

Article

Reconstructing Rural Settlements Based on Investigation of Consolidation Potential: Mechanisms and Paths

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Abstract: Rural settlement consolidation (RSC) is an important tool for improving rural habitat environments, and the potential evaluation of RSC is the premise for rural settlement planning. This paper identified the potential sources of RSC in different reconstruction modes and built an influencing factor system for RSC. We analyzed the spatial differentiation patterns of the theoretical potential and the realistic potential, and we identified the factors influencing the potential realization based on an empirical investigation in China. Influenced by multiple constraints, the potential transition from theoretical to realistic was spatially differentiated and showed a spatial agglomeration at the village level. Rural depopulation had a direct impact on the theoretical potential of RSC, while the distance to the downtown, rural population, per capita GDP, and production and living conditions played an important role in the realistic potential. Particularly, rural settlement basic conditions, rural population, and arable land resources profoundly affected farmer exit willingness and the potential transition from theoretical to realistic. Four optimization paths for rural settlement reconstruction linking to land use policies were proposed, which could provide valuable information for rural settlement planning in socioeconomic transformation regions.

Keywords: rural settlement consolidation; potential transition; spatiotemporal differentiation; influencing factors; optimization paths



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1. Introduction

Rural decline has become an unavoidable global problem today [1]. Urban preference policies have squeezed plenty of rural resources to support urban development, leading to widespread neglect of rural development. Declining rural areas are struggling with a series of problems, such as scale shrinkage [2], marginalization [3], and rural hollowing [4]. Outmigration and aging, industrial depression, and low employment have become the main manifestations of rural decline [5,6]. Rural depopulation directly leads to a decrease in the demand for rural settlement and an increase in the probability of housing abandonment. The spatial optimization and reconstruction of rural settlements become priorities in enhancing rural attraction and realizing rural revitalization [7].

Rural settlement consolidation (RSC) is a process of adjusting the land allocation within rural settlements through economic, technical, and policy means to coordinate the human–land relationship in rural areas [8]. In addition to reconfiguring land parcels to make fragmented rural settlements concentrated and orderly, RSC simultaneously improves rural service facilities and infrastructure [9,10], optimizes rural landscapes [11], and creates large-scale production spaces for agriculture [12,13]. Land consolidation is an effective tool to support the sustainable development of rural settlements [14]. Scholars have carried out a wealth of empirical studies on rural settlement optimization from the aspects of spatial form and structure [15,16], functional transition [17], development patterns [18,19],

and spatial planning strategies [20,21], which have provided useful policy inspiration and practical guidance for RSC.

China is currently in a period of rapid industrialization and urbanization, and rural development elements such as land, capital, and labor have undergone great changes [22]. Massive groups of farmers flock to urban areas for employment opportunities or children's education, but the instability of migrant work makes farmers unwilling to give up their rural homesteads [23,24]. It is common for farmers to leave their settlements unused and build new settlements without demolishing old settlements in rural China. As a result, while rural population loss has become increasingly intensified, rural settlement areas show an inverse growth trend [25]. The Chinese government realized that the coexistence of rural land waste and urban land supply shortages has led to an imbalance in land allocation between urban and rural areas. Consequently, the government started to encourage the flow of land between urban and rural areas. Rural homesteads were required to be transformed from extensive to intensive use. By revitalizing rural land assets to provide necessary land supply for urban real estate, the allocation efficiency of limited resources could be improved [26]. In 2008, the Chinese government proposed a land policy "Increasing versus decreasing the balance of urban–rural construction land", encouraging the consolidation and reclamation of idle and abandoned rural construction land into arable land in exchange for the construction land quota for urban development [27]. The policy was committed to achieving a balance between the increase in urban construction land and the decrease in rural construction land and helping realize the protection of arable land in the "arable land requisition–compensation balance". Policies have promoted the widespread implementation of RSC as a spatial policy instrument for rural reconstruction in China.

Land use policies, as well as the perceptions and actions of stakeholders such as government, rural collective organizations, local elites, enterprises, and farmers, are considered to play key roles in driving RSC implementation [28]. Affected by multiple constraints, the quantitative potential of abandoned rural settlements in RSC is highly uncertain. The realistic potential was generally evaluated by revising the redundant rural settlement area calculated with theoretical methods from the perspectives of natural suitability, economic feasibility, farmers' willingness, and ecological security protection [29]. There is no fixed standard or paradigm for RSC in different regions. Many studies summarized typical practices and modes by analyzing restructuring methods, processes, and results of land, industry, and administration in actual cases to provide empirical guidance for RSC work. The ex-post impact of RSC on rural development was multifaceted. Quantitative studies have discussed the impact mechanism of RSC in reducing rural poverty [30], driving rural industrial development [31], increasing agricultural productivity [32], and improving farmers' living conditions [33]. Different optimization paths for rural settlement spatial reconstruction provided multiple insights into RSC improvement in terms of intervillage social connections [7], livability and population flow [34], village development potential [35], and ecological security protection [36].

A potential evaluation is vital in formulating reasonable RSC implementation plans. Theoretical potential and realistic potential are closely related in quantity and space. Quantitatively, the theoretical potential is the ideal criterion for the realistic potential, and the realistic potential reflects the degree of realization of the theoretical potential. In most cases, the realistic potential is significantly lower than the theoretical potential, and the expected result is to promote the transition from theoretical potential to realistic potential. Spatially, the difficulty of the transition from theoretical to realistic potential varies regionally due to geographic conditions, resource endowment, and settlement layout. The theoretical potential was commonly evaluated by the per capita construction land standard method, but the single criterion causes the results to deviate greatly from the realistic potential [37]. Currently, the RSC potential is mainly calculated from the single perspective of project implementation [38,39]; the linkage between theoretical potential and realistic potential has been widely ignored. The transition mechanism from the theoretical potential to the realis-

tic potential remains unclear, which cannot provide a valuable reference for formulating targeted planning policies.

To fill the research gap, this paper analyzed the potential transition mechanism in the RSC process and proposed optimization paths for reconstructing rural settlements based on village surveys in Zhaoyuan City, China. This study aims to address the following issues: (1) What are the spatial characteristics of the differences between the theoretical and realistic potential of RSC? (2) What are the factors influencing the RSC potential? (3) How can we optimize the spatial reconstruction of rural settlements by combining the influencing factors? This paper is expected to contribute to our understanding of the transition mechanism from the theoretical potential to the realistic potential in RSC and provide decision-making support for planners in rural settlement reconstruction.

2. Potential of RSC Linking to Reconstruction Modes

RSC removes the idle and abandoned rural settlements and relocates the scattered settlements into concentrated residential areas. Generally, RSC is led and funded by the government, which combines top-down organization with bottom-up participation, while respecting the primary status of farmers. The government will conduct surveys based on policy requirements to investigate farmers' preferences, village resources, and external conditions. Professionals make different planning schemes after evaluating the benefits and feasibility of RSC. Following the planning scheme, the government taps into the potential of RSC in different modes. According to the spatial morphological change in rural settlements before and after consolidation, the reconstruction mode of rural settlements can be classified into four types: urban annexation, village merger, internal renovation, and overall relocation. We identified the RSC potential in each reconstruction mode (Figure 1).

