

Sustainable Use Strategies Research on Ningbo's Cultivated Farmland Abandonment under Ecological-Social Effects

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Abstract: The frequent occurrence of cultivated farmland abandonment has further magnified the deficiencies in the protection of cultivated farmland resources across the country. It not only directly reduces regional grain output but also triggers soil erosion, damages regional biodiversity and ecological landscapes, exerting dual negative effects on both socio-economy and natural ecology. Based on remote sensing data, this paper estimates the area of abandoned cultivated farmland in each county and district of Ningbo city, analyzes the changes of abandoned farmland in these areas during the period from 2015 to 2021, explores the inducing factors of abandonment, and puts forward corresponding countermeasures and suggestions.

Keywords: Abandoned Cultivated Farmland; Food Security; Ecological Security; Remote Sensing Data; Protection Compensation Mechanism

1. Introduction

The work relating to agriculture, rural areas and farmers is the top priority in building a modern country in all respects. Cultivated farmland is the foundation of agricultural development and the basis for farmers' livelihoods. However, widespread cultivated farmland abandonment has occurred in China in recent years. The Outline of the National Territorial Planning (2016-2030) makes overall deployments and coordinated arrangements for resource and environmental protection, as well as comprehensive territorial improvement. It sets a protection target of 1.825 billion mu of cultivated farmland by 2030, designates the Sichuan basin as a high-quality cultivated farmland protection area, and proposes

protection measures to strengthen the quality construction of cultivated farmland and basic farmland. It also plans to implement actions for the protection and improvement of cultivated farmland quality and carry out cultivated farmland rotation and fallow in an orderly manner [1-3].

The Guidelines of the Ministry of Agriculture and Rural Affairs on the Overall Planning and Utilization of Abandoned Farmland to Boost Agricultural Production and Development clearly stipulate: to advance the utilization of abandoned farmland in an orderly manner, guide farmers to re-cultivate abandoned land, and improve the cultivation conditions of abandoned farmland [4].

The explanation of the "Suggestions For the 13th Five-Year Plan" emphasized the need to explore pilot programs for implementing a cultivated farmland rotation and fallow system. The implementation of such a system should be based on the premise of ensuring national food security and not affecting farmers' incomes. The situation regarding cultivated farmland rotation and fallow is complex. While it is conducive to the rest and rejuvenation of cultivated farmland and sustainable agricultural development, it also helps balance the contradiction between grain supply and demand, stabilize farmers' incomes, and alleviate financial pressure [5-8].

According to estimates, the number of counties with records of cultivated farmland abandonment across the country has reached 165, and the rate of farmland abandonment in mountainous areas is as high as 14.32%. From a practical perspective, with the continuous deepening of China's urbanization and industrialization, the trend of "high-end marginalization" in cultivated farmland abandonment has become increasingly prominent. Socio-economic abandonment,

characterized mainly by the outflow of labor, is rapidly increasing, primarily manifesting as the accelerated loss of high-quality and fertile cultivated farmland in suburban areas. The frequent occurrence of cultivated farmland abandonment in prime locations has further exposed the deficiencies in the protection of cultivated farmland resources nationwide. It not only directly reduces regional grain output but also triggers soil erosion, damages regional biodiversity and ecological landscapes, and exerts dual negative effects on both socio-economy and natural ecology [9-11].

In the new era, the state has explicitly proposed the food security development strategy of "storing grain in the farmland". The relevant documents of 2019 explicitly require strict adherence to the red line of 1.8 billion mu of cultivated farmland and ensures that the area of permanent basic farmland remains above 1.546 billion mu. The relevant documents of 2020 further emphasize stabilizing the grain sowing area and strengthening the quality construction of cultivated farmland. In 2021, the Ministry of Agriculture and Rural Affairs issued guidelines on the coordinated utilization of abandoned cultivated farmland to promote agricultural production development. The relevant documents for 2024 calls for promoting the utilization of abandoned farmland in light of local conditions, prioritizing grain crops where suitable and cash crops where appropriate, and supporting rural collective economic organizations to cultivate and manage effectively abandoned land that is truly uncultivated through multiple channels. The phenomenon of cultivated land abandonment in rural areas is not only relevant to rural economic development and the protection of farmers' incomes, but also bears on the progress of comprehensively advancing rural revitalization [12]. Currently, China has achieved a comprehensive victory in the battle against poverty and is at a critical juncture of accelerating the implementation of the rural revitalization strategy. In-depth research on establishing protection mechanisms and countermeasures for abandoned cultivated farmland from the dual perspectives of food security and ecological security in the new era holds significant practical importance for adopting targeted measures to effectively alleviate and curb cultivated farmland abandonment, protect cultivated farmland resources, and improve the efficiency of

cultivated farmland utilization.

