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Analysis and Research on Typical Cases of Land Engineering and Rural Sustainable Development

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Abstract: To address genuine problems of large tracts of abandoned land, unused land, and degraded land encountered in rural development in China during the transition period, this paper analyzes typical cases of Yucheng, Yan'an, and Yulin, and systematically interprets the role of land engineering technology in ensuring land and food security, coordinating the rural man-land relationship, and promoting efficient rural land use. The relationship between land engineering and rural sustainable development are investigated. Findings indicate that comprehensive rural land consolidation engineering can help with rural reconstruction, and also enhance rural resilience against external shocks and fluctuations. Land consolidation engineering is an effective way to enable a strategy of rural vitalization, and an important measure for its implementation. It is suggested that land consolidation engineering should fully consider rural suitability and adapt to local conditions, and be realized through scientific planning and design.

Keywords: land engineering; rural restructuring; rural vitalization; rural resilience; sustainable development

1 Introduction

China has undergone rapid industrialization and urbanization in the last 40 years since the reform and opening-up program was launched. During this process, the rural man–land relationship has dramatically changed. There are contrasting realities: many young rural workers—172 million in 2017—toiled outside on the land; yet conversely, rural "hollowing" has spread over time, leading to a steady rise in abandoned and unused rural construction land. Calculations show that comprehensive "hollowing village" consolidation across the country is expected to increase land up to 1.14×10^8 mu (1 mu is approximately 666.67 m^2) [1]. Meanwhile, rural communities have faced issues such as excessive resource consumption and a worsening ecological environment. Moreover, emerging challenges including rural economic recession, low agricultural benefit, and shortages in public services and infrastructure resulting from rural population loss, have severely restricted the sustainable development capacity of China's vast rural environs, making it imperative to place a high value on rural revitalization [2–6].

Land, the most basic production factor, plays a critical role in supporting rural sustainable development, mainly represented by the constrained nature of land area, scarcity of resource supply, and interchangeability of typical land function [7]. China is a country with many people on limited land, making the per capita land area less than

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one-third of the world's average and the per capita quantity of cultivated land just 40% of the world's average. Over the years, China has witnessed a steady decrease in premium cultivated land resources (non-agriculturization, disusing and contaminated land) and serious land degradation (desertification, salinization, and water and soil loss) amid rapid urbanization and industrialization, posing significant threats to land quantity and quality and directly affecting the sustainable development of agriculture and rural communities in China [8–13].

China is making extensive efforts to advance technological innovation in national land and resources, through deep land exploration, deep-sea exploration, deep space earth observation, and innovation in land science and technology. These efforts take into account the current status quo of land resources, food security guarantee, and the need to construct an ecological culture. Innovation in land science, technology, and deep explorations are the key points of strategy for national land and resources during the 13th Five-year Plan period. This emphasizes the role of land engineering technology in improving cultivated land quality, consolidating degraded land, utilizing wasted land, and restoring land ecology, and strengthens the application of engineering-based and ecology-based technologies in land consolidation. It promotes optimized development of mountains, water bodies, farmlands, forests and lakes, and production, living, and ecological spaces of communities. Based on typical case analysis, this paper summarizes the role of land engineering in facilitating sustainable rural development from different perspectives, and presents corresponding policy suggestions for building a sustainable territorial system for the rural man-land relationship based on a rural revitalization strategy.

