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How does land consolidation affect rural development transformation?

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Abstract: China's rural territory is entering a critical stage of transformation and development. Promoting rural development and transformation is an important path to achieve rural vitalization, and land consolidation is expected to become the starting point to boost rural transformation. To clarify the internal relationship between land consolidation and rural development transformation is an important scientific proposition. This paper constructs a theoretical framework of rural land consolidation (RLC) affecting rural development transformation (RDT), and analyzes the historical evolution process and characteristics of RLC and rural development in China. Based on government interviews and household surveys, this paper analyzes the impact of RLC on RDT under different geographic types and different consolidation models from a multi-subject perspective, and empirically tests the effects using the econometric model. China's rural land consolidation has also gradually transformed to multi-type and multi-functional comprehensive consolidation. The results show that there are many explicit and implicit mechanisms of the influence of RLC on RDT in China, such as mechanism of promotion of industrial development, mechanism of integration of development factors, mechanism of urbanization and mechanism of urban-rural interaction. And the results of different modes of RLC impact on RDT are different. Farmers have a high degree of support and satisfaction with RLC since RLC has improved their production and living conditions as well as household and village income. Besides, the effects of various types of RLC on RDT are positive. The authors argue that constructing human-land early warning mechanisms, optimizing the layout and performance evaluation of RLC and promoting multi-type development and multisystem coordination of RLC can elevate the effect of RLC on RDT. This paper provides reference for scientific decision-making of RDT from the perspective of RLC.

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1 Introduction

Rural settlements have been the origin of and basis for human habitation, survival, and development. However, rapid industrialization and urbanization have exerted various influences on rural society. On the one hand, rural space is constantly being eroded by urban space, which causes the rural area to become a lowland of modern development. This is because land and young labor—the two core elements of rural development—have migrated from rural to urban areas and the excessive use of fertilizers and pesticides in agricultural production has led to serious non-point source pollution problems (Gao *et al*., 2021). Among them, land element is usually occupied by cities and transferred to cities by urbanization expansion and land index. Furthermore, rural industrialization and the burial and incineration of urban waste in rural areas have similarly damaged the rural environment. On the other hand, the rural-to-urban migration of surplus agricultural labor has become an important driving force in China's socioeconomic development and investment in rural development as well as in rural residents' income. Farmers' nonagricultural income is used to support the construction of new houses in the countryside, children's education, and consumption of food and durable goods, which has promoted rural development and upgrading (Long *et al*., 2016; Qu and Long, 2018; Long *et al*., 2022). In general, rural production factors have been used more efficiently than urban factors (Chen *et al*., 2020), but the uneven distribution between the two has lowered the potential for rural development to a certain extent.

Under the multiple forces of globalization, industrialization, urbanization, and informatization, as well as in response to the reorganization of rural production factors, rural territories have entered a transformational stage in both developed and developing countries. However, there are obvious differences in rural resource endowments, levels of agricultural development, and welfare systems in various countries, thus their rural transformations as well as the developmental problems they face vary widely (Guenther, 1986; Onitsuka and Hoshino, 2018). Therefore, reversing the decline of rural development, reshaping the power system of urban-rural development, and revitalizing the countryside will become the key topics in the global urban-rural transformation (Liu and Li, 2017). The key to solving rural issues lies in activating the core elements of rural development.

Land, as a finite resource, connects urban-rural territorial systems and vitalizes other core developmental elements (e.g., population and capital). The transformation of land resource allocation and land management systems can drive comprehensive change in agricultural production methods, rural residents' livelihoods, and rural human-land relationships, which will affect the structure and functions of the entire rural territorial system (Long *et al*., 2020). Land consolidation highlights issues relating to natural resources and socioeconomics through the restructuring and reconfiguration of property rights. Currently, rural China faces a series of dilemmas, such as the aging of the population, environmental degradation, industrial hollowing, and underutilization of land elements (Liu and Li, 2017; Ye *et al*., 2022), but it also has vast developmental resources and potential. The Chinese government releases a rural vitalization strategy seasonally, and the long-standing rural land consolidation policies and projects are important ways to facilitate their implementation. At this key stage of Chi-

na's socioeconomic transformation, it is necessary to further clarify how rural land consolidation affects rural development transformation (hereinafter RDT, the change of rural development paradigm). At present, the academic circle has carried out a series of studies on the impact of land consolidation on agricultural and rural development. Rural land consolidation (hereinafter RLC) is regarded as an important way to coordinate production factors and regional development and thus realize rural development (Borrelli *et al*., 2017). Land consolidation is utilized as an essential means to stimulate economic development and environmental protection globally (Pašakarnis *et al*., 2021). Bryan *et al*. (2018) published an article in *Nature*, pointing out that China's land consolidation projects are active adjustments to the unexpected situation of land system sustainable development, and have greatly enhanced the sustainability of China's land system. Some studies have shown that land consolidation, as a technological means, has greatly improved the economic development level of rural Vietnam (Nguyen and Warr, 2020). In China, as a policy tool used to optimize the structure and efficiency of land use, RLC plays an important role in safeguarding food security, promoting rural economic development and increasing farmers' income, promoting urban-rural integrated development, and incentivizing ecologically friendly construction (Wojewodzic *et al*., 2021). RLC can contribute to the development of in-situ urbanization and the optimization of China's urban space usage by rearranging existing production patterns. RLC activities are exerting a profound influence on land use patterns and influencing the process of rural transformation in China through rural restructuring (Long *et al*., 2019). Specifically, RLC has effectively solved the problem of land fragmentation in rural China caused by institutional factors, thereby improving the mechanization level of agricultural production and thus optimizing rural man-land system (Li *et al*., 2019). It has been proven that RLC has an important impact on rural habitats and biodiversity (Shan *et al*., 2019). Moreover, it is an important means for promoting RDT since it contributes to the creation of employment opportunities, the capitalization of land resources, and the optimization of rural territorial systems. RLC plays an important role in improving rural productivity and sustainability by optimizing the relationship between rural communities and their land. However, its effectiveness is determined by local stakeholders (Gessesse *et al*., 2018; Li *et al*., 2018). What needs to be warned is there are significant spatial differences in RLC projects in China, and the approaches to land consolidation between regions are also quite different. The extent to which RLC affects rural restructuring also varies by region.

The role of RLC in promoting land system optimization and rural sustainable development has been recognized by the academic community. RLC is shaped by engineering and policy factors. On the one hand, it promotes rural development in terms of increasing farmland and output. On the other hand, based on policies such as "Linking Increased Urban Construction Land with Decreased Rural Construction Land" (see, e.g., Long *et al*., 2019; Long, 2020), it contributes to urban development by reallocating urban and rural land elements, which in turn exerts an indirect influence on rural development transformation.

Research on RLC has applied multiple methods to evaluate its effectiveness at different scales, but has neglected its impact on rural development and the systematic theoretical research on the role of RLC in RDT from the perspective of the urban-rural territorial systems. RLC links multiple production factors, so it is necessary to explore the effect of RLC in different regions and different modes of rural development based on the existing human-land

system. What impact does RLC have on RDT in China? Does its impact vary due to regional conditions, consolidation models, and residents' wishes and livelihoods? Considering the differences of the type of rural territory, the developmental stage, and the level of socioeconomic development, this paper will select representative counties from the developed eastern coastal areas, the central hilly area, and the Huang-Huai-Hai Plain agricultural area to recognize the effect of RLC on RDT.

To do so, Section 2 constructs a theoretical framework for how RLC affects RDT. Based on this, multiple quantitative model methods are adopted in Sections 3 and 4 to empirically test the effectiveness and heterogeneity of the impact of RLC on RDT. Section 5 discusses the contributions, defects, and future trends of this research, and then presents our concluding remarks.

