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How Different Land Systems Lead to Discrepancy of Rural Population–Land Relationships: Case Study of Heilongjiang Province, China

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Abstract: There are two types of land systems in China: collective-owned and state-owned. Under both systems, differences in land ownership have led to different land-use and management systems, resulting in urban–rural dual structures under the jurisdiction of local governments and urban–rural unitary structures in reclamation areas of the state-owned land system. This has significantly changed the relationship between the rural population and land, which has been intensified by rapid urbanization and industrialization. Therefore, based on the rural population and remote sensing data, this study uses the Tapio decoupling model to determine the relationships between the rural population and residential land under different land systems. The main results indicate that the evolution of the rural population and residential land area under different land systems presents an obvious inverse relationship. From 1995 to 2020, under the jurisdiction of the local government, the land area and population of rural dwellers declined, with the decline in population being faster than that in residential areas. At the same time, the spatial agglomeration of residential areas from the middle to the south of the province expanded. In contrast, the population and residential land area showed significant reverse changes in state-owned domains. Rural residential land area declined, and the rural population increased, most notably in the eastern region. Furthermore, strong negative decoupling between the rural population and rural residential land was observed in areas under local government jurisdiction (accounting for 89.61%), meaning that the population declined while the living area increased, which is not conducive to increasing intensive land-use and productivity. Simultaneously, in state-owned domains, only 33.33% of the rural population and residential land areas presented the above-mentioned negative decoupling, with the remaining 66.67% being coordinated. After 2010, due to the socio-economic gap, the proportion of coordination in local government jurisdiction areas continued to decrease, whereas coordination in reclamation areas remained stable. Therefore, the data suggest that a single land allocation and governance regime across urban and rural domains under the state-owned land system is more helpful in enabling populations and efficient land-use. This suggests that, in the future, it will be helpful to consider promoting the effective integration of urban and rural land markets, optimizing the allocation of urban and rural land resources, and enhancing the reform of the rural land system in order to realize synergistic interactions between the urban and rural populations and construction land in Heilongjiang Province.

Keywords: land system; urban-rural structure; decoupling analysis; population-land relationships; Heilongjiang Province

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1. Introduction

The population boom has become a mainstream trend worldwide. The global population reached 6 billion in 2000 and 7.9 billion in 2021, with an annual average growth rate of 1.32%, an unprecedented level in human history, thus increasing the pressure on land. In this process, some land has become degraded due to inappropriate use, overuse, and so on, while other land is underutilized because of inadequate socio-economic development. The current issue of how to achieve sustainable utilization of land globally is a very important one. However, institutional factors are considered to be some of the most important factors leading to these changes. Related concerns are reflected in various programs and policies, including the 2030 Agenda for Sustainable Development.

It is undeniable that China's urbanization has developed rapidly in the 21st century. For example, China's urban population increased by nearly 500 million from 2000 to 2020, with the corresponding urbanization rate rising from 36.2% to 63.9% [1]. In this process, the urban population has become more concentrated, while the rural population has diminished. By 2020, China's urban population had surpassed 900 million, and the rural population had fallen to 510 million, with only 450 million expected by 2035 [2]. At the same time, land-use in rural areas is not efficient, and the hollowing-out phenomenon of populations on rural collective lands is becoming increasingly apparent. According to statistics, from 1995 to 2020, China's urban construction land area increased by approximately 42,000 km^2, while the rural residential land area increased by 1000 km^2. Therefore, it is a long-term problem for China to improve land-use efficiency through the policy of "increase construction land and decrease linkage" and promoting urban–rural integration.

In fact, China's land system has undergone a complex evolution. In the early days of the founding of New China, it implemented a planned economic system, with land owned by farmers in rural areas and owned by the state in cities. From 1952 to 1957, land owned by farmers in rural areas was grouped for collective use, and a collective-owned land system was implemented. After the reform and opening up in 1978, the transition from a planned economy to a market economy was realized gradually. The collective-owned land system realized the separation of land ownership and use rights [3]. Land ownership still belongs to the collective, but farmers have the right to contract land and have self-management rights over the land they share, and each plot owner is responsible for their farming inputs and earnings. Thus, in local government areas, urban and rural binary systems of land ownership, use, and management have formed between urban and rural areas.

