

The Literature Review of the Theory of Resource Environmental Carrying Capacity at home and abroad

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Abstract

With the rapid development of economy, it has an increasingly serious impact on the environment, which makes the resource environmental carrying capacity become a hot topic concerned by the public. This paper has conducted comprehensive studies from four aspects, namely, the theory of carrying capacity, the theory of resource carrying capacity, the theory of environmental carrying capacity and the theory of resource environmental carrying capacity. As can be seen, with the constant extension and expansion of the connotation of the carrying capacity, it has developed from the ecology to the research fields such as environmental science and economics, etc. The current studies on the resource carrying capacity include the land resources carrying capacity, water resources carrying capacity, mineral resources capacity and forest resources capacity. The previous studies have only considered the relationship between human development and resources from one side, while the future research directions perhaps can focus on a systematic perspective to define the comprehensive resource carrying capacity. The studies on the environmental carrying capacity include the atmosphere environmental carrying capacity, tourism environmental carrying capacity and ecology environmental carrying capacity, etc. Scholars have conducted a relatively mature study of the environmental carrying capacity theory and calculation method, as they take the quality into account, consider the restraint of quantity as well as incorporate the socioeconomic factors into the studies of the carrying system.

Keywords: carrying capacity, resource carrying capacity, environmental carrying capacity

1. Introduction

The resource environmental carrying capacity has always been a hot topic concerned by scholars. The studies on the resource environmental carrying capacity help to guide the humans' social and economic activities and coordinate the relationship between human development and the environment, which shows the study on the resource environmental carrying capacity is of important theoretical value and practical significance. This paper has conducted studies from four aspects, namely, the theory of carrying capacity, the theory of resource carrying capacity, the theory of environmental carrying capacity and the theory of resource environmental carrying capacity, and it has also analyzed and mastered the current situation of the resource environmental carrying capacity at home and abroad. The concept of "carrying capacity" could date back to the year 1880 to 1885 in the earliest time. The introduction of the concept of the carrying capacity has provided a comprehensive framework integrating the physics, socioeconomic science and environmental systems, etc. for the planning of the sustainable development. In the 1990s,

domestic scholars began to focus on the related studies on the resources carrying capacity and environmental carrying capacity. Until the early 2000s, the domestic perspective was gradually transferred to the comprehensive study of the resource environmental carrying capacity. Over ten years later, it has drawn a lot of attention and scholars from all walks of life began the theoretical research of the resource environmental carrying capacity for various elements such as energy carrying capacity, ecological carrying capacity, land carrying capacity, water resource carrying capacity and tourism carrying capacity. This paper has conducted a comprehensive analysis of the definition of carrying capacity in the literature of the resource environmental carrying capacity home and abroad, made a theoretical generalization of the resource environmental carrying capacity and explored the research characteristics and trends home and abroad, which can help provide readers with a clear idea. It is expected to provide effective consultation and reference for those who are willing to learn and use the concept of the resource environmental carrying capacity to solve practical problems and for people from all walks of life who are ready to get engaged in the study of the resource environmental carrying capacity.

This paper has employed the literature study to do research into the relevant literature between 1991 and 2012. Through searching the full text databases of CNKI by Tsinghua Tongfang, web of Science Citation Index Expanded (SCI-EXPANDED) and the Social Sciences Citation Index (SSCI) database, we have retrieved 1527 related papers on the resource environmental carrying capacity (including 1325 CNKI papers and 202 SCI& SSCI papers). After screening them, we have determined 174 papers to be selected as the objects of this study (including 123 CNKI papers and 42 SC/SSCI papers). The statistical analysis of the paper is mainly completed by Excel 2010.

2. The Theoretical Studies on the Carrying Capacity

The concept of carrying capacity was derived from the livestock management, which firstly referred to the biggest amount of livestock that a piece of grass could hold. The “The US Yearbook of the Department of Agriculture” published in 1906 was the first to employ this concept. The time when the concept of carrying capacity appeared in “Webster’s Collegiate Dictionary” was the year 1880 to 1885. Abernethy[1] has proposed that the carrying capacity is mainly used to describe the relationship between human activity and the natural environment as well as serve as a standard and foundation for the sustainable development of the economic society. The Young[2] has defined the carrying capacity as “the upper limit of the population growth”, which shows that the carrying capacity can visually show the relationship between human society and the natural environment. Even the carrying capacity can be considered to be one of the 23 problems faced by the world’s sustainable development and its importance has been agreed on in the academic circle.

