then reaching 1.20 in 2011, which shows a clear upward trend during the last 7 years. The contribution degree of economic carrying capacity is the biggest, which is more than 40% each year, and it is followed by the ecological carrying capacity and environmental carrying capacity. Energy carrying capacity is the lowest which is less than 10% each year, and there is a downward trend since 2008, indicating that the energy issue is the limiting factor in the Beijing-Tianjin-Hebei region.

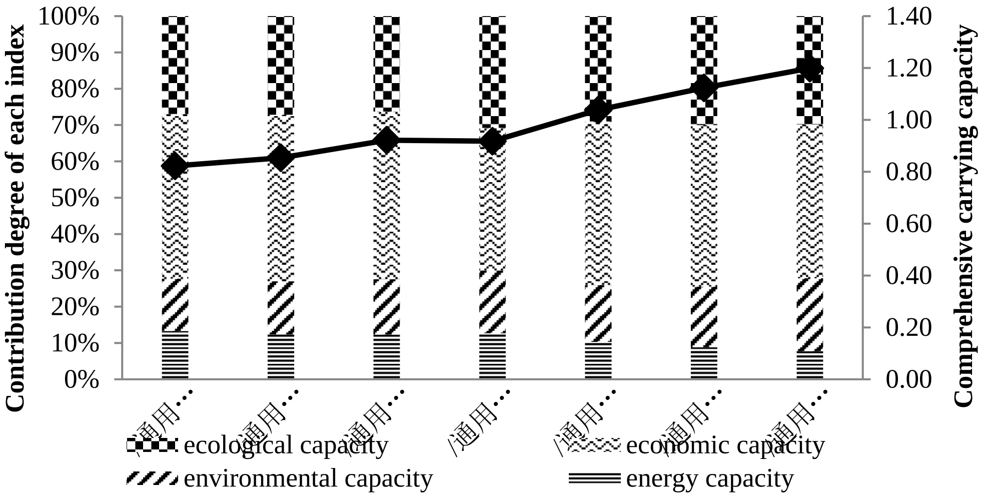

Fig.4.

Comprehensive carrying capacity and the contribution degree of the elements from 2005 to 2011 in BTH region

3.2.1 Economy has the largest effect on comprehensive carrying capacity

The economic carrying capacity of BTH region is in the overall upward trend from 1.05 in 2005 to 1.53 in 2011. As is shown in Fig.5, the area of a circle represents the economic carrying capacity, and the area of the circle increases gradually every 2 years from 2005 to 2011.

Economic carrying capacity is mainly measured by the proportion of the secondary industry, urbanization rate, per capita GDP, rural Engel coefficient and other factors. From the contribution degree of these factors to the economic carrying capacity, it’s obvious that contribution degree of the proportion of high-tech technology industry in sustainable index is the largest, and it has shown an increasing trend since 2005. It has occupied more than 50% of the contribution degree proportion and owned the dominant position in 2011. So we can see that the development level of high-tech industry in the region is far more exceeding than the national average level, and it is rapidly growing. The second is the proportion of the per capita GDP and the rate of the secondary industry, and the contribution degree of per capita GDP since 2005 has increased year by year. In 2011, it has exceeded the proportion of the secondary industry and become the largest index after the high-tech industry's contribution, reflecting that economy of this region is growing rapidly, and people's living standard has been greatly improved. While the contribution degree of the proportion of the secondary industry in the stressed index is still high, especially before 2011when its contribution is just after the high-tech industry, reflecting the proportion of secondary industry in the area is relatively high. In addition, the contribution degree of the proportion of secondary industry has been declining since 2005, reflecting that the proportion of secondary industry is increasing gradually, and it has affected the rise of the economic carrying capacity to a certain extent.