However, in some parts of China—such as the Heilongjiang, Hainan, and Xinjiang provinces—there are also reclamation areas where the state owns land. In such regions, the operating bodies are state-owned farms. Land in urban and rural areas can be paid for, used, transferred, and so on, and the residential land system can be optimized through urban and rural planning and reclamation of abandoned residential land [4]. Thus, in these regions, land ownership, use, and management systems in urban and rural areas are uniform.

The difference between the urban and rural structures caused by the two land systems in China has resulted in obvious differences in food production, household income, and the relationships between people and land. As shown in Figure 1, in areas under local government jurisdiction, the dual urban–rural structure allows farmers to engage in smallholder economic production, and, so, the farm holdings are scattered, not aggregated into concentrated farming zones. Consequently, this leads to a decline in agricultural productivity, as well as a decline in farmer incomes and a devaluation of food supplies [5]. From 1995 to 2020, the per capita income of rural farmers in China increased from CNY 2337.87 to CNY 17,131.5, and, notably, a significant increase in the proportion of wage income (from 15.13% to 40.70%) occurred. The share of primary industry operating income was only 23.20% by 2020. In a nutshell, the decreasing agricultural income affects the living security of households and, so, the rural population has poured into cities.

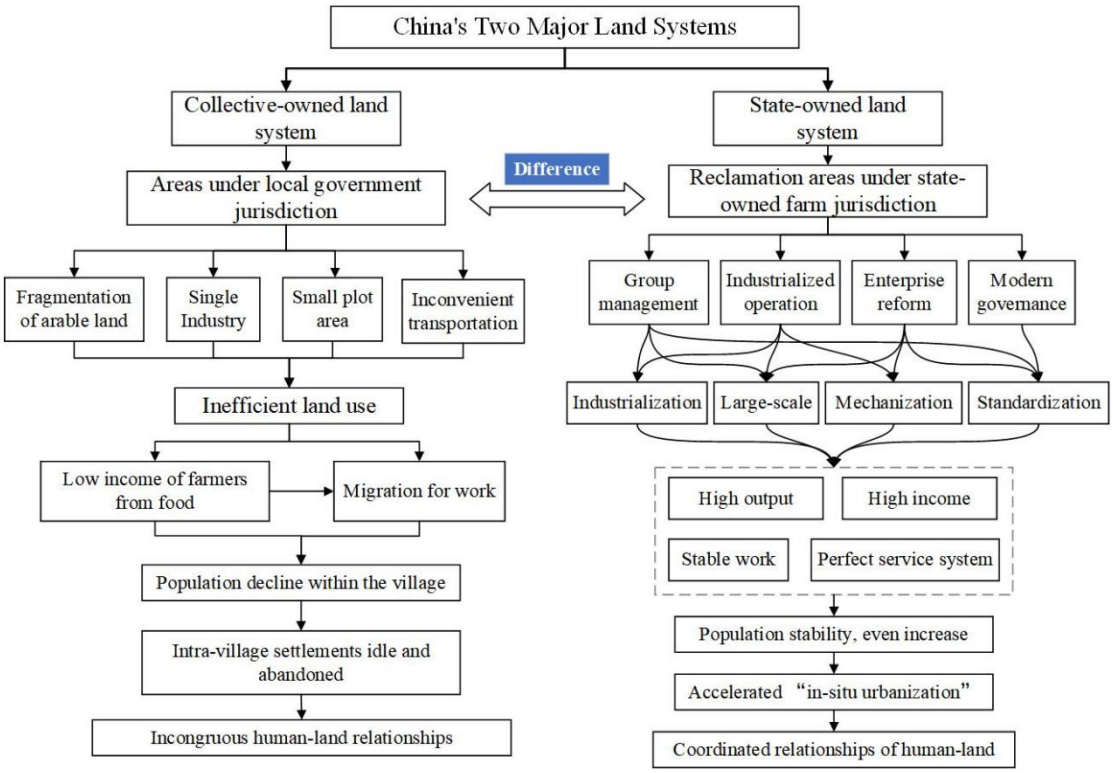


Figure 1. Development of different land systems in China.

Conversely, integrated urban–rural management has been implemented under the state-owned land system, as examined by this study, in Heilongjiang Province. The family farms gradually established by the state have the characteristics of advanced technology, superior machinery, and highly educated talent [6]. By 2017, the total population of the country's family farms had increased by approximately 17% compared to 2000, and the total income had increased by approximately 780 billion. Therefore, in the reclamation areas of state-owned land systems, the unitary urban–rural structures can improve land-use efficiency, provide employment opportunities for peasants, increase farmer incomes, and, to some extent, ease the exodus of people and land contradiction.

