

The Internal Logic and Practice of Comprehensive Land Consolidation in Mountainous Areas Boosting Rural Revitalization

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Abstract Focusing on comprehensive land consolidation in mountainous areas, this paper explores the connotation of comprehensive land consolidation and its internal logic for promoting rural revitalization. Furthermore, it elucidates the effectiveness and experience of mountainous area comprehensive land consolidation in the rural revitalization process by using practical cases. The aim is to provide theoretical reference and practical guidance for leveraging the role of comprehensive land consolidation in mountainous areas for rural revitalization, thereby promoting the sustainable utilization of land resources and the coordinated development of the economy and society in mountainous regions.

Key words Mountainous areas, Comprehensive land consolidation, Rural revitalization

0 Introduction

The Rural Revitalization Strategy is a crucial strategy for addressing the issues related to agriculture, rural areas, and farmers (the "Three Rural Issues") in the new era, holding significant importance for realizing the Chinese Dream of the great rejuvenation of the Chinese nation. Comprehensive land consolidation is a key instrument for implementing the Rural Revitalization Strategy. By conducting comprehensive consolidation of all elements, such as farmland, water systems, roads, forests, and villages within a designated area, it can optimize land resource allocation, improve rural production and living patterns, and promote rural ecological protection.

Mountainous areas in China account for two-thirds of the country's total land area, serving as vital ecological barriers and resource-rich zones, yet they are also regions with relatively lagging economic and social development. Mountainous areas represent challenging regions for conducting comprehensive land consolidation and are also priority areas for the implementation of the Rural Revitalization Strategy. The rational utilization and effective management of land resources in mountainous areas not only play a crucial role in the sustainable development of the mountains themselves but also exert significant influence on the ecological security and socio-economic stability of the entire nation. However, due to complex topography, inconvenient transportation, fragile ecological environment, and other reasons, land use in these areas faces numerous problems, such as fragmented farmland, low farmland quality, wasteful use of construction land, and ecological environmental damage. Consequently, the comprehensive revitalization of mountainous villages encounters many challenges. Therefore, re-

searching how comprehensive land consolidation in mountainous areas can promote rural revitalization holds significant practical importance.

Current research on comprehensive land consolidation primarily focuses on two aspects. The first is research on comprehensive land consolidation itself. Scholars explore the fundamental logic and key issues^[1], path optimization^[2] of comprehensive land consolidation, analyze the relationship between consolidation plan formulation^[3] and existing plans^[4–5], discuss the application of relevant technical measures in consolidation^[6–8], and employ case studies of consolidation at different administrative levels (county/city^[9], township^[10], village^[11]) and under different topographies^[12] to examine aspects such as pilot area selection^[13], consolidation models^[14], and measures^[15]. The second is research combining comprehensive land consolidation with national strategies. This includes exploring the interaction and implementation pathways between comprehensive land consolidation and rural revitalization^[16–22], research on how comprehensive land consolidation breaks down the urban-rural dual structure and promotes integrated urban-rural development^[23–26], and the lessons that the experience of the "Thousand-Village Demonstration and Ten-Thousand-Village Renovation Project" offers for comprehensive land consolidation^[27–28]. Existing research findings on comprehensive land consolidation in mountainous areas are still relatively scarce^[29–30], and most consist of analyses of single practical cases. This paper will analyze and summarize multiple practical cases of comprehensive land consolidation in mountainous areas to derive the experience gained from conducting such consolidation in mountains and its driving effect on rural revitalization.

This paper discusses the connotation of comprehensive land consolidation and the internal logic by which it promotes rural revitalization. It further elucidates the effectiveness and experience of comprehensive land consolidation in mountainous areas concerning rural revitalization by combining practical cases. Using methods such as literature analysis and case studies, the research sys-

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tematically analyzes the theoretical foundations and practical experience of comprehensive land consolidation in mountainous areas, aiming to provide references for advancing the comprehensive revitalization of rural areas in the mountains.

1 The connotation of comprehensive land consolidation and rural revitalization

1.1 The connotation of comprehensive land consolidation

Clarifying the development trajectory of comprehensive land consolidation is key to grasping its scientific connotation. Based on a review of the development history of comprehensive land consolidation (Fig. 1), it can be seen that since the Central Secretariat first proposed the task of "territorial management" in 1981, research on territorial management in China has undergone over 40 years of development^[20]. It has evolved from early land consolidation, de-

velopment, and reclamation to land remediation, then to comprehensive land consolidation, and finally to comprehensive land consolidation at the regional scale. The focus has shifted from singular farmland consolidation towards holistic and integrated governance, and the governance philosophy has transitioned from land-centered to people-centered. Comprehensive land consolidation at the regional scale has developed into an important measure requiring coordination with overall regional planning, serving as a crucial means to optimize the "production-living-ecological" (PLE) spatial pattern and achieve integrated urban-rural development. It plays a significant role in promoting land conservation and intensive use, improving farmland quality to ensure food security, and advancing the construction of livable, workable, harmonious, and beautiful villages, thereby becoming a key tool for achieving comprehensive rural revitalization.

