# Research progress of cultivated land quality monitoring and evaluation

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## Abstract

**This article analyzed the connotation of cultivated land quality, summarized the research progress and application of cultivated land quality monitoring and evaluation index system, cultivated land quality evaluation methods and technical methods at home and abroad. It put forward the research prospects of adjusting monitoring index and developing remote sensing monitoring method on the basis of uniform standards and combined with the purpose and demands of cultivated land quality evaluation.**

## Keywords

**Cultivated land quality, Monitoring system, Evaluation method.**

## 1. Introduction

A Cultivated land is a precious and limited agricultural resource and the basic condition for human survival. The ecological security, agricultural product security and food security of a country are directly affected by the quality of cultivated land, and food security is the fundamental to ensure national stability. The importance of cultivated land quality to the country can be seen. However, the current situation of cultivated land quality in China is not optimistic. The progress of economy and society, the rapid increase of population and the people's increasing living demand have caused great pressure on cultivated land. The occupation of cultivated land by construction land has sharply reduced its area. The pressure of population on food demand has made the application of chemical fertilizer up to 1 / 3 of the global application of chemical fertilizer, and the soil environment of cultivated land has been seriously damaged, Therefore, it is urgent to monitor, evaluate, protect and improve the quality of cultivated land [1].

## 2. Connotation of cultivated land quality

Internationally, the World Resources Institute and the International Institute for environment and development. Cultivated land is clearly defined in, that is, cultivated land includes land for temporary and long-term cultivation of crops, temporary grassland, commercial vegetable garden, family vegetable garden and temporary leisure cultivated land, also includes land for planting coffee, cocoa, fruit trees, rubber, grapes and other crops that will not be replanted after harvest every year, and does not include forest land managed and protected to obtain fuelwood [2]. In China, In the land classification of the second national land survey, cultivated land is defined as the land that can grow crops, including mature land and newly developed, reclaimed and reorganized land, as well as rotation leisure land, land dominated by crops (including vegetables) with sporadic mulberry, fruit trees or

other trees, as well as reclaimed sea land and beach land that can harvest at least one season per year [3].

At present, there is no unified definition of cultivated land quality. The food and Agriculture Organization of the United Nations defines it as a comprehensive land feature that affects the sustainability of specific land use in a specific way [4]. In 1997, at the initial stage of studying cultivated land quality in China, Zhao Denghui et al. [5] considered that cultivated land quality is jointly determined by the geographical location and fertility of cultivated land. Determination is the expression of the comprehensive attribute of cultivated land. This definition does not start from the perspective of society, economy, environment and ecology, and has certain limitations of the times. In 1998, Ni Shaoxiang et al. [6] proposed that the quality of cultivated land is the standard for measuring the yield of cultivated land, with comprehensive, productive, relative stability and regional characteristics. Although the definition considers social and economic factors, ignoring the natural attributes of land, the quality of cultivated land is regarded as an indicator, which is narrow. In 2004, Li Dan et al. [7] proposed that the connotation of cultivated land quality includes the health quality, background quality and economic quality of cultivated land. In 2011, Chen Yinjun et al. [8] proposed that cultivated land quality is the sum of soil quality, environmental quality, management quality and economic quality of cultivated land. In 2018, Kong XiangBin et al. [9] put forward the concept of cultivated land resource complex from the perspective of element process function, and considered that cultivated land quality includes cultivated land production function quality, regulation function quality and landscape function quality.

Different national ministries and commissions also have different definitions of cultivated land quality. In 2008, the former Ministry of agriculture defined in the technical specification for cultivated land productivity investigation and quality evaluation (NY/T 1634-2008): in order to achieve the level of crop growth and cleaner production, cultivated land quality includes cultivated land productivity and cultivated land environmental quality [10]. In 2012, the former Ministry of land and resources. The regulations on agricultural land quality grading (GB/T 28407-2012) points out that the quality of cultivated land is based on the light and temperature production potential of crops. Through the comprehensive evaluation of the difference of cultivated land quality after revising the natural quality, utilization degree and economic level of cultivated land respectively [11]. In 2016, the former Ministry of land and resources issued the code for evaluation of high standard farmland construction( GB/T 33130-2016)It is proposed that cultivated land quality is the ability of cultivated land to meet crop growth and safe production, including social and economic factors such as human land use level and investment in field infrastructure, and natural factors such as cultivated land fertility, soil health and climate factors, so as to meet the requirements of sustainable output of agricultural products and ensuring the safety of agricultural products [12]. In 2016, Measures for investigation, monitoring and evaluation of cultivated land quality (hereinafter referred to as the measures) issued by the former Ministry of Agriculture. It is proposed that cultivated land quality is the ability to meet the needs of sustainable production of agricultural products and safety of agricultural products, which is composed of cultivated land fertility, soil health and field infrastructure [13]. This definition is more comprehensive, accurate and refined from the perspective of the natural quality of cultivated land and the impact of human social activities on cultivated land.