Many scholars in China have studied the relationships between rural settlement land and the rural population [7–9]. Furthermore, many studies have focused on the fundamental laws of spatio-temporal evolution, influencing factors, layout optimization [10–13], hollowing out of the rural population, and characteristics of land transfers in rural settlements [14–16]. Based on this mechanism, the analysis included the characteristics of rural population migration, the change in the use of residential land, and population transfer under the background of population withdrawal [17,18]. In summary, most studies have explored the spatial characteristics of rural settlements in the context of rural population change, but there has been no in-depth discussion on the coupling between rural populations and settlements [19]. Studies have focused on large-scale, such as the national level, and medium-scale, such as the provincial level [2], with less research on the scale of small and medium regions, and studies on the decoupling between the rural population and settlement land under different land systems have not been reported. However, the optimal allocation of urban and rural land resources requires a comprehensive understanding of the dynamic evolutionary trend of regional population and settlement coupling [20]. Therefore, it is very meaningful to analyze the population–land relationships between different land systems in Heilongjiang Province. Additionally, optimizing a land management system for agricultural and rural modernization is necessary for urban–rural integration development. Most existing studies have addressed the changing characteristics of rural settlements unilaterally. Studies that combine the two for coupling or decoupling analysis have also

focused on urban and rural areas at the national and provincial levels [21]. Research on the decoupling between the rural population and settlement land in different land systems has not been reported. Hence, according to the research gaps highlighted above, promoting the implementation of land systems is needed in China, particularly in Heilongjiang Province.

Due to the differences in the land ownership system, there are obvious differences in land-use and management systems between the areas under local governments with urban–rural dual structures and reclamation areas with urban–rural unitary structures, which further leads to changes in the urban–rural land structure and the evolution of population–land relationships. Therefore, this study takes Heilongjiang Province as a research area, discusses how different land systems have led to different population–land relationships and their changing trends in those two regions for the period 1995–2020, and analyzes the differences between the two land systems and their influence on the evolution of population–land relationships in order to provide sustainable development strategies and policies for reform of the rural land system and governance of rural settlements.

2. Materials and Methods

2.1. Overview of the Study Area

Heilongjiang province is located in northeast China, between 121°11′–135°05′ E, 43°25′–53°33′ N. In 2020, the province's land area was 4.53 × 105 km^2, excluding the Jiagedaqi and Songling districts. The topography of the Heilongjiang Province is high in the northwest, north, and southeast and low in the northeast and southwest. By the end of 2020, Heilongjiang Province had 13 municipal divisions and 121 county units (Figure 2). The province's gross domestic product (GDP) stands at CNY 1369.85 billion, and its per capita GDP is CNY 42,635, still well below the national average (CNY 72,000). The income gap between urban and rural residents is clear, with disposable incomes of CNY 29,191 and CNY 13,804, respectively. Although Heilongjiang is a large agricultural province, with the rapid development of urbanization and industrialization, its industrial structure has gradually come to be dominated by the tertiary sector (49.47%), while primary industry development is lagging (25.10%).

