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Design of Trinity Framework for Cultivated Land Protection

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Abstract Starting with the goals and tasks of quantity, quality and ecological protection in different scales, this paper constructs a "trinity" framework of cultivated land protection system, and puts forward the key points of cultivated land protection in different scales. Finally, a preliminary evaluation is made on the quantity, quality and ecological protection of cultivated land on a macro scale in China.

Key words Cultivated land protection, Quantity, Quality, Ecology

1 Introduction

At present, the construction of ecological civilization requires the protection of cultivated land to expand from quantity-quality protection to quantity-quality-ecology protection ("trinity"), but there is little research on the relationship between ecology protection and quantity-quality protection of cultivated land.

2 Protection of cultivated land under the background of ecological civilization

2.1 Ecological civilization and cultivated land protection There are various interpretations of ecological civilization, but its connotation is mainly reflected in three aspects: first of all, human beings maintain the original characteristics of nature and achieve harmonious symbiosis while transforming and making use of objective nature; the second is to integrate human activities into the ecosystem to realize the virtuous circle between human and natural ecosystem; the ultimate goal is to realize the sustainable development of society, economy and nature.

In the practice of cultivated land protection for many years, China has carried out all kinds of work in the aspect of cultivated land protection, such as maintaining the quantity of cultivated land, maintaining the quality of cultivated land, comprehensive renovation and promotion, and achieved good results. It provides a guarantee for China's cultivated land security and food security. In the future work, how to integrate the connotation of ecological civilization into the protection of cultivated land, and how to integrate the concept of harmonious symbiosis and sustainability into the maintenance, protection and renovation of cultivated land is the focus of realizing the harmonious symbiosis and sustainable devel-

opment of human and cultivated land.

2.2 Connotation of cultivated land ecological protection

Different scholars have put forward a variety of understandings on the connotation of cultivated land ecological protection^[1]. Wang Wanmao believes that coordinating the relationship between the planted crops and the surrounding ecological factors is the focus of cultivated land ecological protection, its apparent meaning is the protection of the quantity and quality of cultivated land, and the deep meaning refers to the protection of the structure and function of cultivated land ecosystem^[2]. Zhou Liqiu believes that cultivated land ecological protection is to protect the natural ecosystem where cultivated land is located, and the improvement of cultivated land quality is the main performance of cultivated land ecological protection^[3]. Zu Jian *et al.* set the goal of cultivated land ecological protection as making the characteristics of cultivated land elements in the farmland ecosystem stable and the ecological environment in a good state^[3].

It can be seen that from different angles and scales, the relationship between quantity, quality and ecological elements in cultivated land protection is different. On the basis of considering the interdependent relationship among the three, according to the needs and objectives of cultivated land management at different levels, this paper sorts out the similarities and differences of the three relationships in cultivated land ecological protection at different scales, and organically unifies the relationship between the three. The establishment of a hierarchical and systematic trinity protection system of cultivated land is the trend of cultivated land ecological protection under the background of ecological civilization.

3 Trinity protection system of cultivated land under the background of ecological civilization

In the trinity protection of cultivated land, cultivated land quantity protection is the premise of cultivated land quality protection, quality protection is the guarantee of cultivated land quantity protection, and ecological protection is the basis of cultivated land quantity and quality protection.

Cultivated land protection has systematic characteristics.

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When protecting cultivated land, quantity, quality and ecology should be brought into a whole system. From a systematic point of view, the security and suitability of the three should be evaluated, and the relationship between the three should be coordinated so that the trinity protection can be harmonious and sustainable. Cultivated land protection also has hierarchical characteristics, and its protection and utilization objectives are different from different perspectives, so the relationship between cultivated land quantity, quality and ecological elements is also different in different scales.

From a comprehensive point of view, it can be divided into three levels: macro (national and provincial scale), meso (city and county scale) and micro (micro-geomorphology, small watershed, *etc.*), and formulate quantity, quality and ecological protection content and protection objectives, respectively. The coordination of the relationship among the three should be emphasized at the macro level, the mutual suitability of the three should be protected at the meso level, and the security of the three should be improved at the micro level (Table 1).