2 Theoretical framework of rural land consolidation promoting rural development transformation

2.1 Function and connotation

2.1.1 Function of rural land consolidation

RLC is intended to realize a sustainable relationship between humans and nature. Its main purpose is to solve the problems of the loss of rural development factors and the pollution and inefficient use of land resources and the disorder of "production–life–ecology" space. To this end, planning and design, engineering technology, and other means are essential to consolidating mountains, rivers, forests, farmland, lakes, grasslands, and villages in rural areas to adjust rural human-land relationship to meet the needs of rural endogenous development (Chen and Long, 2020; Zheng *et al*., 2022). RLC in China has gone through four stages, namely arable land supplementation, basic farmland protection and construction, comprehensive consolidation, and national integrated territory consolidation.

Land consolidation projects in China usually treat governments at all levels as the primary entity, who in turn give projects to enterprises or individuals through a bidding process. However, such projects often involve local landowners' contractual rights. On the one hand, farmers will receive compensation from these projects; on the other hand, they can also participate in these projects should they choose to do so. The direct purpose of rural land consolidation is to expand the cultivated land area, improve rural living environments, and optimize rural spatial patterns. The "increasing vs. decreasing balance" policy implemented by the Chinese government makes rural land consolidation projects an important means of raising funding for underdeveloped areas and supporting the development of regional economies.

The transformation of land consolidation based on the government's rural vitalization strategy will become the main force in China's rural land consolidation well into the future. This strategy has endowed RLC with new connotations. RDT has further expanded the functions of RLC in the following ways. (1) *Coordinating and optimizing the rural development system*. By taking land as its basis, RLC activates the population, capital, technology, and other rural development factors through industrial development. The factors flow between the city and the countryside, population migration, etc., and optimize the rural development

system. (2) *Optimizing the urban and rural spatial systems*. The consolidation of rural agricultural land creates conditions for agricultural scale operation, as well as nonagricultural employment opportunities (Rao, 2020) and centralizes rural infrastructure and service facilities (Long and Qu, 2018; Long, 2022), which promotes the construction of central villages. A new form of urbanization—the "village-town"—will enrich and optimize China's urban systems and become an important carrier for the implementation of China's new approach to urbanization (i.e., people-centered urbanization). (3) *Closely connecting urban and rural regional systems*. RLC takes land as the pathway for accelerating the flow of urban-rural development factors, realizing the complementarity of urban-rural functions, and connecting urban-rural territorial systems in terms of space, industry, and manpower.

2.1.2 Connotation of rural development transformation

Rural territorial systems are multifunctional, hybrid, and networked spaces (Woods, 2009; Gao *et al*., 2023). Rural transformation development is a process of reconstructing social and economic forms and territorial spatial patterns in rural territories under the interaction between multiple factors (Woods, 2009; Long, 2020), including changes in the organizational structure of the settlement space, the livelihood of rural residents, the form of industrial organization, and the urban-rural relationship (Liu *et al*., 2016; Long, 2020). There is a difference between rural transformation development and RDT. Rural transformation development focuses more on changes in the developmental level (Francis *et al*., 2022; Ye *et al*., 2023), while RDT is more concerned with developmental forms and paradigms (Figure 1). RDT is reflected through rural transformation development. Rural China is transforming from an agricultural production-led economy to one with multiple functions, such as agricultural production, ecological conservation, tourism, cultural heritage, and social stability.

As globalization continues to deepen, China's countryside has become integrated into the trend toward globalization through grain production, labor migration, and tourism (Liu *et al*., 2022; 2023; Long *et al*., 2022), and the emerging "global countryside" described by Woods (2018) will become a new consideration. Therefore, the concept of RDT can be defined as the process of transforming the rural development paradigm from being strictly productive to being multifunctional and globalized. That is, development paradigm A in Figure 1 is transformed into development paradigm B and C. In this process, the interaction between the core and the external systems of rural development will drive long-term change in rural spaces and functions.

Integrating rural development factors, reorganizing the rural development structure, and optimizing rural development functions are the main pathways to achieving RDT (Chen *et al*., 2023), among which rural spatial transformation and rural residents' livelihood transformation are most important. Rural development transformation usually begins with development factors transformation, and then realizes development structure transformation and finally reaches development functions transformation. However, the three are not absolute in turn, there may be overlapping relationship in the time sequence, and it is a cyclic process.

From the perspective of the rural territorial system, the transformation of rural space is mainly manifested as changing the rural settlement space, including the transformation of landscape and cultural spaces. Based on the perspective of the urban-rural territorial system,

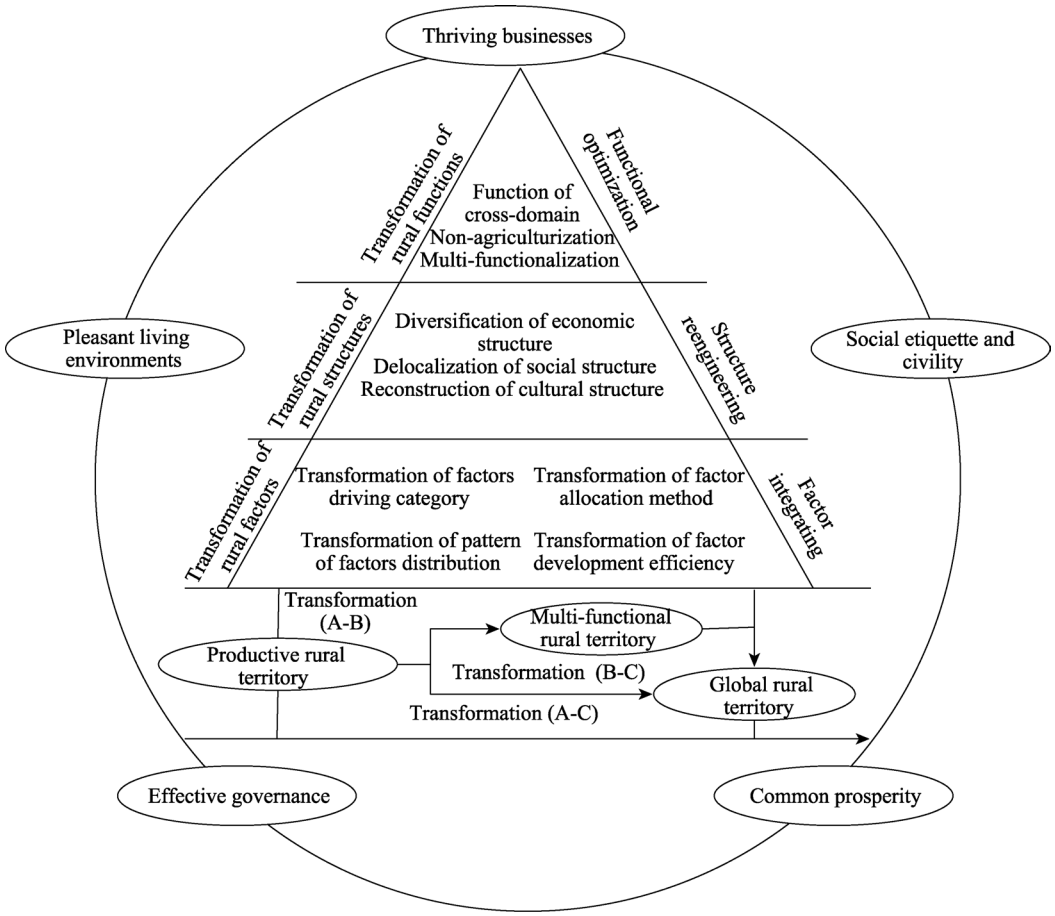

Figure 1 Conceptual framework of rural development transformation

it is the transformation of urban-rural space (i.e., urban spatial expansion and the reallocation of urban-rural land-use indicators) as well as population density and production methods with respect to population growth. Additionally, income and employment, the migration between urban and rural areas, and residential patterns are essential to transforming the livelihoods of rural residents. Further, RDT is both the pathway to and the result of rural vitalization, the purpose of which is to alleviate the issues in uncoordinated urban-rural development with the basic principles of "thriving industry, pleasant living environment, refined rural civilization, effective governance, and prosperous life" (Long *et al*. 2019).