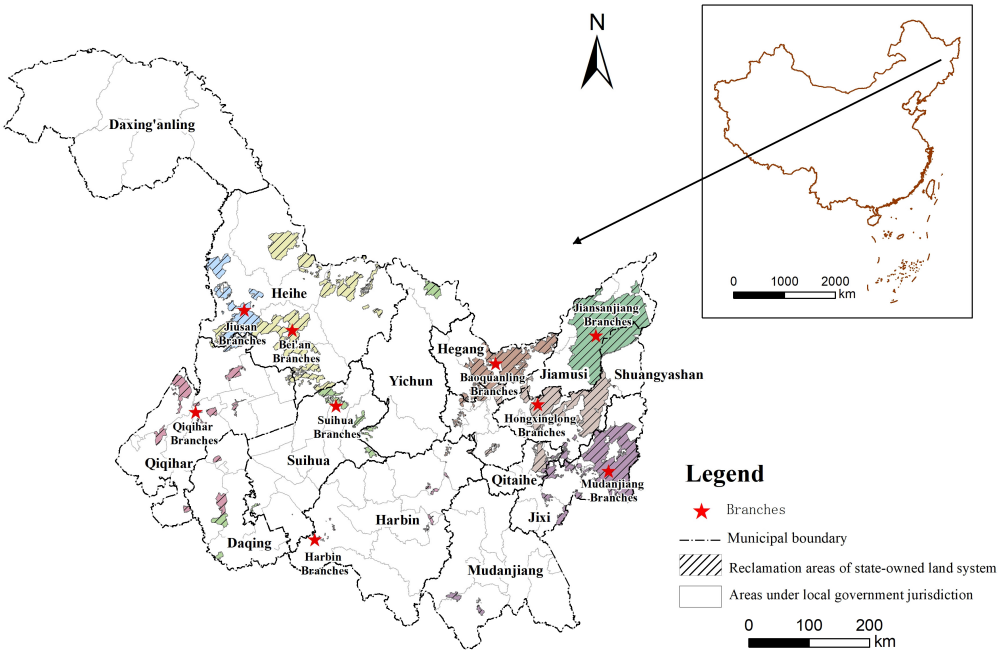


Figure 2. Geographical location of the study area.

Reclamation areas of the state-owned land system in Heilongjiang province have been formed by the Beidahuang Group, the largest and most populous of the state-owned farm areas in the country. In agriculture, its mechanization and technological level are also at

the forefront. It applies a system of compensation for the use of land and can plan and optimize residential land systems at the farm scale. By 2020, it covered nine branches and 113 farms, producing 21.34 billion kilograms of food with a disposable income of CNY 28,789 per person, slightly higher than the national average (CNY 21,908). However, the rural areas of Heilongjiang Province are under the jurisdiction of local governments, the land is still collectively owned, and the use of rural homesteads is distributed without compensation [7]. Therefore, the homestead and settlement systems are managed separately. With the population's exodus, homesteads depend on land expropriation and the "increase construction land and decrease linkage" policy [22]. Adjustment of the resettlement system requires the adoption of provincial or even national policies and cannot fully cover county and village resettlement; therefore, the exit mechanism is not perfect.

2.2. Data Sources

The data were obtained from multiple sources for 1995–2020, including spatial, socio-economic, and agricultural data (Table 1). Agricultural data such as agricultural gross domestic product (GDP), food production index, and arable land reflect the adequacy of land-use [23] and, by extension, directly reflect income and household livelihoods. Accordingly, additional data, such as those related to urban and population evolution, were also collected in order to understand their impact on agricultural land-use. The research unit was based on 77 county-level units in areas under local government jurisdiction and nine branches in reclamation areas of the state-owned land system.

Table 1. Data source information.

Types		Information
Spatial data	Source	The 1:100,000 land-use databases of the Chinese Academy of Sciences http://www.resdc.cn/ (accessed on 10 October 2022)
	Types	National and country boundaries; reclamation areas of state-owned land systems boundaries; rural residential land
Socio-economic data	Source	Statistical yearbooks, http://www.stats.gov.cn/, https://www.rmzxb.com.cn/ (accessed on 26 December 2022)
	Types	Urbanization rate; urban and rural population; net income per capita; production income; wage income.
Agricultural data	Sources	Heilongjiang Statistical Yearbook (1996–2021) Heilongjiang Reclamation Area Statistical Yearbook (1996–2021). The Economic and social statistical synopsis of Beidahuang Group (2021), https://data.cnki.net (accessed on 15 March 2023)
	Types	GDP agricultural; food production index; agricultural land; arable land; level of mechanization.

2.3. Methods

2.3.1. Temporal Changes in Rural Population and Residential Land

An analysis of the study period, both globally and at the interval level, is essential. Therefore, the Rural Population Annual Rate (RPAR), Residential Land Annual Rate (RLAR), and Per Capita Residential Land Annual Rate (PCRLAR) were adopted to measure the changes in the rural population and the land used for rural residences [24]. The formulae are as follows:

$$RPAR_{it} = \left(\sqrt[t]{P_{(1+t)^i} / P_{1i}} - 1 \right) \times 100\%, \quad (1)$$

$$RLAR_{it} = \left(\sqrt[t]{L_{(1+t)^i} / L_{1i}} - 1 \right) \times 100\%, \quad (2)$$

$$PCRLAR_{it} = \left(\sqrt[t]{PCRL_{(1+t)^i} / PCRL_{1i}} - 1 \right) \times 100\%, \quad (3)$$

where $RPAR_{it}$ represents the average annual rate of change in the rural population, $RLAR_{it}$ represents the average annual rate of change of land used in rural settlements, $PCRLAR_{it}$ represents the average annual change in land-use per capita of the rural population, P represents the rural population, L represents the area of land used in rural settlements, and $PCRL$ represents the area of land used by the rural population per capita.