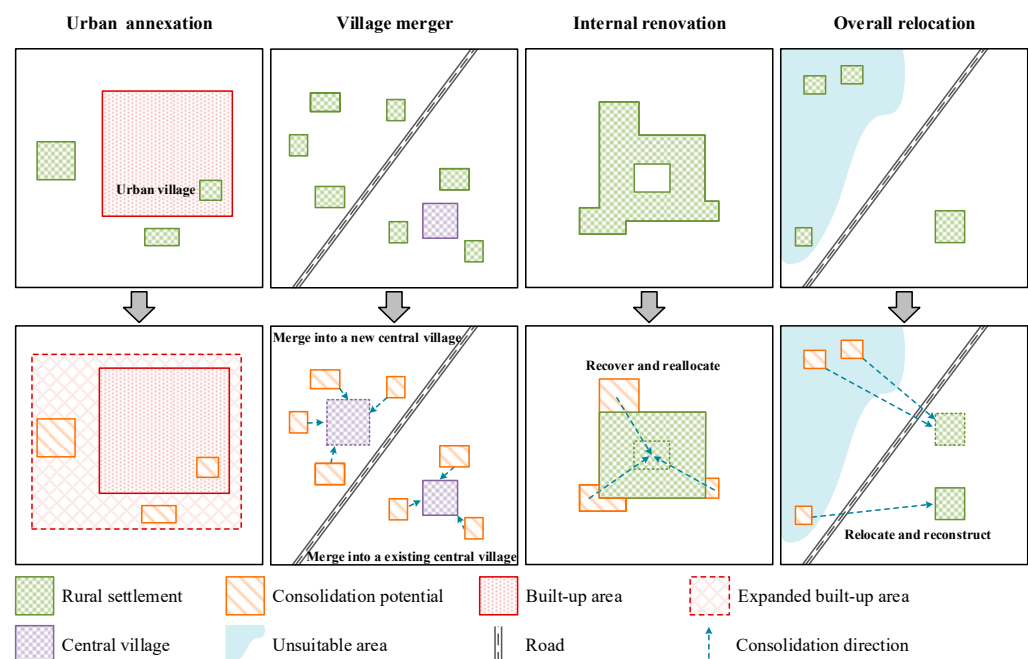


Figure 1. Rural settlement spatial reconstruction modes and consolidation potential.

In the urban annexation mode, urban areas gradually annex the surrounding rural settlements or urban villages, and the annexation of rural settlements is accomplished through land requisition by the government [40]. The annexed rural settlements are transformed into urban land, and rural residents completely exit their rural settlements after moving to urban settlements. In general, the annexed rural settlements are composed of bungalows, while the urban settlements are composed of multistory buildings. Plenty of rural land is released by urban and rural housing replacement, and the consolidation

potential is acquired by decreasing the per capita rural settlement area. Natural villages are the basic settlements' form with simple living facilities, while central villages are hosts to rural administrative organs with better living facilities and infrastructure [41]. According to the proximity planning principle, several natural villages are merged to establish a new central village, or natural villages are merged into an existing central village. Villages merge to form new settlements at a certain scale and have complete functions [42]. Inefficiently used and poorly conditioned settlements are abandoned by rural residents after relocating to the central village, which has a higher standard of intensive settlement use. The areal difference between the original settlements and the new settlements provides an extra land quota for urban–rural construction.

The internal renovation mode adjusts the internal land use structure based on the existing layout of rural settlements to improve rural habitat environments [43]. The main measures of internal renovation are to adjust and reallocate inefficiently used settlements and build new houses using idle and abandoned land as much as possible. The RSC potential of this mode mainly comes from the recovery of the unused homestead, the reduction in rural settlement land caused by lowering the per capita homestead area, and using idle land and abandoned land to build houses. The overall relocation mode is applied to rural settlements in unsuitable areas (with poor living and development conditions), such as rural settlements in remote mountainous areas, ecologically fragile areas, and disaster-prone areas [44]. Rural settlements are gradually relocated and resettled to other existing rural settlements or newly constructed settlements. All the original sites will be demolished for reuse, and the original settlements will all be included in the RSC potential.

3. Materials and Methods

3.1. Study Area

Zhaoyuan City (Figure 2), located in Shandong Province, Eastern China, is a county-level city with 5 subdistrict offices, 9 towns, and 724 administrative villages under its jurisdiction, covering an area of 1432.33 km². Zhaoyuan has numerous mountains and rivers, and the terrain is dominated by low mountains and hills. In 2018, the total population of the city was 562,820, of which the rural population was 315,138 (with urbanization of 44.01%). According to the third national land survey, Zhaoyuan's rural settlement land was 6165.70 hm², with a per capita rural settlement of 195.65 m². In the context of rapid urbanization and industrialization, Zhaoyuan is facing the problem of idle and wasteful utilization of rural settlements, which is also a widespread problem in rural China. The study of RSC potential transitions and settlement optimization in Zhaoyuan can provide a reference for rural spatial reconstruction.

3.2. Data Sources

The land use and basic geographic data, including administrative boundaries, administrative centers, rural settlements, roads, water bodies, arable land, and garden land, were obtained from the third national land survey database. The educational level and the outflow of the rural population in 2018 and the village population from 2009 to 2018 were obtained from the demographic annual report of each township in Zhaoyuan. Both the third national land survey database and demographic data were provided by the Zhaoyuan Natural Resources and Planning Bureau. Gross domestic product (GDP) was obtained from the Zhaoyuan Statistical Yearbook issued by the People's Government of Zhaoyuan. Digital elevation data were acquired from the geospatial cloud platform (<http://www.gscloud.cn/>, accessed on 1 December 2023). The realistic potential of villages was investigated from June to July 2020, including the exit willingness, exit scale, exit time, and resettlement areas of rural settlements. The realistic potential of RSC was acquired according to the two paths of “top-down” and “bottom-up”. Firstly, the Zhaoyuan Natural Resources and Planning Bureau made the overall arrangements for survey organization. The researchers carried out research training sessions for the cadres of each administrative village in groups by township. Village cadres conducted face-to-face interviews with farmers to collect farmers'

willingness to exit and marked the abandoned homesteads on the map after a field inspection. In this way, a “city-township-village” top-down, cascading line of work was formed. Then, we marked each abandoned settlement plot on the map with detailed information and summarized the exit information of villages by taking the town as a unit. Finally, the investigation was summarized from bottom to top to build the city’s RSC realistic potential database. Nonagricultural areas without rural populations or rural settlements were excluded in this study; a total of 674 villages were included in the study area.