Table 1 Trinity framework of cultivated land protection system

Scale	Quantity	Quality	Ecology	Trinity
Macro	Overall protection scale	Overall quality	Overall eco-environmental quality	Three coordinations (i) Coordination between scale of protection and eco-environmental quality; (ii) Coordination between overall quality and eco-environmental quality; (iii) Coordination of protection scale and overall quality
Meso	Regional protection scale target	Regional protection quality target	Regional ecological environment carrying capacity	Three kinds of suitability (harmony) (i) The scale target of regional protection is suitable for the carrying capacity of ecological environment; (ii) The quality target of regional protection is suitable for the carrying capacity of ecological environment; (iii) The scale target of regional protection is suitable for the quality target
Micro	Cultivated land restoration, occupation and compensation balance	Quality improvement, occupation and compensation balance	Build a stable cultivated land ecosystem and ensure the quality and safety of products	Three kinds of security (i) Quantity security: the mode of utilization is stable; (ii) Quality security: the production capacity is stable; (iii) Ecological security: the ecological environment is stable and sustainable, and the product quality meets the ecological standards

3.1 Macro scale On the macro scale, we should carry out "three coordinations" on the relationship between quantity, quality and ecology of cultivated land in China as a whole.

3.1.1 Coordination between scale of protection and eco-environmental quality. It is to coordinate the relationship between the protection scale (basic farmland scale) and different environmental quality grades, which requires that the basic farmland should be distributed in the areas with better environmental quality as far as possible (quantity-ecology coordination). The coordination degree is calculated by the average environmental quality of cultivated land and the average environmental quality of basic farmland. Theoretically, the average eco-environmental quality of basic farmland combined with the regional cultivated land with better eco-environmental quality can be taken as the upper limit of the protection target, and the average eco-environmental quality of all cultivated land can be taken as the lower limit of the protection target. In order to ensure that the protection target is in a better ecological environment, the environmental quality of basic farmland should be at least between the lower limit and the upper limit, and the closer it is to the upper limit, the better the environmental quality of the basic farmland.

3.1.2 Coordination between overall quality and eco-environmental quality. It means that in the same environmental quality classification, the average level of basic farmland should be higher than that of general farmland (quality-ecology coordination). In theory,

the high level cultivated land in areas with good eco-environmental quality can be taken as the basic target of protection. In theory, cultivated land level and environmental level can be comprehensively scored, with the coordination degree of cultivated land with the highest comprehensive score added to the basic farmland as the upper limit, and the coordination degree of all cultivated land as the lower limit. In order to ensure that the quality of the protection target and the ecological environment are good, the coordination degree between the basic farmland quality and the ecological environment should be at least between the lower limit and the upper limit, and if it is closer to the upper limit, it indicates that the basic farmland quality and ecological environment quality will be increasingly in a "double excellent" state.

3.1.3 Coordination of protection scale and overall quality. It means that the average level of basic farmland should be higher than that of general farmland (quantity-quality coordination), and the coordination degree can be calculated through the average level of basic farmland and all cultivated land. Theoretically, the average level of part of cultivated land with the highest level added to the basic farmland can be taken as the upper limit, and the average level of all cultivated land as the lower limit. In order to ensure the better quality of the protection target, the quantity-quality coordination degree of basic farmland should be at least between the lower limit and the upper limit, and the closer to the upper limit, the better the quality of basic farmland.

Quantity, quality and ecology are of equal importance in the protection of cultivated land, but in the process of protection, we often fail to protect a certain amount of cultivated land while ensuring the best quality and the best ecological environment. At this time, it is necessary to make a choice, and it is necessary to distinguish the importance of quantity, quality and ecology according to the characteristics of different regions, calculate the trinity protection perfection index of quantity-quality-ecology based on the coordination degree of quantity-ecology, quality-ecology and quantity-quality, so that the results are finally comparable horizontally and vertically.

3.2 Meso scale The protection goal on the meso scale is to establish the appropriate relationship between the quantity, quality and regional ecological environment of cultivated land.