2.3.2. Spatial Differences in Rural Population and Residential Land

For this study, the Global Moran's I was used to analyze the spatial distribution and agglomeration characteristics of rural population and residential land. The Global Moran's I has a value range of [−1, 1]. Meanwhile, the Local Moran's I was used to identify the spatial dependencies and differences bewteen rural population and residential areas. The formulae are as follows:

$$I = \frac{\sum_{i=1}^{n} \sum_{j \neq i}^{n} w_{ij} (x_i - \overline{x}) (x_j - \overline{x})}{S^2 \sum_{i=1}^{n} \sum_{j \neq i}^{n} w_{ij}}, \quad (4)$$

$$G_i^* = \frac{\sum_{j=1}^{n} W_{ij} X_j}{\sum_{j=1}^{n} X_j}, \quad (5)$$

where x_i and x_j represent the rural population or rural residential land area of each county unit; n represents the total number of research units; w_{ij} represents the spatial weight matrix; and G_i^* represents the statistic of i. When the Global Moran's I > 0, it indicates spatial aggregation, the larger the value, the stronger the correlation. When the Global Moran's I < 0, it indicates spatial differences, the smaller the value, the stronger the difference. Finally, when the Global Moran's I = 0, there is no spatial correlation.

2.3.3. Decoupling of Changes in Rural Population and Residential Land

Decoupling means that the response relationships between two or more physical quantities no longer exist [25]. Using growth ratios to determine changes in growth elasticity to determine the decoupling status is not limited by the study period and requires fewer data; therefore, it is more widely used. Hence, this study uses the Tapio elastic system method to determine the degree of decoupling between the size of the rural population and the area of land used in rural residential areas in order to construct the decoupling model. The formula for the model is as follows:

$$I = \frac{RL}{RP} = \frac{(LA_t - LA_0)/LA_0}{(PQ_t - PQ_0)/PQ_0}, \quad (6)$$

where I represents the decoupling coefficient between the rural residential land area and resident population; RL indicates the rate of land area change in rural settlements; RP indicates the difference in the number of rural people; LA_0 and LA_t refer to the land area used in rural settlements in the early and late stages of the study, respectively; and PQ_0 and PQ_t refer to the rural population at the beginning and end of the study, respectively.

In the study of the decoupling state and Tapio method [26,27], the critical values for the elasticity coefficient were determined to be 0.8 and 1.2 (Table 2, Figure 3).

Table 2. Statistics of the decoupling status.

Decoupling Status		*RL*	*RP*	*I*	Meaning
Decoupling	Weak decoupling	≥0	≥0	$0 \leq I \leq 0.8$	A suitable status, with increased rural residential land area and resident population, but the resident population has increased even more
	Strong decoupling	<0	>0	$I < 0$	A suitable status, with an increased rural population and intensive land-use
	Recessive decoupling	<0	<0	$I > 1.2$	A suitable status, with both decreased rural residential land area and resident population, but the land has declined even more
Negative Decoupling	Weak negative decoupling	≤0	≤0	$0 \leq I \leq 0.8$	An unsuitable status, with rural residential land area and resident population both decreasing, but the population has declined even more
	Strong negative decoupling	>0	<0	$I < 0$	A less suitable status, with decreased rural population and intensive land-use
	Expansive negative decoupling	>0	>0	$I > 1.2$	A less suitable status, with rural residential land area and resident population both increasing, but the land has increased even more
Coupling	Expansion coupling	>0	>0	$0.8 < I \leq 1.2$	An inclined to suitable status, with the condition that rural residential land area and resident population both increased in a similar range
	Recessive coupling	<0	<0	$0.8 < I \leq 1.2$	An inclined to suitable status, with the condition that rural residential land area and resident population both decreased in a similar range

