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# Water-land-Food Production System Interconnections

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**Abstract:** Water-land-food (WLF) is a fundamental resource that supports human survival and development. In the 21st century, with the acceleration of industrialization and urbanization in developing countries, the phenomena of industrial water use squeezing agricultural water use and land encroachment by construction land are very common. To a certain extent, this has aggravated the problems of irrational allocation of water resources in the production system, shortage of land resources and food security. Against this background, this study, based on a large number of literature searches, firstly, summarizes the research progress of water-land-food production system. Secondly, from the perspective of "interconnectedness" of WLF, we summarize the basic resource relationships among the three production systems and construct a systematic study of WLF production systems. Finally, based on the comparison with related studies, it is proposed that the future research focus of WLF production system includes: (1) Regional WLF production system research. (2) Resource regulation of regional WLF production system. (3) benign development of WLF production system under ecological environment. (4) Sustainability of WLF production system under food security.

**Keywords:** Water-Land-Food Production System Development History System Construction.

## 1. Introduction

WLF is at the heart of sustainable development, and the demand for all three is increasing, driven by global population growth, rapid urbanization, dietary changes, and economic growth. However, water scarcity, land resource tension, and food security issues have been plaguing human survival and development.

China is experiencing the largest urbanization process in the history of mankind, with the urban population increasing by 210 million in the decade 2000-2010, and the urbanization rate increasing from 36.22% to 49.68%. At the same time, along with China's industry and economy through a period of rapid development (2002-2011) and other factors. A large amount of agricultural land has been converted to construction land, of which some scholars estimate that about 2.5~3 million farmers lose their land every year. The loss of arable land and urban land expansion have attracted the attention of scholars. And the research on agricultural water use mainly focuses on agricultural water use efficiency, agricultural irrigation technology, and agricultural water price reform. While the research on water-land-food production system has less domestic and foreign research, Zhang et al. (2019) explored the opportunities and challenges faced by the research on FEW correlation relationship, and based on this, from the aspects of resource use efficiency, information sharing and institutional innovation began to put the production factors of soil-water-energy-food into the production system for comprehensive research. However, the research perspective is too novel and the research has not yet reached systematization. There are fewer studies on water-soil-food.

Therefore, on the basis of reviewing the research progress of WLF production system, this paper applies the analysis method of "interconnection relationship" to analyze the relationship between WLFs and construct the WLF production system, so as to point out the direction of China's future WLF research development.

## 2. Progress in WLF Production System Research

Under the influence of relevant research in the West, Chinese scholars began to study issues related to basic resources in production systems, which can be roughly divided into three stages:

The first stage, the single-factor research stage under the current state of resources. Entering the 21st century, China's rapid economic development, especially after the accelerated phase of industrialization and urbanization, has led to problems such as the reduction of land available for agriculture, the increase of water consumption in industry, and food security. Most scholars focus on resource tension as a research entry point to conduct research, respectively, from the system, utilization efficiency, configuration aspects of land resources. For example, Han et al. (2004) attempted to find solutions to the sustainable utilization of land resources from the innovation and re-innovation of agricultural land systems. And Wang et al. (2008) using provincial panel data from 1997 to 2006, measured the technical efficiency of agricultural production and irrigation water use efficiency in China using the stochastic frontier production function (SFA) method, and analyzed the influencing factors of irrigation water use efficiency using the Tobit model. Since the 18th CPC National Congress, General Secretary Xi Jinping has made food security a top priority in the governance of the country, and put forward a new concept of food security, which is "to ensure basic self-sufficiency in grains and absolute safety in food rations", which provides a research perspective for the study of production system. The above studies were basically conducted from a single perspective in the production system, without linking with other elements of the production system.

The second stage is the interlinked research stage under the resource linkage. With the further development of the breadth and depth of the study, domestic researchers do not focus on the study of one element only, but look for the connection

between elements within the production system. Nie et al. (2016) calculated the matching coefficients of soil and water resources and the Gini coefficients of water resources and arable land resources in the Songnen-Sanjiang Plain region by using the agricultural soil and water resources matching measurement model and regional Gini curves to explore the degree of matching of soil and water resources in the region. Yang et al. (2010) based on the two rigid constraints affecting food production--water resources and arable land resources, systematically elaborated the situation of agricultural water and soil resources in China and its impact on food production. The research of the above scholars studied the linkage of basic production factors from the perspective of linkage, without thinking from a more systematic and macro perspective.