2. Research Status

This paper first employs keywords such as "abandoned cultivated farmland", "uncultivated farmland" and "farmland abandonment" to conduct a statistical analysis based on the CNKI database regarding the application of three methods-sample surveys, literature reviews, and remote sensing-across various regions in China [13-16]. It is found that current research on the statistical collection of information on abandoned cultivated farmland primarily focuses on provincial, municipal, or smaller scales, with sample surveys being the predominant approach, mostly in the form of case studies. The number of studies utilizing remote sensing technology to obtain information on abandoned cultivated farmland is gradually increasing. At the national scale, statistical collection of information on abandoned cultivated farmland mainly relies on household survey data, and there are currently few case studies applying remote sensing technology [17,18]. Farmer interviews and field surveys are the primary means to understand the spatial distribution characteristics of regional abandoned cultivated farmland and explore the relationship between farmers and abandoned cultivated farmland, making this method suitable for small-scale research. As the research scope gradually expands, the cost of interviews increases while efficiency decreases. Compared to traditional methods such as field surveys, remote sensing technology offers a more efficient and cost-effective approach for obtaining spatiotemporal information on abandoned cultivated farmland over large scales [10].

3. Estimation of Abandoned Cultivated Farmland and Analysis of Influencing Factors

3.1 Field Research on Abandoned Cultivated Farmland in Ningbo City

In the study of abandoned cultivated farmland, scholars at home and abroad have primarily relied on data sources such as farmland use status maps, MODIS NDVI data, ALOS data, and Rapid Eye data, often supplemented by field surveys [19]. Building upon previous research, this project utilizes data from China's multi-temporal land use/land cover remote sensing monitoring database and employs

30m-resolution land sat 8 remote sensing imagery as the foundational data for extracting information on abandoned cultivated farmland. For Ningbo city, farmland use remote sensing data were extracted every three years from 2015 to 2021. After undergoing a series of preprocessing steps, including radiometric and atmospheric correction, band fusion, mosaicking, and cropping, the resulting remote sensing image fusion and mosaic are presented in Figure 1, and the cropped remote sensing image is shown in Figure 2.



Figure 1. Remote Sensing Image Fusion and Mosaic Map

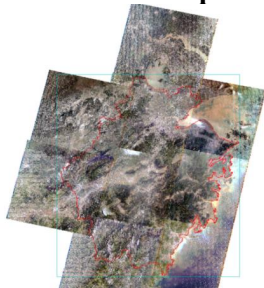


Figure 2. Cropped Remote Sensing Image Map

3.2 Data Analysis of Abandoned Cultivated Farmland in Ningbo City

Using ArcGIS software (a new-generation geographic information system (GIS) software developed by the Environmental Systems Research Institute (ESRI) in the United States, where GIS is an abbreviation for geographic information system), the farmland use status map was digitized and converted into a raster format using relevant commands, employing a commonly used geographic coordinate projection. The farmland use/farmland cover remote sensing monitoring data were classified into six primary categories based on land resources and their utilization attributes, namely cultivated farmland, forest land, grassland, water bodies, construction land, and unused land. From this classification, the current farmland use distribution map of Ningbo City was extracted, as shown in Figure 3. This approach facilitates

the correlation between remote sensing monitoring results of land cover and conventional ground-based land use survey results, as well as the subsequent data augmentation and processing. It holds practical guiding significance in terms of applicability.

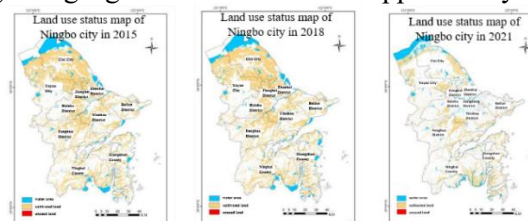


Figure 3. Land Use Status Map of Ningbo City from 2015 to 2021

In conjunction with the administrative division map of Ningbo city, the data statistics were not conducted according to the current administrative divisions. Instead, they were based on the administrative divisions of 2015 to facilitate statistics and analysis, primarily involving three regions: Yinzhou, Jiangdong, and Haishu. The land use map of Ningbo's counties and districts in 2021 was extracted, as shown in Figure 4.