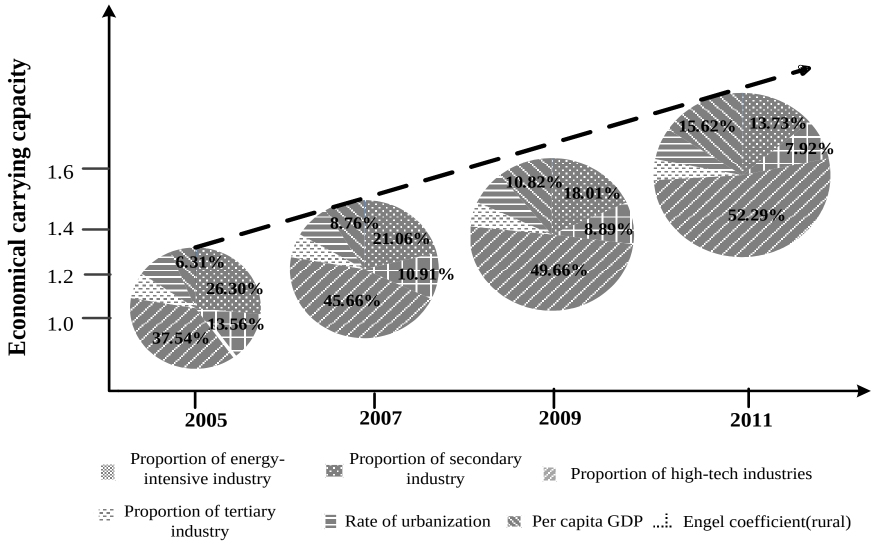

Fig.5. Economic carrying capacity and the contribution degree of each index

3.2.2 The influence of ecological carrying capacity is rising under limited

Ecological carrying capacity in this region demonstrates a rising trend from the results of the comprehensive evaluation index system. In 2005, the ecological carrying capacity is 0.84, while in 2011 it increases to 1.28.

Water resources, the consumption and per capita forest area are selected as the indexes of the ecological carrying capacity. Because the per capita forest area remained unchanged from 2005 to 2011, thus we don't give any analysis. Then the change of supply and demand of water resource is the fundamental reason for the rise of the ecological carrying capacity of BTH. Through the analysis of water resources in this region, it can be concluded that on one hand supply capacity of water resources in this region rises more significantly, the per capita water reserves having increased more than 2005 to 2007 since 2009; On the other hand, with the resource-conservation society and the concept of low carbon environmental protection are more and more popular among people, per capita water consumption and water consumption per 10^4 yuan decreasing year by year. It is the increase of water resource supply capacity and the decrease of water consumption cause the gradual rise of ecological carrying capacity in this area, as shown in Fig.6.

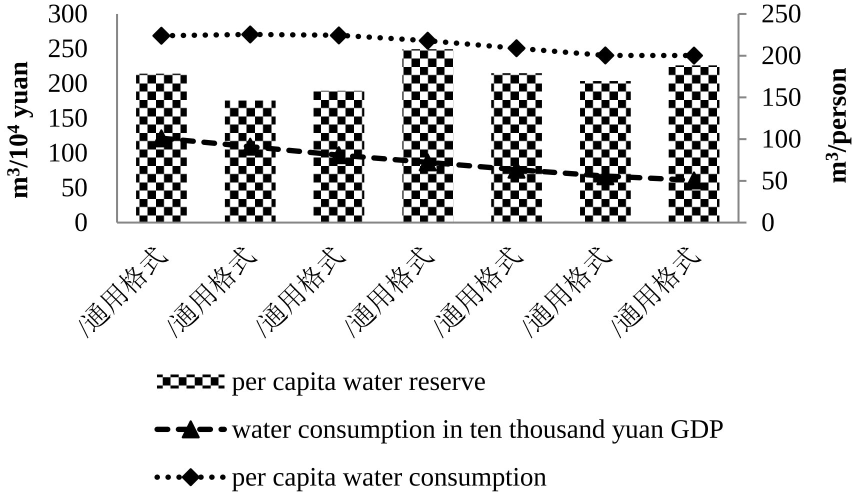

Fig.6. Water supply and consumption trend from 2005 to 2011 in BTH region

Although the ecological carrying capacity is increasing year by year, the pressure and constraints of the region called by water shortages have not been alleviated fundamentally. The total water resources in 2011 in BTH is 19.94 billion m^3, accounting for only 0.86% of the country, while the water consumption is 25.44 billion m^3. Therefore, the low ecological carrying capacity caused by the shortages of water resources will still restrict the comprehensive carrying capacity for a long period in the future.

