Study on the comprehensive carrying capacity of cities in national central cities-Taking Xi'an as an example

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Abstract: As Xi'an enters the new first-tier cities, the urbanization process is accelerating, urban development is uncoordinated, resource reserves cannot keep up with the speed of economic development, and environmental pollution is serious. Based on this, it is particularly important to strengthen the study of urban carrying capacity in Xi'an and seek to solve the path dependence of environmental problems and development problems. Using fuzzy evaluation method, the author studies the population carrying capacity, resource carrying capacity, environmental carrying capacity, economic carrying capacity, social carrying capacity and cultural carrying capacity, and comprehensively measures the comprehensive urban carrying capacity and its changes in Xi'an from 2009 to 2016. The trend is of guiding significance for Xi'an City to seize the development opportunity of “One Belt, One Road” and deal with the development bottleneck.

1. Introduction

Bearing capacity is a mechanical concept, which refers to the maximum load an object can bear under certain conditions, but its application and related research begins with Malthus' population theory. Later, it was widely used in the fields of ecology, economics and demography. From the research content, the research on urban carrying capacity mainly focuses on the judgment of its connotation and the evaluation of bearing capacity and empirical analysis. When Kong Wei and Ren Liang (2017) studied social carrying capacity, they defined it as a specific regional context in which the entire human social system (technical, educational, cultural, and health) can support sustainable development goals. The maximum population load that can meet the normal needs of human beings and ensure the coordinated operation of the social economy; Xing Na, Yang Songmao and other scholars (2017) point out that the urban carrying capacity does not only refer to the existing resources of the city when studying the comprehensive carrying capacity of the city. Endowment, ecological environment, and maximum population load under infrastructure conditions also include the ability of cities to carry human economic and social activities under these conditions. In the empirical aspect, scholars construct different index evaluation systems and adopt different data processing methods to make the bearing capacity as close as possible to the real value; the methods used mainly include DEA method, state index method and analytic hierarchy process. Law, PSR model, etc. From the perspective of carrying factors, the research on bearing capacity is gradually studied from the initial single factor (such as ecological carrying capacity, water resources carrying capacity, resource and environmental carrying capacity, climate carrying capacity, economic carrying capacity, social carrying capacity), and transportation. Research on carrying capacity, public service carrying capacity, etc.) Transition to multi-element research. When scholars study the single factor carrying capacity, they often associate it with the development of population, resources, society and economy. Therefore, the study of urban carrying capacity with multiple factors can better reflect the real situation of urban development. Wang Dan, Chen Shuang and other scholars (2011) divide urban carrying capacity into urban pressure, support, and coordination. The views of scholars such as Zhang Jingchao (2016) are slightly different from those of the former. They believe that the evaluation of urban carrying capacity should include population, economy, society and ecological environment. Because of the different emphases, Sun Li (2009) and other scholars consider urban load capacity as

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a collection of land carrying capacity, water resources carrying capacity, traffic carrying capacity and environmental carrying capacity when evaluating the differences in urban carrying capacity of the five major urban agglomerations. Cheng Guangbin (2015) and other scholars further enriched the index evaluation system of carrying capacity, and used the improved entropy method to measure and analyze the carrying capacity of urban agglomerations and cities within the Northwest. Although the factors considered by many scholars are different when constructing the urban bearing capacity index system, they all take the various activities carried out by human beings as the starting point and comprehensively evaluate the urban carrying capacity.

2. Research methods

In the evaluation of urban carrying capacity, the common methods are Delphi method, analytic hierarchy process, grey relational analysis method, principal component analysis method, etc. After reading a large number of literatures and comparing various evaluation methods, this paper selects fuzzy evaluation method. The evaluation index system is constructed to comprehensively evaluate the urban carrying capacity of Xi'an.

The fuzzy comprehensive evaluation method is a method for comprehensive evaluation of the system by applying fuzzy set theory, that is, the evaluation is based on the given evaluation criteria and the measured values after fuzzy transformation. This method treats uncertain information in a quantitative way, and the decision-making is quantitative decision-making, which increases the authenticity and accuracy of the judgment. Fuzzy comprehensive evaluation is the use of fuzzy mathematics tools to make a comprehensive evaluation of certain things under the influence of various factors.