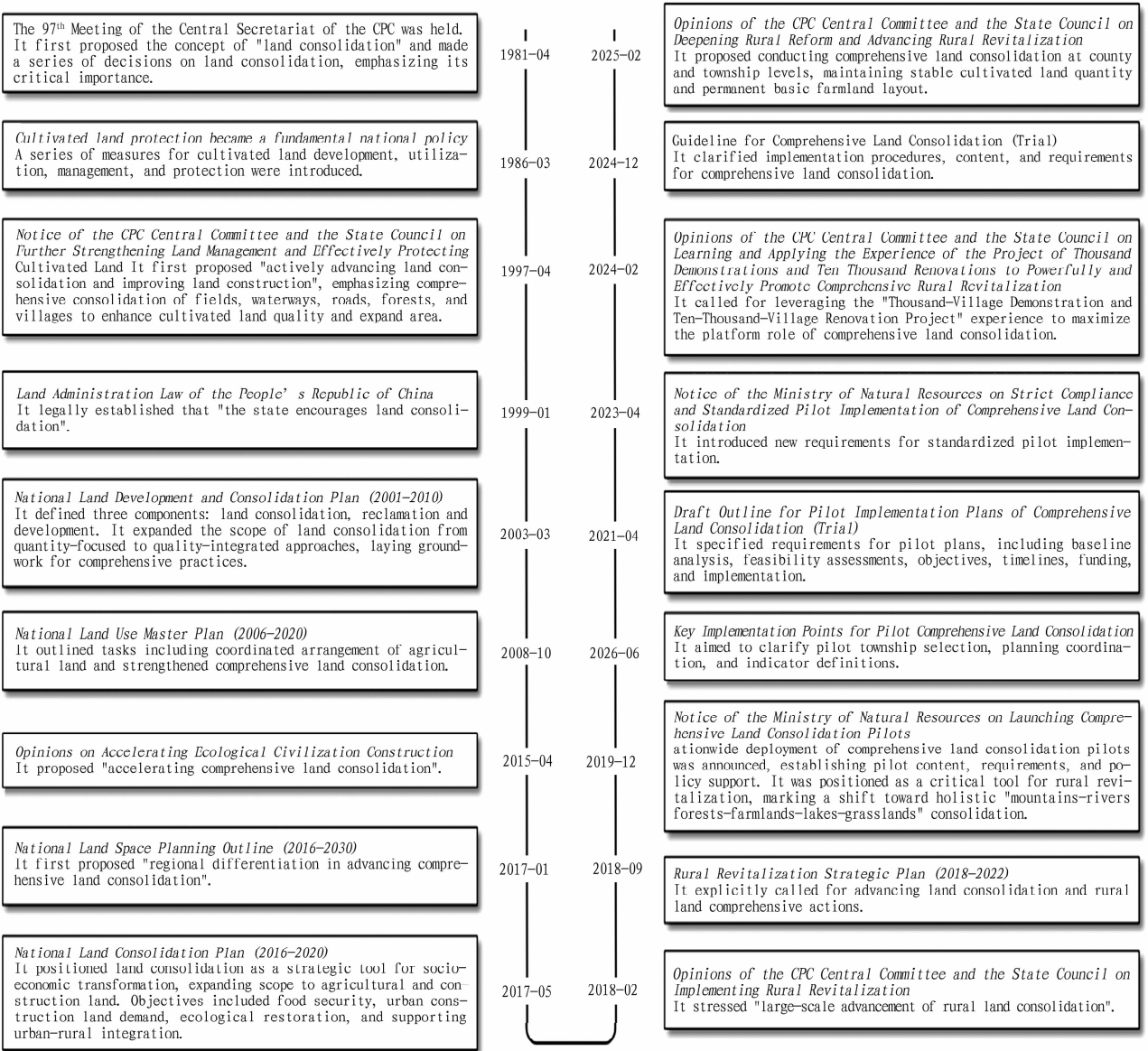


Fig. 1 Timeline of comprehensive land consolidation development

To guide localities in steadily and orderly advancing comprehensive land consolidation work, the General Office of the Ministry of Natural Resources issued the *Implementation Guideline for Comprehensive Land Consolidation at the Regional Scale (Trial)* (hereinafter referred to as the *Implementation Guideline*) in December 2024. The *Implementation Guideline* defines comprehensive land consolidation at the regional scale as a spatial governance activity. It is based on territorial spatial planning and involves, within a designated area, coordinated advancement of agricultural land remediation, construction land consolidation, and ecological protection and restoration to optimize the layout of production, living, and ecological spaces. It aims to enhance spatial functions and value, promote farmland protection and land conservation and intensive use, improve production, living conditions, and the ecological environment, and facilitate the implementation of strategies such as comprehensive rural revitalization and integrated urban-rural development^[31].