To sum up, the connotation of cultivated land quality has multiple attributes, with the characteristics of the times and dynamic changes. The definition of cultivated land quality needs to start from different angles, integrate the previous research results and inject new era connotation at the same time.

## 3. Research and establishment of cultivated land quality monitoring system

Cultivated land quality monitoring is the basis of cultivated land quality evaluation. The dynamic balance between the quantity and quality of cultivated land is the basis for maintaining national food security. The decline of cultivated land quality will lead to the hidden disappearance of cultivated land, and the quantitative occupation and compensation balance is difficult to meet Chinese

population's demand for food [14]. Cultivated land quality monitoring is a basic work, and China mainly focuses on setting monitoring samples and screening monitoring indicators. A series of work was carried out in the aspects of standard, collecting index information and determining evaluation methods, so as to establish a scientific cultivated land quality monitoring system [15]. In 2016, the former Ministry of Agriculture issued the measures. It is proposed that in order to master the change degree and trend of cultivated land quality, cultivated land quality monitoring refers to the dynamic monitoring of soil physical and chemical characteristics, output capacity and environmental quality of cultivated land through fixed-point investigation, field test, sample acquisition, analysis and data analysis. Fixed-point investigation is an important link, and the layout of investigation sample points needs to take into account administrative division and soil quality. Type, land use, management level, integrity of existing information at the site and other factors, cover the main soil types of the county, carry out the investigation of cultivated land site conditions, natural attributes, soil health and field infrastructure at each cultivated land quality level investigation point, and then collect cultivated land soil samples at each sample point according to the current effective national and industrial standards and send them to. Foreign cultivated land quality monitoring work was carried out earlier, and a more mature monitoring system has been formed.

### 3.1 Study on cultivated land quality monitoring system abroad

The United States began to carry out national soil erosion survey since 1934, which promoted the promulgation of the soil conservation law. The Soil Conservation Bureau of the United States Department of agriculture officially released the land potential classification system in 1961 and used the system to evaluate the suitability of national land, which is the first comprehensive land evaluation system in the world. In 1977, the five-year opening period was determined by legislation. The national resource inventory system was developed once, and five inventories were carried out from 1977 to 1997. After 2000, it was changed to annual inventory. The national sampling points were arranged by statistical method, and a grid with a certain density was made on the map on the platform of ArcGIS. The grid density was determined according to the monitoring precision; the "five point method" was used in the determined grid. Obtain soil samples, calculate the amount of soil loss by using the U.S. general soil loss equation (USLE), and obtain the national soil erosion data; prepare and publish the national resource list according to the monitoring results. The monitoring data include crop types, land use methods, water and soil protection measures, cultivation types, irrigation and drainage conditions, etc. [16].

Due to the increasingly prominent phenomenon of national cultivated land quality degradation, Canada held a seminar on cultivated land quality monitoring in January 1988 and formulated the selection criteria of 7 monitoring areas. The sampling points were determined by stratified random sampling method to ensure that each province has monitoring points. In 1992, 23 monitoring points (areas) were determined and sampling. Among them, two monitoring points are satellite remote sensing control sites adjacent to the points, which are used to carry out long-term observation of main indicators such as farm history, soil and topographic location, soil characteristics, etc. in addition, they are divided into three types according to the variability of soil properties, namely, easily changeable, moderately changeable and immutable [17].