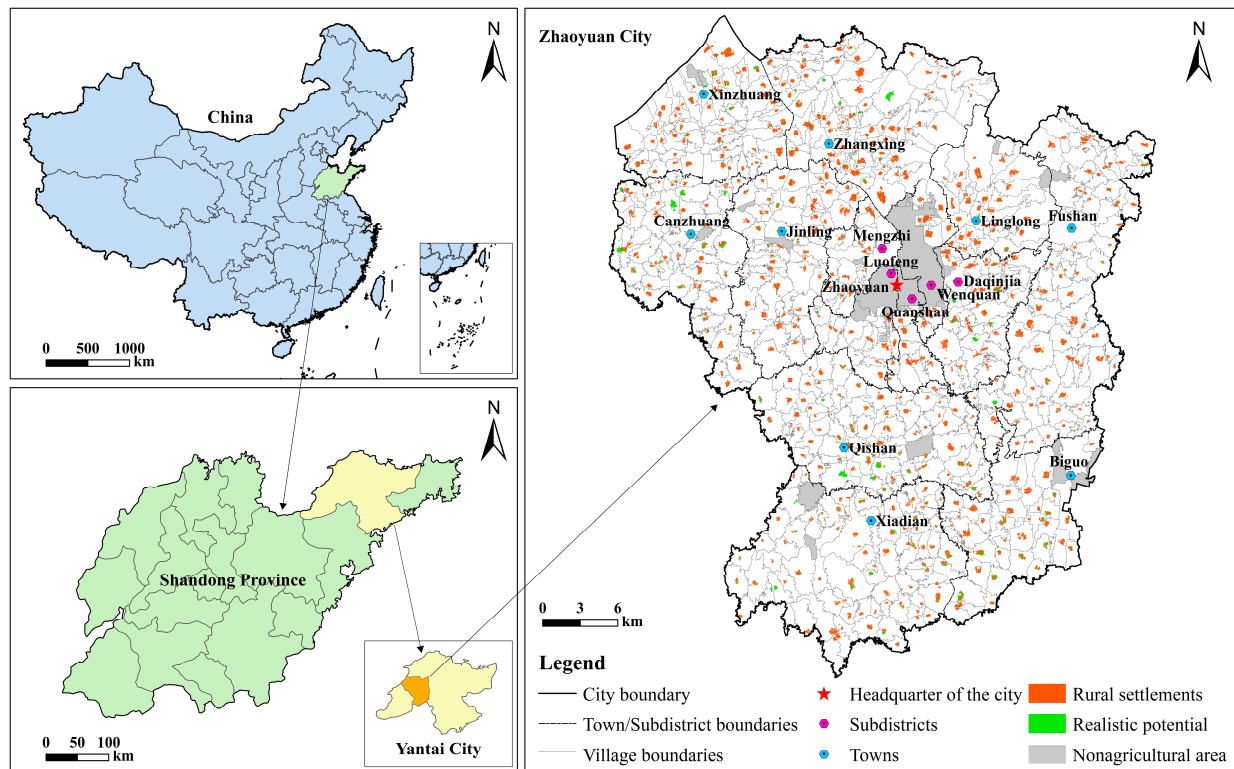


Figure 2. Location of Zhaoyuan City and distribution of rural settlements.

3.3. Methodology

3.3.1. Theoretical Potential Calculation

The traditional method calculates the RSC potential by setting the per capita construction land standard, and the rural settlement area exceeding the standard is the theoretical potential [45]. According to the “Shandong Province Construction Land Control Standard (2019 Edition)” [46], we set 100 m² per person as the control standard of rural settlements. The formula is expressed as follows:

$$\Delta S = S_0 - B_t \times Q_t \quad (1)$$

where ΔS is the theoretical potential of RSC; S_0 is the current scale of rural settlement; B_t is the per capita construction land standard for rural settlements; and Q_t is the rural population.

In this study, the theoretical potential was analyzed through two scenarios: the current rural population scenario and the rural population loss scenario. The research year selected for the rural population loss scenario was 2035, which was also the target year for the new phase of territorial spatial planning in China. The theoretical potential in the current rural population scenario was calculated based on the village population in 2018, while the theoretical potential in the rural population loss scenario was calculated based on the projected village population in 2035. The rural population in 2035 was predicted based on

the rural population in 2018 and the average change trend of the village population from 2009 to 2018.

$$P = P_0 \times (1 + r)^n \quad (2)$$

where P is the rural population in the predicted year, P_0 is the rural population in the base year, r is the annual average rate of population change, and n is the number of years interval.

3.3.2. Identification of the Influencing Factors

Geographic conditions that restrict the distribution of rural settlements serve as the spatial foundation of the RSC potential [47]. Socioeconomic levels mirror the development statuses of villages, and production and living conditions significantly affect farmers' living preferences, both of which are the core driving forces of RSC [48]. Informed by previous research and the specific situation of the study area, this paper selected factors related to geographic conditions, socioeconomic levels, and production and living conditions to explore the respective influencing factors of the realistic potential and the potential transition (Table 1). Terrain, waters, roads, and location were general indicators of the geographic conditions of rural settlements [49]. Per capita GDP, as well as the size, quality, and mobility of the rural population were used to reflect the socioeconomic level of the village [50]. Arable land and garden land were considered as the main means of production in rural areas [51]. The scale and layout of rural settlements helped to represent the basic living conditions of farmers [34].

Table 1. Influencing factors of RSC potential.

Aspects	Influencing Factors	Indicator Representation
Geographic conditions	Distance to the town/subdistrict center	Downtown areas and town/subdistrict centers have an attraction to rural populations and influence rural migration.
	Distance to the downtown	
	Distance to the main road	The accessibility of roads and the undulation of the terrain affect the engineering difficulty and cost of RSC.
	Distance to water bodies Topographic relief amplitude	Water sources and terrain influence the direction of relocation and consolidation of settlements.
Socioeconomic levels	Per capita GDP	GDP can be used to judge the fund guarantee of RSC.
	Rural population	Rural population and their outflow affect the actual land demand for rural settlements.
	Percentage of the total population out of the village for more than half a year	
	Educational level of rural population	Educational level of the rural population is related to the farmers' support and understanding of RSC.
Production and living conditions	Rural settlement scale	The scale and per capita occupied area of rural settlements are the reflection of the current situation of settlement land use.
	Per capita homestead area	
	Per capita arable land area	Arable land and garden land are the livelihoods of farmers.
	Per capita garden land area	
	Patch density of rural settlements	Patch density of rural settlements reflects the characteristics of agglomeration and dispersion of rural settlements.

The geographical detector is a set of statistical methods that detect spatial differentiation and reveal the driving force behind them [52]. This paper used the factor detector of the geographical detector to explore the magnitude of each factor's effect on the realistic potential and potential transition difference of the RSC. The formula is expressed as follows:

$$q = 1 - \frac{\sum_{h=1}^L N_h \sigma_h^2}{N \sigma^2} \quad (3)$$

where the q value is the explanatory power index of factor X to the spatial differentiation of variable Y , and $q \in [0, 1]$. L is the strata of variable Y or factor X , N_h and σ_h^2 are the sample size and variance of layer h , respectively. N and σ^2 are the sample size and variance of the whole study area, respectively.