1.2 Rural revitalization Rural revitalization is the overarching focus for work related to agriculture, rural areas, and farmers ("Three Rural Issues") in the new era. General Secretary Xi Jinping first proposed the implementation of the Rural Revitalization Strategy at the 19th National Congress of the Communist Party of China. The General Secretary summarized the overarching requirements of the Rural Revitalization Strategy as "thriving businesses, pleasant living environments, social etiquette and civility, effective governance, and prosperity". He emphasized comprehensive rural revitalization, encompassing industrial revitalization, ecological revitalization, cultural revitalization, organizational revitalization, and talent revitalization^[17].

Industrial revitalization involves consolidating and elevating the foundational role of agriculture. This is achieved by developing modern agriculture, promoting large-scale agricultural production, enhancing specialization and informatization, fostering the integrated development of primary, secondary, and tertiary industries in rural areas, extending the agricultural industrial chain, and increasing the added value of agricultural products. Ecological revitalization requires strengthening the protection of the rural ecological environment, advancing the improvement of rural living environments, and enhancing rural infrastructure construction. Simultaneously, it emphasizes the protection and restoration of villages' natural ecosystems, safeguarding rural natural resources such as mountains, waters, forests, farmlands, lakes, and grasslands. The goal is to create a beautiful, clean, and comfortable rural living environment, transforming the countryside into a beautiful homeland where people live and work in contentment. Cultural revitalization entails implementing ideological and moral construction in rural areas, practicing the core socialist values, inheriting and promoting excellent farming civilization, and cultivating civilized rural customs, sound family traditions, and simple folkways. Organizational revitalization involves establishing and improving a modern rural social governance system, adhering to the combination of autonomy, rule of law, and rule of virtue. It requires strengthening the building of rural primary-level Party organizations, enabling them to serve as strongholds, improving the villagers' self-governance system, and enhancing farmers' aware-

ness of democratic participation and self-management capabilities. Talent revitalization necessitates cultivating a large contingent of personnel equipped with professional knowledge and skills relevant to agricultural and rural development, and who possess a high level of enthusiasm for contributing to rural construction. Corresponding policies should be introduced to attract various types of talent to engage in rural development. As a systematic project, rural revitalization encompasses multiple aspects that are interconnected and mutually reinforcing, collectively constituting the rich connotation of rural revitalization.

2 The internal logic of how comprehensive land consolidation boosts rural revitalization

The implementation of rural revitalization has an urgent demand for production, living, and ecological spaces. Through comprehensive land consolidation, the rural land use structure is optimized, land use efficiency is improved, and fragmented land resources are integrated. This provides reasonable land space for rural industrial development, infrastructure construction, and the layout of public service facilities, promotes the orderly advancement of rural construction, enhances the village appearance, and contributes to achieving the goals of ecological livability and beautiful villages in rural revitalization. Starting from a systemic perspective, comprehensive land consolidation rationally plans the priorities and sequence of village construction, coordinates construction and management, explores rural development models that align with local characteristics, fully considers the carrying capacity of land resources and rural development needs, avoids blind construction and resource waste, achieves scientific and rational utilization of land resources, promotes the sustainable development of rural construction, and provides a solid land guarantee for rural revitalization (Fig. 2).

2.1 Expanding development space to promote industrial revitalization Through agricultural land remediation, comprehensive land consolidation consolidates fragmented and scattered farmland into contiguous plots and constructs high-standard farmland, creating conditions for modern agricultural production. Consequently, this enhances agricultural production efficiency, increases farmers' income, and drives agricultural revitalization. By revitalizing idle and inefficient rural land, comprehensive land consolidation frees up space for building factories, rural tourism facilities, *etc.*, promoting the integrated development of the primary, secondary, and tertiary industries in rural areas and fostering comprehensive industrial revitalization.

2.2 Optimizing spatial layout to promote ecological revitalization Comprehensive land consolidation carries out ecological protection and restoration projects, systematically managing ecological elements such as mountains, waters, forests, farmlands, lakes, and grasslands. This protects and restores rural ecological functions, maintains ecological balance, and provides good ecological products and services. Simultaneously, it consolidates rural construction land, concentrates the construction of rural residential areas, improves infrastructure and public service facilities, enhances the rural living environment, elevates farmers' quality of life, and achieves ecological livability.