The carrying capacity is a new subject developed by multidisciplinary disciplines and it has close relationship with statistics, biology and ecology. Scholars have taken the Malthusian population theory as the basis to propose the calculation model of the carrying capacity from different angles. Hardin[3] has also proposed the ecological carrying capacity is the first commandment of ecology and Mayr[4] has believed it has become an important concept in the field of life sciences. Verhulst[5] and Pierre[6] believes the proposition of carrying capacity is to solve the practical problems faced by the US range land management and to determine the maximum tolerable number of livestock for the ranch. The experiments of the same biological population number both in indoors and in the wilderness in the early 20th century provided the empirical basis for the existence of the carrying capacity from the perspective of ecology.

The “Limits of Growth” by Meadows in 1972[7] and the “Ecological Basis” by Odum[8] in 1953 greatly promoted the theoretical research on the carrying capacity. Published in 1991, the book named “the Protection of the Earth” also proposed the concept of carrying capacity. In the early times, the application of the carrying capacity was only limited to the ecological field. With more and more problems arising such as land changes, environmental pollution and the population increase, etc, anthropologists and biologists believe that all of the problems such as the destruction of the ecological environment, the reduction of the ecological resources, the increase of the population as well as social & economic development are associated with the carrying capacity. Thus, the concept and significance of the carrying capacity have experienced corresponding changes.[9] In summary, the carrying capacity refers to the maximum ability of the earth or any ecosystem to withstand. It can be growing by means of humans’ science and technology, but the price is to reduce the development of biodiversity and impair the functioning of the ecological environment.

Through the comprehensive analysis of the documents and literature on the carrying capacity home and abroad, it can be seen that the carrying capacity has developed itself from ecology to the research fields like environmental science and economics, etc with its connotation in constant extension and expansion. The variables judging the carrying capacity have changed from ecological factors to socioeconomic factors, which include the consumption patterns of human society, the development situation of society, economy and technology as well as social values, etc. The changes of the factors determining the carrying capacity have led to many types for the carrying capacity, but the main types are resource carrying capacity, environmental carrying capacity and resource environmental carrying capacity, etc. In terms of the application aspects, the theories of resources environmental carrying capacity can be divided into the resource carrying capacity, environmental carrying capacity, composite ecosystem carrying capacity, tourism & entertainment management, economic & social planning, natural resource management and environmental influence assessment. Among them, the resource carrying capacity can be divided into energy carrying capacity, water resources carrying capacity, land carrying capacity, grassland carrying capacity and mineral resources carrying capacity, etc.; The environmental carrying capacity can be divided into land, water, sea and air, etc.; The composite ecosystem carrying capacity can be divided into the regional carrying capacity, biosphere carrying capacity, watershed carrying capacity, urban carrying capacity and oasis carrying capacity.

3. The Theoretical Research on the Resource Carrying Capacity

In the early 1980s, the UNESCO defined the resource carrying capacity as the fact that “the resource carrying capacity in a country or region referred to the number of people supported by a country or region constantly by means of local energy and natural resources, intellectual and technology, etc. under the circumstances of ensuring the material living standards to be in line with its social and cultural norms within the foreseeable periods” In 1949, the “Way of Existence” by William Vogot continued to follow the theoretical framework by Malthus and take the food as a reference to come up with the land resource carrying capacity, which promoted the development of the theories of carrying capacity. Vogot thought the environment was a double-edged sword for humans, as humans relied fully on the environment while influencing and restricting it. The humans’ daily lives were completely dependent on soil, water, plants and animals to acquire energy, but this behavior was constantly impacted by the external environment and constrained by human factors. William Allan held different views with Vogot, and he believed the number of population supported by land resources in a certain area and in a certain period could be roughly

estimated. Meanwhile, through excluding the land investment of the agricultural sector, ignoring the feedback of all economic sectors for the land utilization rate and taking the food as the main target to employ the equation of land carrying capacity, the maximum value[10] of the population number held by the land in this region in a certain time could be calculated with the land maintaining the original state instead of land degradation as a precondition as well as with the total land area, arable land and farming elements as the main reference elements.