Let U = { u1 , u2 , ..., um} denote the m evaluation index factors of the evaluated object, and V = { v1 , v2 , ..., vn} denote a limited set of comments for each index factor.

(1) The indicator for determining the object of judgment is determined by n factors, the factor set is U, U = { u1 , u2 , ..., um} , and each factor ui (i = 1, 2... m) is determined for the object of judgment. The degree of influence of the ranks is different, that is, their weights are different. The weight distribution is a fuzzy subset A on the factor U, A={ a1 , a2 , ..., an} , where ai is the weight value of the factor set ui, Ai $\geq$ 0 and $\sum$ai =1.

(2) Let each factor ui contain s sub-factors, the factor set is ui, ui = { ui1 , ui2 , ..., uis}, and the corresponding weights are Ai = { ai1 , ai2 , ..., ais} , air Indicates the weight of uir in ui, air $\geq$ 0, and $\sum$air =1.

(3) The object of judgment can be divided into n levels, and the evaluation set is V = { v1 , v2 , ..., vn}, which means the reviews from high to low.

(4) Comprehensive evaluation of the m factors of each ui according to the initial model. From ui to V, use the fuzzy matrix Ri to describe.

Ri= (S =1,2, ...,m; j =1,2, ...,n)

Where rij =, indicating the membership of the factor indicator uis for the j-level comment vj.

(5) Get the comprehensive evaluation score set of the target according to the following fuzzy operation relationship

B=A·R=(a1 , a2 , ...am)·=(b1 , b2 , ...bm).

3. Construction of comprehensive evaluation index system

When constructing the evaluation index system of urban comprehensive carrying capacity, it is necessary to fully study the relevant literature of urban comprehensive carrying capacity and related theories of sustainable development, and comprehensively consider the constituent elements of urban comprehensive carrying capacity and the construction principles. The construction of the indicator system needs to follow the principles of scientificity, comprehensiveness, representativeness, sustainability, and comparability.

On the basis of the above principles, taking full account of the requirements of the DEA method,

this paper divides the urban comprehensive carrying capacity into two categories of input and output indicators, including six first-class indicators and 20 second-class indicators and 40 three-category indicators (see Table). 1).

Table 1 Evaluation index system of urban comprehensive carrying capacity

type	First-level indicators	Secondary indicators	Three-level indicators
Input Indicators	Population carrying capacity	Population size	Population density(person/square kilometre)
		Population quality	unemployment rate(%)
	Resource carrying capacity	land resource	Available land resources per capita(m^2/person)
		water resource	Available water resources per capita (m^3/personperson)
		energy resources	Per capita electricity consumption
			Per capita consumption of liquefied petroleum gas (ton/person)
			Per capita gas consumption (m^3/person)
	Environmental carrying capacity	industrial pollution	Discharge of industrial wastewater (10,000 tons)
			Industrial exhaust emissions (100 million cubic meters)
			Industrial solid waste discharge (10,000 tons)
		Agricultural pollution	Fertilizer consumption per unit area of cultivated land (ton/mu)
			Pesticide dosage per unit area of cultivated land (kg/mu)
		Life Pollution	Municipal domestic sewage treatment rate (%)
			Pollution-free disposal rate of municipal solid waste (%)
		noise pollution	Urban environmental noise(dB(A))
			Environmental Noise of Traffic Trunk Line(dB(A))
Output Indicators	Economic carrying capacity	Economic Scale	Per capita GDP (￥/person)
			Investment in Fixed Assets (RMB 100 million)
		economic structure	The proportion of secondary industry output value (%)
			The proportion of tertiary industry output value (%)
		Residents'Economic Level	Per capita disposable income of urban residents (RMB)
			Engel coefficient of urban residents (%)
	Carrying capacity of social services	Medical level	Number of beds per 1,000 people
			Number of doctors and nurses per 1,000 people
		Urban construction	Per capita Road area(m^2/person)
			Per capita park green space area(m^2)
		social security	Number of Urban Basic Medical Insurance Participants (Ten Thousands)
			The Number of Workers'Pension Insurance Participants in Urban Enterprises (Ten Thousands)
		Transportation	Private car ownership
			Total Passenger Transport (10,000 persons)
			Every 10,000 people own public transport vehicles
	Cultural Bearing Capacity	Culture	Book collection per 100 people in public libraries
			Number of screenings
		education	Average number of students in Institutions of higher learning per 10,000 people
			Number of teaching staff in basic education
			Total expenditure on education (RMB 100 million)
		science and technology	R&D Project (Topic) (Item)
			Expenditure on science and technology (RMB 100 million)