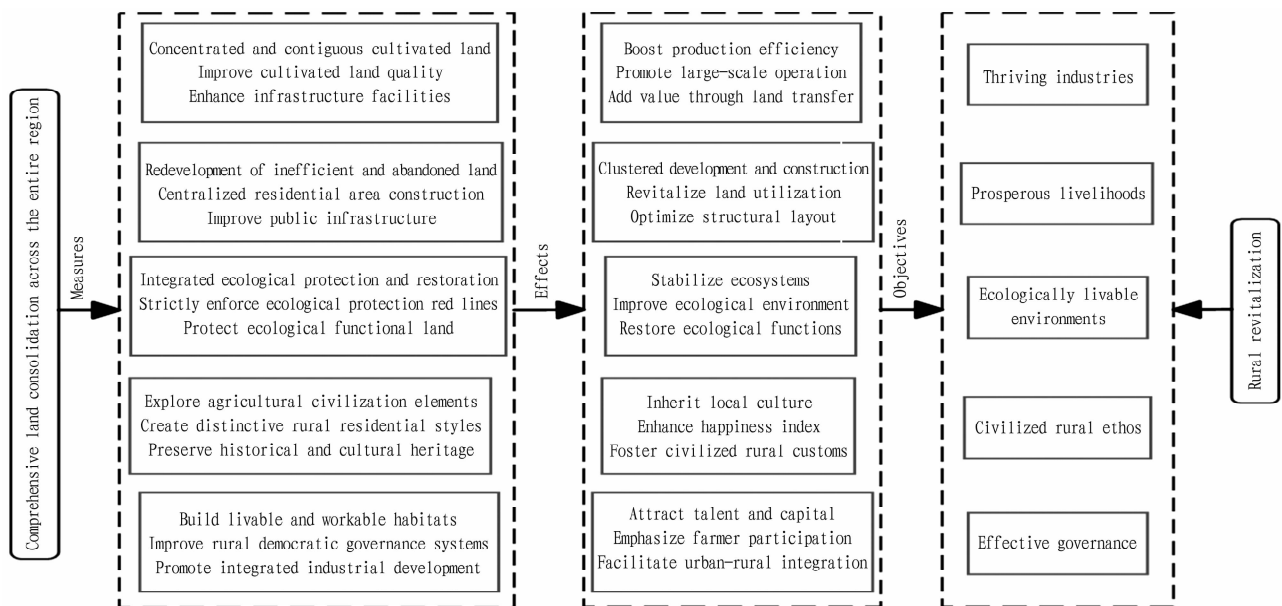


Fig. 2 The internal logic of comprehensive land consolidation in mountainous areas promoting rural revitalization

2.3 Activating cultural vitality to promote cultural revitalization

Comprehensive land consolidation emphasizes the protection and restoration of carriers of local culture, such as ancient villages, historic buildings, and cultural heritage sites. It avoids damage to traditional culture during rural construction and development, preserving the historical memory and cultural roots of the countryside. It delves into the cultural connotations of rural areas, integrates local culture with industries like rural tourism and leisure agriculture, creates cultural brands with local characteristics, achieves a positive interaction between cultural inheritance and economic development, and injects cultural impetus into rural revitalization.

2.4 Enhancing governance capacity to promote organizational revitalization

Comprehensive land consolidation involves the vital interests of farmers. During project implementation, it fully respects farmers' wishes and encourages villagers to participate in all stages, including consolidation planning, project execution, and supervision and management. This enhances villagers' sense of ownership and responsibility, promotes effective rural democratic management and governance, improves rural social order, fosters a harmonious rural social atmosphere, advances the building of civilized rural customs, and strengthens cohesion among villagers.

2.5 Facilitating factor flow to promote talent revitalization

By optimizing land resource allocation, comprehensive land consolidation breaks down the urban-rural dual structure and facilitates the exchange and flow of factors such as land, capital, talent, and technology between urban and rural areas. The support of policy funds and the improvement of the rural environment make the prospects for rural development promising. Young people become more willing to stay in their villages to build and develop their hometowns. Simultaneously, it attracts outstanding external talent and

advanced technology to flow into the countryside, bringing new momentum to rural development.