3.2.1 Suitability of quantity and ecology. It is to consider the impact of cultivated land on the natural ecological environment and the scale of cultivated land that can be carried by the natural environment in the region in theory, and evaluate the carrying capacity of regional cultivated land under the condition of ecological security. Based on this, we can judge the suitability of cultivated land quantity and ecological environment.

3.2.2 Suitability of quality and ecology. It mainly refers to the cultivated land quality that can be supported by the regional natural ecological environment in theory, and the sustainability of cultivated land quality is evaluated under the premise of suitable environment.

3.2.3 Suitability of quantity and quality. It refers to the quality that can be achieved under the protection scale of regional cultivated land, and the stability and promotion potential of regional cultivated land quality can be judged by calculating the average quality of cultivated land and the theoretical highest quality.

Through the evaluation of suitability, we finally get the capacity of the quantity and quality of cultivated land that can be supported by the ecological environment in the region, so as to ensure the stability and sustainability of the overall production capacity of the region.

3.3 Micro scale On the micro scale, the main goal is to maintain the quantity and quality of cultivated land while ensuring the virtuous cycle of material and energy flow between cultivated land and natural ecosystem, to ensure the sustainability of cultivated land function.

3.3.1 Quantity security. It mainly refers to the restoration of the damaged cultivated land and the supplement of the occupied cultivated land through the balance of occupation and compensation to ensure that the cultivated land will not decrease.

3.3.2 Quality security. It mainly refers to adoption of measures for quality maintenance and replenishment of cultivated land so that the quality is not lower than that of the occupied cultivated land to ensure that the level of cultivated land does not decline.

3.3.3 Ecological security. It mainly includes three aspects. The first is to establish a stable cultivated land ecosystem (which can

maintain a sustained and stable flow of material and energy in a certain scale, and can make small watersheds, micro-geomorphological units, and connected arable land used for large-scale production of certain crops) with a certain scale of cultivated land. If the area of cultivated land is too small (not every piece of land has to build its own ecosystem), it is difficult to build an ecosystem with good integrity and stability; if the area is too large, it is difficult for the ecosystem to take into account the characteristics of different regions, and the efficiency and function will be reduced. Second, according to the regional natural conditions, planting patterns, crop growth needs and the impact on the environment, the cultivated land ecosystem and water, forest, grass and other ecological elements should be coordinated to maintain a virtuous circle of energy and matter between cultivated land and ecological environment. Third, according to the supporting capacity of the natural environment to the normal production activities of cultivated land in the region, we should maintain the safety of product quality and production capacity of cultivated land for a long time without having a negative impact on the ecosystem.

Through micro-protection, the ultimate goal is to make the utilization of micro-units stable, coordinate with the surrounding ecological environment and maintain stable and high-quality grain production activities.

4 Current situation of quantity, quality and ecological environment of cultivated land on a macro scale in China

Based on the 2018 Bulletin on the State of China's Ecological Environment issued by the Ministry of Ecology and Environment, the achievements of various provinces and cities, and the distribution of cultivated land and basic farmland in various provinces and cities, a preliminary assessment is made on the relationship between the quality, quantity and ecology of cultivated land in China.

4.1 Coordination of quantity-ecology of cultivated land From a national point of view, Hainan Province and Fujian Province have the highest coordination degree of cultivated land-ecology, and it is also high in Zhejiang, Jiangxi, Hunan, Guangdong and other provinces in the southeast. This shows that the level of ecological environment of cultivated land in these provinces is high, the provinces with lower coordination degree mainly include Xinjiang, Ningxia, Shanxi and so on, and the overall coordination degree of quantity-ecology in North China is lower than that in South China. Through calculation, the coordination of quantity-ecology of basic farmland in most provinces is between the upper and lower limits, and there is some room for improvement.

4.2 Coordination of quality-ecology of cultivated land The coordination degree of quality-ecology of cultivated land in Hubei Province and Guangdong Province is the highest, because its ecological quality and cultivated land level are high. Although the ecological environment of Hainan Province is the best in the country,

the level of cultivated land is lower than that of Guangdong. The coordination level of quality-ecology is at a high level with Guangxi, Hunan, Jiangxi, Fujian, Zhejiang, Jiangsu provinces. Due to the middle level of environmental quality and the low level of cultivated land, the coordination between cultivated land quality and ecological environment in Gansu and Inner Mongolia is the worst.