4. Results and Analysis

4.1. Spatiotemporal Characteristics of RSC Potential

4.1.1. Theoretical Potential of RSC

In the current rural population scenario (Figure 3a), the total theoretical potential of RSC was 2240.39 hm². There were 39 villages without a theoretical potential in Zhaoyuan, and they were mostly distributed around town and subdistrict centers. However, villages lacking a theoretical potential did not necessarily mean that there was no realistic potential, as there were 12 villages in this situation. Proximity to urban areas and small rural settlement areas were the primary features of these villages, where the realistic potential arose because some rural settlements were converted into urban land or scattered settlements in the periphery were concentrated inside the village. The per capita settlement land area exceeded the standard in 635 villages, and the theoretical potential of villages was mostly less than 5 hm². The theoretical potential of subdistricts was lower than that of peripheral towns, mainly because many villages of the subdistricts had completed the transformation from rural settlements to urban communities. RSC in the subdistricts was carried out earlier with the process of urban expansion, while the RSC of the peripheral towns lagged.

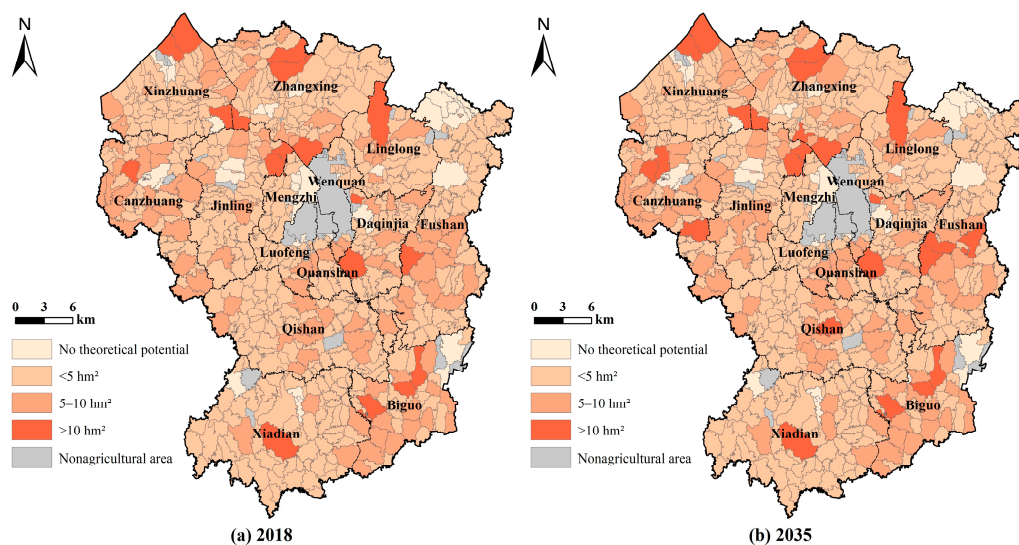


Figure 3. Theoretical potential of rural settlement consolidation (RSC) in 2018 and 2035.

The change in rural population directly affected the quantity of theoretical potential in the future. In the rural population loss scenario (Figure 3b), the number of villages without a theoretical potential decreased to 37, villages with a theoretical potential in the range of 0–5 hm² decreased by 10, and villages in the range of 5–10 hm² and over 10 hm² increased by 6. The total theoretical potential of RSC increased by 139.28 hm². Among the towns and subdistricts, Zhangxing, Fushan, Qishan, and Xiadian had larger theoretical potential increments, which were caused by the current rural population size. In the context of the continuous advancement of urbanization, rural–urban migration is the main reason for the idle and abandoned land in rural settlements, and the loss of rural population has a considerable impact on the theoretical potential of RSC. Rural depopulation influenced the theoretical potential of RSC by its scale and rate. Villages with larger populations had greater scope for reduction, offering more opportunities and space to enhance the theoretical potential. In areas close to the downtown area and on the edge of the city, high

rates of rural depopulation could lead to substantial increases in theoretical potential. The rate of rural depopulation increased near the downtown area due to the transformation towards nonagricultural status, whereas the rural population loss was pronounced at the city's edge because of lagging development.

4.1.2. Realistic Potential of RSC

According to the investigation results, 514 plots with an area of 549.87 hm² would be consolidated in RSC (realistic potential). The consolidation plots were scattered in space. There were 434 villages in Zhaoyuan without a realistic potential, which meant farmers in two-thirds of the villages did not intend to carry out RSC. The realistic potential varied greatly between villages, mostly concentrated in two intervals, <0.1 hm² and >1.5 hm². The realistic potential that conformed to farmers' willingness was significantly different from the theoretical potential. Only 39 villages have no theoretical potential, but 434 villages did not have rural settlements to exit, indicating that there was still great resistance to implementing RSC in Zhaoyuan.

Kernel density analysis was used to reveal the spatial distribution of the realistic potential of RSC (Figure 4). Four high-density agglomeration areas formed in Zhangxing, Canzhuang, Qishan, and Daqinjia showed a flak-like distribution characteristic gradually extending outwardly from the center of the high kernel density. The per capita rural settlement area in the township seriously exceeded the national standard, which provided a large space for the exploration of realistic potential. The medium-density areas were mainly distributed in Xiadian, Biguo, and Xinzhuang. All three towns were located on the edge of Zhaoyuan, far from the city center. No realistic potential area or low-density area was mainly distributed in Wenquan and Mengzhi in the central region, close to the downtown area. Located in the hilly area in the northeast, Fushan had difficulty advancing the RSC, so the realistic potential kernel density value was also low.

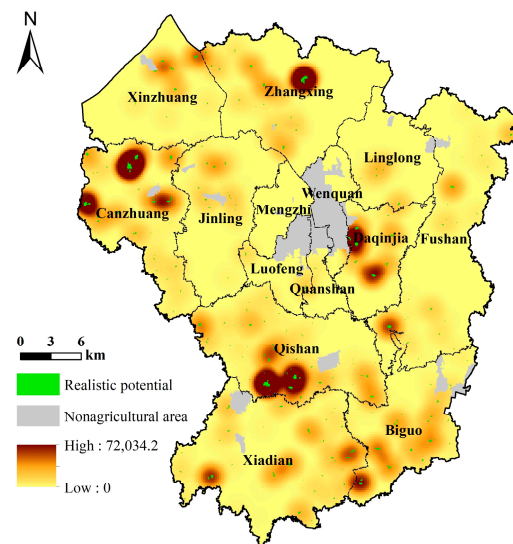


Figure 4. Kernel density analysis of the realistic potential of RSC.