3 The practice of comprehensive land consolidation in mountainous areas boosting rural revitalization

China has vast mountainous areas with complex and diverse topography. Influenced by natural conditions and human activities, land resources in mountainous areas face problems such as severe farmland fragmentation, poor farmland quality, increasingly acute human-land conflicts, inadequate public infrastructure, chaotic layout of construction land, and fragile ecological environment. The case studies for this research were selected based on the following three aspects. First, Guangxi, Yunnan, and Chongqing are all typical mountainous provinces/regions, with mountainous terrain accounting for over 75% of their area; widespread mountains make studying development issues in these regions representative. Second, the selected mountainous areas have inherently fragile ecological environments^[32], coupled with prominent problems of irrational land use, creating a practical need for implementing comprehensive land consolidation in these areas. Third, the selected mountainous areas are key and challenging regions for implementing rural revitalization. They have relatively weak economic foundations, rely mainly on traditional agriculture with a singular industrial structure, and employ outdated traditional planting models. The sole pursuit of expanding grain cultivation area and increasing yield easily leads to a "farmland-grain abundance" resource curse^[33], resulting in low agricultural returns, rural impoverishment, and ecological environmental degradation in the mountains, hindering the progress of the rural revitalization strategy.

3.1 Case analysis

3.1.1 Shuangfeng Town, Bobai County, Yulin City, Guangxi.

(i) Pre-consolidation overview. Shuangfeng Town is located in the southern part of the Liuwan Mountains, surrounded by mountains on its northwest, west, and east sides. The terrain features rolling hills, abundant resources, and is the hometown of Lüzhu, a famous beauty from the Western Jin Dynasty. It possesses numerous old houses and ancestral halls built during the Tongzhi reign of the Qing Dynasty, indicating significant potential for tourism resource development. The town produces characteristic agricultural products such as tea, star anise, and *Dendrocalamus latiflorus* (a type of bamboo), and has relatively strong comprehensive agricultural production capacity. Before the comprehensive land consolidation project was initiated, the area had not undergone ecological management. Problems included extensive land use, fragmented farmland hindering land transfer, lagging public service facilities, "dirty, disorderly, and poor" conditions within villages, and deteriorating ecological environment.

(ii) The main approaches to implementing comprehensive land consolidation: (a) Optimizing spatial layout. The overall planning layout was designed as "One Center, Five Functional Zones", rationally planning the layout of the "production-living-ecological" (PLE) spaces. By implementing farmland quality improvement projects and the urban-rural construction land increase-decrease linkage policy, supplementary farmland quotas and linkage quotas were obtained, and the revenue generated was reinvested into rural construction. (b) Creating rural complexes. Social capital was introduced and operated using the Engineering – Procurement – Construction (EPC) general contracting model to promote the large-scale and industrialized development of modern agriculture. Multiple planting bases for *Dendrocalamus latiflorus*, passion fruit, and tea were established. Utilizing pastoral scenery, ecological landscapes, and Hakka historical and cultural re-

sources, rural complexes integrating ecological agricultural tourism, rural vacationing, and pastoral health and wellness were developed. (c) Tapping into cultural resources. Emphasis was placed on excavating and protecting local Hakka historical and cultural resources. Old houses and ancient ancestral halls were renovated, a Hakka folk culture exhibition hall was created, and tourism cultural display points like the Lüzhu Cultural Village landmark were built. Simultaneously, the village's appearance and ecological environment were planned and designed according to the production, living habits, and customs of the Hakka people. (d) Encouraging universal participation. An agricultural industrialization consortium following the "Company + Party Branch + Base + Farmers" model was established. Villagers were encouraged to participate through means such as contributing land transfer income and housing as shares, sharing profits via "guaranteed rent + surplus dividends + labor income". For simple construction projects, village collectives organized villagers to contribute labor and resources.

(iii) Consolidation outcomes: (a) Promoting industrial integration. The creation of agricultural rural complexes and the layout of diversified, large-scale planting drove the development of industries like leisure tourism, achieving integrated development of primary, secondary, and tertiary industries. Both villager and village collective incomes increased significantly. (b) Improving living environment. The implementation of village appearance improvement projects and comprehensive ecological clean small watershed soil and water conservation management projects improved the "dirty, disorderly, and poor" conditions within the villages, purified water quality, restored the ecological functions of river channels, enhanced infrastructure, and increased villagers' sense of happiness.