4.3 Coordination of quantity-quality of cultivated land The province with the highest average level of cultivated land is Hubei Province, and the average level is also high in Henan, Jiangsu, Jiangxi and Guangdong provinces. The average level of cultivated land and basic farmland is low in Qinghai, Gansu, Inner Mongolia. There is still great potential to improve the average level of basic farmland in the central and eastern regions and the three eastern provinces.

4.4 Comprehensive situation To sum up, it can be seen that the quantity, quality and ecological environment of cultivated land in China are high in the southeast and low in the northwest. Through the comprehensive analysis of the level of environmental quality, the level of cultivated land and the proportion of basic farmland, Guangdong Province and Hubei Province are the best areas to realize the "trinity" of cultivated land in China. Hainan, Jiangxi, Fujian, Zhejiang, Jiangsu, Anhui provinces also have a high level of protection. The three eastern provinces are in the middle level with Central China and Southwest China. The regions with the worst comprehensive coordination are Tibet, Xinjiang, Qinghai, Gansu, Inner Mongolia, Shanxi.

5 Discussion

5.1 Improving the technical measures for ecological protection of cultivated land At present, the eco-environmental quality assessment in China is based on the standards formulated by the Ministry of Ecological Environment, which covers a wide range and can reflect the overall environmental quality of the region, but because of its weak pertinence, it is difficult to reflect the typicality of cultivated land ecology in practical application. Therefore, the formulation of technical norms (standards) for eco-environmental quality assessment that can serve the protection of cultivated land is the premise of accurate assessment of cultivated land ecological environment. According to the different protection objectives at the macro-meso-micro level, evaluation schemes are made respectively to reflect the hierarchy and systematicness of cultivated land ecological protection.

In the protection of cultivated land, the protection and delimitation of basic farmland are mainly based on the quality of cultivated land at present. In the next step, the eco-environmental quality should be added to the rigid index for the delimitation of basic farmland, and the cultivated land with higher environmental quality should be included in the basic farmland as far as possible. And through comprehensive analysis and other means, on the basis of the assessment of the quality and ecological environment of cultivated land in the whole country, and according to the different nat-

ural endowments of each region, it is necessary to formulate the objectives of quantity, quality and ecological protection of cultivated land in the whole country and regions, put the "trinity" protection of cultivated land into practice.

5.2 Quality and ecological risks in the balance of occupation and compensation In the balance of occupation and compensation of cultivated land in China, the occupied cultivated land in the eastern region is replenished in the western region from time to time, resulting in the transfer of the center of gravity of cultivated land to the northwest. Although there are some requirements for the quality of supplementary cultivated land, there is no requirement for the occupation-compensation balance of "cultivated land ecological environment". Through the evaluation, it is found that at present, the cultivated land in southeastern China shows a trend of "double high" in quality and ecology, while the northwest shows a "double low" situation. "Occupation in the east and compensation from the west" has the risk of reducing the quality of cultivated land and ecological environment at the same time.

5.3 Correctly understanding the ecological function of cultivated land On the basis of protecting the quantity and quality of cultivated land, we should further understand the stability and sustainability of cultivated land ecosystem and the process of material and energy exchange between cultivated land and other ecological elements. The perspective of cultivated land management should be promoted from agricultural production to ecological maintenance, and cultivated land should be brought into the ecosystem for management. In the process of management, in addition to maintaining the material output function of cultivated land, attention should also be paid to the ecological functions of cultivated land, such as biodiversity, soil and water conservation, and climate regulation.

5.4 Reasonably determining the tillage intensity of regional cultivated land For a long time, China is in pursuit of the improvement of cultivated land production capacity, which leads to the decline of cultivated land quality and ecological environment in this process. Therefore, on the basis of the evaluation of the cultivated land quantity and quality carrying capacity of ecological environment, the tillage intensity of regional cultivated land can be determined reasonably, and the hidden danger caused by high-intensity utilization of cultivated land can be alleviated by fallowing and rotation.

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