Many provinces in the Netherlands have established a soil quality monitoring network since 1991. Its purpose is to deeply understand soil quality and provide decision support for environmental protection, such as limiting some land use types and cleaner production processes. Soil quality monitoring in the Netherlands mainly focuses on micro and macro elements, especially on the soil surface (mainly heavy metals and polycyclic aromatic hydrocarbons) and groundwater. The assessment shows that the monitoring network is an effective tool to understand the differences between soil and soil quality. Later, it will focus more on the effectiveness assessment of measures taken in various fields and provide more information on soil quality on a larger scale [18-19].

The mature foreign cultivated land quality monitoring system has certain reference significance for China to carry out relevant research. The national resource inventory system of the United States is

worthy of reference, and its cultivated land quality monitoring methods also have shortcomings, such as the difference of evaluation indicators and the integrity of evaluation units are difficult to reflect in the grid, and can not fully reflect the changes of cultivated land quality in the study area. Canada the cultivated land quality monitoring system in the Netherlands takes the whole country as the research area, uses a unified index system, and does not consider regional differences. The soil quality monitoring in the Netherlands mainly aims at environmental pollution. Through the evaluation of the monitoring network, analyze the reasons for the differences in network layout, and then use it as a guideline to continuously improve the monitoring network and ensure the diversified development of monitoring objectives.

### 3.2 Study on domestic cultivated land quality monitoring system

Chinese cultivated land quality monitoring system includes monitoring index system, monitoring method, monitoring cycle, division of monitoring area, selection and layout of monitoring points [20], and the monitoring index system is an important part of it. Wu Yupeng et al. [21] used analytic hierarchy process and land comprehensive evaluation method to divide the evaluation factors into target layer, quality factor layer and factor layer among the factors of land quality, the main variable factors are selected as the monitoring indicators, and their values are jointly determined in combination with field sample collection and indoor experimental analysis. Ge Xiangdong et al. [22] used the pressure state response model to select the factors that have a great impact on the output capacity of cultivated land and are easy to change with farming methods or cultivated land utilization as the quantitative monitoring indicators factors that are not easy to change are used as supplementary qualitative monitoring indicators. Zhang Yuzhen et al. [23] Based on the principle of dominant factors, regional differentiation and operability, selected several factors from the soil, topography and hydrology affecting cultivated land quality as the primary factors for cultivated land quality grade monitoring, and determined the final monitoring indicators through correlation analysis. Peng Lei et al. [24]Based on the results of agricultural land classification, by analyzing the stability and variability of indicators, summarize their attribute properties, find the driving force of each indicator on cultivated land quality, summarize all indicators that directly or indirectly affect cultivated land quality, and select indicators with greater impact to determine the cultivated land quality monitoring index system. Ma Jianhui et al. [25] from natural factors, environmental health factors [26] and society based on economic factors, the cultivated land quality monitoring index system is determined according to the principles of comprehensiveness, operability and minimum data set.

At present, Chinese cultivated land quality monitoring mainly adopts the method of zoning, point distribution and laboratory test. Ma Jiani et al. [27] proposed the method of direct and indirect monitoring of cultivated land quality using remote sensing data. Zhang Yuzhen et al. [23] used factor combination method, dominant factor method, patch method and grid method to divide cultivated land quality monitoring units, and compared the monitoring effects of various division methods based on the monitoring unit, Zhang Yuzhen et al. [28] used the secondary area data of cultivated land system, combined with Chinese land resources atlasBased on the ArcGIS platform, the monitoring areas of standard sample plots are divided according to the land potential zoning map in. Yan Guoqiang [29] used the time series model and influencing factor analysis method to evaluate the change trend of cultivated land quality, and established the corresponding monitoring index system combined with natural and socio-economic indicators. Wu Kening et al. [30] discussed the selection principle of standard sample plots for cultivated land quality monitoring, This paper analyzes the research direction of cultivated land quality monitoring based on standard sample plots. Zhuang Yating et al. [31] discussed the method of arranging cultivated land quality monitoring points based on MODIS Image and Kriging interpolation method. Peng Ruyan et al. [32] applied the results of agricultural land classification, after determining the cultivated land quality monitoring index system and evaluation method, selected the target standard sample plots and carried out the monitoring by using the standardized monitoring method dynamic monitoring of cultivated land quality. Guo Lina et al. [33] set up provincial cultivated land quality monitoring sample areas based on grid method and landscape diversity index method, and determined the monitoring points by stratified sampling

method. Sun Yabin et al. [34] discussed the sample point layout method of county cultivated land quality grade monitoring based on potential index. Liu Yi et al. [35] took the ecological fragile area in the West as the experimental area and studied the selection methods of taking cultivated land quality benchmark monitoring counties and mutation monitoring counties and regions.

