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Evaluation of the carrying capacity of marine industrial parks: A case study in China

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ABSTRACT

Carrying capacity is an important index used to evaluate the status of regional resources, ecological environment, and regional economic development. Marine industrial parks have gained substantial attention from domestic and foreign investors and governments at all levels; in particular, these parks are an essential part of the national blue economy development plan of the Chinese government. The carrying capacity of a marine industrial park is important to all related stakeholders. In this study, an evaluation system was established based on the literature review and expert interviews by using 32 indices under three dimensions (pressure, bearing, and transformation) to determine the carrying capacity of a marine industrial park. The carrying capacity of marine industrial parks in Shandong Province was evaluated using this system across diverse dimensions by incorporating state space and analytic hierarchy processes. Results indicated that carrying capacity significantly differed among regions, parks, and specific dimensions. Comparison among different types of marine industrial parks indicated that the modern marine service industry and fishery industrial parks showed improved and efficient development with relatively high bearing rates. By contrast, the modern marine manufacturing industry and strategic emerging industrial parks were significantly underdeveloped. This study proposes academic approaches and practical implications for the involved governments and managing committees. Furthermore, suggestions on park planning, policy support, industrial cluster, and industry–university–research institute alliances are provided to the government and enterprise perspectives to increase the carrying capacity of marine characteristic industrial parks.

1. Introduction

Technological industrial parks are a special economic zone that integrates high-ended, advanced technological research and development (R & D), with high-tech products' manufacturing. Technological industrial parks refer to the administrative area where a government aims to promote regional economic development by providing land, tax benefit, and other preferential policies to attract a large number of enterprises gathered from the community. This differs from industrial clusters that refer to the concentration of the relevant enterprises in a certain industry. The synergetic development of industrial parks and clusters lie in mutual cooperation and mutual coordination. Successful technological industrial parks are usually a significant feature of industrial clusters, such as the Silicon Valley in the USA, the Bangalore Industrial Park of India, and the Taiwan Hsin Chu Industrial Science Park [24]. Different types of industrial parks function as a pool of open economy, a new economic growth point, and a new important platform for enhancing external entry and international cooperation. As such, industrial parks are vital to national economic development. Currently, significant attention is being drawn to the developing process of industrial parks in a way that balances economic profit and environmental preservation. China has achieved unprecedented rapid economic development in the last decades: during which, the development of industrial parks' has evolved to a new stage where the harmony of nature and economic development is getting more and more attention. China's technological industrial parks, established to attract investment, primarily dominated by local governments, were strongly government policy-oriented. In the early stage of development, the government's support used to be the essential factor for the development of the parks, which in the short term contributed to the rapid expansion of the scale of the park, and accelerated the rapid growth of local economy. Severe environmental problems began to appear as a result of the technological industrial parks' operation, which significantly impeded the sustainable development of technolo-

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gical industrial parks [8,37].

Under the circumstance of a new round of national "open-up" plans, the "blue economy" (i.e., marine economy) has become another focus of national macroeconomic policy. The marine industrial park is hence an essential part of the new marine economic development plan in China. Accordingly, the State Council approved the *Blue Economic Zone Development Plan* on the Shandong Peninsula and the development has gradually upgraded to a large scale. Considering various construction carriers, such as different types of industrial parks, new marine economic zones, Sino-foreign cooperation industrial parks, and intensive use of sea areas, the council has fine-tuned policies to continuously optimize the industrial structure and attract more Foreign Direct Investment (FDI) to the industrial parks. Since optimizing the industrial structure is important to attain sustainable development in developing countries [13], and social economic development can only be sustained within the carrying capacity of an ecosystem [29], it is becoming extremely significant to indicate and explore the regional carrying capacity in the aforementioned area. The overdevelopment of marine industrial parks may result in significantly severe environmental, ecological, and energy problems, and eventually deteriorate sustainable development. This type of development must be established based on an integral ecosystem, a sustainable resource supply, and a long-term available capacity of the environment, whose nature is the sustainable carrying capacity of the ecosystem [17]. As an important evaluation tool of regional carrying capacity (RCC), analysis of carrying capacity, which has already been widely used in resource, environmental, and ecological research, is an important reference index that guides regional economic and social development [35]. Carrying capacity is, therefore, significantly important as an essential guideline of strategic plan making for local governments and committee managers. Besides, evaluation of carrying capacity will also be a significant reference for future marine policy studies.