2.2 Evolution and trends

2.2.1 Evolution of China's rural development and policies

Since 1949, China's rural development has made remarkable achievements, but there are still several issues that must be resolved. At the beginning of 1953, the agrarian revolution abolished the feudal land ownership that had been practiced for thousands of years and implemented private land ownership by allocating agricultural land to every farmer. This greatly enhanced farmers' enthusiasm and restored rural economic forces. China established the people's commune system in 1958. In rural China, the practices of land nationalization

and agricultural collectivization were implemented, which lasted until 1978. At this stage, China favored heavy industry and implemented a household registration system that prohibited the free movement of population in order to prevent an agricultural production surplus from accumulating capital and ensure the development of industries and cities. The impairment of development rights in rural China has directly caused the decline of rural areas.

Since 1978, the migration of rural workers into cities has created a strong impetus for China's urbanization and provided financial support for the reconstruction of rural communities. In 2005, the agricultural tax was abolished and thus the scale of agriculture-related investments continued to expand. Rural governance has achieved a historic change from "taking" to "giving." In 2013, the "beautiful rural construction" policy was implemented and emphasized. In 2015, the largest poverty alleviation project in human history was initiated. As of November 2020, China had eliminated the presence of absolute poverty and become the first country to complete the poverty eradication mission of the United Nations 2030 Agenda for Sustainable Development (SDGs). Moreover, in 2017, the Chinese government put forward the national strategy of "rural vitalization," which outlined China's agricultural and rural development goals for the next three decades.

Rural China has undergone a process of transformation from unilaterally serving the city to engaging in urban-rural integrated development. At present, rural China has entered a new stage of its transformation. Accordingly, how to promote the transformation of the rural development paradigm and revitalize rural areas will be its core consideration for the foreseeable future.

2.2.2 Evolution of rural land consolidation

Under the dualistic structure of urban-rural land system, RLC in China is not only an engineering activity that increases production and improves living conditions, but also a policy tool that guides cross-regional and urban-rural land allocation (Chen *et al*., 2020a). In the early days of the founding of the People's Republic of China, the Chinese government tiniti-ated land consolidation campaigns such as the construction of reservoirs. Land consolidation was written into national policy documents in 1997. In 1999, practices intended to "encourage land consolidation" were written into the "Land Management Law." In 2019, the Ministry of Natural Resources launched a nationwide pilot program for land consolidation. RLC in China has gone through four developmental stages: supplementation of arable land, basic farmland protection and construction, comprehensive land consolidation, and comprehensive management of rural landscapes such as mountains, water resources, forests, fields, lakes, and grasslands. RLC has shifted from being a monofunctional land engineering activity designed to increase the area of arable land to a being a multifunctional tool that considers social, economic, and ecological benefits as a whole (Chen and Long, 2020). RLC has also been transformed from taking three traditional forms—namely, agricultural land, empty and abandoned homesteads, and the industrial and mining land (Long and Qu, 2018; Liu *et al*., 2022; Liao *et al*., 2023)—to taking a multitype approach.

2.3 Mechanism: Theoretical analysis

RLC in China is both a type of engineering project and a policy tool that promotes the multidimensional transformation of rural development through the factor, industrial, urbaniza-

tion, and urban-rural interaction channels (Figure 2). In terms of engineering projects, RLC can effectively improve the efficiency of land resource utilization and allocation while using land resources as a link between labor, capital, technology, and other resources. In terms of policy tools, RLC is not only a tool for optimizing the allocation of urban and rural development factors, but also a tool for the spatial restructuring of rural and urban development areas. RLC also connects urban and rural regional systems and facilitates interaction between urban and rural areas. Additionally, RLC has both explicit and implicit effects on rural development transformation.

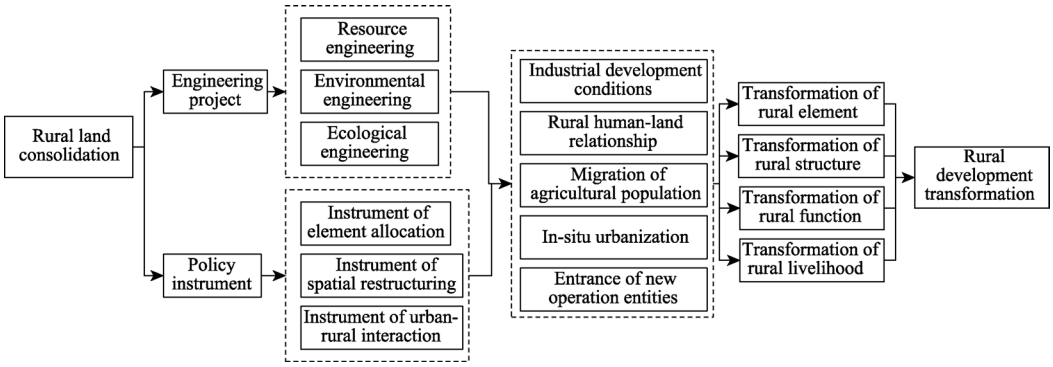

Figure 2 Theoretical framework of rural land consolidation promoting rural development transformation

2.3.1 Mechanisms of RLC promoting rural development transformation

RLC promotes RDT through by optimizing land use conditions and their associated effects. The dominant mechanisms of RLC include the following two aspects. First, it promotes industrial development. RLC can address farmland fragmentation through engaging in engineering projects, improving the flatness of farmland, building roads as well as irrigation and other types of infrastructure to improve agricultural conditions and further increase land use efficiency. The improvement of farmland conditions is conducive to promoting the modernization of the agricultural industry while promoting new businesses to accelerate rural development and transform rural residents' livelihoods through economic development. Second, it integrates development factors. Using land elements as the link, RLC can integrate, optimize, and enhance urban and rural development factors. By improving agricultural production conditions, it optimizes the distribution of the agricultural population. Meanwhile, RLC advances the technological level in rural areas and enhances the productivity of older workers. Additionally, RLC can help promote large-scale agricultural operations, accelerate the cultivation of new business entities, improve agricultural production services, and optimize the allocation of capital and technology in urban-rural areas.

2.3.2 Recessive mechanism

The urban-rural dual system has led to an obvious gap in China's development. RLC promotes RDT through hidden mechanisms such as urbanization and urban-rural interactive development by adjusting the relationship between rural people and land. (1) *Urbanization mechanism*. RLC takes land as the foundation to realigning the rural human-land relationship. On the one hand, it promotes the migration of the surplus agricultural population; on the other hand, it increases nonagricultural employment through industrial development,

which is conducive to urbanization. RLC is also a policy tool that can replace construction land in both rural and urban areas and promote the development of urban space. Urban space has higher production efficiency and offers more employment opportunities, and the spillover effect of urbanization will also effectively promote RDT. (2) *Urban-rural interactive development*. RLC uses population, land, capital, and technology as channels to connect urban and rural areas, improve the efficiency of factor allocation, and promote rural development transformation and the integrated development of urban and rural areas. RLC can optimize the allocation of both urban and rural development space by coupling land resources and the cross-regional allocation of construction land index, and adjusting spatial development.

3 Materials and methods

3.1 Study area

3.1.1 Overview of study area

The impact of RLC on RDT will vary significantly depending on the type of rural territory, the developmental stage, and the level of socioeconomic development. Following the principle of connecting national strategies and highlighting regional differences, this paper selected representative counties from the developed eastern coastal areas, the central hilly area, and the Huang-Huai-Hai Plain agricultural area—namely, Deqing county of Zhejiang province, Liuyang city of Hunan province, and Yucheng city of Shandong province. Three to five typical villages in each county were selected as the typical research area (Figure 3).

Deqing county is located in the most economically developed region of the Yangtze River Delta and has developed industries, trade, and tourism. Liuyang city is located in the hills and mountains of central China whose industry and commerce are relatively well developed. Among them, the fireworks industry is prominent. Although Yucheng city is located in China's economically developed Shandong province, it is a typical traditional agricultural area. It is not only the core area of farmland protection and an important grain production base in China, but also a densely populated area with a lack of resources to dedicate to infrastructure and public services. At the same time, the three typical counties are all pilot areas in the latest round of rural land reform in China, and all of them have carried out large-scale land consolidation efforts. Land use has undergone a relatively comprehensive transformation, but the driving factors are quite heterogeneous between the three areas, which allows for the impact of rural land consolidation on rural development and transformation to be studied. Land consolidation covers a variety of forms, such as land leveling, land reclamation, and land improvement, but there is no doubt that the ultimate purpose of land consolidation is to optimize land use conditions and improve land use efficiency. Therefore, in this paper, we do not specifically distinguish the specific forms of land consolidation but rather identify the heterogeneity of land consolidation according to specific land types.