Table 1 Case analysis of comprehensive land consolidation in mountainous areas

Case studies	Key problems	Key practices	Consolidation outcomes
Shuangfeng Town, Bobai County, Yulin City, Guangxi	① Fragmented cultivated land ② Extensive land use patterns ③ Difficulties in land transfer ④ Weak infrastructure ⑤ Poor village environmental conditions ("dirty, chaotic, and dilapidated") ⑥ Deteriorating ecological environment	① Overall planning as "One Core, Five Zones": Shuangfeng Village Core Zone, Ecological Agriculture Zone, Camellia Oil Planting Demonstration Zone, 5-Km Industrial Corridor Zone, Specialty Fruit Zone, and Ecological Forest Conservation Zone. ② Introducing social capital to establish an agricultural industrial consortium of "Company + Party Branch + Base + Farmers", with villagers sharing benefits through "rental guarantee + surplus dividends + wage income".	① Established agricultural complexes integrating industries, improved infrastructure, and enhanced rural living environments ② Successful land transfer for scaled operations, increased farmer income, and improved well-being
Eryuan County, Yunnan	① Irrational land development and utilization ② Low cultivated land quality ③ Inadequate agricultural infrastructure	① Supplementing cultivated land through consolidation ② Improving irrigation, water management, and road infrastructure	① Expanded cultivated land area ② Improved cultivated land quality
Zhong'ao Town, Dazu District, Chongqing	① Fragmented cultivated land ② Low cultivated land quality ③ Severe cultivated land abandonment	① Town and village cadres conducted policy publicity on idle land consolidation at farmers' households ② Developing a "Village Collective + Enterprise + Farmers" cooperation model	① Remarkable progress in idle land consolidation ② Reactivated cultivated land utilization and farmer income growth

3.1.2 Eryuan County, Yunnan. (i) Pre-consolidation overview. Areas such as Tuanjie Village in Xishan Township and the E'mu Group in Eryuan County feature rugged mountains and steep terrain, having a typical high-altitude cold mountainous area. A large amount of land had not been rationally developed or utilized. Field irrigation facilities were inadequate, farmland quality grade was low, and village access roads were dirt roads, constraining local agricultural development.

(ii) The main approaches to comprehensive land consolidation: Focusing on creating the supplementary farmland pilot project through land consolidation in Tuanjie Village, Xishan Township, and the E'mu Group, with a total investment of 27.023 million yuan. Simultaneously, implementing comprehensive land consolidation projects in areas like Songqu Village, Yousuo Town, to improve irrigation and water conservancy facilities and road infrastructure.

(iii) Comprehensive outcomes: (a) Increasing farmland area. After the implementation of the project in Tuanjie Village, Xishan Township, and the E'mu Group, 52.3 ha of new farmland was added. Multiple field roads and production roads were constructed, enhancing the momentum for agricultural development. (b) Improving farmland quality. The comprehensive land consolidation project implemented in Songqu Village, Yousuo Town, not only improved infrastructure conditions but also enhanced farmland quality. It promoted the optimization and adjustment of the industrial structure, creating conditions for the local large-scale cultivation of green and organic rice. (c) Creating demonstration zones. By implementing multiple comprehensive land consolidation projects, the project areas were transformed into modern agricultural demonstration zones, model zones for urban-rural integration, and new highlands for industrial development, thereby boosting rural industrial revitalization.

3.1.3 Zhong'ao Town, Dazu District, Chongqing. (i) Pre-consolidation overview. Zhong'ao Town is located in the northwest of Dazu, with terrain mostly consisting of mountains and hills. The land is barren, and plots are scattered and fragmented. Economic development relies mainly on traditional agriculture, with a relatively singular industrial structure. Industrial and service sector development lags behind. Coupled with young people migrating for work, large areas of farmland were left abandoned.

(ii) The main approaches to comprehensive land consolidation: (a) Publicity and guidance. Town and village-level cadres visited farmers' homes to publicize policies on abandoned land remediation, raising villagers' awareness and enthusiasm for land consolidation. (b) Innovative model. Adopting the "Village Collective + Enterprise + Farmers" model, enterprises were introduced to sign land transfer agreements with local villagers, revitalizing land resources. This formed a pattern where introduced enterprises manage part through transfer, the village collective holds part in trusteeship, and villagers cultivate part themselves.

(iii) Consolidation outcomes: In 2024, a total of 333.33 ha of abandoned land was remediated. Planting industries such as

chili peppers, mulberry trees, corn, and soybeans were developed, forming a new local agricultural landscape. A win-win situation was achieved with enterprise development, village collective economic growth, and increased farmer income.

3.2 Summary of experience As seen from the above cases, land resources in mountainous areas face problems such as severe farmland fragmentation, poor farmland quality, increasingly acute human-land conflicts, inadequate public infrastructure, chaotic layout of construction land, and fragile ecological environment. The root causes of these problems lie in the inefficient utilization and ecological degradation of land resources in mountainous areas. These severely constrain the socio-economic development and ecological environmental protection of the mountains, impacting the prosperity of mountain industries, ecological livability, and the construction of beautiful villages. They pose significant challenges to comprehensive rural revitalization. Comprehensive land consolidation addresses this by optimizing land resource allocation, improving ecological environment quality, formulating scientific and rational consolidation strategies, achieving sustainable utilization of mountainous land resources, and laying a solid foundation for rural revitalization in mountainous areas. In summary, the practical experience of comprehensive land consolidation in mountainous areas boosting rural revitalization can be condensed into the following five aspects (Fig. 3).

