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Research on the Path to Improve Rural Land Use Efficiency from the Perspective of Comprehensive Land Consolidation——A Case Study of Huangshu Village

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Abstract: Rural areas are an important foundation for the stable development of the national economy, and the efficiency of rural land use is directly related to the improvement of the land resource structure and the increase of regional agricultural benefits. The efficient use of rural land resources has an impact on national food security, agricultural production structure, and social and economic development. Due to rapid economic development, rural land use faces a series of problems, resulting in low efficiency. Comprehensive land consolidation in the whole region is an important direction in the field of land consolidation. As a key means of land use, it can effectively restore the regional ecological environment, optimize the layout of various land uses, and help improve rural land use efficiency. Taking Huangshu Village as an example, this paper identifies existing problems in rural land use, clarifies the relationship between comprehensive land consolidation and rural land use efficiency, and explores paths to improve rural land use efficiency through comprehensive land consolidation. The research is expected to solve land use problems in the rapid development of rural areas, providing a reference for giving full play to the role of comprehensive land consolidation and improving rural land use efficiency.

1. Introduction

In recent years, due to the lack of planning and the rapid development of industrialization and urbanization, a large amount of high-quality cultivated land and ecological land in rural areas has been damaged. Construction land has "increased while the population decreased", homesteads are scattered and idle, and problems such as disorderly, excessive, and fragmented rural land development have become increasingly serious [1]. Due to China's special and complex natural environment with a fragile ecological base, under excessive interference from human activities, ecosystem degradation, environmental pollution and other problems have become more severe. Rural areas face multiple problems such as non-agricultural and non-grain conversion of agricultural land, disorderly and inefficient use of construction land [2]. These require comprehensive land consolidation to integrate various land uses, ensure the orderly operation of rural systems, and thus improve the efficiency of rural land resource use [3]. However, with the rapid development of cities and towns, rural development is relatively slow. As an important

measure to optimize the territorial spatial pattern, comprehensive land consolidation plays a positive role in ensuring national food security, improving land use efficiency, and promoting rural development [4].

Scholars now recognize the positive role of comprehensive land consolidation in rural development. Zhou Yuanbo believes that implementing comprehensive land consolidation is an important means to implement the rural revitalization strategy [5]; Liu Tianke argues that comprehensive land consolidation promotes comprehensive rural revitalization by adjusting the man-land relationship and optimizing the rural spatial pattern [6]; Liu Tian believes that comprehensive land consolidation should be carried out based on regional spatial differentiation and development stages to activate endogenous rural development momentum [2]; Qu Yanbo holds that measures related to comprehensive land consolidation can optimize the spatial layout of "production-living-ecological" functions in rural areas and rationalize the use of land resources [1]. Regarding land use, Scharstein D et al. point out that current urban development land mainly comes from land around cities and rural collective land, and the efficient use of such land has promoted regional economic development and formed new land use patterns. Currently, research on rural land use efficiency mainly focuses on homestead idleness, improvement of cultivated land use efficiency, and related influencing factors [7-8].

Using literature research, qualitative and quantitative analysis, and empirical research methods, this paper selects a typical case based on theoretical research from the perspective of comprehensive land consolidation, aiming to identify deficiencies in current rural land use. Through measures related to comprehensive land consolidation, it promotes cultivated land protection and intensive and efficient use of rural land, optimizes the production, living, and ecological spatial patterns, and further integrates comprehensive land consolidation with land use science, which is of practical significance for improving rural land use efficiency.

2. Theoretical framework

2.1 Comprehensive Land Consolidation

Comprehensive land consolidation originated from the "Three-Year Action Plan for Comprehensive Rural Land Consolidation and Ecological Restoration" implemented in Zhejiang Province in 2018, and was later promoted nationwide as a pilot project. After 2019, pilot projects of comprehensive land consolidation were launched nationwide and became a long-term ongoing task [9].

Comprehensive land consolidation refers to activities carried out within a certain area (usually planned at the town level) based on territorial spatial planning and related plans, targeting all elements (including mountains, rivers, forests, farmlands, lakes, grasslands, and deserts), with the main content of agricultural land consolidation, construction land consolidation, basic farmland protection, and rural ecological protection and restoration, to optimize the territorial spatial pattern and improve land use [10]. With the core goals of protecting cultivated land, using land intensively and economically, and improving the rural ecological environment and style, comprehensive land consolidation is characterized by being cross-departmental, all-space, all-element, and full-cycle.