2. Theoretical background

Carrying capacity, a physical parameter in physical mechanics, refers to the critical loads of objects against damages. Community ecology was the first discipline that cited carrying capacity to express "a big population under a specific environmental condition (mainly a combination of ecological factors, such as survival space, nutrient substances, sunshine, etc.)" [10]. This parameter is widely used to describe the maximum carrying capacity of regional systems for external environmental changes [20]. The index is then adopted to describe development restrictions. The use of carrying capacity has been extended to different extents in various environmental, economic, and social fields, thereby generating diversified carrying capacities. Scholars have included human social economic activities to the general research scope and proposed a comprehensive evaluation index, namely, RCC, which integrates resources, the environment, ecology, and human social economic activities.

The early literature on carrying capacity was closely related to the development of ecology, which is defined as "the maximum accommodation of the number of individuals in a given environment", or "the environment of a certain region that can withstand the threshold of human activities under certain conditions". The environmental carrying capacity indicates a strong degree of human activity that can be permanently carried by a region at an acceptable level of living. This concept reveals the multidimensional connotation among resources, the environment, society and ecological capacity. In resource dimensions, environmental carrying capacity refers to the resources supply capacity environmental system to human demand; in the environment dimension, environmental carrying capacity refers to the function of migration and transformation of pollutant dilution and self-purification; in the ecological dimension, environmental carrying capacity is the ability to provide support and regulate the environmental system, as well as the cultural and ecological service for human beings; in the social dimension, environmental carrying capacity refers to the human activities changing the supply of resources, environmental pollution, and ecological service ability, thus changing the environment carrying capacity.

Environmental carrying capacity is of a certain quantity, whose measure index system can be divided into three categories: Natural resources support, including non-renewable resources, such as fossil fuels, mineral resources, and land resources; environmental production support, including renewable resources in the production cycle, such as biological resources, water, air, etc., and the migration and diffusion capacity of pollutants; The level of social and economic technical support, including the social material foundation, the industrial structure, the economic integration level, and the technical support system [9].

Marine carrying capacity originated from the concept of ecology and was originally used to measure the maximum number of individual species in certain environmental conditions. At present, the research on marine carrying capacity could be mainly divided into three aspects: the marine ecological environment carrying capacity, the coastal zone carrying capacity, and the seawater carrying capacity. With the rapid development of China's marine economy, severe environmental problems started to occur. This situation requires more attention to the protection of the marine ecological environment in the process of marine economy development, the carrying capacity of the marine environment, and promotes the harmonious development of the marine economy.

As a basis for judging whether the economic activities of human society are coordinated with the marine environment, the main features and the evaluation index have been widely studied. A corresponding conceptual model and computation model of the marine ecological carrying capacity were further proposed to analyze impacts of the marine ecological construction, which has provided a basis for quantitatively researching the carrying capacity of the marine ecological environment and the scientific basis for the sustainable utilization and management of the marine resources [19]. presented the principles of selecting factors for regional carrying capacity domestically and abroad, combining the practice of the marine ecological environment [5]. applied the model of ecosystem health to establish the general measuring indicators for Liaoning marine ecological carrying capacity and conducted a decade-long research on the Liaoning marine system [2]. analyzed ocean resource carrying capacity and its segmenting index by making use of the comprehensive weighting adjustment method, the fuzzy comprehensive evaluation method, and the factor analysis method during 2006–2011 [33]. selected a series of economic benefits, social benefits, and environmental benefits factors and functional accordance to establish an evaluation model of the spatial arrangement of marine fishery over the Shandong Blue Zone.

RCC based on sustainable development refers to the maximum population and corresponding economic and social aggregates (human and social economic activities) that could be supported by a regional human land system within a specific spatial–temporal scale. In RCC, rational resource development and utilization as well as virtuous cyclic development of the ecological environment must be maintained. Chinese and foreign scholars prefer to analyze the influences of the ecosystem on human activities from resource and environmental perspectives [3]. The carrying capacity of one region is composed of a series of interacting development variables and restriction variables [29].

Scholars have analyzed the responses of the society–economy–nature complex ecosystem to human activities through resource and environmental perspectives. Theoretical use and application of ecological carrying capacity analysis to regional studies have also been reported [11,12]. Existing associated research has mainly focused on the carrying capacity of coastal zones [21] and urban carrying capacity [25]. GIS spatial analysis [23] and comparative analysis [22] are the common research methods used.