2 Evolution and development journey of rural land engineering

Land engineering is a process that can help foster a harmonious relationship between man and land. It addresses land issues through engineering, changing unused land to available land, or utilizing used land in an efficient and sustainable way. At its core, there is a theory: organic restructuring of the soil body [14]. The role of land engineering has grown, from improvement of agricultural production in its early days to its current wider purpose of bettering rural production conditions, employment, infrastructure, and public utilities [15]. From as early as the 1780s, Denmark in Northern Europe and other countries put land reform into action through land consolidation in order to address the issue of land fragmentation. After the Second World War, the engineering practice of modern land consolidation was initiated in Western Europe. Germany, the birthplace of modern rural land consolidation, valued the adjustment of property rights, the combination of farmland parcels, and the planning preparation in rural land consolidation [16], and conducted unified planning and construction of rural land by practicing land consolidation in order to adjust rural industrial structure, enlarge the scale of farm operation, improve farmland irrigation and drainage conditions, and enhance rural housing, communication and other facilities. Rural land consolidation in Germany enabled villages to transition from traditional agriculture to multifunctional and comprehensive development, whilst protecting the rural environment, landscape, and culture, and improving people's wellbeing. The "Bavaria Test," conducted in Germany's State of Bavaria in the 1960s, sought to rebuild villages through land planning and consolidation; it was a success story in which land engineering advanced rural sustainable development [17]. Similarly, rural land consolidation also played an integral part in enabling Japanese rural development, including rural infrastructure consolidation, village consolidation, and farmland protection. Prior rural land consolidation in Japan was mainly designed to increase land and grain cultivation by constructing paddy field drainage and irrigation facilities, and reclaiming farmland. In other words, from the mid-1960s to the mid-1970s, rural land consolidation in Japan largely addressed the issue of farmland fragmentation by constructing farmland water conservancy facilities and leveling land. This expanded the size of farmland operations, adjusted the structure of agricultural production, and achieved agricultural mechanization. Since then, rural land consolidation in Japan has gradually shifted to the comprehensive construction of rural infrastructure and improvements in the community's living environment [18].

Large-scale land consolidation in China started from the *Notice of the Central Committee of the Communist Party of China and State Council on Enhancing Land Management and Protecting Cultivated Land* announced by the State Council in 1997 [19]. On the basis of ensuring the dynamic balance of all cultivated land, land consolidation has developed widely and meticulously in China. Central and local bodies dedicated to land consolidation have been established, and a relatively integrated land consolidation execution system has been initiated. As a result of more than 20 years of development, land consolidation practices have gradually evolved from farmland consolidation to village consolidation, and some areas have combined farmland consolidation with the consolidation of construction land while implementing comprehensive regional land consolidation within the scope of entire towns and villages. Currently, China has diversified objectives, goals, and models of land

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consolidation; the country is working to optimize urban-rural land use structure and arrangements, improve the ecological environment of the land, and enhance the quality and grain production capacity of cultivated land. It is coordinating the relationship between comprehensive land consolidation and cultivated land protection, industrial development, and urban-rural development by connecting land consolidation with the increase or decrease of urban-rural construction land. This promotes the integrated consolidation of farmland, water bodies, road networks, forests, and villages (i.e., integration of resources), and allows for overall planning and aggregation of funds [20]. To sum up, land engineering has adapted to the practical needs of the changing rural man–land relationship and the restructuring of rural space amid rapid urbanization and industrialization in China. In short, land engineering helps with rural sustainable development [21,22].

3 Typical practices of land engineering and rural sustainable development

3.1 Comprehensive consolidation project of hollowing villages in Yucheng, Shandong

For now, China's extensive rural community is faced with worsening "hollowing" and, as the rural population migrates, the land of rural settlement has increased rather than decreased, and has become the major obstacle to rural revitalization and urban-rural integration. This has imposed urgency on the comprehensive consolidation of "hollowing villages." This paper uses the Yangqiao Community in Lunzhen Town, Yucheng City, Shandong Province as an example to analyze the relationship between the comprehensive consolidation project of "hollowing villages" and rural sustainable development. The analysis is based on a demonstration of the comprehensive consolidation of "hollowing villages" and its findings through critical technology research—a topic under the national sci-tech support plan.