The selected counties (cities) have large differences in terms of their location, socioeconomic development levels, urbanization levels, and topographical conditions, which can represent the differences in the rural development in China to a certain degree (Table 1). Given the stage of RDT and RLC, interviews with the natural resources administrations of the three counties (cities), and the conduciveness to field research work, 12 villages (communities) were selected as the study areas (Figure 3).

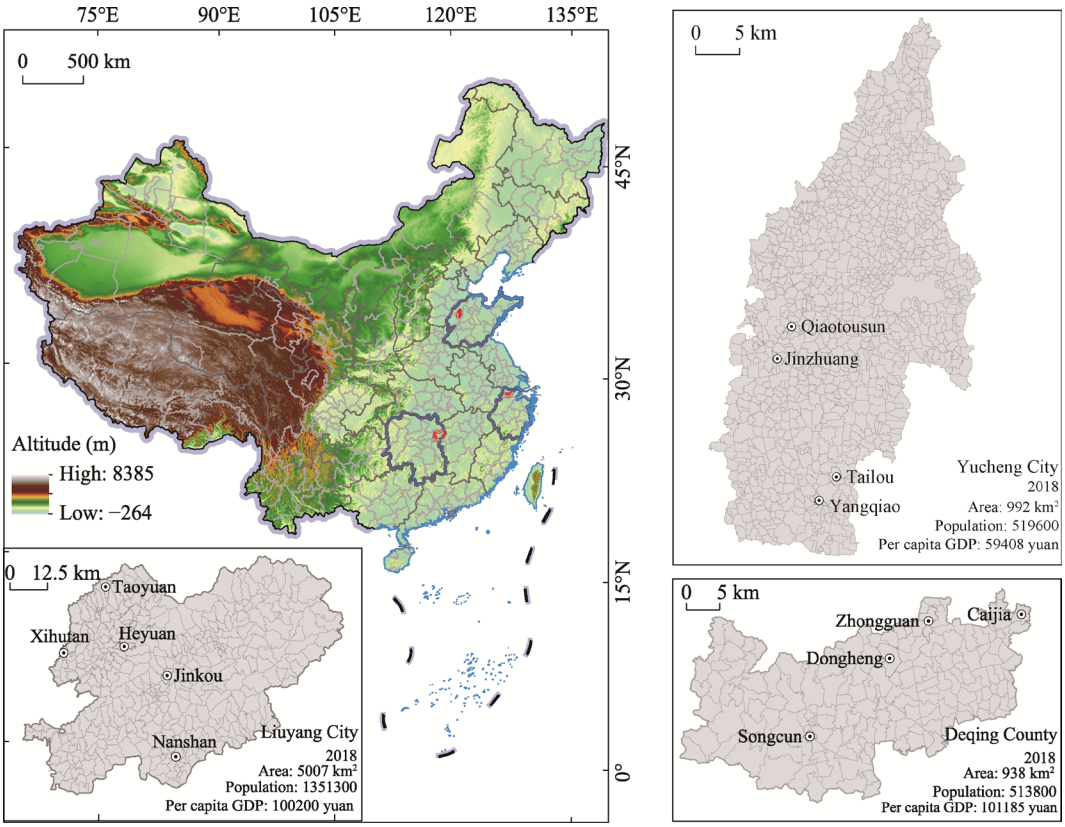

Figure 3 Typical study areas in this study

3.1.2 Patterns of rural land consolidation

The modes and measures of land consolidation in the three typical regions vary (Table 1). Deqing county in Zhejiang province is a whole-area land consolidation model. Farmland consolidation is mainly a function of land leveling and infrastructure construction, while homestead consolidation is one of comprehensive reconstruction. Land consolidation in Liuyang mainly involves the construction of high-standard farmland and the demolition of empty and abandoned homes. Yucheng engages in more idle land consolidation, empty and abandoned homestead demolition, and village relocation.

3.2 Data collection

Through field research such as semi-structured interviews, in-depth interviews, and questionnaire surveys, the Agricultural Geography and Rural Development Research Team at the Institute of Geographic Sciences and Natural Resources Research (IGSNRR), CAS, obtained the data for these villages and farmers. The research team completed the work in Deqing county, and Liuyang city on July 15–27, 2020, and the field research in Yucheng city was conducted on September 10–18, 2020.

Stratified sampling and random sampling were used in the sample selection of this paper. First, according to the research purpose and the suggestions of the natural resource administrations of the corresponding provinces, Deqing, Liuyang, and Yucheng were selected as

study areas, and then 12 sample villages were selected according to their implementation of land consolidation and level of socioeconomic development (Table 2). Second, 28–60

Table 1 Patterns of RLC and its impacts on RDT

	Farmland consolidation		Homestead consolidation		RDT
	Mode	Main measures	Mode	Main measures	Characteristics
Deqing county	Territorial RLC	Land leveling; Squaring the field; Infrastructure support	Territorial RLC	1. Demolish old houses and build new houses; 2. Centralized residences; 3. Standard housing area	1. Scale of ploughland; 2. Nonagricultural employment of villagers; 3. In-situ urbanization
Liuyang city	High-standard farmland construction	Project-based consolidation; High-standard farmland construction	Demolish old houses	1. Demolish old houses for reclamation; 2. Financial compensation; 3. Pay for the excess area; 4. Replacement land	1. Increase in agricultural production and income; 2. Intergenerational division of forces; 3. Transformation of residents' livelihood
Yucheng city	Unused land consolidation	Unused land consolidation; Land reallocation by the village collective	Demolish old houses	1. Demolish old houses; 2. Financial compensation not available for most farmers; 3. Replacement land	1. Enrich the collective economy; 2. Transformation of rural governance

Table 2 Details of the selected villages

Location		Total population	Labor population	Agricultural labor population	Annual per capita income (10,000 yuan)	The main source of income	Village collective income (10,000 yuan)	Arable land (mu)	Number of homesteads
Deqing county	Dongheng village	3909	1600	200	4.8	Work, land share, company share	2577	8900	785
	Zhongguan village	3892	2200	95	3.5	Work	97	3000	997
	Caijie village	3250	1800	2	3.7	Work, materials processing, private enterprise	276	5000	750
Yucheng city	Jinzhuang village	510	311	291	3	vegetable greenhouse	15	937	143
	Qiaotou village	540	300	140	1.8	Work, farming	17	1354	150
	Yangqiao village	404	120	60	2	Work, farming	3.5	348	125
	Tailou village	679	440	260	1.5	Work, farming	7	1979	183
Liuyang city	Nanshan village	3698	2400	200	2.8	Fireworks industry	12	1480	1090
	Jinkou village	5320	2500	1000	4	Work, business, transportation, family workshop	80	2500	1000
	Taoyuan village	1942	500	300	1.3	Work, farming, transfer payment	20	1200	600
	Xihutan village	3400	2300	1000	2.8	Work, farming, collective share	90	4100	800
	Heyuan village	10000	4400	1000	2.1	Work, business, farming	20	7000	2144

Note: The data come from interviews with village officials in each village. The labor force includes "half labor," which is workers older than 65 that are still working and can engage in simple handicraft operations or agricultural planting. The labor force includes part-time farmers.

farming households were selected in each village by random sampling. In this survey, 445 questionnaires were issued and 441 valid questionnaires were returned, for an effective response rate of 99%.

Of the 441 research samples, 155 were taken from Deqing county, including 60 from Dongheng village, 121 from Yucheng city, and 165 from Liuyang city, and 42 people were sampled from Nanshan village. Among 441 respondents, 310 were male, accounting for 70.29%; Only 65 people were engaged in agricultural production, and the proportion of non-agricultural employment reached 85.26%. The age distribution of respondents is 15–93, among which the labor force population aged 15–65 years accounts for 74.38%.

