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## Retrospect and Prospect of Research on Resource and Environment Carrying Capacity

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# Retrospect and Prospect of Research on Resource and Environment Carrying Capacity

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**Abstract:** The carrying capacity of resources and environment is an important topic in the study of sustainable development. It is of great significance to analyse and summarize the relevant progress at home and abroad for future research in this field. This paper analyses the domestic and foreign bearing capacity related literature in chronological order, and divides the development process of bearing capacity into four stages: concept proposing, connotation expansion, method and model development, and comprehensive bearing capacity. And the progress in the evaluation and evaluation methods of bearing capacity in recent years is reviewed. According to the research status at home and abroad, it is proposed that the research should be strengthened in the aspects of comprehensive urban carrying capacity, index system and improvement of quantitative methods.

## 1. Introduction

The term “capacity” was first derived from population biology and was used to measure the maximum number of individuals in a particular species that could sustain a particular species under certain environmental conditions. Subsequently, it gradually attracted widespread attention from scholars and the public in many disciplines such as ecology, economics, demography, environmental science, and geography. Nowadays, with the wide application of the concept of carrying capacity, it has been extended to varying degrees in various fields of environment, economy and society. The research process and the latest developments of domestic and international carrying capacity will help to better apply the bearing capacity tool to environmental planning and urban construction under the new situation.

## 2. The development of bearing capacity

### 2.1 Early research stage: the concept of the proposed

The study of bearing capacity abroad has begun with the concept of carrying capacity. In 1798, Malthus published the book "Population Principles", which first explained the binding effect of food on population growth, and believed that the population increased exponentially and food increased linearly. According to this, Malthus proposed a famous prophecy: if population growth exceeds the food supply, it will lead to a reduction in per capita possession of food. Malthus's population theory basically reflects the conceptual basis of the carrying capacity of “cultivated land—food-population” and has had an important impact on later demographic and economic studies. The bearing capacity of the original concept is all about "certain conditions (living space, region, etc.), a number of individual existence of the limit", more concentrated in the field of applied ecology and population biology, used for special habitat and ecosystem management, such as pasture, land, wildlife, and tourism



management. For example, in 1922, after studying the reindeer population in Alaska, Hadwen and Palmer<sup>[1]</sup> defined the concept of carrying capacity of the pasture ecosystem as the number of livestock that could be supported on the pasture without damaging the pasture. In 1949, the American scholar Paul voigt first proposed the concept of ecological imbalance in his book "the road to survival", that is, the impact of human overexploitation of natural resources and destruction of the environment on the ecosystem, thus triggering people's thinking on ecological imbalance. The description of the concept of bearing capacity is no longer limited to the description of total volume and capacity, but also emphasizes that the host (such as grassland, land) is not damaged, reflecting people's concern for the ecological environment. For example, American scholar Allan<sup>[2]</sup> defines land carrying capacity as: a region can permanently support the population and human activity levels while maintaining a certain level without causing land degradation.

### *2.2 improvement stage: rich connotation and expanded scope*

After the 1960s and 1970s, with the acceleration of the industrialization and urbanization of human society, there has been a global population expansion, resource shortages have become more prominent, and the contradiction between man and nature has become increasingly acute. Scholars began to explore the relationship between population growth, economic development and excessive resource consumption, environmental degradation and food production. For example, Catton<sup>[3]</sup> included human disturbance, technology and other factors into the connotation of carrying capacity, and simply defined environmental carrying capacity as the maximum sustainable carrying capacity, that is, human factor technology can keep the utilization level of resources within the maximum carrying capacity of the environment. Cohen<sup>[4]</sup> proposed that the carrying capacity is not static and single, but changes with technology, production and consumption structure, and it is also related to the changing relationship between human body and ecological environment. With the rise of the theory of sustainable development, people gradually realize that development and the environment are an organic whole. Human development should be based on the protection of natural resources and ecological environment, and coordinate with the carrying capacity of resources and environment. Therefore, the research on the carrying capacity of this stage has more or less brought the idea of sustainable development, and the connotation is more abundant. The research scope of carrying capacity has also expanded to forest resources, mineral resources, environmental resources, water resources and other aspects, causing people to reassess global resources.