4.1.3. Potential Transition from Theoretical to Realistic

In the current rural population scenario (Figure 5a,c), there were 592 villages with higher theoretical potential. Most of the villages did not reach 100% of the potential transition efficiency, and 65.13% of the villages had a potential transition efficiency < 10%, 12.17% were between 10% and 40%, 6.38% were between 10% and 40%, 4.15% were between 10% and 40%, and only 12.17% reached 100%. Of the remaining 82 villages, 27 had neither theoretical nor realistic potential, and 55 had more realistic potential than theoretical potential. The villages with 100% transition from theoretical to realistic potential were mostly near the center of towns and subdistricts with convenient transportation, where farmers had a

strong willingness for consolidation. Although a similar pattern was observed between the current and rural population scenario, the average potential transition efficiency of the whole city would drop from 22.15% to 21.17% (Figure 5b,d). In the future, the population loss of the villages would lead to an increase in vacant houses, so the sum of the newly added potential and the existing theoretical potential exceeds the realistic potential.

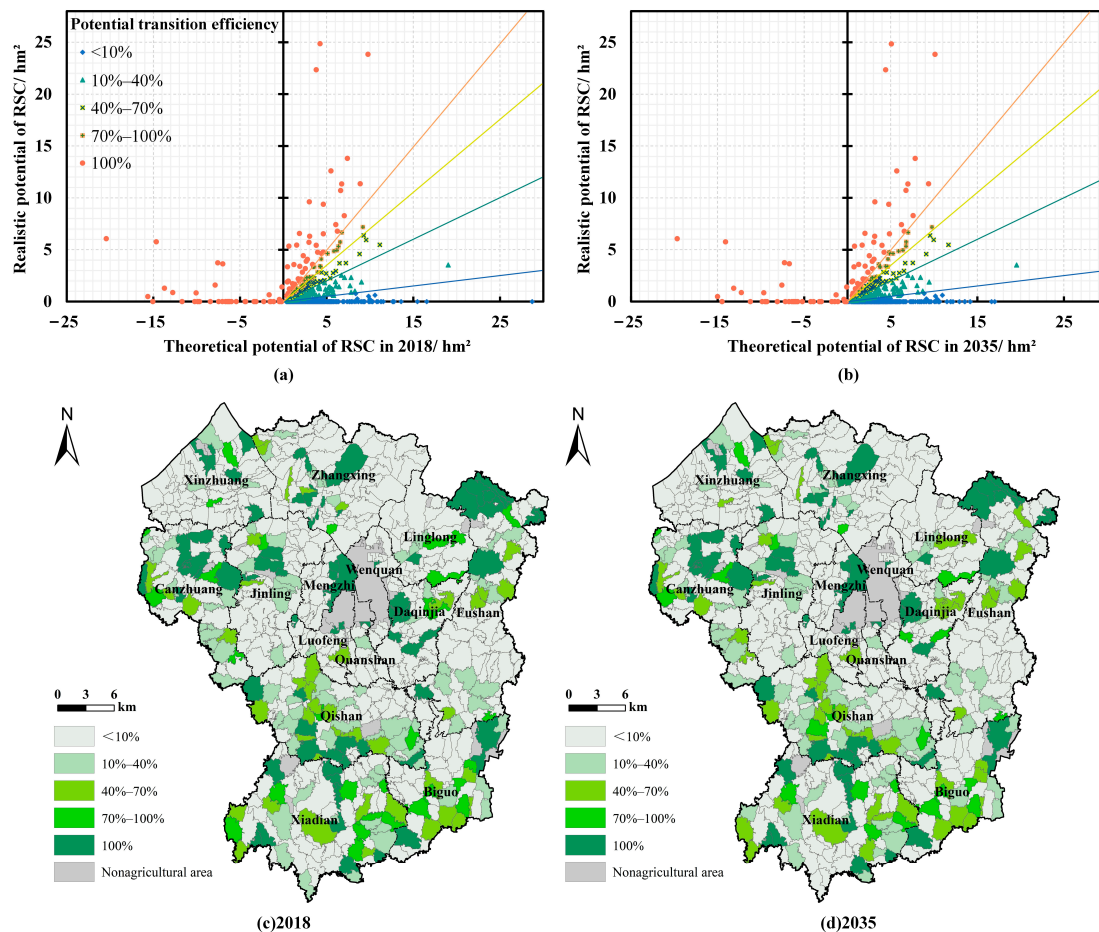


Figure 5. Transition efficiency from theoretical potential to realistic potential. (a,b) represent the potential of RSC in 2018 and 2035, respectively; (c,d) represent the potential transition efficiency in 2018 and 2035, respectively.

The transition difference was a direct embodiment of the gap between the theoretical and the realistic potential of RSC. There was an aggregation of villages with large transition differences, concentrated in Jinling, Zhangxing, Linglong, and the central area of Fushan. The potential transition difference presented a spatial pattern of high in the middle and low at the periphery. While there were many redundant rural settlements in the periphery villages, there were also many abandoned homesteads, resulting in a low transition difference under the combined effect. In the middle zone between the edge and the center, farmers' weak willingness in RSC led to low transition efficiency and high transition differences. Spatial differences in the potential transition from theoretical to realistic highlighted the uneven development of rural settlements. Rural settlements in the vicinity of the downtown area tended to be more fully exploited, while those situated far away from the downtown area were the principal contributors to the generation of RSC potential. Both the potential transition difference and the transition efficiency exhibited significant spatial divergence. There remained considerable room for improving the potential transition of RSC. To bolster RSC, it is essential not only to augment the realistic potential but also to enhance the efficiency of the potential transition.

4.2. Mechanism of Potential Transition from the Theoretical to Realistic

4.2.1. Factors Influencing the Realistic Potential

The results of the geographical detector showed that the realistic potential was highly related to the distance to the downtown area (Table 2). The expansion of the central city provided a strong boost to the RSC in the urban annexation mode. Proximity to downtown areas made it more convenient for farmers to engage in nonagricultural work, facilitating livelihood transformation and agricultural status change. Underdevelopment and rural hollowing of marginal villages might be severe, and some farmers with strong earning abilities chose to relocate to urban areas, which contributed to the emergence of the realistic potential of other modes.

Table 2. Geographical detector analysis results of influencing factors of RSC potential.

Aspects	Influencing Factors	Realistic Potential		Transition Difference	
		<i>q</i> Value	Explanatory Ability	<i>q</i> Value	Explanatory Ability
Geographic conditions	Distance to the town/subdistrict center	0.003		0.057 ***	4
	Distance to the downtown	0.020 **	4	0.007	
	Distance to the main road	0.009		0.005	
	Distance to water bodies	0.007		0.003	
	Topographic relief amplitude	0.006		0.005	
Socioeconomic levels	Per capita GDP	0.020 **	5	0.002	
	Rural population	0.050 ***	2	0.014 *	7
	Percentage of the total population out of the village for more than half a year	0.005		0.010	
	Educational level of rural population	0.002		0.072 ***	3
Production and living conditions	Rural settlement scale	0.075 ***	1	0.290 ***	2
	Per capita homestead area	0.007		0.404 ***	1
	Per capita arable land area	0.025 ***	3	0.014 *	6
	Per capita garden land area	0.005		0.005	
	Patch density of rural settlements	0.020 **	6	0.033 ***	5

Notes: ***, **, * represent significance at the 0.01, 0.05, and 0.1 levels, respectively.