3.2.1 Scientifically preparing plans and optimizing spatial pattern. Based on the natural resource endowment of the consolidation area and fully considering factors such as mountainous topography and the ecological environment, it is necessary to formulate a comprehensive land consolidation plan compatible with territorial spatial planning, enhancing the plan's feasibility and operability. It is necessary to scientifically delineate ecological protection redlines, permanent capital farmland, and urban development boundaries, comprehensively optimize the spatial layout, rationally plan land for rural industrial development, infrastructure construction, and ecological protection, providing spatial guarantee for rural revitalization. It is necessary to strengthen the supervision and management of plan implementation to ensure the smooth execution of the plan.

3.2.2 Leveraging platform functions to build the "land consolidation plus" model. It is necessary to fully leverage the platform function of comprehensive land consolidation and enrich the consolidation content based on local conditions. It is necessary to utilize the unique resource advantages of mountainous areas in different regions to develop industries such as characteristic agriculture and ecotourism, promoting the integrated development of primary, secondary, and tertiary industries. It is necessary to implement projects such as farmland quality improvement and reclamation of abandoned homesteads to enhance land use efficiency and increase effective farmland area. It is necessary to promote agricultural technologies like water-saving irrigation and slope terracing to increase agricultural production efficiency. By improving farmland quality and supporting infrastructure, external capital investment

can be attracted, leading to the exploration of models such as land transfer and shareholding cooperation, thereby promoting large-scale and intensive land management. It is necessary to cultivate new types of agricultural business entities, extend the industrial chain, and increase added value. It is necessary to strengthen brand building to enhance the market competitiveness of characteristic mountain products.

3.2.3 Strengthening ecological protection and restoration to create harmonious and beautiful countryside. Comprehensive land consolidation in mountainous areas must prioritize implementing ecological protection and restoration projects such as soil erosion control, rocky desertification control, and mine ecological restoration to restore and enhance ecosystem functions. It is necessary to

integrate land consolidation with ecological protection and restoration. In eligible areas, it is necessary to promote the mutual transformation of "lucid waters and lush mountains" into "invaluable assets", develop green industries such as ecological agriculture and under-forest economy, optimize ecological industries, leverage ecological resource advantages, tap into the multiple values of ecological products, and achieve the unity of ecological and economic benefits. It is necessary to advance the improvement of the rural living environment to enhance village appearance. It is necessary to use the proceeds from consolidation for rural public infrastructure construction, plan and lay out residential areas according to local topography and folk cultural characteristics, creating a picture of harmonious coexistence between humans and nature.

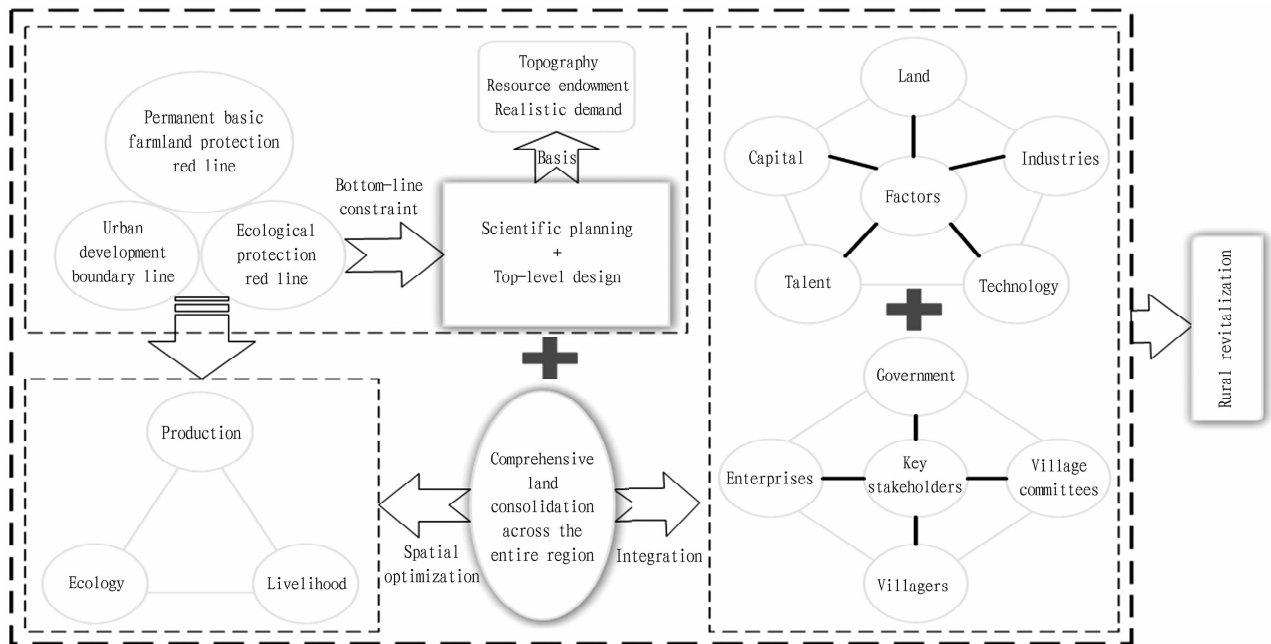


Fig.3 Practical experience of comprehensive land consolidation in mountainous areas for rural revitalization