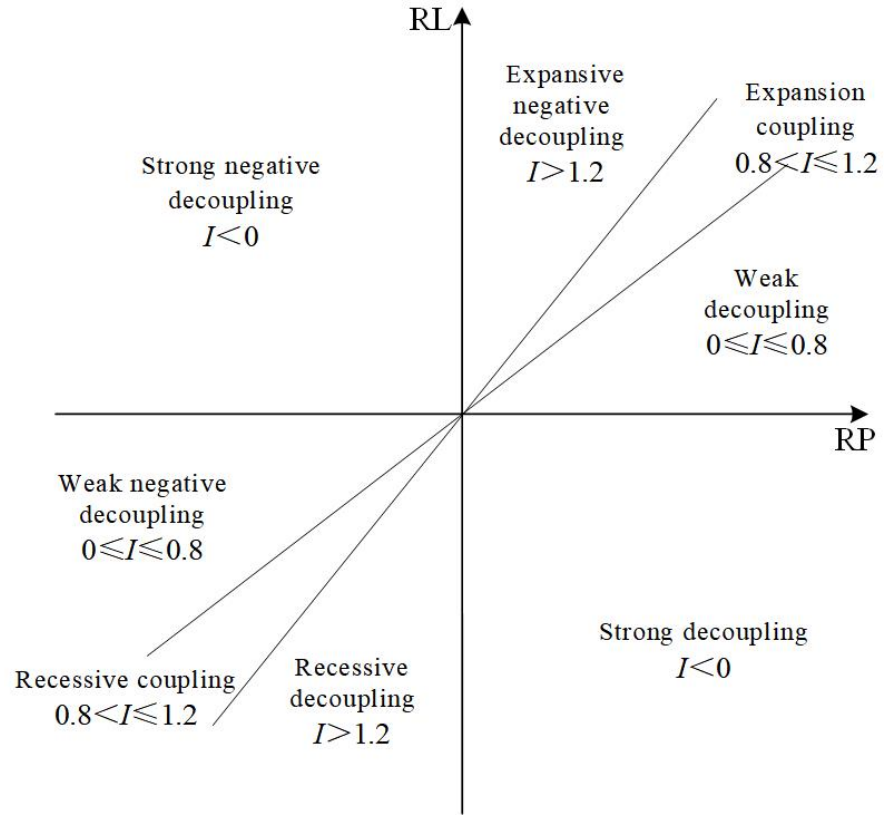


Figure 3. Decoupling status coordinate diagram.

3. Results

3.1. Changing Characteristics of Population and Rural Residential Land under Local Government Jurisdiction

3.1.1. Temporal Evolution Characteristics

Figure 4 shows the trends of population and residential land area changes under local government jurisdiction in Heilongjiang Province during the study period. The rural population in areas under local government jurisdiction remained largely stable from 1995 to 2010, with the highest number in 2010 (at 19.32 million). Conversely, the rural population declined rapidly to 10.92 million in 2010–2020, with a decline rate of 43.50%. During the same period, however, the number of rural residents appeared to be declining and fluctuating. The largest rural residential area was 6696.45 km^2 in 1995. Later, many villages were submerged and abandoned as a result of flooding of the Songhuajiang and the Nenjiang, and the area of rural settlements was reduced. Since China began implementing the Northeast Revitalization Strategy in 2003, the return of part of the rural population has led to an increase in the size of rural settlements. However, with the rapid expansion of large cities such as Harbin, Daqing, and Jiamusi, a large number of rural settlements were occupied. Therefore, under the combination of the above factors, the area of rural settlements has fluctuated. This phenomenon indicates that the current land control mechanism for rural residents has not achieved obvious results and has also put some pressure on urban and rural construction land.