3.2.3 Environmental carrying capacity is the rising thrust

The environmental carrying capacity in BTH region has a rising trend from 2005 to 2011 as shown in Fig.7. In 2005, the environmental carrying capacity is 0.62 and it reaches to 1.07 in 2011. Especially after 2009, the environment carrying capacity is rapidly increasing, which has driven comprehensive carrying capacity to increase.

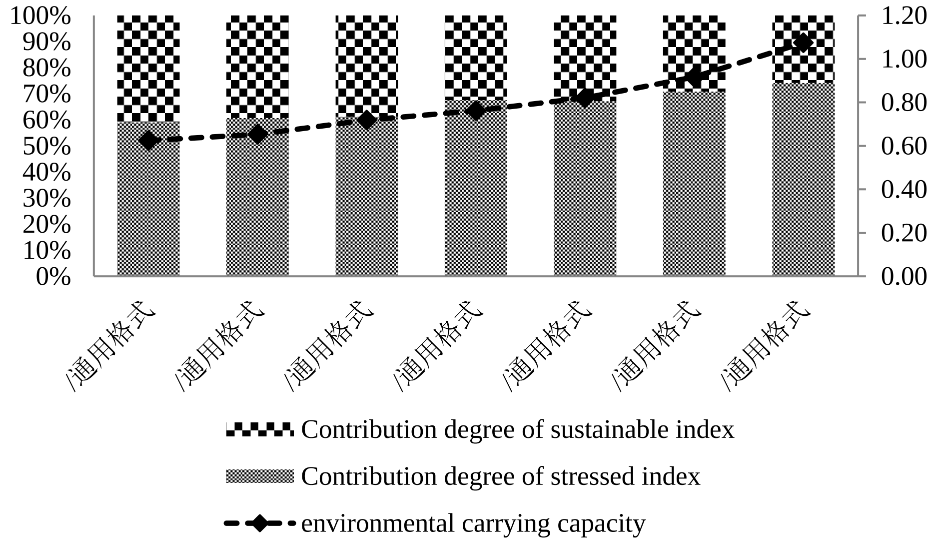

Fig.7. Environmental carrying capacity and contribution degree of the two major indexes in BTH region from 2005 to 2011

Environmental carrying capacity mainly measured by 5 stressed indexes (such as wastewater per 10^4 yuan, CO_2 emission intensity) and 3 sustainable indexes (such as the proportion of environmental protection investment in GDP). It can be concluded that the contribution degree of the stressed indexes is above 60%, the rising trend of which indicates that the stressed indexes are in a declining trend and the environment quality has improved recently. The main reason of this situation is that the government has strengthened the supervision on high emissions enterprises and adopted new technologies to reduce their emissions. While the contribution degree of sustainable indexes are low and there is a downward trend, reflecting that the rate of wastewater utilization and the environmental protection investment is relatively lower than the ideal value in our country, and thus cause a low contribution to the carrying capacity of the environment. Therefore the government not only strengthened the supervision in the high emission enterprises, but also promoted the rate of the waste utilization and increased investment in the environmental protection, which add the contribution degree of sustainable indexes.

3.2.4 Energy is the key limiting factor for BTH's development

Energy carrying capacity in this region is low on the whole, about 0.6, and is showing a downward trend, among which energy shortage is the key factor for the development of this region.

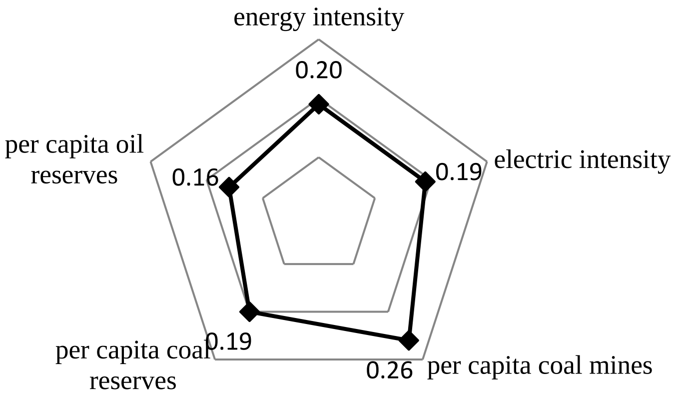

Fig.8. The proportion of each index in energy carrying capacity

In the evaluation system of energy carrying capacity, five indicators such as energy intensity, electricity intensity, per capita coal mines, per capita coal reserves and per capita oil reserves are selected. As demonstrated in Fig.8, main factors that influencing the energy carrying capacity are per capita coal mines and energy intensity, which accounts for 26% and 20% respectively.