### *2.3 development stage: method and model application*

The research on constructing the bearing capacity model to calculate and evaluate the bearing capacity has begun to appear, which greatly promotes the quantitative evaluation and calculation of bearing capacity. For example, the "Roman Club" composed of scholars led by Professor D. Meadows<sup>[5]</sup> of the Massachusetts Institute of Technology, applied the system dynamics model to construct a famous "world model" structure for the world's land, The relationship between water, food, mineral resources and other environmental and human relationships such as water, atmosphere and sound has been systematically evaluated. In 1980, British scholar Slessor<sup>[6]</sup> proposed a new method to calculate the bearing capacity with ECCO model. The model assumes that everything is energy. By comprehensively weighing the interrelationship between population, resource, environment and development, a system dynamics model was built to simulate the elastic relationship between population, resource and environment carrying capacity and development under different development scenarios with energy as the conversion standard, so as to determine the optimal development plan. Through practical application in some countries and regions, the model has achieved good results in practice and passed the approval of the United Nations Development Program. In 1984, the Scottish<sup>[7]</sup> Resource Utilization Institute used the data provided by the Kenyan government to conduct a pilot study using a system dynamics model and achieved remarkable results.

#### *2.4 maturity stage: the concept of comprehensive bearing capacity is formed*

The human social system is only a part of the ecological system, and its structure and function depend on the structure and function of the ecological system. Therefore, in the past 20 years, scholars have gradually shifted their research focus from single factor to multi-factor synthesis, and developed the concepts of regional bearing capacity, urban bearing capacity and human (social) bearing capacity.

Regional carrying capacity takes regional resources and environment as the object, and studies the relationship between it and human economic and social activities. To study the bearing capacity of a city divided into regions is the bearing capacity of a city. In 2002, K,Oh,Jeong<sup>[8]</sup> put forward a relatively clear definition of urban carrying capacity, that is, a human activity, population growth, land use and material development level can make the urban human settlement environment system develop sustainably without causing its degradation and irreversible damage. He believes that the comprehensive urban carrying capacity refers to the maximum load that the city can withstand without any damage. In 2012, Linyu Xu<sup>[9]</sup> summarized the urban ecosystem carrying capacity and compared the city's metabolism to human metabolism: the city consumes natural resources from the environment and discharges the waste into the environment.

### **3. Research progress in evaluation methods and application of bearing capacity**

#### *3.1 evaluation and evaluation methods*

The problems of environmental degradation caused by urbanization, poor infrastructure, shortage of resources and insufficient public services have prompted scholars to explore ways of regional sustainable development. Therefore, there are many studies on the comprehensive evaluation index system of carrying capacity. Most of the cities and urban agglomerations are used as the region to analyze the main influencing factors of regional carrying capacity, and to screen indicators that can reflect the status quo of these factors to construct an evaluation index system. In 2005, for example, Kyushik Oh<sup>[10]</sup> the inclusion of the concept of bearing capacity to the urban development and management, points out that should be based on the current urban infrastructure and land use to determine the density of the development of energy, green belts, road, the subway system, water supply, sewage treatment, waste disposal these seven decisive factor to determine the bearing capacity of the city, and on the basis of the development of a city carrying capacity evaluation system. Fu Qiang<sup>[11]</sup> et al. established a comprehensive evaluation index system of water and soil resources based on DPSIR model. Taking sanjiang plain as an example, the projection pursuit model (PP) was used to evaluate the carrying capacity of water and soil resources in the region. The evaluation results show that the water resource utilization rate, reclaimed wasteland, urbanization rate, the amount of fertilizer per unit area of farmland, the rate of farmland irrigation, the amount of water per unit of GDP and the rate of agricultural land output are the key factors affecting the agricultural water use and the bearing capacity of land resources in sanjiang plain. With the development of technology, the research methods of carrying capacity are more mature and perfect, paying more attention to the applicable scale and space-time conditions of different methods. For national, provincial, and regional scale assessments, geographic remote sensing (RS) and geographic information systems (GIS) are used to make results more accurate. Existing urban scale bearing capacity assessment methods include: energy analysis method, IPAT equation, graphical model, ecological footprint model, pressure-state-response model.

#### *3.2 Application progress*

In recent years, carrying capacity has been used as a tool for urban planning, tourism management, and resource management, taking full account of the impact of human activities on regional sustainability and guiding regional sustainable development decisions. Most of them are application models and indicator systems to assess or compare the resource and environmental carrying capacity of the region, and propose corresponding planning recommendations based on the evaluation results. For example, in 2013, Nadia A.<sup>[12]</sup> used Tehran as an example to introduce a spatial decision support