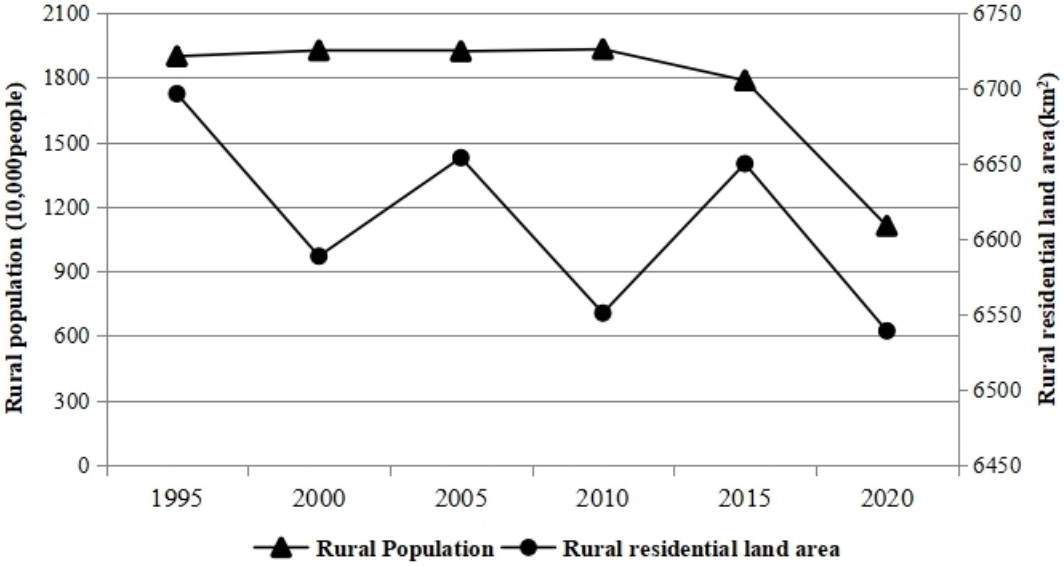


Figure 4. Changes in rural population and residential land under local government jurisdiction in Heilongjiang Province.

3.1.2. Spatial Characteristics

Based on the ArcGIS platform, the Global Moran's I of rural population and residential land under the local government jurisdiction of Heilongjiang province was calculated for 1995–2020 (Table 3). The results show that, in 1995, 2000, 2005, 2010, 2015, and 2020, the Global Moran's I for the rural population was 0.1124, 0.1221, 0.1199, 0.1218, 0.1114, and 0.0973, while the Global Moran's I for rural residential land was 0.2004, 0.2368, 0.2285, 0.3730, and 0.3755, respectively. Both passed the significance test ($z > 1.96$, $p < 0.05$), indicating that there is a significant spatial correlation between the rural population and residential land in the local government area of Heilongjiang Province, which shows a significant convergence trend. However, the Moran's I of the rural population dropped from 0.1124 to 0.0973, indicating a gradual decrease in spatial correlation, while the Moran's I for residential land rose from 0.2004 to 0.3799, indicating a gradual increase in spatial

agglomeration. This further confirms that, in this region, the rural population is declining at a faster rate than residential areas.

Table 3. Summary of Global Moran's I of rural population in areas under local government jurisdiction.

Year	Rural Population			Rural Residential Land		
	Global Moran's I	*z*-Score	*p*-Value	Global Moran's I	*z*-Score	*p*-Value
1995	0.1124	2.6488	0.0081	0.2004	4.0706	0.0000
2000	0.1221	2.8086	0.0050	0.2368	4.7389	0.0000
2005	0.1199	2.7035	0.0069	0.2285	4.6303	0.0000
2010	0.1218	2.7463	0.0060	0.3730	7.0955	0.0000
2015	0.1114	2.5941	0.0095	0.3755	7.1291	0.0000
2020	0.0973	2.3239	0.0201	0.3799	7.1956	0.0000

The Local Moran's I was used to calculate the Local G* for rural population and residential land under the local government jurisdiction of Heilongjiang Province from 1995 to 2020, as well as to map the spatial agglomeration (Figures 5 and 6). As can be seen from the previous analysis, during the study period, the rural population was in a state of extreme decline, such that the spatial agglomeration of the population distribution was not obvious, mainly presenting low–low cluster areas. The high–high cluster areas were mainly concentrated in the central part, mainly including Suiling County, Wangkui County, and Suihua City. Low–low cluster areas in the south are more spread around Harbin City, such as Bin County, Shangzhi City, Wuchang City, and so on. At the same time, due to the cold climate, topography, and forestry economy transition development, rural construction in Huzhong and Xinlin District of the Daxing'anling Mountains (northwest of Heilongjiang Province) was imperfect and the population migration was severe. Therefore, there were some low–low cluster areas here.