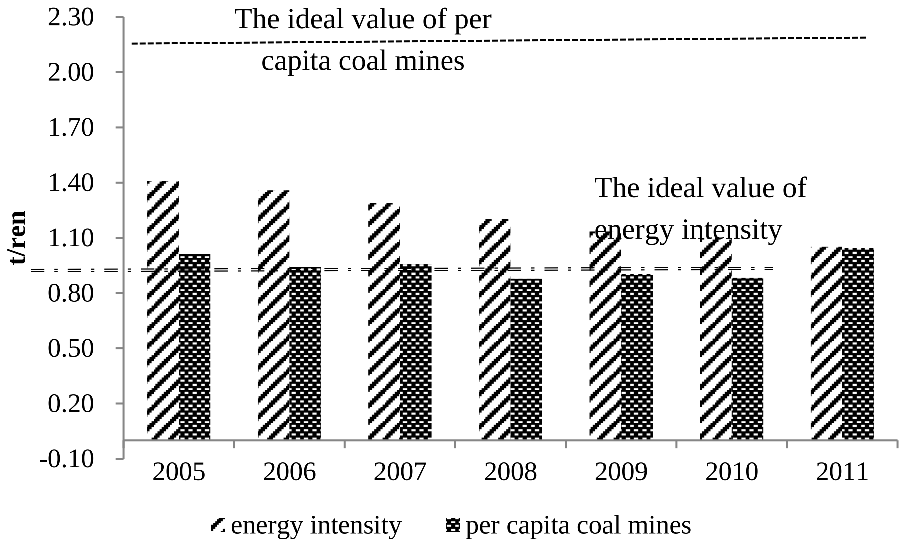

Fig.9. The main affecting indexes of energy carrying capacity

The energy consumption structure of BTH region is dominated by coal, especially in Hebei which is a large province of the coal consumption. Coal consumption in this region has reached 0.384 billion tons in 2011, of which in Hebei is more than 0.3 billion tons which accounts for 80% in this region, even more than the total coal consumption of Germany. It can be seen from Fig.9, the sustainable index of pet capita coal mines is far less than the ideal value, and it is also in a declining trend. Although energy intensity within the region was in the downward trend since 2005, it is still relatively large when compared with the ideal level of our country. The shortage of the energy supply and the low efficiency of energy utilization restrict the development of regional economy.

4. Conclusions and Policy Implications

4.1 Conclusions

In recent years, China has concerned for the sustainable development of the BTH region. This paper mainly evaluated the bearing capacity of the BTH region based on the state space model for multi-dimensional analysis and description, trying to solve the current problems of the environment and resources.

Our results suggest that in recent years the comprehensive carrying capacity in BTH region shows a clear upward trend, from 0.82 in 2005 to 1.20 in 2011. The energy is a key constraint to the sustainable development in BTH region, the low overall energy capacity, hovering around 0.6, which is the most important problem about the development of BTH region to be solved. In addition, the carrying capacity of regional performance in the economic, ecological and environmental aspects is relatively good, and the economic carrying capacity is the biggest contributor to this region, every year more than 40%. What’s more, the ecological and environmental carrying capacity of the region is rising year by year, becoming the main driver for the increase of the comprehensive capacity in BTH region. But compared with the national ideal level, we found that the BTH region is in a disadvantage position and still affected by water shortages. So it should be further improved for developing better and faster.

4.2 Policy implications

Based on the above study, problems existing in the development of Beijing-Tianjin-Hebei region can be described profoundly. Thus, corresponding countermeasures and suggestions should be proposed from the economic, ecological, environmental, and energy four aspects respectively, prompting the better realization of the sustainable development in the region.