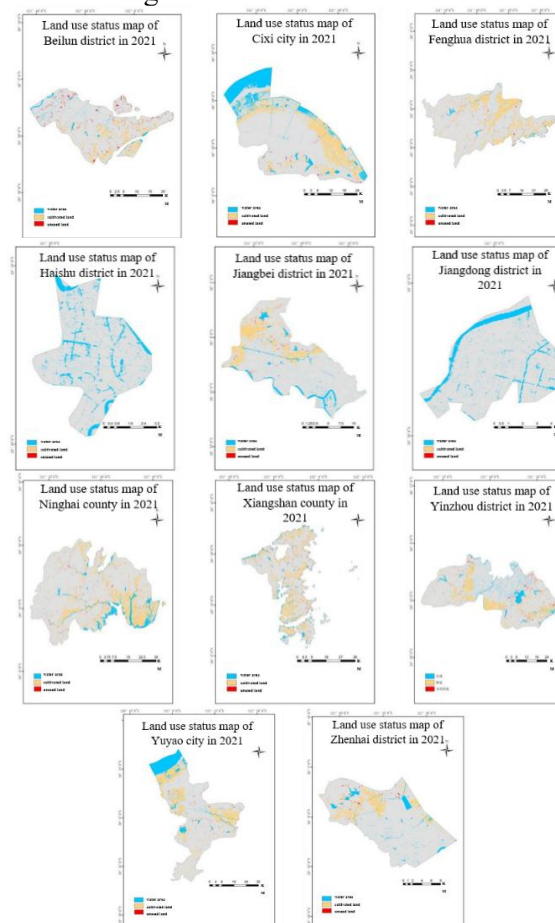


Figure 4. Land Use Distribution Map of Counties and Districts in Ningbo City in 2021

3.3 Case Application Analysis of Abandoned Cultivated Farmland in Ningbo City

Based on the aforementioned land use map of counties and districts in Ningbo City for 2021,

Table 1. Statistics on the Total Amount of Abandoned Cultivated Farmland in Various Counties and Districts of Ningbo City (Based on Remote Sensing Data)

No	Region	Category	Abandoned Area	Abandoned Farmland (mu)	Proportion (%)
1	Beilun District	Abandoned Farmland	13676950	20505	1.89
2	Cixi City	Abandoned Farmland	4496802	6742	0.27
3	Fenghua District	Abandoned Farmland	12169369	18245	0.76
4	Haishu District	Abandoned Farmland	133	0.20	0.00
5	Jiangbei District	Abandoned Farmland	1063602	1595	0.39
6	Jiangdong District	Abandoned Farmland	2418	4	0.01
7	Ninghai County	Abandoned Farmland	16775774	25151	0.78
8	Xiangshan County	Abandoned Farmland	22235792	33337	1.54
9	Yinzhou District	Abandoned Farmland	18765444	28134	1.06
10	Yuyao City	Abandoned Farmland	12120914	18172	0.59
11	Zhenhai District	Abandoned Farmland	971164	1456	0.33

Note: Jiangdong district was merged into Yinzhou district in 2016, but retained here as per the original context.

Meanwhile, through investigations conducted with the Natural Resources Planning Department of Ningbo City and the Ningbo Municipal Bureau of Agriculture and Rural Affairs, and in conjunction with the analysis of data on abandoned farmland areas submitted in accordance with the requirements outlined in the "Notice from the Zhejiang Provincial Department of Natural Resources and the Zhejiang Provincial Department of Agriculture

specific data on abandoned cultivated farmland in each district were extracted. Through data processing, a statistical table was generated, as shown in Table 1.

and Rural Affairs on Conducting a Thorough Investigation into the 'Non-Agriculturalization' and 'Non-Grain Production' of Cultivated Farmland," it was found that as of May 2022, Ningbo City had achieved a 100% completion rate in restoring abandoned farmland to cultivation, as required. The statistics on the relevant areas of abandoned farmland are presented in Table 2.

Table 2. Progress Schedule for Restoring Abandoned Farmland to Cultivation in Various Counties and Districts of Ningbo City in 2022

County (City, District)	Abandoned Farmland Area	Progress of Restoring Abandoned Farmland to Cultivation	Area of restored and replanted cultivated farmland		
			Cultivated farmland	Among which: Permanent basic farmland	Among which: Grain production functional areas
Haishu District	216.73	100.00%	216.73	190.69	141.49
Jiangbei District	781.08	100.00%	781.08	397.06	158.47
Zhenhai District	0	0.00%	0	0	0
Beilun District	199.35	100.00%	199.35	71.62	0
Yinzhou District	73.95	100.00%	73.95	65.84	45.61
Fenghua District	1052.45	100.00%	1052.45	728	189
Yuyao City	2505.72	100.00%	2505.72	2505.72	0
Cixi City	511.47	100.00%	511.47	187.37	2.29
Ninghai County	2907.4	100.00%	2907.4	1355	288
Xiangshan County	1621.03	100.00%	1621.03	941.68	113
Hangzhou Bay	318.5	72.68%	231.5	194.26	0
High-tech Zone	28.88	100.00%	28.88	9.3	0.9
Dongqian Lake	129.15	100.00%	129.15	48.54	0
Total	10345.71	99.16%	10258.71	6695.08	938.76

Note: Data was submitted by the Agriculture and Rural Affairs Bureau

3.4 Analysis of Incentives for Farmland Abandonment in Ningbo City

Since farmland abandonment is the result of the combined effects of multiple driving forces at a certain stage of socio-economic development, despite the implementation of a series of policies by national and local governments to actively

prevent farmland abandonment, the current trend of increasing farmland abandonment in China has not been effectively curbed. Studying the mechanisms underlying the formation and intensification of farmland abandonment holds practical significance for curbing the increase in abandoned farmland and revitalizing existing resources. Therefore, this paper intends to

analyze the incentives for farmland abandonment from four perspectives: environmental, economic, social, and policy and institutional factors. (1) Decision-making under varying conditions of the foundational environmental quality of cultivated farmland resources; (2) Economic benefit trade-offs under opportunity costs; (3) Social effect drivers under the urban-rural dual structure; (4) Failures in macro-regulation by policies and institutions.