system for sustainable urban environmental planning and management, based on the bearing capacity model based on the bearing capacity concept and 30 indicators. Monitor the environmental load of urban ecosystems. The research on tourism carrying capacity is a hot spot in recent years, mainly caused by the increase in the number of tourists and the deterioration of the tourist environment. Scholars define the connotation of tourism environmental carrying capacity as the quality of resources that can be maintained to a certain extent, and use auxiliary research tools to propose improvements to the number of tourists in the scenic spot, daily management and environmental protection. For example, Steenweg, Robin<sup>[13]</sup> and others evaluated the carrying capacity of the beach in Arrabida Natural Park, Portugal, and recorded the number and dynamics of visitors to the beach through on-site statistics, time-lapse photos and traffic counters, and used questionnaires to understand how visitors feel about beach crowding. The results show that the number of tourists in the scenic spot is in a proper state, but the number of on-street parking exceeds the limit, which should be paid attention to in the management of the protected area. Rijiberman.J et al.<sup>[14]</sup> used bearing capacity as a measure of urban water security assurance in the study of urban water resources assessment and management systems; Sawunyama T. et al.<sup>[15]</sup> used remote sensing technology to assess the carrying capacity of small reservoirs in south eastern Africa, and pointed out that small reservoirs should be fully utilized in the planning and management of water resources as part of the water resources system.

## 4. Summary and outlook

### 4.1 Summary

Resource and environment carrying capacity as a measurement tool to describe the complex relationship between resources, environment and human economic and social subsystems, its connotation is enriched with human cognition, and has made great progress in theoretical research and applied research. Through the combining and induction of bearing capacity related research, this paper divides the research process of bearing capacity into four stages: concept formation, connotation expansion, method and model application, and concept integration. After the concept of carrying capacity is put forward, scholars first apply it to the areas where land, biology and other aspects are most closely related to human production and life, and then gradually expand to the study of the bearing capacity of various single factors and multiple elements, exploring the evaluation model and method of carrying capacity. In the past two decades, it has integrated the concept of sustainable development and conducted research on issues such as shortage of resources, environmental pollution, and habitat destruction, the trend of quantitative research is becoming more and more obvious, and the bearing capacity is developed into a decision-making reference tool for regional resources and environmental planning.

### 4.2 Research Outlook

In view of the current status of research on resource and environment carrying capacity, we will look forward to the future research direction:

First, the comprehensive bearing capacity of the city will become the focus of research. The human society subsystem is only part of the ecosystem. A single factor that focuses on resources and the environment is not enough to relieve the survival crisis facing humanity. Therefore, research on bearing capacity must integrate factors such as population, resources, environment, economy and society, and pay attention to the complex relationship between elements, which interact, interact and influence each other, in particular, a change in factors causes the relationship of other related elements to change. The comprehensive resource and environmental carrying capacity of the city can provide a theoretical guidance basis for coordinating the relationship between population size, economic development, city scale, transportation capacity and ecological protection, and resource and environmental development, and will be the focus of future research.

Second, improve and unify the indicator system. The scientific and reasonable index system is the basis of the research on bearing capacity. There are a large number of quantitative and qualitative

indicators in the study of carrying capacity, covering all aspects of engineering technology and policy management. So far, a comprehensive and accurate description of resources, society, economy and ecology has not yet been formed. The environmental system can also describe the evaluation index system of the bearing capacity, which greatly hinders the in-depth development of regional bearing strength research, and is not conducive to the normative research of bearing capacity. Therefore, it is of practical significance to establish a comprehensive, well-recognized and comprehensive regional bearing capacity evaluation index system.

Third, strengthening the quantitative measurement method of bearing capacity. The quantitative study of carrying capacity is to coordinate the relationship between population size, economic development, city scale, traffic capacity equivalent ecological protection, resource environment development, and can strengthen the quantitative measurement method based on the calculation methods of bearing capacity index and bearing pressure. Research provides a theoretical basis for sustainable urban development. Therefore, the author believes that in the future research, this quantitative work will continue to deepen. On the basis of existing theories and methods, using modern computer technology, geographic remote sensing technology (RS) and geographic information system (GIS) to study the resource and environmental carrying capacity. In this way, not only can the various resource and environment information with spatial attributes be effectively managed, but also the dynamic monitoring and analysis of the resource environment and production activities in multiple periods can be effectively monitored. In particular, RS and GIS can help the resource environment and ecology. The system and the socio-economic system are organically integrated to promote the interconnection of individual systems. Based on these technical means, quantitative research on bearing capacity will be developed in the direction of spatial optimization and digitization, the model will be more perfect, and the theory will be more abundant.

## 5. Conclusion

The connotation of resource and environmental carrying capacity is enriched with the improvement of human understanding. With the improvement of science and technology level, the evaluation and evaluation of carrying capacity will be more accurate and accurate in the future, and the carrying capacity will play a greater role in the areas of urban sustainable development planning, regional pollution prevention, and ecological protection red line delineation.

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