Guided by Xi Jinping Thought on Ecological Civilization, comprehensive land consolidation takes the concepts of "respecting, adapting to, and protecting nature" and the principles of "giving priority to conservation, protection, and natural restoration" as guidelines, which are implemented throughout the entire consolidation process and all aspects. Comprehensive land consolidation is based on territorial spatial planning, emphasizing protection, conservation, and ecology, and is based on China's strict cultivated land protection system, land conservation system, and ecological protection system [11]. It adheres to "comprehensive goals, comprehensive means, and

comprehensive benefits", comprehensively diagnoses comprehensive problems in the overall space, integrates all elements such as mountains, rivers, forests, farmlands, lakes, grasslands, and deserts, conducts overall planning, comprehensively designs ecological, living, and production spaces, and strengthens the concept of the whole region [12-13]. Finally, through various measures of comprehensive land consolidation, overall planning is realized, the man-land relationship is optimized, and the goals of intensive and efficient production space, moderately livable living space, and ecologically sound ecological space are achieved [14].

2.2 Relationship between Land Consolidation and Comprehensive Land Consolidation

Traditional land consolidation focuses on quantity but ignores ecological management. In the process of land consolidation, due to various factors, it often causes significant interference to natural and artificial vegetation. Firstly, surface vegetation is damaged. Secondly, water resources are wasted. Farmland water conservancy projects, power plants, and environmental protection departments involved in land consolidation may have unreasonable water use, which burdens surface water and increases water loss. Thirdly, soil erosion is intensified. Unreasonable water use in land consolidation can disrupt the soil ecosystem and exacerbate soil erosion.

Comprehensive land consolidation is more comprehensive, with expanded scope and connotation, representing an advanced stage of land consolidation development [15]. In terms of objectives, it has changed from simply supplementing cultivated land, saving and intensively using land, and improving the functions of single elements to comprehensively considering all regional elements, optimizing the man-land relationship, and improving the functions of comprehensive space, thereby promoting rural revitalization and achieving coordinated urban-rural development. In terms of means, it has shifted from project-based to a combination of projects, engineering, and policy tools, flexibly utilizing policy advantages [16]. Compared with traditional land consolidation, comprehensive land consolidation pays more attention to the importance of ecosystem functions, highlights overall and comprehensive awareness, and attaches more importance to the effective combination of biological, technical, and engineering measures [17]. The policy mechanism has also transformed from a "one-size-fits-all" policy to more diverse and varied implementation, with multiple policies used comprehensively. In terms of scope, it has changed from relatively scattered, independent, and single-type land consolidation projects to overall planning, integrated design, and comprehensive consolidation, while considering other regions and river basins.

2.3 Rural Land Use Efficiency

As a spatial regional system with natural, social, and economic characteristics, rural areas have multiple functions such as living security, agricultural production, social security, industrial development, cultural inheritance, and ecological conservation, becoming one of the main spaces for human activities [18]. As a non-renewable and scarce basic resource, land has always been an important target of various plans and protections. Land use is the most direct human activity, representing the entire process of human development, utilization, improvement, or protection of land resources, and is a product of the combination of human intervention and natural conditions [19].

The term "efficiency" originates from physics, referring to the ratio of input energy to output energy of a system. A higher ratio indicates lower internal consumption and higher efficiency. Later, efficiency was introduced into economics to express the relationship between production and operation activities and resource allocation, representing the realization degree of input resources. Land use efficiency refers to the benefit level obtained per unit of land when using land resources for production and living. Rural land use efficiency is mainly reflected in the efficiency of

agricultural land use, construction land use, and ecological land use.

2.4 Internal Connection between Comprehensive Land Consolidation and Rural Land Use Efficiency

In the context of the new era, rural areas, as the main front for addressing development shortcomings, are of pivotal importance. Driven by reality in terms of resource use, spatial governance, development concepts, and supply-demand relationships, the natural, resource, social, ecological, economic, and public attributes of land require rural land use to adhere to man-land coordination. As a key means of land use, comprehensive land consolidation can revitalize all rural elements and optimize resource allocation through resource integration, spatial coordination, project integration, and subject coordination.

Rural areas hold the greatest potential for building a modern socialist power and serve as a key platform for comprehensive land consolidation. This process integrates regional elements, systematically manages natural resources, and protects ecosystems through diverse measures. It promotes cultivated land concentration via farmland upgrading and development, enabling large-scale agriculture, characteristic farming, and higher agricultural income. It optimizes construction land use through readjustment, structural improvement, and infrastructure enhancement. It also improves rural landscapes and ecology via residential upgrades, reserve establishment, and river management. Its core goals—protecting cultivated land, intensifying rural land use, optimizing spatial patterns, and enhancing living environments—closely align with boosting rural land use efficiency.