4. Discussion and Countermeasures

Effectively revitalizing abandoned cultivated farmland is crucial for stabilizing grain production, advancing rural revitalization, and protecting ecological security. Building on favorable policies such as agricultural subsidies and farmland circulation currently in place, tailoring measures to local conditions based on the multiple motivations for farmland abandonment in different regions will be an effective way to revitalize abandoned cultivated farmland.

(1) Improve basic farmland conditions and facilities to enhance the comprehensive quality of cultivated farmland.

Governments or functional departments should take the initiative to promote the establishment of a soil environmental quality monitoring network, strengthen soil environmental quality monitoring and pollution prevention and control, and implement measures such as soil testing and formula fertilization and straw returning to the field to continue to improve soil fertility. They should increase investment in improving rural infrastructure to reduce farmers' grain production costs, scientifically plan and support farmland infrastructure and irrigation systems, optimize the layout of ditches, roads, forests, and canals, increase effective cultivated farmland area, and enhance the comprehensive production capacity of cultivated farmland.

(2) Adjust farmland layout and industrial structure according to local conditions to develop characteristic agriculture.

On the premise of ensuring that the quantity and quality of basic farmland do not decrease, comprehensively evaluate farmland quality, abandonment rate, infrastructure, etc., and scientifically adjust the layout of basic farmland. Cultivated farmland with convenient farming conditions and good quality should be adjusted to basic farmland, while basic farmland with disadvantaged location conditions, poor soil

quality, and incomplete infrastructure should be adjusted to general cultivated farmland. Meanwhile, based on farmland suitability evaluation, adjust the farmland planting structure, aim at market demand to plant economic crops with stable benefits, develop facility agriculture, characteristic agriculture, creative agriculture, etc., and increase the agricultural output value of cultivated farmland.

(3) Promote diversified farmland use right transfers and advance large-scale operations.

Based on local conditions, explore mechanisms and channels for the voluntary and compensated withdrawal, transfer, and leasing of contracted farmland and homesteads originally owned by farmers who have settled in cities, and encourage leading enterprises, agricultural cooperatives, and large-scale farmers with operational capabilities to actively accept farmland transferred from farmers for large-scale planting to improve farmland production efficiency. Actively guide migrant workers and farmers who are unable to cultivate their farmland to participate in agricultural production on a large scale and intensively through diverse methods such as farmland shareholding in enterprises, cooperative management, and farmland trusteeship.

(4) Innovate sales and distribution channels for agricultural products to accelerate the conversion of their market value.

Fully utilize modern marketing tools such as e-commerce, logistics, and WeChat official accounts to strengthen the marketing of characteristic agricultural products in various regions, solve problems such as single market channels and poor circulation, increase farmers' income, thereby improving the overall benefits of cultivated farmland, and continuously enhancing farmers' enthusiasm for engaging in agricultural production.

(5) Promote the integration of cooperatives and central villages to comprehensively achieve rural revitalization goals.

Gradually promote the integration of cooperatives and central villages in accordance with the principle of "voluntary participation by villagers and government guidance" and provide complete educational, medical, industrial, cultural, and other service facilities. At the same time, increase rural ecological civilization construction to create a livable rural environment. Identify and cultivate a group of practical, hardworking, and capable young

"three rural" cadres who understand agriculture, love rural areas, and care for farmers, introduce universities to participate, leverage the "leading goose effect" of outstanding talents, and achieve the rural revitalization goals of "prosperous rural industries, livable ecological environments, civilized rural customs, effective governance, and common prosperity in life".

(6) Conduct experimental demonstrations on revitalizing abandoned cultivated farmland and implement them by region and step.

Organize experts in relevant fields to diagnose villages and towns with different types of incentives for farmland abandonment in different regions, formulate strategies for revitalizing abandoned cultivated farmland, and carry out experimental demonstrations. After forming a typical model for revitalizing and managing abandoned farmland, governments or functional departments should formulate relevant policies to promote targeted applications in different regions and steps within Ningbo, and combine natural resource monitoring to promptly grasp the dynamics of abandoned cultivated farmland and provide timely and targeted diagnoses of new trends in farmland abandonment.

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