Located in the southwest part of Lunzhen Town, the Yangqiao Community project involves the consolidation and combination of 11 villages, including Yuanying, Juntun, Dingzhuang, Shihusong, Wasun, Hebeizhang, Yangqiao, Hekouzhao, Zhuwang, Qinzhuang, and Hekouli. In all, 4536 people are expected to be resettled. The project plans of Phase I aim to resettle five villages, namely Zhuwang, Hekouzhao, Hekouli, Yangqiao, and Qinzhuang, consisting of 489 households and a total of approximately 1500 people. Using remote-sensing images, aerial photos from unmanned aerial vehicles, and field study, the project actualized data on the status quo of land utilization, such as the degree of "hollowing" and house site utilization pattern of these villages, and measured the potential for village land consolidation. As presented in Table 1, the house site utilization rate of five villages involved in Phase I of the project is lower, with ample idle land, including unused and abandoned house sites, making them typical "hollowing villages." The number and size of abandoned and unused house sites of the five villages account for 29.72% and 28.45% of the average value of total number and area of house sites, respectively. The consolidation potential of the five villages averaged 565.83 mu each, with a consolidation land increase rate of 24.17%.

Table 1. Land use conditions and land consolidation calculations of some villages of Yangqiao community.

Villages	In use		Unused		Abandoned		Land consolidation calculations	
	Proportion of number (%)	Proportion of area (%)	Proportion of number (%)	Proportion of area (%)	Proportion of number (%)	Proportion of area (%)	Consolidation potential (mu)	Land increase rate via consolidation (%)
Yangqiao	64.98	66.71	23.63	21.80	11.39	11.49	813.15	25.29
Zhuwang	67.44	67.35	4.65	5.26	27.91	27.37	351.60	17.89
Hekouzhao	73.85	75.25	20.77	19.94	5.38	4.82	313.35	19.97
Hekouli	72.73	76.43	24.24	21.91	3.03	1.66	493.05	27.78
Qinzhuang	74.14	74.51	21.84	22.38	4.02	3.11	858.00	29.91
Average value	70.28	71.55	21.52	20.63	8.20	7.82	565.83	24.17

Based on scientific planning and design, Yangqiao Community selected a site within the central area of the 11 villages to facilitate resident mobility and agricultural production. The act of reclaiming house sites and converting them into farmland follows the principle of backfilling surface soil and balancing earthwork. When the direction of reclamation is farmland, surface soil should be backfilled at the thickness of no less than 20 cm, and when the direction of reclamation is cultivated land, the backfilling thickness should exceed 30 cm so that the thickness of the soil layer meets relevant requirements and reduces field slope. Meanwhile, in this case, the project also expedited the implementation of a "three-in-one" engineering technology plan which included soil body creation, soil layer reformulation, and soil texture improvement for the area. The first layer was filled with abandoned bricks, tiles, concrete blocks, and other construction waste arising from the demolition of "hollowing villages," with a filling depth of 0.3 m and is then grounded six times by a crawler excavator. The second layer is filled with wall soil, courtyard soil, and other rural soil with fewer stones and bricks to a filling depth of 0.35m. The third layer consists of four types of matter based on different soil layer reformulation plans, namely courtyard soil, reformulation of courtyard soil and swag sediment, reformulation of courtyard soil and sand, and reformulation of saline-alkali soil and sand, and has a filling depth of 0.35 m. Reclaimed cultivated land and original cultivated land are converted into agricultural enterprises in a unified manner to realize scale operation. While earning rent, peasant households are freed from agricultural production and can continue to engage in non-agricultural production for a higher income (Fig. 1).

(a) Aerial photos of idle and abandoned house sites of Yangqiao Village

(b) Abandoned house sites of Yangqiao Village

(c) New-type residential community

(d) Reclamation of house sites to cultivated land

Fig. 1. Comprehensive consolidation project of hollowing villages of Yangqiao community.

The core of the land consolidation of "hollowing villages" lies in the replacement of land use and optimization of the spatial pattern. When it comes to functional orientation, the construction of Yangqiao Community reinforces the fact that one instance of consolidation can deliver returns in three ways when assessed as part of overall planning of urban-rural land use in the region. Land is increased by village consolidation, returning village land to farmland, forest, and garden (construction) through village land consolidation [23]. In addition, the construction of Yangqiao Community took into consideration the lives of residents, agricultural production, and the ecological environment. As a result of this new type of community construction and reclamation of house sites to farmland, the sweeping consolidation project of "hollowing villages" has not only vitalized idle land resources of villages, but also optimized spatial patterns of villages, revamping production, living, and ecological spaces.