4.2.1 Accelerate technological progress, and promote the optimization and upgrading of industrial structure

Through the research, economic carrying capacity is the key factor to promote the comprehensive carrying capacity of BTH region. In the economic carrying capacity, the contribution of high-tech industry is bigger, which is the key factor of driving it to increase, but the declining of the secondary industry and its contribution degree limit the rise of economic carrying capacity. Therefore, the BTH region should make full use of its political and cultural center status, and encourage the development of high-tech industries to optimize the industrial structure constantly. At the same time, the government should increase investment in science and technology, and focus on cultivating the emerging industries of high value-added and low polluted. In addition, limiting the development of energy intensive and high polluted industry and promoting the development of the tertiary industry is essential. To realize the cycle utilization and the reduction of the energy consumption, the government also can rely on the innovation of clean technology system and the upgrade of technical structure.

4.2.2 Improve the contradiction between supply and demand of water resource，and break through the bottleneck.

The shortage of water resources in BTH region is an important short board which restricts the regional development. So it is necessary to combine revenue and cutting expenditure, reducing the demand for water resources to realize the balance of supply and demand of water resources, which is the fundamental way to break through the constraint of water resources. The supply of water resources in BTH is single and it highly depends on groundwater, while the water pollution aggravates the shortages. So the government needs to accelerate the South to North Water Diversion Project and try to complete as soon as possible. Government should also encourage the coordinated development of the near regions to make us gain more water resource from them. And this region should focus on technological transformation of high water consumption enterprises such as power, textile, metallurgy, pharmaceutical, paper making, and chemical industry and so on, make efforts to reduce per unit GDP of water consumption and build a water-saving economic structure early. Besides, the government should take water saving strategy as a long-term strategy for this region. Introducing some advanced technology of wastewater treatment and circulation, increasing the investment in the improvement of water quality, and further improving the efficiency of water use.

4.2.3 Develop recycling economy, and realize the coordinated development of economy and environment

With the deepening of the concept of low carbon environmental protection gradually in BTH region, environmental carrying capacity is on the rise year by year, especially the stressed index has been gradually declining, reflecting the environment in the region has been improved. But to some certain, indexes which have a tendency to deteriorate in recent years, such as per unit GDP of emissions, are increasing year by year since 2008 after the Beijing Olympics, which causes the increasing of PM2.5 in the region year by year, as well as affects the local environment improvement. In addition, the contribution degree of sustainable indexes is reducing which also reflects the lack of investment in environmental protection. In view of this, the pollution emissions of enterprises should focus on remediation within the region, at the same time put the concept of recycling economy into the various enterprises. Combine the source control and end treatment of industrial pollution, shut down and transfer high emissions of enterprises, make the economic development that is in the range of ecological environment can withstand. The government should add the investment on environmental protection, even though the investment in which has increased in recent years. Because the increase amplitude is small and still need to increase environmental protection investment. In addition, the government should formulate preferential policies to encourage science and technology innovation in environmental protection, especially attract venture capital firms, environmental protection enterprises and scientific research institutes to set up environmental protection technology development alliance, so that we can achieve accurate docking between the environmental protection technology and production, improve the conversion efficiency of environmental protection technology, comprehensively improve the environmental carrying capacity.

4.2.4 Save energy, and improve energy efficiency

Economic development demands vigorously support of natural resources, with the development of economy, demanding for resources in the BTH region is also rising. We can conclude that the energy carrying capacity is seriously insufficient because of the shortage of natural resources in this area. Based on these inherent deficiencies, the fundamental way to develop in this region is to save energy, improve the efficiency of resource utilization and reform the resource property rights and operating mechanism. Broaden the income and reduce expenditure of energy resources and put the saving resources in the first place. This region should promote the application of saving mode in terms of production, consumption and city construction, pay attention to the conservation and rational utilization of resources. The government should establish resource-saving technical support system relying on the technical advantages of the area, vigorously develop the resource-saving and high-tech industries, phase out the high energy consuming enterprises and subsidize the enterprises achieving low energy consumption through technology innovation, so that can solve the regional resource problems.

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