Research on the Connotation of Urban Carrying Capacity

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Abstract. With the rapid growth of the world population and the decrease of the cultivated land area year by year, people begin to re-examine and evaluate the carrying capacity of our land. The article absorbed the idea of sustainable development, and finished the interpretation of the connotation of urban carrying capacity from the starting point of urban carrying capacity. The author thinks that the urban carrying capacity is the number of people that a city can carry and the intensity of various human activities under a certain level of economy, society, environment and resources. From the perspective of carrying status, urban carrying capacity is an organic combination of economic carrying capacity, social carrying capacity, environmental carrying capacity and resource carrying capacity.

Keywords: Urban carrying capacity · Social carrying capacity · Economic carrying capacity · Environmental carrying capacity · Resource carrying capacity

1 Introduction

With a large number of people gathering in cities, the rapid economic and social development and the continuous expansion of urban scale, the limitations of urban carrying capacity have begun to emerge [1]. This limitation transcends the single limitation based on the short board effect, and is composed of resources, environment, society, economy and other factors. Starting from the 11th Five Year Plan, China's national level has continuously introduced new policies and regulations, which clearly define the need to enhance the carrying capacity of the urban economy, infrastructure, public services, resources and environment to the population, and effectively prevent and control urban diseases. The urban carrying capacity is not only related to the development prospects of the city itself, but also affects the healthy and efficient sustainable development of its surrounding areas.

2 Origin and Development of Urban Carrying Capacity

The ideological origin of carrying capacity in China can be traced back to the "harmony between man and nature" first advocated by Confucianism [2]. Traditional Confucianism believes that people should live under the laws of nature, that is, only by conforming to

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the will of God can the country be peaceful and the people be safe. The first change from thought to concrete is that Warren News proposed "Man and Nature Relationship" in General Theory of Geography in 1650, that is, the relationship between man and nature [3]. Although his thought was influenced by materialism, he combined natural phenomena with human activities, emphasizing the unity of man and nature. In 1798, Thomas Robert Malthus first proposed a similar concept called "human bearing capacity" in An Essay on the Principle of Population, which was the first time to introduce the thinking about bearing capacity. Because the natural resources on the earth are limited, Malthus put forward a forward-looking view: first, the theory of overpopulation, that is, the earth can only support a limited population permanently; Secondly, the explosive growth rate of population is far greater than the growth rate of resources [4]. The rapid depletion of food resources, fossil fuels, fresh water, fertile topsoil and minerals has led to the limitation of natural resources. Based on the above two theories, he believes that the natural resources supporting human survival will become limited. Despite some criticisms, his logical reasoning about "resource demand population" provides an important basis for the concept of carrying capacity [5].

After about half a century of development, people began to use mathematical models to study natural problems. In 1838, Belgian mathematician Pierre Fran ç ois Verhulst proposed that population growth is not only related to the existing population but also related to available resources, that is, there is a population carrying capacity [6]. He first reflected the nutrition relationship in the mathematical model of the population, and proposed the Logistic equation, which is the first time to use a mathematical model to measure the carrying capacity. Verhulst not only used the population data of Belgium, England and other regions to verify the effective properties of the equation, but also further provided mathematical support for Malthus's population theory [7, 8].

$$\frac{dP}{dt} = rP\left(\frac{E-P}{E}\right) \tag{1}$$

where P is the population; r is the assumption of the speed of population growth; E is the capacity of the environment, which reflects the shortage of food. Although the equation only considers the growth of a single element and does not consider external factors, its application of mathematical methods provides a milestone significance for people to understand nature and study nature. Since then, the application of the equation has gradually expanded and appeared in the internationally famous academic journal Nature, and people pay more and more attention to its application.

Since then, for nearly a hundred years, although people have been constantly exploring the balance between nature and human life, there were relatively few studies in this area because of the relatively small population and rich natural resources [9]. Until the 1930s, Parker and others borrowed the physical terms in geology to use the concept of carrying capacity in the field of ecology for the first time, and gave a reasonable definition: under specific ecological accommodation conditions (mainly including living space, natural resources, nutrients), the maximum number of certain organisms that nature can accommodate [10]. They require that the main body of grassland should not be damaged, which is a reflection of the idea of sustainable development. On the other hand, this definition reflects the idea of interaction between animal population and

environmental state, shifting attention from "maximum population" to environmental quality balance. For the first time, ecological carrying capacity has explored the overall unity, mutual coordination and long-term sustainability of carrying capacity, laying an early theoretical foundation for promoting the sustainable health of the ecosystem and the harmonious development with human beings [11].

3 Interpretation of the Connotation of Urban Carrying Capacity

Environmental problems, resource problems, transportation problems and problems that cannot provide services for a large number of people in the existing infrastructure due to excessive development and concentration are highlighted. In order to solve these problems, we need to take practical measures to incorporate the concept of carrying capacity into the management of urban development. (Urban carrying capacity, UCC or Urban Comprehensive Carrying Capacity is an important barometer of urban sustainable development. Due to the different meanings, principles and priorities of urban carrying capacity, it is essentially a research topic that is not easy to standardize. Three typical historical development stages can describe our scholars' understanding of carrying capacity: the first stage was before the 1990s, due to the popularity of the reform and opening policy The rapid development of urban economy has resulted in insufficient supply of urban natural resources and destruction of resources and environment [12].