The concept of water resource carrying capacity was first proposed by Xinjiang Water Resource Science Research Group[11] in 1985, who believed the water resource carrying capacity referred to the maximum values to maintain the development and utilization of the industry and the agriculture as well as the number of human population after the water resources firstly meet the needs of the ecological environment. In 1992, Shi Yafeng[12] further proposed the concept of the water resource carrying capacity based on the outcomes of previous scholars as the fact that with the progress of society and history as well as the development speed of scientific technology, water resource carrying capacity is the maximum ability to tolerate the agriculture, industry, urban development as well as population size in a certain region under the circumstances of not destroying the ecological environment. Its goal was to adapt to the changes of the human society, economy and scientific & technological development. In 1993, Xu Youpeng[13] thought that water resource carrying capacity referred to the fact that water resources could still meet the water needs of the industrial and agricultural production, humans' daily life and ecological & environmental protection when the technical and economic conditions as well as the social production reached certain levels. Moreover, he also added that though the water resources were developed and used by people to the largest extent, people would not waste and destroy the water resource environment, in which the water resources could also adjust their own natural cycle and provide new water resources. In 1999, Feng Shangyou[14] redefined the water resources carrying capacity as the fact that water resources were still able to continue to meet the water needs of people of this generation and next generation when people were in a certain region and their living standards reached a certain material level. In 2005, the scholar Ding Renzhong[15] gave a new definition to the water resources carrying capacity as the fact that water resources had made the greatest contribution to the economic development in the particular economic and social development mode of local regions as well as owned the greatest tolerable ability to sustain the good ecological environment in a certain region. In 2005, Qi Yabin[16] came up with a new carrying capacity in his study of the resource carrying capacity, which was called mineral resources carrying capacity. He defined it as the fact that within an expected period, people made the effective use of mineral resources in order to ensure humans' normal material life as the prerequisite and that mineral resources provided the protection abilities for the resources to sustain the local economic and social development in a direct or indirect way.

4. The Theoretical Research on the Environmental Carrying Capacity

In the 1970s, the environmental carrying capacity was the first to be put forward and it was evolved by the connotation of environmental capacity. The specific studies on the environmental carrying capacity at home and abroad were rare. The major studies abroad were as follows: in 1974, Bishop gave the definition of the environmental carrying capacity as the fact that it referred to the maximum degree for an area size to hold human activities forever in the acceptable living conditions. In 1978, Schneider believed that the environmental carrying capacity referred to the maximum tolerable ability of the increasing population in the conditions of natural resources and man-made environmental systems under the premise

of the environment not being seriously damaged by human beings[17] The main studies in China were as follows: Ye Wenhui and Tang Jianwu[18] defined the environmental carrying capacity as the fact that the environment provided a threshold value on supporting the human social and economic activities in particular certain periods of time and certain regional ecological environment, and that a certain environmental state meant the structural quantification area which was not conducive to the shift of mankind survival direction in environmental systems and people were constantly trying to employ different indicator functioning state-space methods to quantify the regional environmental carrying capacity. Peng Zaide[19], et al also proposed a new point of view for the regional environmental carrying capacity and he believed the regional environmental carrying capacity referred to the fact that within a specific time and region, through taking the maintenance of the unchanged environmental systems as the premise, the environment in this region should be changed towards the direction of functional optimization and the regional environmental system could carry the moderate burdens by human social economic activities. Wang Zhonglei[20]established the evaluation system for the environmental carrying capacity and applied it to the coastal areas, which proposed the concept of the coastal environment carrying capacity. It meant there were a supplying capacity and a self-regulated ability between the coastal resources and environment subsystems in a particular time and spatial range, which could withstand the development critical value of the social and economic subsystems inside the oceanic internal systems.