Comprehensive land consolidation is a means to improve rural land use efficiency, and improving rural land use efficiency is the goal of comprehensive land consolidation.

3. Analysis of Changes and Causes of Land Use Efficiency in Huangshu Village

3.1 Overview of Huangshu Village

Taocheng Town belongs to Langxi County, Xuancheng City, Anhui Province, located in the southeast of Langxi County.Huangshu Village has a plain terrain with local small hills, where low hills, farmland, and villages are intertwined, and there are crisscrossing water surfaces, with a good environment. It has a subtropical monsoon climate, with warm winters and hot summers, good light conditions, sufficient precipitation, and a long frost-free period. The area is rich in agricultural resources such as rice, rapeseed, and wheat. The overall terrain of Huangshu Village is gentle with small undulations, mainly plain with local small hills.

The administrative area of Huangshu Village is approximately 539 hectares. It has 11 villager groups, 834 households, and a total population of 2585. The registered population of Huangshu Village shows a decreasing trend. Currently, about 450 people in Huangshu Village work outside, and the permanent residency rate of registered population is basically stable at around 80%. The total land area of Huangshu Village is 538.72 hectares. Agricultural land totals 343.35 hectares, accounting for 63.8% of the total land area. Construction land totals 65.67 hectares, accounting for 12.2%. Land water area is 129.38 hectares, accounting for 24%. The ecological space of Huangshu Village is 33.74 hectares, mainly distributed in a small area on the northern edge of the village. Agricultural space is 439.37 hectares, distributed in areas with relatively gentle slopes that are easy for agricultural production, mainly along roads.

3.2 Status of Land Use Efficiency in Huangshu Village

3.2.1 Low Agricultural Income

Huangshu Village's industrial development is dominated by traditional agriculture, supplemented by breeding and processing. It grows wheat, rice, rapeseed, etc., and mainly breeds soft-shelled turtles. The village mainly focuses on rice processing, with a weak industrial foundation. As shown in Table 1, the net income per mu of rice per season is about 1240 yuan, with two harvests a year, resulting in an annual net agricultural income of about 2480 yuan per mu, indicating low agricultural income.

Table 1 Income from Rice Cultivation

Average rice yield per mu (jin/mu)	1100
Average selling price (yuan/jin)	1.5
Total input of seedlings (yuan/mu)	90
Total input of insecticides (yuan/mu)	60
Total input of herbicides (yuan/mu)	40
Total input of chemical fertilizers (yuan/mu)	120
Total input of irrigation (yuan/mu)	35
Total input of machinery (yuan/mu)	65
Net income (yuan/mu)	1240

3.2.2 Idle Homesteads with Excessive Area

The phenomenon of "hollow villages" is becoming increasingly serious. Currently, about 450 people in Huangshu Village work outside, leaving homesteads uninhabited for a long time. Some rural residents have moved their household registration to cities but have not returned their homesteads as required. Due to traditional concepts, there is a large gap between households, with courtyards and gardens built, wasting land. Meanwhile, the phenomenon of one household with multiple homesteads is common. Some villagers choose new locations to build houses to improve living conditions but do not demolish old houses, resulting in idle and abandoned homesteads.

3.2.3 Infrastructure needs to be improved

Residents maintain traditional agricultural lifestyles, working from sunrise to sunset and living in harmony with nature. However, infrastructure needs improvement. Huangshu Village requires enhanced transportation facilities, including insufficient paved roads for household access and residential connections that hinder passage. Fire trucks cannot navigate some internal village roads due to safety hazards, while certain sections are blocked by buildings or courtyard walls preventing vehicle passing. Some road sections are too narrow, and parking facilities are inadequate. Secondary roads lack streetlights, and key areas like fitness squares receive basic lighting. The village has only one clinic located in Shajiao. There are no kindergartens, primary schools, or secondary schools, indicating a severe shortage of educational resources.

3.3 Causes of Changes in Land Use Efficiency in Huangshu Village

With urbanization and industrialization, cities have expanded outward, leading to the occupation of vast rural lands through construction projects. This has resulted in a "few people, much land" dilemma in rural areas, where limited arable land resources face severe depletion.