3.3 Methods

3.3.1 Model

This paper used in-depth interviews and questionnaires to understand the effectiveness of RLC from the dual perspectives of village officials and farmers, and then empirically examined the impact of RLC on RDT and its effectiveness through an econometric model. Given the previous theoretical analyses and the availability of data, this paper selected household income per capita and the proportion of household agricultural income to reflect the income level and structure of rural residents as the proxy variable for RDT. The model selected in this paper is a multiple linear regression model, and the model form is as follows:

$$RDT_i = \alpha_i + \sum_{j=1}^{2} RLC_{ij} + \sum_{n=1}^{4} X_{in} + \varepsilon_i. \quad (1)$$

RLC is the core variable of rural land consolidation, which includes two variables: farmland consolidation and homestead consolidation. *X* is the control variable. Human capital, farmland transfer, household labor ratio, and topographical variables are included in the regression model. *i* is the number of samples, *j* and *n* are the numbers of variables, α is the intercept term, and ε is the random disturbance term.

3.3.2 Variables

The data used in this paper are survey data of typical farmers. The variables are defined and described in Table 3.

Table 3 The summary statistics of variables

	Obs.	Mean	Std. dev	Min	Max
Per capita income of household (10,000 yuan)	441	3.746	5.392	0.200	71.429
Proportion of agricultural income of household	441	0.146	0.286	0	1
Farmland consolidation	441	0.605	0.489	0	1
Homestead consolidation	441	0.596	0.491	0	1
Human capital	441	2.144	0.834	0	5
Farmland transfer (mu)	441	–0.525	10.859	–20	196
Labor force ratio	441	0.605	0.244	0	1
Terrain	441	0.626	0.484	0	1

Source: Based on the questionnaire data.

Dependent variable: *RDT*. Rural development transformation has a broad connotation and includes rural development factors as well as their structure and function. However, the key to the RDT is still rural residents, who are the basis for rural development. Improving the living standards of rural residents is the permanent goal of RDT. Therefore, this paper selects the per capita income of rural residents and the proportion of agricultural income as the proxy variables of RDT.

Core independent variable: *RLC*. The core variables of this paper include two dummy variables (Yes = 1, No = 0) to indicate whether the consolidation of agricultural land and homesteads has been carried out among peasant households and to what degree. Within the three counties involved in this study, such consolidation has been carried out to varying degrees, and there are large differences at the village level. The consolidation of agricultural land and homesteads has a positive impact on agricultural production conditions and the intergenerational division of labor in rural families will increase rural incomes and exert a positive impact on RDT.

China's rural land consolidation is implemented in the form of projects. There is a concern that the implementation of land consolidation projects may be endogenous to rural development. However, this concern is relatively minor in this study because the land consolidation in Deqing covered all villages in the jurisdiction. Shandong is one of the earliest regions in China to carry out land consolidation. Land consolidation in Liuyang does not cover the whole area, and the project selection may be related to village characteristics, but the sample selected in this paper is a sample of micro farmers, who do not participate in land consolidation. The practice of portraying land consolidation as an exogenous variable has also been adopted by scholars such as Hu *et al*. (2021) and Nguyen and Warr (2020).

Control variables: (1) *Human capital*. The endogenous growth theory holds that technological progress is the determinant of economic growth, and human capital is the driving force of technological progress (Becker, 1966; Lucas, 1988). Human capital enhances the endogenous power of rural development and is a fundamental element of RDT (Albertus *et al*., 2020). In this study, the educational level is used to characterize the human capital of rural households. The formula is:

$$Human\,capital = \frac{\sum_{i=1}^{n} E}{n} \tag{2}$$

where n is the household size of the respondent, E is the respondent's education level (e.g., uneducated elementary school, junior high school, high school (secondary school), college, undergraduate, master's, or doctorate) with values ranging from 1 to 8. (2) *Farmland transfer*. The separation of ownership and contractual management rights of cultivated land in rural China makes farmland transfer an important method for reallocating cultivated land resources (Long, 2020; You *et al*., 2020). To a certain extent, farmland transfer can alleviate the fragmentation of and promote the large-scale management of cultivated land. More importantly, farmland transfer can promote the reallocation of rural labor (Zhou *et al*., 2020) and nonagricultural employment, thereby promoting rural development transformation. In this paper, the scale of farmland transfer is represented by the difference between the scale of the farmland operated by farmers and the scale that contracted by farmers. Farmland transfer can have a positive impact on RDT. (3) *The labor force ratio*. The proportion of

family labor is an important indicator of the structure of the rural population. We define it as the ratio of the labor force in a household to the household size. The ratio of the labor force reflects the financial pressure faced by the family, which influences its consumption. It will also have an important impact on the family's income and employment, thereby affecting the process of RDT. (4) *Terrain*. Terrain is the natural condition of rural development, which has a significant impact on rural production, settlement patterns, and human-land relationships. The transformation processes of rural areas under different terrain conditions are significantly different. The type of regional terrain studied in this paper is mainly plains and hills. In the empirical test, the variable value is 1 if the local terrain is a plain and 0 otherwise.

4 Results and analysis

4.1 The impacts of rural consolidation on rural development transformation based on a village survey

There are significant differences in the geographic conditions, resource endowments, and socioeconomic development levels in the three regions as well as certain differences in their RLC models and their effect on RDT (Table 1).

At the end of the 20th century, Zhejiang province initiated a large-scale RLC program. In terms of farmland consolidation, Deqing county has carried out farmland leveling work, changed the shape of farmland into rectangles, and equipped it with motorized roads and irrigation and water conservancy facilities. This completely solved the problem of farmland fragmentation. As part of RLC, the large-scale transfer of cultivated land has introduced new management entities and the large-scale management of cultivated land. The agricultural labor population in villages of Dongheng, Zhongguan, and Caijie accounted for only 5.3% of the total labor force. RLC has greatly promoted the nonagricultural employment of rural residents in Deqing. From the perspective of the homestead consolidation, the villages in Deqing covered in the survey have all demolished their old houses, financially compensated farmers, and built new contiguous housing structures with unified infrastructure. Although the rural residents of Deqing are registered permanent residents of the countryside, their employment and lifestyle have been urbanized, which is typical of in-situ urbanization.

The consolidation of agricultural land in Liuyang city has mainly been in the form of high-standard farmland construction projects. Although there are only few types of projects involved in RLC in Liuyang, they still play a positive role in increasing agricultural production and income. Moreover, the construction of high-standard farmland has boosted agricultural mechanization, thus enabling the rural elderly population to continue to engage in agricultural production. This has promoted the formation of the intergenerational division of labor by which "the elderly work in agriculture and the young work in city," which promotes rural upgrading and transformation and thus the overall transformation of the village.

Yucheng city in Shandong province is a traditional agricultural plains area with relatively flat land and little fragmentation. However, the collective economy of the four villages included in the survey is very weak, which has led to weak rural governance. The farmland consolidation in the four villages is mainly in the form of consolidation of small plots of unused land. After the unused land is converted into arable agricultural land, the village col-

lective leases it to villagers or new business entities for farming. Homestead consolidation is mainly done by demolishing old and dilapidated houses for reclamation. In some areas, the extra construction land resulting from homestead consolidation can be sold to urban areas through the policy of "linking increased urban construction land with decreased rural construction land" to raise funding for village construction. Land rents have become an important source of income for these villages and thus RLC represents a breakthrough in the transformation of rural governance.

4.2 The effect of rural land consolidation based on a household survey

This paper evaluates the effectiveness of farmland consolidation from the perspective of farmer households by conducting a survey among typical farmers. The content of the survey mainly involves the degree of support for farmland consolidation and how farmland consolidation has improved their production, living conditions and income. Of the 441 rural households surveyed, 258 are still engaged in agricultural production; 60.86% of the 258 farming households expressed their support for farmland consolidation, but 29.84% did not (Figure 4). The results of the survey show that 71.71% of the farmers interviewed indicated that farmland consolidation has improved their family's living conditions, and 83.33% reported that their production has increased (Figure 4). The consolidation of agricultural land has increased villages' collective incomes. However, due to the presence of large-scale farms and nonagricultural employment in China, farmland consolidation does not significantly increase rural households' income (Figure 4).