Although domestic scholars have done a lot of work in the monitoring index system of cultivated land quality, the research on the zoning selection of monitoring indicators is not extensive enough. The research content mainly focuses on the overall construction of monitoring index system, the principle of index selection, the conceptual description and qualitative selection methods of index selection, and lacks the quantitative description and definition of monitoring index system the boundaries of some indicators are fuzzy, so we should focus on the quantitative research of the monitoring index system in the future. In terms of cultivated land quality monitoring methods, different research scales correspond to different monitoring areas and monitoring points. The monitoring accuracy at the national level is lower than that at the provincial level, and the monitoring accuracy at the provincial level is lower than that at the city and county level. Due to the large amount of monitoring data and inconsistent regional standards, the integration of data has not been realized level by level summary and sharing. Later research should focus on unified standards, level by level summary and big data sharing.

## 4. Research and application of cultivated land quality evaluation system

Cultivated land quality evaluation has the demand and purpose of human society. Its essence is to judge the comprehensive productivity of cultivated land. From the initial research on the natural quality of cultivated land such as soil properties and basic soil fertility, it has gradually developed to the resource value management evaluation of man land integration considering nature, economy and society [36]. Because cultivated land quality evaluation has the subjective purpose of human beings Xiao Bilin et al. [37] proposed that cultivated land quality evaluation includes soil fertility evaluation, agricultural production capacity evaluation, cultivated land suitability evaluation, agricultural land grading and evaluation, and cultivated land quality evaluation based on Farmers' understanding. Li Ting et al. [38] proposed that conventional cultivated land quality evaluation includes soil environmental quality evaluation and cultivated land productivity evaluation price and soil health quality evaluation.

Chinese cultivated land quality evaluation is mainly led by the Ministry of natural resources and the Ministry of agriculture and rural areas. The former Ministry of land and resources was the first to deploy cultivated land quality monitoring and evaluation, and established "regular comprehensive evaluation, annual update evaluation and annual monitoring evaluation" In 1999, the first national soil survey led by him deployed the classification of agricultural land, and released the first batch of cultivated land quality grade investigation and evaluation results in Chinese history - Chinese cultivated land quality grade investigation and evaluation in 2009At the end of 2011, it carried out the supplement and improvement of cultivated land quality grade, and obtained the evaluation results of cultivated land quality grade based on the second adjustment in 2013; in 2014, it deployed the annual update and evaluation of cultivated land quality grade to update the increase and decrease of cultivated land area and the change of cultivated land quality grade. The former Ministry of agriculture carried out the national Cultivated Land Fertility Survey and evaluation in 2002, and the supplementary survey was conducted based on the data of soil survey in 1980; the national soil testing and formula fertilization project was launched in 2005, which obtained 13.17 million soil samples, nearly 100 million soil test data, as well as more than 80000 field experiments, more than 110000 field demonstration and 11.2 million household survey data, which accumulated a large amount of data for cultivated land quality evaluation; the measures were issued in 2016And the national standard quality grade of cultivated land (GB / T 33469-2016) (hereinafter referred to as the standard), which clearly stipulates the evaluation method of national cultivated land quality grade; in 2017, it was based on the standard to carry out cultivated land quality grade evaluation, the country is divided into 9 regions, and the evaluation index system is established in different regions. The same large regions