3.2 Key ditch governance, land reclamation and land consolidation project of Yan'an, Shaanxi

China has been engaged in the project of returning grain plots to forestry since 1999, in order to reclaim large areas of cultivated land to forestry, shrub, and grassland. This project aims to improve water and soil loss in ecologically fragile areas, including the Loess Plateau. As the most important ecological restoration project in China, USD 28.8 billion has been allocated in the last ten years to reclaim farmland in areas with more than a 25° slope [24]. Between 1999 and 2011, the project to reclaim grain plots for forestry spanned an area of 2.9×10^7hm^2, 9.3×10^6hm^2 of which was reclaimed from original cultivated land, and 1.97×10^7 hm^2 was reclaimed from barren

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hills and desolate beaches. Yan'an is located in the heart of the Loess Plateau and, as a result of long-term and effective reclamation of grain plots to forestry, the coverage rate of forest and grassland rose from 46% in the year 2000 to 67.7% in 2013.

However, the implementation of the project of returning grain plots to forestry has led to a significant decline in cultivated land in the project area. Between 1996 and 2009, Shaanxi province witnessed the reduction of cultivated land by 1.14 × 10^6hm, accounting for about 28.6% of total cultivated land of Shaanxi province in 2009. In the meanwhile, after the compensation period for returning grain plots to forestry expired, local farmers were urgently in need of new land for cultivation and grain production; otherwise they might once again deforest and reclaim wasteland on mountains. Chen Yiping et al. believed that expanding the project scale after the first project cycle of returning grain plots to forestry ended in 2013 would generate food shortages in the project area [25]. In order to sustain the effects of the project and help people in the project area develop, earn income, and ensure food security, the Ministry of Land and Resources, Ministry of Finance, and other authorities authorized Yan'an to implement the key ditch governance and land reclamation project (2013–2017) in 2013, involving a total of 5.067 × 10^5 mu land of 134 towns and townships of 13 counties of the city, and an investment of RMB 4.83 billion through national funding. According to the master spatial layout of returning grain plots to forestry on mountains and ditch governance and land reclamation down the hills, the key project facilitated the integrated development of farmland, dams, roads, forests, channels, drainage systems, reconverted farmland, and industry. It did so by utilizing integration technologies of land engineering, and soil and water conservation engineering, such as recombination construction, biological recovery and land improvement, and ecological protection and landscape reshaping. This realized the goal of comprehensive land consolidation of the Loess Plateau area [26]. First, the project effectively enhanced the capacities of channels to prevent and control flooding, control sediment deposits, reduce erosion, and maintain the balance of regional water resources, thus elevating the water- and fertilizer-retaining capacities of the soil [27,28]. Moreover, the project comprehensively analyzed slope texture, and then restored vegetation by selecting crops in a scientific and reasonable way before planting them on channel slopes, thereby effectively boosting the ability of slope soil to resist water erosion and, thus, maintaining the stability of the entire slope.

The ditch governance and land reclamation project has led to square farmland, connected channels and roads, overall improvement in land development and utilization quality, and significant enhancement of agricultural production conditions (Fig. 2). More importantly, the productivity of newly-increased cultivated land with channels is three times that of mountaintop cultivated land, and five times that of slope cultivated land. This has effectively avoided and eliminated deforestation and wasteland reclamation by the public in ecologically fragile areas, protected the achievement of returning grain plots to forestry, and enhanced the quality of the land ecological system of the Loess Plateau area. Over the years, as a result of the scale operation and development of agricultural mechanization, grain production in this area has changed from being defined as "extensive cultivation" to now being defined as "higher yield." The statistical data of five prefecture-level cities in Shaanxi province indicates that, as the project of returning grain plots to forestry was implemented, seeded area was down from 2.28 × 10^6 hm^2 to 1.87 × 10^6 hm^2, while the per hectare grain output was up from 3.07 t to 4.28 t from 1996 to 2012 [29,30].