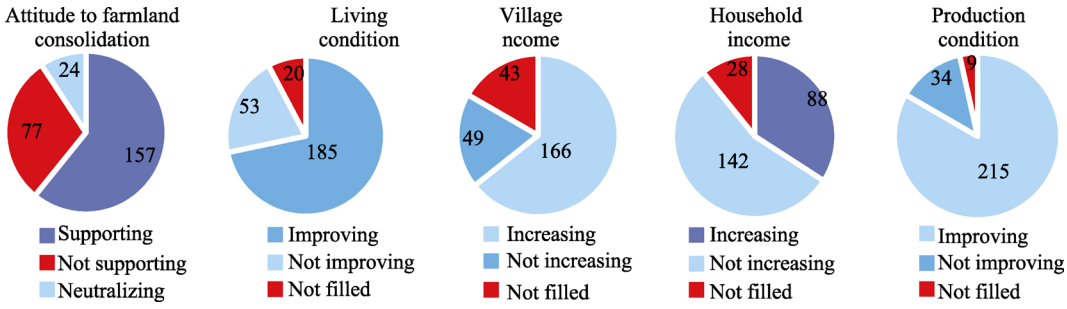

Figure 4 Effect of farmland consolidation on living and production condition and income

More than half of the respondents recognized that farmland consolidation has a positive effect on improving the flatness of cultivated land and road conditions. More than two-thirds of the interviewees indicated that the farmland consolidation in their village has optimized irrigation conditions and facilitated mechanized operations. Some 31.78% believed that farmland consolidation increases arable land. The respondents also believed that farmland consolidation has little effect on improving soil quality and mitigating drought and flood (Figure 5). Ninety-one percent of the respondents said that farmland consolidation has an obvious effect on improving the landscape of their villages. The vast majority of respondents realize the effect farmland consolidation has on improving village infrastructure. In addition, nearly one-third of the interviewees said that farmland consolidation is conducive to increasing grain production and income and can effectively mobilize labor (Figure 6).

Homestead consolidation is more closely related to farmers' livelihoods. Among the 441

interviewed households, 352 were located in villages that had carried out homestead consolidation. Among them, 192 expressed great satisfaction and 129 expressed satisfaction with the consolidation of their homesteads, for a total satisfaction rate of 91.19%. 94.3% of the respondents said that homestead consolidation has improved the living environment, and 70.17% of the farmers who had moved into new houses stated that it has achieved significant results in terms of the intensity of land use. Nearly 30% of rural households recognized the effectiveness of homestead consolidation in ensuring food security, achieving a prosperous life and promoting rural modernization (Figure 7).

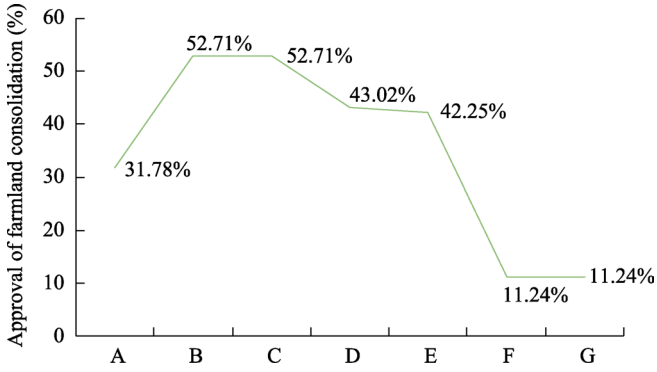

Figure 5 Effect of farmland consolidation on agricultural production

Note: A, B, C, D, E, F, and G represent "increase the area of farmland," "improve the flatness of farmland," "improve the tractor road," "optimize irrigation conditions," "facilitate mechanized operations," "improve the soil quality," and "reduce drought and flood disasters," respectively.

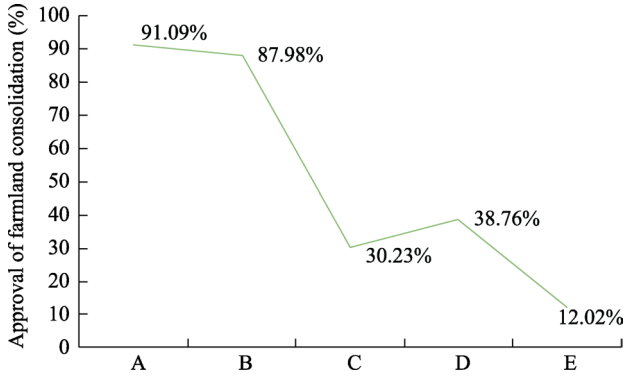

Figure 6 Effect of farmland consolidation affecting the household living condition

Note: A, B, C, D and E represent "beautify village landscape," "improve infrastructure," "increase production and income," "liberate the labor force" and "enhance democratic participation," respectively.

The survey results of typical farmers show that farmers' support and satisfaction with RLC are both high. RLC has effectively safeguarded the vital interests of rural development subjects. RLC has significantly improved the production and living conditions of rural residents by enhancing the flatness of farmland, improving agricultural irrigation conditions, the living environment and village infrastructure as well as promoting intensive land use. It has also increased village collective incomes, promoted the overall development of the village, and created conditions for rural development transformation.

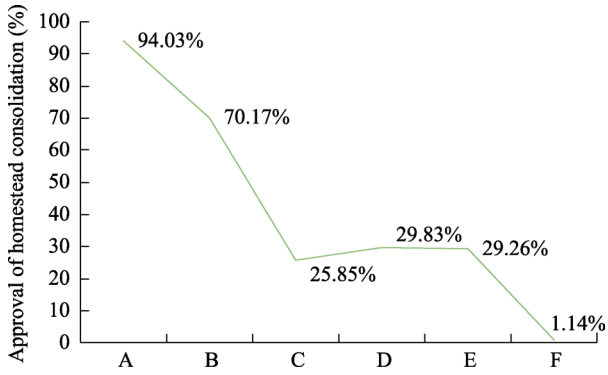

Figure 7 Effect of homestead consolidation

Note: A, B, C, D, E, and F represent "improve human settlements," "promote intensive land use," "guarantee food security," "achieve prosperous life," "promote local civilization," and "I do not know," respectively.

4.3 Result of econometric models of the effect of RLC on RDT

An econometric model was adopted to further test the impact of RLC on RDT. Considering that the two core independent variables in this paper are both dummy variables and the study areas have undergone both farmland and homestead consolidation, simultaneously incorporating the two core independent variables into the regression model may result in multicollinearity. Therefore, this paper incorporated them into the regression model for testing and to better identify the differences in their effects on RDT.

The ultimate goal of RDT is to improve rural development and the living standards of residents. The income level and structure of rural residents are important indicators of their living standards. First, the variables for farmland and homestead consolidation were included in the regression model to test the impact of RLC on the income of rural residents. It was found that the coefficients of the two variables were both positive and passed the 1% significance test, thus indicating that RLC has increased rural residents' income. After the control variables were included in the regression model, the coefficients of the RLC variables were still significantly positive. The regression analysis of the income structure of rural residents (i.e., the proportion of agricultural income) was performed by further incorporating RLC variables into the model, and it was found that the RLC variables were still positive at the 1% significance level and thus the conclusions remained valid the control variables after included (Table 4). It can be seen that RLC can effectively increase rural residents' agriculture-related income. The channels in the effect of RLC on RDT are mainly reflected in the following two aspects. (1) RLC has reorganized rural development and improved the overall income level of rural residents by improving agricultural production conditions and optimizing the allocation of rural development factors such as population and land. (2) By improving agricultural production conditions, RLC has improved the management and technological level of agricultural production, which strengthens the intergenerational division of labor in Chinese rural families. This further increases the productive efficiency of the elderly agricultural workers as well as agricultural income. Moreover, it safeguards rural agricultural production, which is one of the basic functions of rural China and the foundation of RDT.