Rural population and per capita GDP in socioeconomic levels showed their influence on the realistic potential. Numerous rural populations corresponded to more diverse livelihood modes and housing needs, which made it more difficult to coordinate the employment and resettlement of farmers. In the urban annexation mode, part-time farmers around urban areas might be more resistant to giving up rural land than villagers fully engaged in nonagricultural work. Farmers were also divided over being resettled into urban communities or converting their rural houses into apartments. Sizeable rural populations further aggravated the obstacles to realizing the realistic potential in the overall relocation mode in terms of adapting to the new environment and reconstructing social connections. Per capita GDP roughly reflected the level of economic development. Governments in economically developed regions could provide generous compensation for land acquisitions and resettlement in the urban annexation mode, as well as provide adequate funds for RSC projects in different modes. But in fact, Qishan, Xiadian, and Biguo, the bottom three in per capita GDP, occupied 43.8% of the realistic potential. The meager income could hardly meet the material needs of farmers and reduced their attachment to their hometown. Especially in extremely poor villages, the overall relocation implemented due to poverty alleviation would generate enormous realistic potential.

Production and living conditions were the most important factors for farmers to consider before exiting rural settlements, and the rural settlement scale had the most prominent impact on the realistic potential. While annexation by urban areas might lead to higher realistic potentials, direct conversion of large settlements was more difficult due to the constraint of the urban land expansion rate, making more moderate measures appropriate

in the urban annexation mode. The diseconomy of configuration was a cause of backward infrastructure and services in small rural settlements. The purpose of concentrating rural settlements in order to improve rural public services has driven the merger of small settlements. Large-scale rural settlements had plenty of idle and abandoned homesteads, only 32% of rural settlements exceeded 10 hm² in scale, but they held 56.8% of the realistic potential. Large rural settlements might be prioritized for internal renovation because of the large potential exploitation space to facilitate the implementation of large-scale RSC projects. The average patch density of rural settlements in villages with no realistic potential, realistic potential, and realistic potential exceeding 5 hm² was 6.7, 5.3, and 3.9 per km², respectively. The scattered layout might be a catalyst for generating realistic potential. Improving land fragmentation, low governance efficiency, and inadequate public infrastructure coverage faced by scattered rural settlements would promote the merger of low-density villages [53]. The internal renovation of scattered settlements from the periphery of the village to the interior could enhance inter-village communication and avoid social isolation. Arable land was the main livelihood resource for farmers, but nonagricultural income became a partial or even the main source of farmers' incomes around the urban area. In villages with scarce arable land, livelihood pressure forced young laborers to leave for employment, resulting in the coexistence of arable land shortages and rural labor drainage. There was an urgent need to increase livelihood capital in these villages by reclaiming redundant settlements into arable land through RSC.

4.2.2. Factors Influencing the Potential Transition

Rural populations and their educational levels influenced the potential transition of RSC. High educational levels facilitate the potential transition, as the average score of educational levels in villages with transition efficiency exceeding 90% (1.84) was significantly higher than the average of all villages (1.75). Highly educated farmers around urban areas preferred nonagricultural jobs and urban lifestyles and were more inclined to transform into urban residents [54]. Reluctance to leave native land and lack of livelihood skills were the biggest obstacles to the overall relocation of poorly educated farmers. Better-educated villagers were more able to understand, support, and actively participate in RSC, making the potential of RSC in different modes more realizable. Rural populations influenced both the theoretical and the realistic potential; rural populations determined the theoretical redundant area of rural settlements while the identity change and residence transfer of rural populations determined the generation of the realistic potential. Satisfaction rates of resettlement schemes in urban annexation and overall relocation modes and grassroots mobilization success rates of RSC in each mode were difficult to effectively improve in large rural populations, inhibiting the efficiency of potential transition.

Four out of five factors in the production and living conditions influenced the potential transition to varying degrees. Per capita homestead area had the strongest impact on the potential transition, followed by the rural settlement scale. Villages with large rural settlements and excessive per capita homesteads generated high realistic potential, but in fact, their theoretical potential was much higher. The average potential transition efficiency of villages with per capita homestead areas over 150 m² was only 16.58%. High potential space and low transition efficiency jointly caused a significant difference in the potential transition. Resettlement would be more efficient in the potential transition than directly reducing the excessive area of rural settlements under habitation. The difficulty of downsizing the excessive rural settlements currently being used led to unsatisfactory potential transition efficiency for RSC, especially for the interior renovation mode. In villages with high agricultural dependence, arable land facilitated the potential transition. RSC reclaimed settlement land into arable land in the village merger and internal renovation modes, transforming dormant assets back into productive resources for farmers. For farmers in the overall relocation, they had the opportunity to obtain a larger or better arable land in resettlement to get rid of the livelihood dilemma. The average potential transition efficiency of villages with rural settlement patch densities of less than five per km² reached

26.69%. Compared with concentrated rural settlements, scattered rural settlements had a higher probability of being directly abandoned and relocated in each mode, promoting the potential transition efficiency.

4.3. Optimization Paths for Spatial Reconstruction in RSC

This paper proposed four optimization paths for spatial reconstruction in RSC based on the prominent influencing factors of RSC in each rural settlement spatial reconstruction mode, namely, urban leading, agglomeration development, transformation and upgrading, and migration and reconstruction (Figure 6).