3.3 Land consolidation and modern agriculture dual-optimization project of Yulin, Shaanxi

Agro-pastoral transition zones in the north of China are characterized by an arid and semiarid continental monsoon climate, poor natural conditions such as frequent drought and wind-sand disasters, severe water and soil loss, and weak infrastructure, which have led to land desertification and degradation, and consequently declining productivity—severely damaging people's production and life experiences [31,32]. As population has steadily increased over time, coal and other mineral resources have been developed intensively, and irrational land use has imposed greater pressure on the ecological environment. This has sparked severe damage to the ecological system of the northern part of Shaanxi, causing imbalance in the agro-pastoral structure, low and unstable agricultural production, and worsening land desertification and degradation in the area.

In 2015, the Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, worked with the Institute of Agricultural Science of Yulin to establish the "Test Station of Yulin Modern Agriculture Dual-Optimization Project," with a view to provide the best soil formulation ratios for crop growth in agro-pastoral transition zones, planting the best and most suitable crops in different soils, and selecting suitable crop varieties based on different soil formulation ratios through the land consolidation project (Fig. 3). After extensive tests, the study developed the composite technology system for optimized formulation of soil body, and optimized selection of improved varieties of modern agriculture for land consolidation. The study promotes the refined consolidation of degraded land and precisely promotes improved varieties, realizing order-based land consolidation and the planting of improved crops on fertile land. It provides scientific and technological support for the linked development of degraded land consolidation and modern agriculture in agro-pastoral transition zones in the north of Shaanxi (Yulin).

Fig. 2. Key ditch governance and land reclamation project of loess plateau.

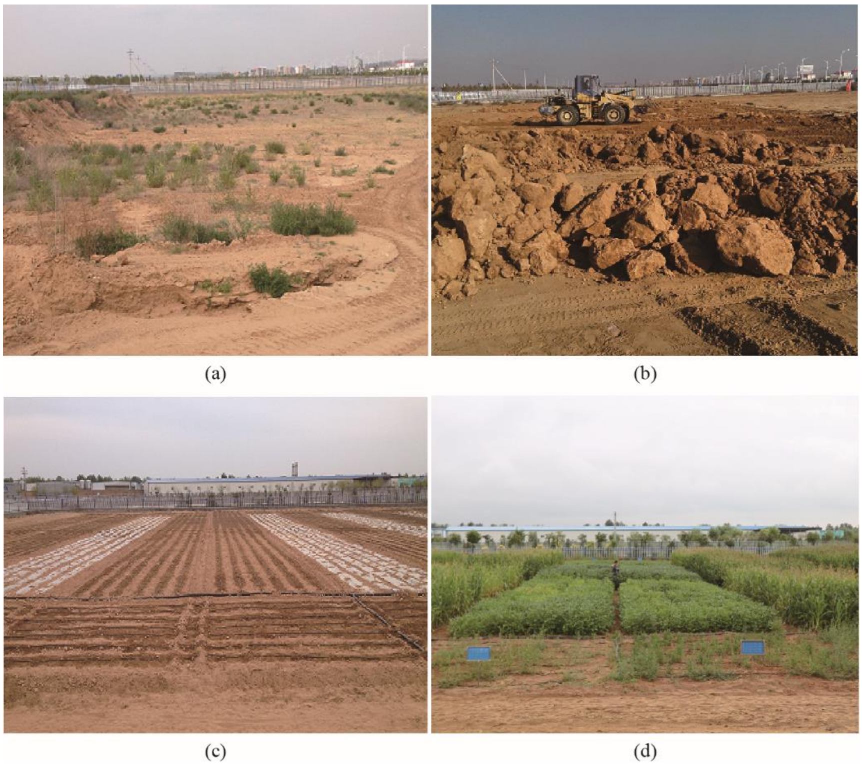

Fig. 3. Test station of Yulin modern agriculture dual-optimization project.