Human capital is the most important endogenous driving force for rural development. In the estimation model, all human capital variables are significantly positive and thus have a

Table 4 Regression results

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Per capita income of the household				Proportion of agricultural income of the household			
Farmland consolidation		1.5906***		1.7233***		0.2409***		0.6149***
		(3.06)		(3.28)		(9.47)		(12.44)
Homestead consolidation	1.6214***		1.5632***		0.2066***		0.1763***	
	(3.13)		(3.00)		(7.95)		(6.83)	
Human capital			0.7407***	0.8164***			0.0293**	0.0468***
			(2.41)	(2.68)			(1.95)	(3.2)
Farmland transfer			0.0527**	0.0528**			–0.0032***	–0.0031***
			(2.17)	(2.17)			(–2.74)	(–2.72)
Ratio of labor			1.0640	1.3921***			–0.0990*	–0.0558
			(1.02)	(1.32)			(–1.93)	(–0.11)
Terrain			–0.0862	–0.1388			0.1061***	0.0982***
			(–0.16)	(–0.26)			(4.11)	(3.89)
Constant	2.7791***	2.7830***	–0.4727	0.0329	0.7307***	0.7081***	0.6778***	0.6149***
	(6.94)	(6.87)	(6.47)	(0.030)	(36.4)	(35.79)	(13.86)	(12.44)
Observations	441	441	441	441	441	441	441	441
R^2	0.022	0.021	0.049	0.053	0.126	0.170	0.189	0.227

Note: *, **, and *** represent 10%, 5%, and 1% significance levels, respectively; t values are in parentheses.

positive effect on RDT. This is consistent with our expectations. Farmland transfer has reallocated land use rights and reorganized rural agricultural production in China (You *et al*., 2020). Farmland transfer has also optimized the allocation of labor resources and increased the rural residents' income. The coefficients of the farmland transfer variables in Models (3) and (4) are 0.7407 and 0.8164, respectively, and they pass the 1% significance test, which meets our expectations. Farmland transfer promotes large-scale land management, which implies that the incomes of some farmers will shift from being related to agriculture to being related to property. In addition, land transfer releases the size of the rural labor force and increases the nonfarm income of rural households, which also confirms the negative impact of land transfer on residents' agricultural income. In traditional farming communities, the terrain has a direct effect on agricultural production, which will have an important impact on household income and rural development. At present, with the increasing diversification of livelihoods among rural residents in China, topographical constraints on household income will be reduced. The results show that the terrain variables failed the significance test in the model with household income as the dependent variable, but are significantly positive in the model with the ratio of agricultural income as the dependent variable. It can be seen that terrain has a small impact on rural household income, but the flatness of the topography still has a significantly positive impact on rural residents' agricultural income.

5 Discussion

5.1 Deepening the understanding of land system science to expand the functions of RLC

Currently, the land research is evolving from land change science to comprehensive land

system science (Verburg *et al*., 2015). Land system science is committed to understanding human-environment interaction and transforming scientific discoveries into sustainable land use solutions. RLC closely connects the two systems of humanity and nature. Therefore, it is necessary to deepen the scientific understanding of land system to expand the functionality of RLC. From the perspective of land system science, land system is placed in the framework of urban-rural territorial systems to understand the effect of RLC on RDT and urban-rural integrated development.

RLC should be regarded as an important method for optimizing land system. It is also necessary to clarify the pathway through which RLC affects the operation of land system and RDT. In addition, it is essential to improve the diversity of RLC in terms of enhancing resource value, optimizing the ecological environment, mobilizing urban-rural factors, reforming rural production, and optimizing rural production. Further, the effect of RLC on optimizing rural space, economy and governance, as well as promoting rural production, employment, and cultural functions should be further enhanced.

5.2 Negative effect of RLC on RDT

RLC is an important tool for promoting rural development transformation. However, if its effects are out of balance with the needs of RDT, it may negatively affect RDT. Before implementation, the target of RLC needs to be connected with the needs of rural development, and corresponding industries and governance mechanisms should be provided to support the implementation of RLC. RLC is an engineering project that increases the amount of arable land and optimizes land use, but the consolidated farmland requires labor, capital, technology and other inputs (Chen and Long, 2020).

Taoyuan village in Liuyang city, located in a hilly area, consolidated a large number of valleys and low-lying land, but flood facilities were not installed in time, thus resulting in the farmland being destroyed by flooding. The current RLC projects in China are mainly funded by the government, which allows for contractors to generate massive profits. In particular, it is necessary to be vigilant against the blind launch of RLC projects that are motivated by self-interest. Of the 441 interviewees in this study, 10 said that RLC has destroyed local vegetation or caused soil erosion, and 43 considered that local RLC has caused conflicts between contractors and normal villagers or among normal villagers. In the foreseeable future, a large proportion of the rural population will still migrate to urban areas, and it is therefore necessary to prevent land abandonment after consolidation. Mountainous areas require the most attention. Due to topographic constraints, poor farming conditions and significant population loss, the abandonment of land is widespread. If RLC were to be enforced again, the process of RDT would be hindered.

The Chinese government has implemented a land policy of “Linking Increased Urban Construction Land with Decreased Rural Construction Land” to promote the conversion of unused land into cultivated land. However, a large amount of the high-quality cultivated land is already occupied and the phenomenon of “taking the superior but returning the inferior” is widespread. Therefore, it is essential to be vigilant against abuse of the land policy and inefficiency in RLC projects.

5.3 Policy recommendations and future research

To further strengthen the role of RLC in RDT, we put forward the following policy recom-

mendations. (1) *Construct human-land early warning mechanisms*. The results show that there are individual and regional differences in the impact of RLC on RDT. RLC plans should be scientifically formulated to encourage the nonagricultural transfer of rural populations and the return of migrants to agricultural communities. At the same time, it is necessary to incorporate the effects of the changes brought about by industrialization, technological development, e-commerce, etc., on the relationship between rural communities and land. (2) *Optimize the layout and performance evaluation of RLC*. It is found that the impacts of different types of land consolidation on rural development transformationare significantly different, and the impact in different areas also varies widely. By taking the RDT needs in different regions into consideration, RLC projects can be proposed based on changes in the rural human-land relationship, geographic conditions, input and output status, resource carrying capacity and environmental suitability. The negative effect of RLC should be eliminated to further promote RDT. (3) *Promote multitype development and multisystem coordination of RLC*. Efforts should be made to connect the implementation of RLC projects with the needs of RDT, in accordance with local conditions. At the same time, the reform of the rural land and property rights systems should be promoted to enhance the effectiveness of RLC in rural areas. In addition, industrial development policies can provide solid support for RLC. Furthermore, the trend of urban-rural integration is also of great importance to the scientific decision-making necessary for effective RLC.

6 Conclusions

This paper analyzes their evolution and the related policies in China, and constructs a theoretical framework for how RLC affects RDT and test the effect. The research results show that since 1949, China's rural areas have been developing sporadically but have now entered a critical stage in their transformation. RLC in China has also transformed to being multitype and multifunctional comprehensive management, and the scale of land consolidation in China shows a fluctuating upward trend while the overall is decreasing from east to west. Land consolidation in China involves both engineering projects and policy tools and promotes RDT by promoting industrial development, the integration of development factors, urbanization, and integrated urban-rural development. The impacts of different RLC models on RDT vary. Farmers in the survey area show a high degree of support for and satisfaction with RLC since it has increased their production and improved their living conditions. The results indicate that the effects of various types of RLC on RDT are significantly positive.

This paper clarifies the difference between rural development transformation and rural transformation development, and discusses the impact mechanism of RLC on RDT under the comprehensive framework of land system and urban-rural territorial system. The effects of RLC on RDT were diagnosed by territorial type and consolidation mode. A perspective of land consolidation for the optimization of rural development transformation is provided. Due to the limited size of the research sample, this study did not incorporate regional differences into the model. Future research on RLC and RDT should therefore dynamically analyze changes in rural development needs, reexamine the policy attributes of RLC, investigate the impact of RLC on urban-rural transformation and integrated development, and measure negative effects of RLC. More importantly, future research should be supported by

land system science to study the systemic impact of RLC on the interaction between urban and rural communities and natural ecosystems.