The third stage, the systematic research stage under resource integration. Along with the complexity and severity of the problem, researchers began to consider the problem in a comprehensive way. At the same time, various elements are unified and generalized into the system of production system for analysis. For example, Yang et al.（2016）applied the coordination degree function model to comprehensively evaluate the coordination degree of the population-cultivated land-food system in 11 prefecture-level cities in Hebei Province from 2000 to 2011, and analyzed the spatial and temporal variations of the coordination degree in each region. Zhao et al.（2016）believe that the study of regional "water-soil-energy-carbon" coupling system can help to reveal the influence mechanism of multiple resources coupling development process on carbon emission, and to explore the relationship between the combination pattern and utilization efficiency of various resources and energy sources in the process of integrated development and production in the region and the efficiency of carbon emission, and further clarify the operation status and efficiency of regional "nature-society-economy" system through the study of resource coupling mechanism, and provide a new theoretical perspective for the study of regional system resources coupling and its environmental effect. It also helps to further elucidate the operation status and efficiency of the regional "natural-social-economic" system through the study of resource coupling mechanism, and provides a new theoretical perspective for the study of resource coupling and its environmental effects in the regional system. Gao et al. () studied the correlation relationship of the food-energy-water (FEW) system in the city of Guangzhou as an example analyzed. The above scholars used a systematic approach to consider basic production resources within the production system, but neglected to analyze the WLF production system in a specific way.

# 3. WLF Production System "Correlation Relationship" System Construction

"The term "nexus" is not a new concept in scientific research, but has been used successively in philosophy, cell biology and economics to refer to the connection or link between several different entities. In 1983, the United Nations University (UNU) launched a research program on "food-energy" nexus, which was the first time that "nexus" was introduced into the field of natural resources, and attempted to realize the concept of "nexus" from the perspective of "nexus" and "food-energy". It was an attempt to explore effective solutions to the problems of food security and energy shortage from the perspective of "food-energy nexus". Later, many researchers introduced this method into natural resources research. For example, Zhang Xiaoli analyzed the conceptual connotation and practical challenges of the food-energy-water nexus, and Zhao Rongqin analyzed the coupling mechanism of water-soil-energy-carbon in the region using this method.

WLF, as an extremely important component of the production system, has emphasized the importance of water, energy and food nexus as early as 2012 in the report of the United Nations Panel on Global Sustainability, and in the 2014 report of the United Nations Panel on Global Sustainability, the importance of water, energy and food nexus was especially emphasized. As early as 2012, the importance of the water, energy and food nexus was emphasized in the report of the UN Panel on Global Sustainability, and in the 2014 UN Global Sustainability Report, the "climate-land-energy-water nexus" was specifically mentioned. Unfortunately, the water-land-food nexus has not been singled out for "nexus" studies.

In the WLF interactions, we can find that water is one of the basic conditions for agricultural production, and it can be said that agricultural production cannot be carried out normally without water, let alone the existence of human beings and the land for human life. Water also plays an important role in the land, and the lack of water resources can lead to desertification of the land. Agricultural production is based on the development of high-quality soils that store water, fertility, heat, etc. for crop growth. At the same time, there are differences in their interactions in the context of integrated and specialized environments.

# 4. WLF Production System Research Outlook

Future research on water-soil-energy production system should be further strengthened in the following aspects:

(1) Regional WLF production system research. China's vast land area, from south to north across the equatorial belt, tropical, subtropical, warm temperate, temperate, frigid six temperature zones with complex climatic conditions, which also leads to the production system of basic resources there are more obvious differences in the location. The specific zones vary under the influence of a variety of factors. Researchers can first study the WLF production system from a macro perspective, and then go deeper into the WLF production system under special zonal conditions.

(2) Resource regulation of regional WLF production systems. In the development process of industrialization and urbanization in China, many regions, in order to develop industry, allocate resources to industrial production on a priority basis, so as to achieve the purpose of achieving the rapid development of industry. However, under the condition that the total amount of regional resources is certain, the development of industrialization and urbanization will inevitably allocate the resources originally belonging to the agricultural production system to industrial production. This will inevitably cause the agricultural production system to be threatened by resources. Therefore, an in-depth analysis of the realization of the normal function of the WLF production system is carried out from the perspective of resource regulation.

(3) Benign development of WLF production system in ecological environment. China's ecological environment is

more complex, there are natural factors leading to ecological vulnerability, but also in order to develop at the expense of resources and environment caused by man-made factors of ecological vulnerability, and the reasons for the formation of each region are also different. At the same time, the ecological environment problems faced by different regions are also very different, and must be analyzed on a case-by-case basis. The ecological environment and the production system are closely linked. Therefore, the production system research must fully consider the ecological environment.

(4) Sustainability of WLF production systems under food security. General Secretary Xi Jinping emphasized, "For a large country like ours with a population of 1.4 billion, the basic position of agriculture cannot be neglected or weakened at any time, and having food in our hands and not panicking in our hearts is the truth at all times." The issue of food security has risen to the national level, and the issue of food security is directly linked to the WLF production system. Through the sustainable study of WLF production system, in-depth national food security perspective.

# 5. Conclusion

This paper analyzes the water-soil-food coupling system and the links between its elements from the perspective of association, and the three elements of the WLF production system exist in the triple scenario of mutual influences, interactions, and mutual threats under the constraints of specific external forces and their own conditions, and at the same time, constructs the system structure of the WLF production system.

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