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Based on traits and peculiarities of sandy land, such as poor water-retaining and fertilizer-retaining capacity, the test chooses materials available locally, and mixes red clay and loess widely abundant in Yulin as clay and powder particles with sand in the ratios of 1:1, 1:2, 1:3, and 1:5 respectively. Meanwhile, crops (corn, soybean, and potato) are planted in soil bodies with the same ratios and different composites (sand and red clay, sand and loess) to conduct contrast analysis. To ensure the reasonable structure of newly-built soil bodies, it is necessary to crush large blocks of red clay and loess to the size of less than 5 cm, so that particles will fill the gaps between sand grains. In order to ensure a rational soil level after mixing, the sandy soil is covered with 30 cm of red clay or loess, then that layer is covered by 15 cm of original sandy soil, after which a cultivator ploughs the surface sandy soil with the top 15 cm of red clay or loess below it several times to fully mix them, creating a ploughed layer of soil with a thickness of 30 cm (with the remaining 15 cm of red clay or loess at the bottom serving as the water-retaining and fertilizer-retaining layer). Organic fertilizer and chemical fertilizer are applied to the newly-reformulated soil to increase nutrition content and speed up the maturing process of the soil.

Indicators that need to be monitored in the test include the emergence rate, plant height, stem, output and quality of crops, composition of soil particles, aggregate, unit weight, organic matter and other physical characteristics, total nitrogen, total phosphorus, total potassium, available nitrogen, available phosphorus, available potassium and other chemical characteristics of soil, microbial community structure, abundance of microbial functional gene of nitrogen cycle, diversity, and other biological characteristics of soil. By observing, monitoring, and comparing the growth and output of corn, potato, and soybean under different reformulation plans, the test selects the best reformulation ratios suitable for the growth of different crops. The test will provide technological support for increasing the quality of degraded land and optimizing the formulation of soil suitable for crop growth in agro-pastoral transition zones. It will additionally build the water-retaining and fertilizer-retaining capacities of reformulated soil body through reformulation engineering, and reduce the pressure of agricultural production on resources and environment.

4 Conclusion and discussion

By analyzing the typical cases of Yucheng, Yan'an, and Yulin, the paper methodically interprets the role and effect of land engineering technology in the consolidation of idle and abandoned land, the governance of unused land, and the restoration of degraded land (see Fig. 4). The existence of a comprehensive rural land consolidation project has made flexibility possible in the face of a changing rural man-land relationship, background development and objective needs for water and soil environment changes in agricultural production—all amid China's rapid urbanization and industrialization. By carrying out land engineering practices, rural communities will see improved quality in cultivated land, better quality of public life, and the conservation of the ecological environments. This optimizes rural production, enhances living space and the ecological area, and safeguards cultivated land and food security, whilst promoting agricultural operations of scale, and advancing conservation-minded and intensive utilization of rural land resources.

Currently, China's efforts to advance a rural revitalization strategy are all-embracing and far-reaching. The country's immense rural areas are less able to adapt to external shocks and changes due to factors of rapid non-agriculturization production and the swift aging and weakening of rural players. As a comprehensive territorial system, villages need to reconstruct their social and economic forms and optimize territorial spatial patterns by revamping allocation and effectively managing material and non-material elements which affect rural development. In doing so, they can reform and elevate internal structure and enhance the function of rural territorial systems, and coordinate and complement functions among urban-rural territorial systems [33,34]. During this process, land engineering can effectively integrate and allocate land resources, and reconstruct rural spatial patterns, providing a means for the transition of economic and social development in rural territories. Scientific and effective land engineering is conducive to improving the stability of rural territorial systems (economy, society and ecology), reshaping rural development formats, coordinating the rural man-land relationship, and enhancing the capacity of rural territorial systems to cope with external changes and shocks; in other words, bolstering rural resilience. Beyond that, the combination of land consolidation engineering with the construction of high-standard farmland, reform in rural land property rights systems, and linked increase and decrease of urban-rural construction land will help realize the transition of rural land from resources to assets and capital, becoming an effective way to advance rural revitalization strategy, and lay a solid foundation for rural sustainable development.