References

Albertus M, Espinoza M, Fort R, 2020. Land reform and human capital development: Evidence from Peru. *Journal of Development Economics*, 147: 102540.

Becker G S, 1966. Education and the distribution of earnings. *American Economic Review*, 56 (1): 358–380.

Borrelli P, Robinson D A, Fleischer L R *et al*., 2017. An assessment of the global impact of 21st century land use change on soil erosion. *Nature Communication*, 8.

Bryan B A, Gao L, Ye Y *et al*., 2018. China's response to a national land-system sustainability emergency. *Nature*, 559: 193–204.

Chen K Q, Long H L, 2020. Land consolidation and rural development transformation: Mutual feedback mechanism and regional regulation. *China Land Science*, 9: 1–9. (in Chinese)

Chen K Q, Long H L, Liao L W *et al*., 2020. Land use transitions and urban-rural integrated development: Theoretical framework and China's evidence. *Land Use Policy*, 92: 104465.

Chen K Q, Wang Y X, Li N H *et al*., 2023. The impact of farmland use transition on rural livelihood transformation in China. *Habitat International*, 135: 102784.

Francis A H, Kwaku A B, Diego A V B *et al*., 2022. Graduate unemployment, artisanal and small-scale mining, and rural transformation in Ghana: What does the 'educated' youth involvement offer? *Journal of Rural Studies*, 95: 125–139.

Gao J J, Gai Q G, Liu B B *et al*., 2021. Farm size and pesticide use: Evidence from agricultural production in China. *China Agricultural Economic Review*, 13(4): 912–929.

Gao P C, Xie Y R, Song C Q *et al*., 2023. Exploring detailed urban-rural development under intersecting population growth and food production scenarios: Trajectories for China's most populous agricultural province to 2030. *Journal of Geographical Sciences*, 33(2): 222–244.

Gessesse A T, Li H J, He G *et al*., 2018. Study on farmers land consolidation adaptation intention: A structural equation modeling approach, the case of Sichuan province, China. *China Agricultural Economic Review*, 10(4): 666–682.

Guenther S, 1986. Land consolidation in Bavaria: Support given to rural areas. *Irrigation Engineering and Rural Planning*, 9: 53–59.

Hu X Y, Su K Y, Chen W H *et al*., 2021. Examining the impact of land consolidation titling policy on farmers' fertiliser use: Evidence from a quasi-natural experiment in China. *Land Use Policy*, 109: 105645.

Li Y H, Wu W H, Liu Y S, 2018. Land consolidation for rural sustainability in China: Practical reflections and policy implications. *Land Use Policy*, 74: 137–141.

Li Y R, Li Y, Fan P C *et al*., 2019. Impacts of land consolidation on rural human-environment system in typical watershed of the Loess Plateau and implications for rural development policy. *Land Use Policy*, 86: 339–350.

Liao L W, Long H L, Ma E P, 2023. Factors influencing the recessive morphology of farmland use under labor changes based on production input willingness and behavior of farmers. *Journal of Geographical Sciences*, 33(12): 2467–2488.

Liu H M, Li G X, Wang K Q, 2022. Homestead reduction, economic agglomeration and rural economic development: Evidence from Shanghai, China. *China Agricultural Economic Review*, 14(2): 274–293.

Liu Y Q, Dai L, Long H L *et al*., 2022. Rural vitalization promoted by industrial transformation under globalization: The case of Tengtou village in China, *Journal of Rural Studies*, 95: 241–255.

Liu Y Q, Dai L, Long H L, 2023. Theories and practices of comprehensive land consolidation in promoting multifunctional land use. *Habitat International*, 142: 102964.

Liu Y S, Li Y H, 2017. Revitalize the world's countryside. *Nature*, 548(7667): 275–277.

Liu Y S, Long H L, Chen Y F *et al*., 2016. Progress of research on urban-rural transformation and rural development in China in the past decade and future prospects. *Journal of Geographical Sciences*, 26(8): 1117–1132.

Liu Y S, Zheng X Y, Wang Y S, 2018. Land consolidation engineering and modern agriculture: A case study from soil particles to agricultural systems. *Journal of Geographical Sciences*, 28(12): 1896–1906.

Long H L, 2020. Land Use Transitions and Rural Restructuring in China. Singapore: Springer, 297–298.

Long H L, 2022. Theorizing land use transitions: A human geography perspective. *Habitat International*, 128: 102669.

Long H L, Ma L, Zhang Y N *et al*. 2022. Multifunctional rural development in China: Pattern, process and mechanism. *Habitat International*, 121: 102530.

Long H L, Qu Y, 2018. Land use transitions and land management: A mutual feedback perspective. *Land Use Policy*, 74: 111–120.

Long H L, Qu Y, Tu S S *et al*., 2020. Development of land use transitions research in China. *Journal of Geographical Sciences*, 30(7): 1195–1214.

Long H L, Tu S S, Ge D Z *et al*., 2016. The allocation and management of critical resources in rural China under restructuring: Problems and prospects. *Journal of Rural Studies*, 47(B): 392–412.

Long H L, Zhang Y N, Tu S S, 2019. Rural vitalization in China: A perspective of land consolidation. *Journal of Geographical Sciences*, 29(4): 517–530.

Lucas R E, 1988. On the mechanics of economic development. *Journal of Monetary Economy*, 22: 3–42.

Nguyen H Q, Warr P, 2020. Land consolidation as technical change: Economic impacts in rural Vietnam. *World Development*, 127: 104750.

Onitsuka K, Hoshino S, 2018. Inter-community networks of rural leaders and key people: Case study on a rural revitalization program in Kyoto Prefecture, Japan. *Journal of Rural Studies*, 61: 123–136.

Pašakarnis G, Maliene V, Dixon-Gough R *et al*., 2021. Decision support framework to rank and prioritise the potential land areas for comprehensive land consolidation. *Land Use Policy*, 100: 104908.

Qu Y, Long H L, 2018. The economic and environmental effects of land use transitions under rapid urbanization and the implications for land use management. *Habitat International*, 82: 113–121.

Shan W, Jin X B, Ren J *et al*., 2019. Ecological environment quality assessment based on remote sensing data for land consolidation. *Journal of Cleaner Production*, 239: 118126.

Verburg P H, Crossman N, Ellis E C *et al*., 2015. Land system science and sustainable development of the earth system: A global land project perspective. *Anthropocene*, 12: 29–41.

Wojewodzic T, Janus J, Dacko M *et al*., 2021. Measuring the effectiveness of land consolidation: An economic approach based on selected case studies from Poland. *Land Use Policy*, 100: 104888.

Woods M, 2009. Rural geography: Blurring boundaries and making connections. *Progress in Human Geography*, 33(6): 849–858.

Ye C, Yang D Y, Zhao J N, 2022. An empirical study of the registered population transformation in China's megacities. *Journal of Geographical Sciences*, 32(12): 2525–2540.

Ye W L, Wang Y, Wu K S *et al*., 2023. Exploring the rural transformation of the Loess Plateau from a perspective of community resilience: A case study from the Jiaxian county, northwestern China. *Applied Geography*, 154: 102919.

You H Y, Wu S Y, Wu X *et al*., 2020. The underlying influencing factors of farmland transfer in urbanizing China: Implications for sustainable land use goals. *Environment Development and Sustainability*, 9: 10.1007/s10668-020-00990-w.

Zheng Y H, Long H L, Chen K Q, 2022. Spatio-temporal patterns and driving mechanism of farmland fragmentation in the Huang-Huai-Hai Plain. *Journal of Geographical Sciences*, 32(6): 1020–1038.

Zhou X S, Ma W L, Renwick A *et al*., 2020. Off-farm work decisions of farm couples and land transfer choices in rural China. *Applied Economics*, 52(57): 6229–6247.