4. Empirical analysis

According to the fuzzy evaluation method, the comprehensive bearing capacity of Xi'an from 2009 to 2010 was calculated (see Table 2). In order to more intuitively observe the changing trend of Xi'an comprehensive carrying capacity, population carrying capacity, resource carrying capacity, and Environmental carrying capacity, economic carrying capacity, social service carrying capacity, cultural carrying capacity and comprehensive carrying capacity trend chart (see Figure 1-7).

Table 2 City bearing capacity measurement results

	2009	2010	2011	2012	2013	2014	2015	2016
Population carrying capacity	0.500	0.539	0.586	0.730	0.655	0.564	0.552	0.500
Resource carrying capacity	0.507	0.524	0.575	0.403	0.332	0.437	0.484	0.475
Environmental carrying capacity	0.622	0.602	0.467	0.335	0.462	0.384	0.339	0.479
Economic carrying capacity	0.331	0.364	0.433	0.604	0.713	0.587	0.613	0.642
Carrying capacity of social services	0.105	0.317	0.444	0.526	0.643	0.643	0.745	0.764
Cultural Bearing Capacity	0.063	0.227	0.272	0.469	0.559	0.710	0.752	0.928
Comprehensive bearing capacity	0.355	0.429	0.463	0.511	0.561	0.554	0.581	0.631

4.1 Population carrying capacity

As shown in Table 1, the population carrying capacity shows a trend of rising first and then decreasing. The change in population carrying capacity has a considerable relationship with Xi'an's population policy in recent years. In 2009-2012, the population carrying capacity is rising. In terms of population, first, due to the family planning policy, Xi'an has a small population base and a slower growth rate. Second, due to the slow economic development and low salary of Xi'an compared with the southeastern region, a large number of people have been drained. In terms of population quality, on the one hand, although there are many colleges and universities in Xi'an, a large number of talents are cultivated, but Xi'an can provide limited employment opportunities and limited development opportunities. Therefore, many college graduates choose to go to Beishangguang and other regions to develop and brain drain. On the other hand, in terms of talent introduction, Xi'an lacks a large incentive policy to attract talents, and there are still some shortcomings in the relevant systems, such as difficulties in setting up households. Therefore, this makes the population carrying capacity show an upward trend. In September 2013, General Secretary Xi Jinping proposed a cooperative initiative to build the “New Silk Road Economic Belt” and the “21st Century Maritime Silk Road”, which made Xi'an, the ancient city that started from the Silk Road on the land, attract much attention. With a large number of state-level projects in Xi'an, the employment environment in Xi'an has gradually improved, employment opportunities have gradually increased, and Xi'an has opened up its policies, attracting a large influx of people, and the proportion of college graduates leaving Xi'an has also increased significantly. As a result, the population carrying capacity of Xi'an has declined. Further, the population carrying capacity of Xi'an has declined slowly since 2014, but the data shows that Xi'an's population density has increased significantly. This is because Xi'an's comprehensive carrying capacity has been continuously strengthened, enabling Xi'an to carry As the population increases, the impact of a large population increase on the population carrying capacity of Xi'an is smaller than before.

4.2 Resource carrying capacity

It is not difficult to find that the resource carrying capacity of Xi'an has been decreasing first and then increasing during the period of 2011-2015, while the changes in 2009-2011 and 2015/2016 are relatively small and the trend is relatively stable (see Table 2). Although Xi'an has a huge energy consumption, Shaanxi Province is an energy-rich region. Its proven coal reserves and natural gas reserves rank third in the country, oil reserves rank fifth in the country, and wind and solar resources are abundant, and the wind direction is stable. Building a wind power plant. In addition, the domestic use of other capabilities is becoming more and more mature, which greatly compensates for the shortcomings of some resources shortage in Xi'an.