The comprehensive rural land consolidation project should adapt to local conditions. It is vital to honor period features and practical demands of rural territorial development and act in accordance with rural residents whilst expediting land consolidation engineering that respects local conditions and is enacted on the basis of scientific planning and design. Moreover, during the implementation of land consolidation, it is essential that the attributes of traditional rural life and collective memory are preserved, such as bridges, ancient dwellings, and mature trees, so countryside culture may endure.

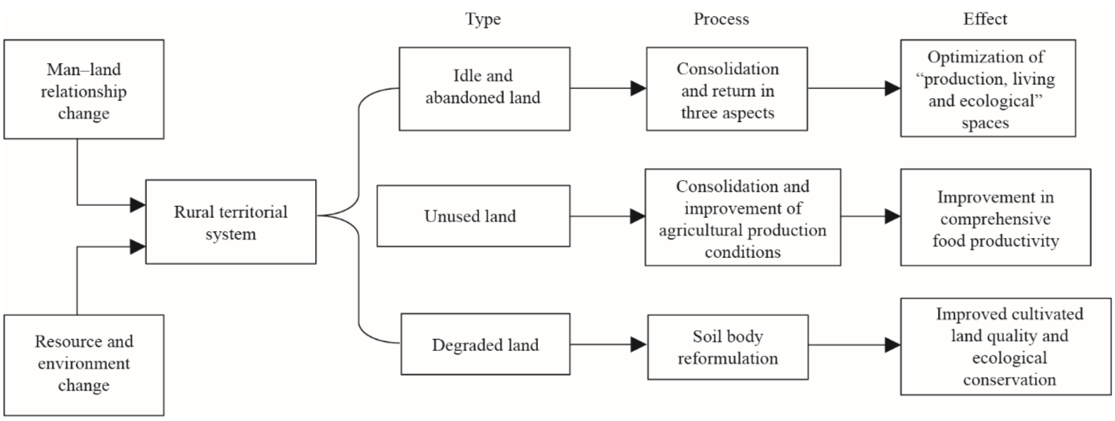

Fig. 4. Mechanism diagram of comprehensive rural land consolidation.

References

[1] Liu Y S, Long H L, Chen Y F, et al. China's rural development research report—Rural hollowing and its consolidation measures [M]. Beijing: China Science Publishing & Media Ltd., 2011.Chinese.

[2] Wood R E. Survival of rural America: Small victories and bitter harvests [M]. Lawrence, KS: University Press of Kansas, 2008.

[3] Woods M. Rural geography: Processes, responses and experiences in rural restructuring [M]. London: SAGE Publications Ltd., 2005.

[4] Carr P J, Kefalas M J. Hollowing out the middle: The rural brain drain and what it means for America [M]. Boston: Beacon Press, 2009.

[5] Li Y H, Liu Y S. Investigation of the resource & environment issues in the urban-rural transition in China [J]. Economic Geography, 2013, 33(1): 61–65. Chinese.

[6] Liu Y S, Li Y H. Revitalize the world's countryside [J]. Nature, 2017, 548: 275–277.

[7] Ye Y M, Wu C F. The basic theories, subject construction and technique support system of land science [J]. China Land Science, 2002 (4): 4–9. Chinese.

[8] Zhao Q G, Luo Y M, Teng Y. strategic thinking on soil protection in China [J]. Acta Pedologica Sinica, 2009, 46(6): 1140–1145. Chinese.

[9] Zhang G L, Wu Y J, Zhao Y G. Physical suitability evaluation of reserve resources of cultivated land in China based on SOTER [J]. Transactions of the Chinese Society of Agricultural Engineering, 2010, 26(4): 1–8, 392. Chinese.

[10] Lu S J, Wang Y Y, He L H. Soil environmental quality survey and monitoring in China [J]. Environmental Monitoring in China, 2014, 30(6): 19–26. Chinese.

[11] Xing F L. The release of monitoring report of China's desertification [N]. China Environmental News, 2015-12-30(001). Chinese.