Through the theoretical study of the environmental carrying capacity, scholars derived the theoretical studies such as the atmospheric environmental carrying capacity, tourism environmental carrying capacity and ecology environmental carrying capacity, etc. Some scholars believed it was the atmospheric consumption capacity of maximum pollutant emissions in a certain unit environment. Taking the sulfur dioxide pollutants as representatives of pollutants, the current atmospheric pollutants were classified in the downtown and we had employed the atmospheric dispersion model to calculate the carrying capacity of atmospheric pollutants in the whole city in different environmental qualities. The main components of the tourism environmental carrying capacity theory were the ecological carrying capacity energy, the resource space carrying capacity energy, the mental carrying capacity energy and economic carrying capacity. The tourism environmental capacity could be summarized into the maximum strength that local tourism activities could bear by means of taking the existing state of certain tourism environment as a premise and causing no damage to the tourism environmental structural combination by contemporary and future people. Cui Fengjun[21] further set different types of influencing factors for the tourism environmental carrying capacity, and he appointed the density index of tourists as the social and cultural environmental factors, the tourism economic benefits index as the socioeconomic environmental factors and the land-use intensity index as ecology environmental factors. On this basis, this paper took the scenic spot of Mountain Tai as an example to establish a mathematical formula for the index of tourism environmental carrying capacity. The scholars of the ecological carrying capacity summarized it as the wildlife management science. Li Xiaowen[22]thought it referred to the fact that in an ecological environment region, there was no hunting or the normal hunting which would cause no influence to the animal population, so that there would appear a balance between animal population and the ecological environment as well as between the animal habitats and the survival of finite ecological resources.

5. The Theoretical Research on the Resource Environmental Carrying Capacity

The resource environmental carrying capacity refers to the competence that the resources and

environment have to carry the living population by taking the sustainable development as the prerequisite in a certain time range and technical condition.[23] Liu Diansheng[24] discussed the concept of “resources and environment comprehensive carrying capacity”, believing the resource environmental comprehensive carrying capacity was composed of the integrated factors that were mutually restrained and developed among the natural resource variables, social condition variables and environmental resource variables. Deng Wei[25] thought that the resource environmental carrying capacity could be summarized as follows: in a specific time, it was the resource environmental carrying capacity in different regions for the population size and economic total amount by ensuring the rational exploitation of resources as a prerequisite and by protecting a good cycle of the ecological environment as the condition. Gao Xiangjun[26] proposed the resource environmental carrying capacity as the fact that in a certain period and region, the regional resource environmental system bore all kinds of social and economic activities in order to maintain the regional resource structure was in line with the needs of sustainable development as well as the stable situation of the environmental function in the region. The basic elements of the resource environmental carrying capacity could be summarized as the carrier, carrying objects, and loading rate. The commonly used methods were the index system method, state space method, system model law and the ecological footprint method, etc. For example, Slessor[27], a British scholar, employed the ECCO model to calculate the resource environmental carrying capacity. He took the energy as the conversion standard and took four elements into account of the population, resources, environment and development, as well as established a system dynamic model. The most typical representative domestic scholars were Mao Hanying and Yu Danlin[9]. They integrated the actual situation of the Bohai Sea regions and explored the definition, characteristics and influencing factors of the resource environmental carrying capacity in the Bohai Sea regions. Moreover, he employed the state space method to conduct the status quo analysis on the regional carrying capacity as well as applied the evaluation indicator system and system dynamics models, etc. to make forecasts and dynamic simulation for the regional environmental carrying capacity and carrying status.

To sum up, the study of the resource environmental carrying capacity is evolved from the studies on resource carrying capacity and environmental carrying capacity. The resource environmental carrying capacity includes three meanings, the first being the supporting ability of the resource environmental systems, the second being the consumption power of the carrying objects within a certain range and the third being the moderate pressure that the resource environment can withstand. It can be inferred that the ultimate goal of the resource environmental carrying capacity is the sustainable development of human society. In order to achieve this goal, people have to lay good foundations for the sustainable carrying ability for the resource environmental systems.

6. Conclusions and Prospects

Through a comprehensive study of the theories of resource environmental carrying capacity, this paper has found that the resource environmental carrying capacity slowly develops into the theoretical research of resource carrying capacity and environmental carrying capacity through proposing the concept of the carrying capacity. Since the proposition of the concept of sustainable development, the resource environmental carrying capacity has become a hot topic as well as the cutting-edge issue in the research areas such as ecology, economics and management science. Today, with the resource scarcity, environmental degradation and the consumption & pollution of human activities on the resources and environment, it has prompted scholars to conduct an in-depth study into the resource environmental

carrying capacity in terms of theories and methods, and it is expected to provide guidance for the sustainable development of the humans' resource environment effectively.

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