4.3 Environmental carrying capacity

Overall, Xi'an's environmental carrying capacity fluctuated and experienced a decline-growth-decrease-growth process during 2009-2016 (see Table 2). The main reason is that Xi'an's urban development and industrial layout are too dense, and there are many heavy industrial enterprises. The discharge of industrial pollutants is large and concentrated, far greater than the environmental capacity, which poses a huge threat to Xi'an's environmental carrying capacity. . However, as the government and the people have paid more and more attention to sustainable development, a number of policy interventions have been adopted, and the environmental carrying capacity has shown an upward trend since 2015. However, as the degree of environmental pollution is much greater than the degree of environmental governance, the overall environmental carrying capacity shows a downward trend.

4.4 Economic carrying capacity

Overall, Xi'an's economic carrying capacity showed a volatility upward trend, showing a steady growth trend after a brief decline in 2013-2014 (see Table 2). Specifically, the first is the gradual advancement of the “One Belt, One Road” strategy, which has provided assistance for the urban economic development of Xi'an. Two national-level innovation reform pilot zones and free trade pilot zones have landed in Xi'an, and the Xi'an municipal government seized the opportunity. Actively attract investment and introduce talents. At the same time, the “One Belt, One Road” strategy has further activated the rapid development of tourism industry inside and outside Xi'an. Second, the supply-side structural reform has provided direction and path for Xi'an development. Third, under the support of major national strategies, the status of Xi'an transportation hub city has been further consolidated. In recent years, with the rapid development of transportation infrastructure, the logistics industry and transportation industry in Xi'an have developed rapidly, and the industrial structure has been optimized, which has activated the economic development of Xi'an.

4.5 Social service carrying capacity

Table 2 shows that in recent years, the social carrying capacity has risen considerably, which fully reflects that the living standards of the people of Xi'an have been greatly improved, and the people's lives have been more guaranteed. Its main performance is as follows: First, the improvement of medical level and service. Furthermore, Xi'an pays more attention to the training of medical personnel and the introduction of high-end talents, which has enhanced the soft power of medical care in Xi'an. Third, the scope of social security is broader and more powerful. The coverage of medical insurance has almost reached full coverage, especially for the poor, and the reimbursement rate of new rural cooperative medical insurance and major illness insurance has reached 90% (data from Shaanxi third-party evaluation and research). The standards for endowment insurance and urban subsistence allowances are also increasing year by year. Fourth, the urban greening rate has increased, and urban construction and planning are more reasonable. Fourth, the traffic is more convenient. In recent years, with the construction of public transportation facilities such as Xi'an subway, high-speed rail and public transportation, Xi'an's urban social service capacity has gradually improved.

4.6 Cultural capacity

As shown in Table 2, the cultural carrying capacity shows a rapid upward trend with a large increase. The reason is that Xi'an is the ancient capital of the 13th Dynasty, with profound cultural heritage and cultural development advantages. The other is to focus on technological development. Science and technology is the weapon to enhance the bearing capacity of urban culture, and it is also the decisive driving force for the comprehensive carrying capacity of cities. Therefore, the state and the government have greatly supported the development of science and technology. The government's expenditure on research funding has increased year by year, and the number of scientific research projects established has also increased. The more and more, the Xi'an colleges and universities provide an intellectual foundation for urban development, which laid the foundation for the development of science and technology and the comprehensive carrying capacity of Xi'an.

4.7 Comprehensive urban carrying capacity

As shown in Figure 1, the city's comprehensive carrying capacity is increasing year by year. To a certain extent, the city is constantly developing and progressing, and the factors such as population, resources, environment, economy, social service and culture are intertwined to affect the comprehensive carrying capacity of the city. Especially under the new development opportunities, Xi'an's comprehensive urban carrying capacity has started a new round of growth. However, due to the constraints of resources and environment, the continued growth of the city's comprehensive carrying capacity is under greater pressure. It is not difficult to find that if the restrictions on population resources can be broken, there is still a large room for improvement in the comprehensive urban carrying capacity of Xi'an.