are evaluated with the same analytic hierarchy process model and membership function model, so that the cultivated land quality grades of counties and regions in different regions are comparable, which is of great significance for finding out the current situation of cultivated land resources in China and carrying out overall management. The evaluation index system is established in different regions, However, this method also has shortcomings: first, compared with the fertility evaluation based on soil testing formula in 2005, the number of sampling points in this round of cultivated land quality evaluation is less, resulting in the number of construction surfaces based on spatial interpolation. Second, in the actual evaluation, it is found that some counties may not be suitable for the evaluation index system and subordination relationship of their regions. For example, the higher the degree of farmland forest networking in Yeji District of Anhui Province, it will reduce crop yield, which is contrary to the higher the degree of farmland forest networking, and the higher the degree of subordination. It can be seen that in mountainous and hilly areas, the smaller the field area, the higher the degree of farmland forest networking. It will affect the absorption and utilization of crop nutrients. In plain areas, the high degree of farmland forest network will improve the farmland microclimate and effectively reduce the adverse impact of dry hot wind on the yield of wheat and other crops. Therefore, the membership degree of farmland forest network should be further adjusted and improved according to the terrain and landform. Third, the record table plays a decisive role in the evaluation of cultivated land quality grade, and many indicators are not determined. The quantity standard is affected by subjective cognition when filling in, resulting in the results not being objective and accurate. In the future evaluation of cultivated land quality grade, we can appropriately increase the sampling points, formulate an appropriate index system and membership function according to the special conditions of special counties and regions, clarify the classification standard of each index, and further improve the evaluation accuracy [39-42].

## 5. Application of cultivated land quality monitoring and evaluation results

### 5.1 Guide land improvement and improvement of cultivated land quality

Based on the monitoring and evaluation results of cultivated land quality, analyze the correlation between the limiting factors of cultivated land quality at all levels, and determine the main limiting factors of cultivated land quality level, that is, through the correlation analysis between irrigation and drainage conditions, terrain location, degree of farmland forest network, organic matter, soil bulk density and cultivated land quality level, find the regional limiting factors of cultivated land quality level [43]. Based on the comprehensive analysis of the characteristics of the limiting factors of cultivated land quality, from the perspective of land regulation engineering, determine the quality level that can be achieved through engineering construction measures, predict the potential for improving the quality level of cultivated land, and guide the planning and development of land regulation research. Land consolidation is an important measure for the protection and improvement of regional cultivated land quality. For a long time, cultivated land in various regions of China. There are different limiting factors for the quality, such as low content of soil organic matter, soil salinization, acidification and imperfect irrigation and drainage facilities, which lead to the overall low quality of cultivated land. By identifying the limiting factors of regional cultivated land quality level and carrying out land remediation and high-standard farmland construction, the quality level of regional cultivated land can be effectively improved [44].

### 5.2 Guide the construction of high standard farmland

The construction of high standard basic farmland is divided into three parts, namely, special planning of high standard basic farmland, project scientific research design and construction, completion acceptance and later management and protection. In the link of special planning of high standard basic farmland, the monitoring and evaluation results of cultivated land quality grade are mainly used to estimate the construction potential, put forward the overall plan, delimit key areas, and make overall arrangements for key projects and projects. In the scientific research, design and construction links, the results are mainly used to analyze the main limiting factors of cultivated land quality, and put forward targeted cultivated land quality improvement measures accordingly; in the completion

acceptance and later management and protection links, the results are mainly used to guide the evaluation of high-standard farmland construction effect, make overall deployment according to the evaluation results, reasonably delimit key areas and scientifically arrange key construction projects item [45].

## 6. Expectation

The introduction of the measures and standards has played a promoting role in the monitoring and evaluation of cultivated land quality in China, and all regions follow the standards carry out site survey and monitoring, integrate the monitoring data into the cultivated land resource management unit, evaluate the counties and districts according to the standards of their respective regions, summarize the results level by level, and finally submit them to the national database, which provides a solid foundation for the national overall management of cultivated land resources. In the future research on cultivated land quality monitoring and evaluation, unified standards should be taken as a prerequisite, the cultivated land quality monitoring indicators should be adjusted and updated accordingly in combination with the purpose and demand of cultivated land quality evaluation, and the cultivated land quality evaluation objectives should develop in a comprehensive and diversified direction. With the progress of remote sensing technology, the monitoring method will gradually develop from manual monitoring to remote sensing monitoring. At present, remote sensing monitoring has been applied to the inversion of vegetation type, coverage and a small number of indicators remote sensing monitoring method of cultivated land index will be an important research direction of cultivated land quality monitoring in the future. Realizing the integration of cultivated land quality monitoring and evaluation, cultivated land quality protection and improvement is of great significance for cultivated land quality construction and management.

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