[12] Li Y H, Li Y R, Westlund H, et al. Urban-rural transformation in relation to cultivated land conversion in China: Implications for optimizing land use and balanced regional development [J]. Land Use Policy, 2015 (47): 218–224.

[13] Liu Y S. Introduction to land use and rural sustainability in China [J]. Land Use Policy, 2018 (74): 1–4.

[14] Han J C. Introduction to land engineering [M]. Beijing: China Science Publishing & Media Ltd., 2013. Chinese.

[15] Pašakarnis G, Maliene V. Towards sustainable rural development in Central and Eastern Europe: Applying land consolidation [J]. Land Use Policy, 2009, 27(2): 545–549.

[16] Magel H. Land consolidation and village renewal [D]. Munich: Technical University of Munich, 2007.

[17] Stroessner G. Land consolidation in Bavaria: Support given to rural areas [J]. Irrigation Engineering and Rural Planning, 1986 (9): 53–59.

[18] Yuan Z Y, Du J F, Wang F. Experiences of land consolidation in China and its implications for China [J]. Land and Resources Information, 2012 (3): 15–19. Chinese.

[19] Yun W Q, Zhu D L, Tang H Z. Reshaping and innovation of China land consolidation strategy [J]. Transactions of the

DOI 10.15302/J-SSCAE-2019.02.013

Chinese Society of Agricultural Engineering, 2016, 32(4): 1–8. Chinese.
[20] Xia F Z, Yan J M. Research on transformation development of land consolidation under the background of new-type urbanization in China [J]. Social Sciences in Ningxia, 2014 (4): 28–31. Chinese.
[21] Long H L. Land consolidation: An indispensable way of spatial restructuring in rural China [J]. Journal of Geographical Sciences, 2014, 24(2): 211–225.
[22] Li Y H, Wu W H, Liu Y S. Land consolidation for rural sustainability in China: Practical reflections and policy impli cations [J]. Land Use Policy, 2018 (74): 137–141.
[23] Liu Y S, Zhu L, Li Y H. The essential theories and models of rural land consolidation in the transitional period of China [J]. Progress in Geography, 2012, 31(6): 777–782. Chinese.
[24] Feng X M, Fu B J, Lu N, et al. How ecological restoration alters ecosystem services: An analysis of carbon sequestration in China's Loess Plateau [J]. Scientific Reports, 2013, 3(2846): 1–5.
[25] Chen Y P, Wang K B, Lin Y S, et al. Balancing green and grain trade [J]. Nature Geoscience, 2015 (8): 739–741.
[26] He C X. The situation, characteristics and effect of the gully reclamation project in Yan'an [J]. Journal of Earth Environment, 2015, 6(4): 255–260. Chinese.
[27] Liu Q, Wang Y Q, Zhang J, et al. Filling gullies to create farmland on the Loess Plateau [J]. Environmental Science Technology, 2013, 47(14): 7589–7590.
[28] Li Y H, Du G M, Liu Y S. Transforming the Loess Plateau of China [J]. Frontiers of Agricultural Science and Engineering, 2016, 3(3): 181–185.
[29] Shaanxi Province Bureau of Statistics. Shaanxi province statistical yearbook (1997) [M]. Beijing: China Statistics Press, 1997. Chinese.
[30] Shaanxi Province Bureau of Statistics. Shaanxi province statistical yearbook (2013) [M]. Beijing: China Statistics Press, 2013. Chinese.
[31] Liu Y S, Zhang X P, Li X W, et al. Mechanism and regulation of land degradation in Yulin District [J]. Journal of Geographical Sciences, 2003, 13(2): 218–224.
[32] Yang S H, Yan H L, Guo L Y. The land use change and its ecoenvironmental effects in transitional agro-pastoral region—A case study of Yulin City in northern Shaanxi province [J]. Progress in Geography, 2004 (6): 49–55. Chinese.
[33] Woods M. Rural [M]. London: Routledge, 2011.
[34] Long H L, Tu S S. Rural restructuring: Theory, approach and research prospect [J]. Acta Geographica Sinica, 2017, 72(4): 563–576. Chinese.