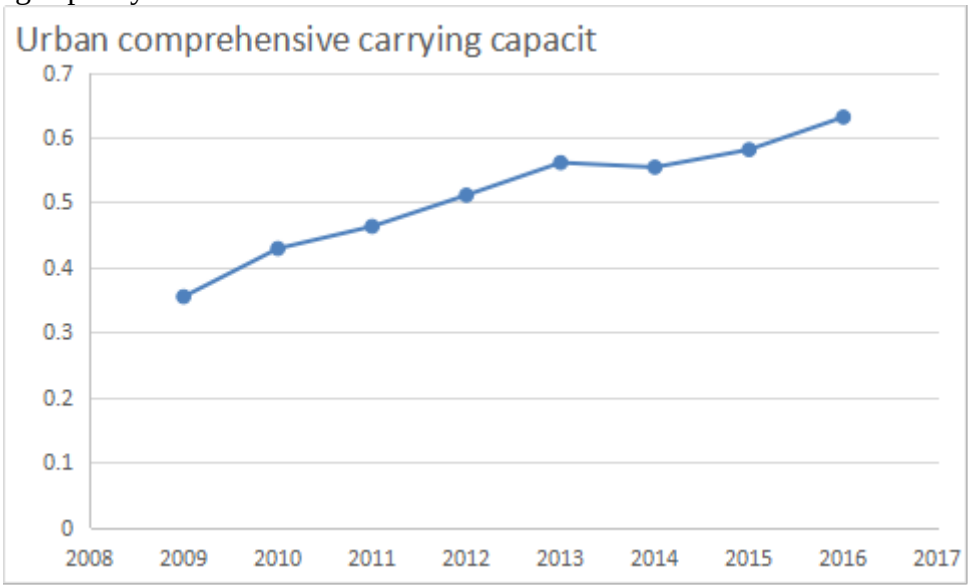

Figure 1 Urban comprehensive carrying capacity trend chart

5. Conclusions and countermeasures

From the perspective of all bearing capacity trends, population carrying capacity and environmental carrying capacity need to be improved; while the development trend of resource carrying capacity and social carrying capacity is slowing down; economic carrying capacity and cultural carrying capacity have room for further development. The improvement of urban carrying capacity has important guiding significance for implementing the requirements of the healthy development of national urbanization, achieving sustainable urban development, and coping with urban challenges.

The comprehensive carrying capacity of a city is affected by various factors. Therefore, urban development should be regarded as a whole, and all departments should coordinate and develop together. Therefore, improving the comprehensive carrying capacity of cities can be considered from

the following aspects: First, adjust the economic structure to adapt to economic development. Seize the opportunity of supply-side reform, vigorously develop the tertiary industry, and transfer the development focus from the secondary industry to the tertiary industry as soon as possible; transfer urban heavy industry, and improve the production technology of the secondary industry, increase resource utilization, and reduce pollution emissions. At the same time, the internal reform of the enterprise, especially for small and medium-sized enterprises, regulate its operating model and optimize its management system. Secondly, Xi'an has a large population base but relatively few hydropower resources. Therefore, in addition to encouraging people to save resources, it is necessary to restrict the areas where resources are wasted and to regulate the hydropower management system. And vigorously promote the development of science and technology, actively develop new energy sources, and make up for the shortcomings of lack of hydropower resources by increasing the utilization rate of other energy sources. Thirdly, while attracting talents, it is necessary to comprehensively consider the economic development potential, social security pressure, educational resource pressure and environmental pressure brought about by the settlement of the population, and limit the urban population to the scope of sustainable development. Finally, starting from the overall situation of urban development, coordinate the development of economy, transportation, social security, housing, education, etc., so that the city operates reasonably and efficiently. Grasp the development opportunity of “One Belt, One Road”, improve the quality of the population, standardize the economic market, increase social security, meet people's demand for housing and education, and promote the sustainable development of the city.

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