3.2.4 Encouraging multi-stakeholder participation to fully leverage the primary role of the masses. It is necessary to establish a governance model characterized by "government leadership, farmer participation, departmental coordination, social involvement, enterprise support, and market operation" to encourage multiple stakeholders to participate in comprehensive land consolidation in mountainous areas. It is necessary to strengthen publicity and education to enhance farmers' understanding and comprehension of comprehensive land consolidation. It is necessary to establish and improve farmer participation mechanisms, fully respect farmers' wishes, and safeguard their rights to information, participation, and decision-making. Through reasonable benefit distribution mechanisms, it is necessary to effectively protect the legitimate rights and interests of the masses, ensure farmers gain tangible benefits from consolidation, and stimulate their enthusiasm for participation.

3.2.5 Broadening funding channels and coordinating funds effectively. It is necessary to increase fiscal funding support and establish special consolidation funds. It is necessary to promote urban-

rural integrated development through comprehensive land consolidation, accelerate the two-way flow of funds, talent, *etc.*, between urban and rural areas, actively guide social capital participation, strengthen market-oriented operations, attract investments from enterprises and financial institutions through models like PPP, EPC general contracting, and land transfer income mortgages. This alleviates difficulties in fund matching and the problem of singular financing channels, easing fiscal pressure. Simultaneously, it is necessary to integrate various types of agriculture-related funds to improve fund utilization efficiency. For eligible consolidation projects, it is necessary to actively apply for funding support policies related to territorial space ecological protection and restoration projects, obtain credit preferences, *etc.*, and improve the linkage mechanism between government investment and financial and social inputs.

4 Conclusion and discussion

Comprehensive land consolidation in mountainous areas is a

crucial measure to solve land use problems, optimize land resource allocation, improve the ecological environment, promote rural industrial development, and enhance farmers' living standards in the mountains. It is an important means and effective pathway to drive rural revitalization in mountainous areas, aiding in the achievement of all objectives of comprehensive rural revitalization.

In the implementation process of comprehensive land consolidation in mountainous areas, it is essential to conduct thorough and detailed consolidation suitability evaluations based on the characteristics of the target mountains, formulate scientific plans, ensure the operability of consolidation measures, and carry out differentiated consolidation tailored to local conditions. Attention must be paid to the fact that mountain land consolidation should not solely pursue quantity increase but should prioritize the improvement of quality post-consolidation. Consolidation should adopt a holistic perspective, integrate various resources, and emphasize integration with rural industrial development and ecological environment restoration to achieve sustainable utilization of land resources and coordinated socio-economic development in mountainous areas. Consolidation also requires strengthened policy support and guarantees, encouragement of multi-stakeholder participation, expansion of funding channels, and increased marketization.

Due to differences in natural endowments and economic development gaps among regions, the three case studies of comprehensive land consolidation in mountainous areas selected in this paper cannot encompass all possible consolidation measures. Future efforts should further strengthen research and practice on comprehensive land consolidation in mountainous areas, continuously improve consolidation models and mechanisms. By leveraging surveying, mapping, and geographic information technologies, it is necessary to provide full lifecycle technical support—from formulating consolidation plans to monitoring progress—enhancing consolidation effectiveness. This will offer more solid support for the comprehensive revitalization of mountainous villages and achieve sustainable socio-economic development in mountainous areas.

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County government can cultivate new quality productive forces and assist in the development of *G. pentaphyllum* industry through the following channels: developing digital agriculture talent through education-technology-talent synergy to energize agricultural modernization; establishing technology incubation platforms via government-university-enterprise collaborations to accelerate research commercialization; creating new industrial formats through agricultural integration with health, education, culture, and tourism sectors to enrich agricultural development channels, and promote agricultural transformation and upgrading^[15].

6 Conclusion

While possessing large-scale production foundation, Pingli's *G. pentaphyllum* industry requires technological empowerment, brand upgrading, and industrial chain extension for high-quality development. Through policy-market synergy in the next five years^[9], the industry is poised for breakthroughs, potentially becoming a model for rural revitalization in the Qinba Mountain region.

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