Although the research on urban carrying capacity in this period gives consideration to urban resources and environment, most urban builders still focus on economic development [13]. The second stage began in the 1990s and lasted until the beginning of the 21st century. Scholars began to attach great importance to the resource and environmental pressure of cities due to the social problems caused by rapid economic growth [14]. At present, China is in the third stage of urban carrying capacity research, that is, when considering resource factors, environmental factors and economic factors, it starts to consider social factors. The social factors include not only the intuitive improvement of the city brought by the basic public facilities, but also the improvement of the software conditions brought by the basic public services. In the whole development process, although the connotation of urban carrying capacity is constantly enriched, it is still in the initial stage of research. In the initial stage, the research depth and breadth of the article are insufficient, and the model method is single and has not formed a unified and stable basic theory.

Different scholars generally study urban carrying capacity from two aspects of supply and demand. The supply of urban carrying capacity corresponds to the perspective of carrying capacity while the demand of urban carrying capacity corresponds to the perspective of carrying status. Based on the above two perspectives, scholars have formulated different frameworks for urban carrying capacity, and conducted research based on their own defined framework. From the perspective of carrying capacity, the concept of "maximum quantity" is used to study the urban carrying capacity, such as "the maximum population carried", "the maximum scale of human activities", etc. Although many people have defined urban carrying capacity through their own understanding, there is little difference in the definition of carrying capacity [15].

From the perspective of bearing state, the definition of bearing capacity starts from the components of bearing capacity and decomposes from the demand of bearing capacity

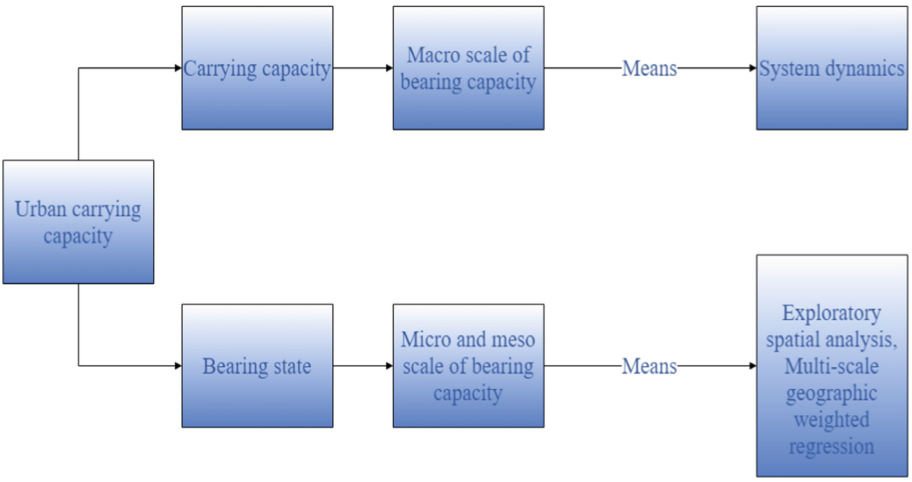

Fig. 1. Urban built-up area extraction results and grey scale values for 2016

itself. Wei Yigang, School of Public Policy Management, Tsinghua University, believes that urban carrying capacity is a coupling function of environmental impact and natural resources, infrastructure and urban services, public awareness, institutional setting and social support capacity [16].

$$UCC = f(En\ and\ Na,\ In\ and\ Ur,\ PP,\ IS,\ So) \tag{2}$$

where, *En* and *Na* refer to environmental impacts and natural resources; *In* and *Ur* refers to infrastructure and urban services; *PP* means Public Perception; *IS* stands for Institution Setting; *So* stands for Society Supporting Capacity.

From the perspective of supply and demand, this paper divides the connotation of urban carrying capacity into two parts: the perspective of carrying capacity and the perspective of carrying status. By absorbing the essence of previous scholars' research, we can get the following conclusions: based on the perspective of carrying capacity, urban carrying capacity is the number of people a city can carry and the intensity of various human activities without external interference. From the perspective of carrying status, urban carrying capacity is an organic combination of economic carrying capacity, social carrying capacity, environmental carrying capacity and resource carrying capacity. For this explanation, the author designed a research framework (Fig. 1). The macro scale of Shanghai's carrying capacity is interpreted from the perspective of carrying capacity and SD method. The micro and meso scale are interpreted from the perspective of carrying state and by using mathematical functions and multi-scale geographical weighted regression.

4 Conclusions

From the perspective of geographical science, the external performance (integrity and self similarity) of urban carrying capacity conforms to the first law of geography, and presents obvious fractal characteristics. Using the knowledge of geospatial science to study the

micro urban carrying capacity is an innovation of perspective, and also makes up for the lack of current research. From the perspective of urban planning, the spatial-temporal evolution of urban carrying capacity and the simulation of multi scenarios are conducive to urban decision-makers to make reasonable judgments on the formulation of future urban population control, traffic design, environmental protection and other policies. The study of urban carrying capacity is one of the specific means of implementation under the framework of sustainable theory.

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