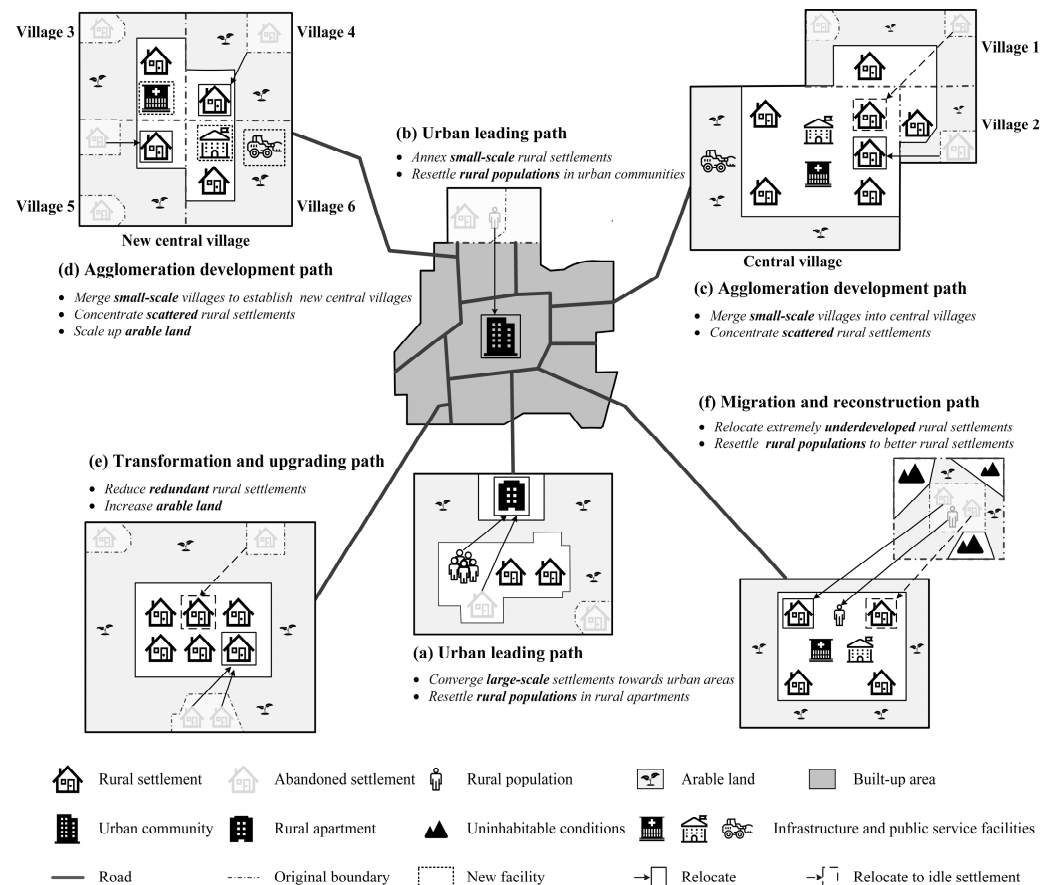


Figure 6. Optimization paths for spatial reconstruction in RSC. (a) represents the urban leading path for large-scale rural settlements; (b) represents the urban leading path for small-scale rural settlements; (c) represents the agglomeration development path for rural settlements where a central village exists; (d) represents the agglomeration development path for rural settlements where a central village does not exist; (e) represents the transformation and upgrading path; (f) represents the migration and reconstruction path.

The urban leading path aims at the spatial optimization of rural settlements around or inside the urban area, focusing on three key factors: location, rural population, and rural settlement scale. The optimization objective is to guide the transformation of rural populations and land into urban areas. Since uncontrolled and disorderly urban expansion is curbed, large-scale rural settlements can take the mitigation measure of gradually moving closer to urban areas to prepare for urbanization. Idle settlements are taken back directly, outlying scattered settlements are relocated towards the urban area, and new rural apartments will be built for resettlement (Figure 6a). Small-scale rural settlements adjacent to urban areas can be converted into urban land by way of “village-to-community” (Figure 6b). After the rural houses are demolished, the vacated land can be used for urban

development or farmers' resettlement. Farmers engaged in nonagricultural work who are willing to give up rural land can be resettled in urban communities after transforming their resident identities. Part-time or full-time farmers who retain their agricultural status can be resettled in rural apartments or unannexed rural settlements around the urban area. The implementation of RSC should be people-oriented to achieve a healthy transition from rural settlements to urban areas, and farmers should be given choices rather than be forced into resettlement.

Focusing on the impact of the rural settlement scale, per capita arable land area, and rural settlement patch density on the RSC potential transition in the village merger process, the agglomeration development path accomplishes the concentrated and large-scale utilization of land to improve farmers' livelihoods and service accessibility through land and administration restructuring. The implementation of the village merger which guides farmers to centralized villages has been recognized as an effective way to economize administrative resources and improve the social service efficiency of public resources [55]. Underserved small villages (villages 1 and 2) can directly share better infrastructure and public service facilities by merging into fully functional central villages (Figure 6c). Marginal settlements of small-scale villages are relocated to concentrated settlements, and the idle and abandoned settlements are directly taken back. If there is no fully functional central village nearby, several villages (villages 3, 4, 5, and 6) can be merged to establish a new central village, with scattered marginal settlements moving to concentrated settlements while public facilities and infrastructure are added in the new central village (Figure 6d). Relocated settlements preferentially move to idle settlements, followed by other areas in concentrated settlements, gradually realizing the concentration of rural settlements. Rural settlements abandoned in the process of village mergers will be prioritized for reclamation to form concentrated and contiguous arable land, reducing fragmentation and facilitating large-scale agricultural operations. Land unsuitable for reclamation can provide space for adding public service facilities or developing nonagricultural industries to improve farmers' livelihoods.

The transformation and upgrading path to improve rural habitat environments and land use efficiency focuses on reducing redundant rural settlements and increasing arable land. The specific measure is to relaunch settlement planning, strictly implement the principle of "one household, one housing", "demolish old while building new", and prohibit the occupation of arable land for new housing. Idle and abandoned settlements at the edge of villages are directly taken back. Scattered settlements at the edge of the village are gradually relocated to the interior and preferentially resettled in the redundant idle settlements recovered (Figure 6e). This enables the control of the expansion of village construction boundaries on the periphery and adjusts the layout of houses, roads, and arable land at the interior so as to make the layout of rural settlements orderly. High-standard farmland construction shall be carried out along with rural settlement reclamation in order to improve agricultural productivity by increasing the quantity and quality of arable land. During the RSC process, the residential appearance beautification, road hardening, and sanitary rectification can be synchronized to create a beautiful, comfortable, and livable rural living space.

The migration and reconstruction path aims to improve the living and livelihood conditions of farmers in extremely underdeveloped villages through relocation implemented by RSC. Rural populations will move out of rural settlements where livelihood resources have difficulty in maintaining an adequate standard of living. The entire settlement scatters to relocate to large, affluent settlements with good living conditions nearby (Figure 6f). Migrant farmers are preferentially resettled in idle settlements to avoid or reduce the occupation of the arable land. The original rural settlements can be reclaimed into arable land or naturally restored as forest or grassland according to the natural conditions [32]. Farmers should be guided and organized to relocate on the premise of fully respecting their willingness. Agriculture remains the income source for most farmers after relocation, so farmers should be allocated adequate arable land to maintain a normal life. It may take a long time for farmers' psychological adaptation and social relationship integration.

Therefore, farmers and acquaintances in their social networks should be resettled in the same areas as much as possible.

5. Discussion

5.1. Priorities in Implementing RSC in Practice

As rational subjects pursuing the maximization of personal interests, farmers paid more attention to living conditions and livelihood development when they decided whether to participate in RSC [56]. Considering the importance of arable land on the livelihood of rural households, the abandoned settlement should be reclaimed as arable land or other agricultural land first as much as possible. In this way, RSC not only reduces redundant settlements and renders scattered settlements more compact overall but also increases the arable land area and reduces its fragmentation. The improvement of agricultural productivity makes the positive results of RSC directly benefit farmers.