The severe abandonment of farmland, coupled with poor management practices, has resulted in substandard soil quality. Traditional farming methods have prevented large-scale agricultural utilization, leading to low productivity and poor economic returns. With limited diversified

cultivation techniques, Huangshu Village remains predominantly engaged in conventional agriculture. While some areas have developed rice processing industries, the incomplete industrial chain continues to hinder agricultural income growth. Driven by villagers' pursuit of improved living standards, some rural residents have moved to cities to purchase homes, leaving their ancestral homesteads vacant and abandoned. Rural government agencies have failed to fulfill their responsibilities by lacking unified planning frameworks, inadequate control over construction land use, insufficient management expertise, and insufficient understanding of land's vital importance. Consequently, infrastructure development remains poorly coordinated, with scattered, isolated, and disorganized layouts that suffer from both quantity and quality deficiencies.

4. Study on the Improvement of Land Use Efficiency in Huangshu Village under the Comprehensive Land Consolidation

4.1 Research Ideas on Improving Land Use Efficiency in Huangshu Village

By integrating bottom-line control requirements with comprehensive village planning needs, topography, and landscape features, we will advance agricultural land consolidation, construction land reorganization, development of cultivable reserve resources, and ecological restoration projects within village boundaries. This initiative aims to optimize the overall spatial configuration of national territory, creating a harmonious environment characterized by safety standards, ecological sustainability, scenic beauty, rational construction land distribution, and efficient utilization. Comprehensive land consolidation represents a crucial initiative in the new era to enhance rural land utilization efficiency and comprehensively advance ecological civilization construction[7]. This approach has evolved from single-factor remediation to holistic spatial management encompassing all elements, shifting focus from isolated functional improvements to achieving integrated spatial functions that harmonize human-land relationships.

4.2 Research on Improvement of Agricultural Land Utilization Efficiency

Through concrete measures including high-standard farmland development, converting dry fields into paddy fields, developing suitable reserve arable land resources, and consolidating other agricultural lands, we uphold the "1.8 billion mu (approximately 200 million hectares) red line" for cultivated land to ensure both quantity and quality while safeguarding national food security. This initiative enhances soil fertility, promotes large-scale farming operations and standardized agricultural products to achieve sustainable agricultural development, and improves production conditions to facilitate the transition from traditional to modern agriculture.

4.2.1 Construction of High-Standard Farmland

The total potential area for constructing high-standard farmland within the region totals 305.88 hectares. Primarily utilizing existing cultivated land from the Third National Land Survey (TNS) that has not yet undergone high-standard farmland development, these areas are mainly distributed along both sides of the Li-Ning Expressway. By implementing measures such as field surface filling and excavation, construction of field ridges, improvement of irrigation and drainage systems along with field roads, and increased application of organic fertilizers, we aim to enhance field flatness, reduce fragmentation, improve soil quality, and ultimately boost grain production capacity.

4.2.2 Conversion of Dry Land to Paddy Fields

These projects are primarily located in Houle and Shajiao areas, where the terrain features gentle slopes, contiguous farmland, and well-developed irrigation systems. By optimizing existing irrigation infrastructure and improving water supply reliability, the initiative guides standardized conversion of dry land to paddy fields based on local conditions. This approach enhances agricultural machinery efficiency and boosts grain production yields while maintaining sustainable development.

4.2.3 Agricultural Scale Operation

The agricultural planting ecological zone, primarily focuses on existing farmland with a focus on rice and rapeseed cultivation to establish a large-scale agricultural area. The modern agricultural planting zone includes organic rice fields and rapeseed plantations. By leveraging the existing rice field infrastructure, this zone expands planting scale through modern technologies to achieve agricultural industrialization and modernization, while establishing supply and marketing channels with surrounding areas.

4.3 Research on Improvement of Construction Land Efficiency

Develop rural homesteads and inefficient land use management to promote comprehensive integration of rural development elements, unlocking the potential of idle homesteads. By implementing systems such as urban-rural construction land balance, urban-rural linkage, and land circulation, we can revitalize underutilized rural land resources and facilitate market-oriented flow of land factors. Based on village planning, optimize land use structure through rational layout of various land types. Advance public infrastructure development to enhance transportation accessibility and improve living convenience.