To promote the potential transition, it is necessary to improve the potential transition efficiency of large-scale rural settlements with seriously excessive homesteads per capita, and the focus is to identify the redundant old and abandoned houses in villages to revitalize the stock land. RSC in practice should be oriented by the concentration of settlements. The consolidation process should be combined with village planning, strictly adhere to the village construction boundary, and improve the concentration of rural settlements.

Poor public infrastructure, backward agricultural development, and dilapidated landscapes contribute to the outflow of the rural population [57]. When implementing RSC, local governments should allocate part of the financial revenue from RSC projects to improve and add infrastructure, renovate village environment, and shape rural landscapes to enhance the attractiveness of rural areas. In addition to increasing the concentration and connectivity of the arable land to attract investment from family farms and agricultural companies, RSC can also reserve space for the development of nonagricultural industries such as rural enterprises and rural tourism to facilitate rural industrial transformation.

RSC is influenced by location, the size and educational level of the rural population, GDP, settlement scale and layout, and arable land, and these factors interact to change rural settlements. For instance, advantageous locations attract population and investment, catalyzing GDP growth and industrial transformation, with more compact settlements and less reliance on the arable land of consequence. The rural population directly affects the demand and allocation of settlements and the arable land. GDP correlates with population quality and mobility, and financial support is essential for demolition, land reclamation, and reconstruction. Educational level influences the job skills and residential preferences of rural residents, thereby affecting settlement and arable land planning. The interplay between settlement and arable land in scale and layout is crucial: settlement scale must be matched with the scale of the arable land to ensure agricultural supply, while rational settlement layout can enhance land use efficiency and minimize the occupation of arable land. The availability of arable land directly determines the productivity of farmers, with an expansion in arable land leading to increased yields, influencing population size and farmers' income. To ensure the feasibility and effectiveness of rural settlement planning, it is imperative to consider all these factors and their complex interactions.

5.2. Policy Enlightenment for the Potential Transition of RSC

Land use policies, especially the “increasing versus decreasing the balance of urban–rural construction land” and “arable land requisition–compensation balance”, provide an action framework and policy incentives for RSC. RSC helps the country accomplish the arable land protection goal, helps local governments obtain urban construction land quotas or fiscal revenue, and helps farmers increase the amount of arable land and obtain new housing. However, RSC has been blindly and radically implemented by local governments as a tool for grabbing land profits in some villages, resulting in forced relocation, impoverished farmers, substandard reclaimed arable land, and other practical problems. RSC is not only the demolition and reconstruction of settlements, but also a systemic project involving

farmers' livelihood, resettlement, public services, arable land, and rural environment. It is necessary to clarify and improve the key policies for implementing RSC.

Desirable land acquisition compensation and resettlement policies are critical to promoting the potential transition of RSC in the urban annexation mode. Financial incentives have facilitated farmers' relocation decisions, but the short-term compensation policy unilaterally formulated by the government often undercompensates farmers [58]. Affordable and appropriate housing contributes to the successful resettlement of farmers, but current rural resettlement communities are mostly modeled after urban communities, which can hardly cater to farmers' lifestyles and increase their living burden. Local governments need to open up channels for farmers to participate in policy formulation and actively accept farmers' proposals on land compensation standards and rural community design. Long-term and multidimensional compensation policies including social insurance, livelihood subsidies, and income security should be developed to stimulate farmers' enthusiasm for participating in RSC.

Concentrated rural resettlement policies and moderate scale operations of agriculture are the driving forces behind village mergers. The increased accessibility of infrastructure and public services resulting from the concentration of rural settlements and the scale of arable land after the village merger facilitates the potential transition. The key measures are to improve the infrastructure such as roads, electricity, communication networks, irrigation, and water conservancy facilities, and increase the supply of public service facilities such as schools, health clinics, and squares. The implementation of village mergers should be carefully evaluated, neither large-scale mergers nor forced demolitions should be allowed, and farmers should be resettled voluntarily out of public services and infrastructure rather than being forced [59].

As a basic land management institution, "economical and intensive land use" aims to improve land use efficiency by controlling the increment of construction land and revitalizing the stock [60]. The rigid standard of per capita homestead under "economical and intensive land use" is the leading force to urge RSC to improve the utilization efficiency of rural settlements in the internal renovation mode. Since it is difficult for farmers to voluntarily cooperate with mandatory policy requirements, clarifying the supervision and management measures of idle rural settlements and refining the reward and punishment policies of excessive rural settlements will help to realize the effective transition of potential.

Farmers are in a vulnerable position in the overall relocation process, and effective resettlement policies and livelihood support policies can help farmers adapt, integrate, and maintain their new lives more quickly. Resettlement policies will be more conducive to the potential transition of RSC by reducing the economic burden of relocated farmers through financial subsidies as much as possible, within the government budget. Livelihood support policies should consider the differences in farmers' family structure and earning capacity, provide relocated farmers with different agricultural and nonagricultural employment opportunities, and enhance the sustainability of farmers' livelihood development through skills training.

5.3. Limitations and Prospects

This paper paid special attention to the influencing mechanisms of the RSC potential and proposed optimization paths for spatial reconstruction using RSC. However, there were still some limitations. For example, the influence of ecological environments, customs, and cultures on the RSC potential transition could be further explored to enrich the multidimensional influencing factor system. Additionally, although a variety of different rural settlements were covered in our case, there was still a shortage of RSC studies for rural settlements with special conditions like ethnic minority gathering areas and modern agricultural development zones.

Future research on RSC potential and rural settlement spatial reconstruction could focus on the following two aspects: Firstly, there are differences in rural population flow in different urbanization stages, which have different impacts on land use in rural settlements.

It is possible to focus on the long-term dynamic observation of rural population mobility and study the impact of rural population loss on RSC potential at different urbanization stages. Secondly, the optimization paths for the spatial reconstruction of rural settlements proposed based on RSC could incorporate the target orientation of intervillage social connections and farmer interaction needs.

6. Conclusions

Promoting the maximum transition of the RSC theoretical potential into the realistic potential has a strong practical significance for improving the rural habitat environment. This paper compared the difference between the theoretical and realistic potential of RSC and revealed the spatiotemporal differentiation patterns and influencing factors of RSC based on an empirical study in China. We found that the theoretical and realistic potentials were significantly different at the village level. Although rural depopulation will directly lead to an increase in the theoretical potential, most villages have no plans to carry out RSC. Production and living conditions and socioeconomic levels played important roles in the realistic potential of RSC. Basic rural settlement conditions and arable land resources were the key factors affecting the participation of rural residents in RSC. This paper clarified the influencing mechanisms of the RSC potential and proposed optimization paths for rural settlement spatial reconstruction, which could provide valuable information for improving intensive rural land use and habitat environments.

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