4.3.1 Demolition and Adjustment of Village Construction Land

The demolition of village construction land primarily occurs in the Zhouwan, Yangtian, Tuwan, Houle, and Qianle villagers' groups, targeting settlements with dilapidated houses, abandoned properties, or poor transportation access. The total demolition area spans 12.18 hectares, with 11.80 hectares planned for farmland reclamation. This initiative consolidates scattered settlements with substandard infrastructure, poor transportation connectivity, and unfavorable geographical conditions.

4.3.2 Optimization of Stock Land Structure

The structural optimization of existing rural construction land is distributed across Shajiao Group and Ruanqiao Villager Group, involving the conversion of rural homesteads to commercial use and government institutions to industrial use. The total optimized construction land area within the region amounts to 2.74 hectares, including 0.07 hectares of rural homesteads and 0.15 hectares designated for agricultural facilities.

By optimizing the structure and layout of construction land, we can enhance the efficiency of land use. The building density and floor area ratio for commercial construction land shall be determined according to local administrative regulations. In compliance with the requirement that public service facilities and infrastructure projects must not occupy traffic areas, any housing developments along major roads within the village—including the Lining Expressway and Provincial Highway 202—must adhere to road setback requirements.

4.3.3 Improve Infrastructure

Following the "central village-natural village" two-tier configuration, the primary community (central village) establishes essential public services including village committee offices, health clinics, senior activity rooms, cultural centers, rural libraries, and cultural halls. The infrastructure for rural mail and logistics (village post offices and courier service points) is upgraded to meet villagers' online shopping needs. Municipal facilities such as bus stops, parking lots, fitness plazas, waste collection points, public restrooms, and small sewage systems are also provided. The secondary community (natural village) focuses on fitness plazas, public restrooms, and rainwater/sewage engineering projects.

4.4 Research on Improving the Efficiency of Ecological Land Use

Through the ecological protection and restoration of mountains, rivers, forests, farmland, lakes and grasslands, we can restore ecological functions, improve rural living environment, and promote the construction of beautiful villages; ensure the sustainable and effective supply of high-quality ecological products, highlight the ecological value of "lucid waters and lush mountains are invaluable assets", and give consideration to the sustainable development of rural areas[7].

4.4.1 Comprehensive River Management

The comprehensive river management project primarily focuses on the Langchuan River and surrounding waters of Shajiao Central Village, covering a total area of 47.72 hectares. Through implementing engineering measures such as water conservancy infrastructure and ecological bank protection, the project aims to enhance terrestrial ecosystems along riverbanks while reducing impacts from non-point source pollution like surface runoff on water bodies.

4.4.2 Ecological Environment Improvement

Clean up riverbank debris and conduct ecological restoration of water channels to purify water quality. When organizing water system shorelines, both natural and formal approaches can be adopted. Curved and winding designs are recommended to create varied shoreline spaces, complemented by added facilities like piers, waterside platforms, and wooden boardwalks that enhance the livability and recreational value of waterfront areas. Reinforced retaining walls should harmonize with the natural environment, prioritizing natural-style structures that blend seamlessly with surroundings. Waterside walkways should utilize materials evoking rural charm, with their layout echoing the riverbank's contour to avoid excessive paving. Roadside greening should be implemented without disrupting traffic flow. Secondary road greenery should closely integrate with rural life, preserving rustic charm. Residential areas should maximize available spaces to avoid exposed soil, creating pocket gardens, orchards, and flower beds that beautify surroundings while boosting courtyard economies, ultimately fostering fragrant living environments.

5. Conclusion

This study examines the relationship between comprehensive land consolidation and rural land use efficiency improvement at the village level. Through integrated land management, we aim to address multiple challenges including disorganized land allocation, fragmented farmland conversion for non-agricultural purposes, and ecological degradation. The initiative seeks to optimize rural spatial planning, promote intensive land use, and ultimately achieve effective farmland

conservation.

Comprehensive land consolidation represents an evolution and innovation in land management practices. Unlike traditional land reclamation approaches, this integrated strategy adopts a holistic regional perspective, encompassing all types of land categories, elements, and areas. A fundamental requirement for enhancing rural land utilization efficiency lies in enabling land users to optimize their land use through comprehensive measures, thereby improving land productivity and driving sustainable rural development.

Through research on Huangshu Village, it has been found that implementing comprehensive land consolidation as a starting point for holistic improvement across all land categories and elements serves as a viable approach to enhance rural land utilization efficiency. This requires thorough analysis of natural and human resources, prioritizing ecological conservation while addressing villagers' needs. By adjusting land use structures and optimizing village layouts through comprehensive land consolidation, sustainable development can be ensured.

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