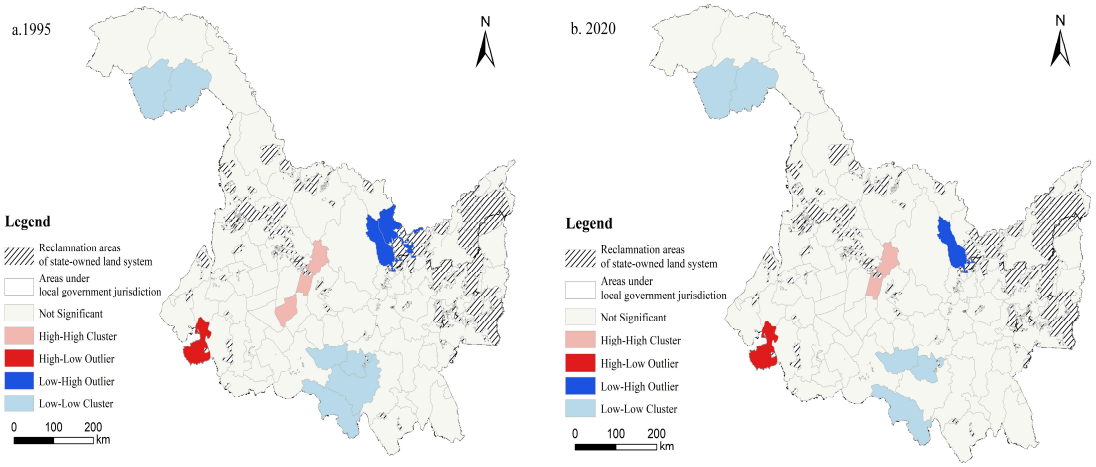


Figure 5. LISA agglomeration map of spatial distribution of rural population under local government jurisdiction in Heilongjiang Province.

According to the Local G* Index, rural residential land areas under local government jurisdiction presented a noticeable trend of southern migration of agglomerations. The high–high cluster areas extended from the central to the southern parts of the region, while the low–low cluster areas were agglomerated from the north to the southeast. Figure 6a shows that, in 1995, the high–high cluster areas of residential land were mainly located in Qiqihar, eastern Heilongjiang Province (e.g., Keshan County, Kedong County, Yi'an County, Baiquan County), and Zhaodong County and Wuchang County in southern Heilongjian. Low–low cluster areas were mainly located in Jiayin County, Luobei County, and Tongjiang City in northern Heilongjiang Province. Compared to 1995, since 2010, high–high cluster

areas have gradually expanded into large areas of the south as populations have moved south, forming high-value clusters in big cities such as Harbin, Daqing, Suihua, and Qiqihar. At the same time, due to the attractiveness of large urban clusters, the range of low–low clusters in the eastern part of large urban clusters gradually expanded and the low–low cluster areas also expanded, connecting Mudanjiang City, Qitaihe City, Shuangyashan City, and other counties to form a low-value banded zone. High–low outlier areas were still distributed in Yichun City, Fujin City, and Huanan County.

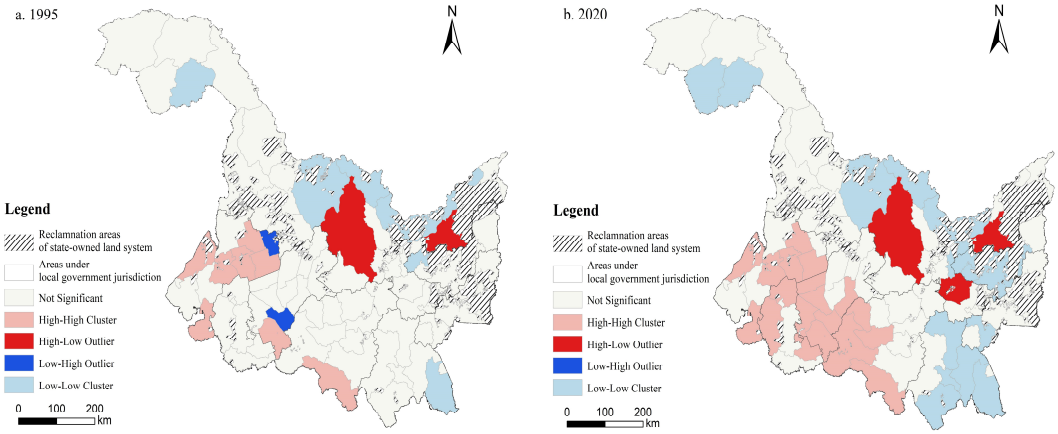


Figure 6. LISA agglomeration map of spatial distribution of rural residential land area under local government jurisdiction in Heilongjiang Province.

3.2. Changing Characteristics of Population and Rural Residential Land in Reclamation Areas of State-Owned Land System

3.2.1. Temporal Evolution Characteristics

Figure 7 shows the changes in rural population and residential land area in reclamation areas of the state-owned land system in Heilongjiang Province. As can be seen from the graph, during the study period, the population and residential land area showed significant reverse changes. The rural population grew linearly from 1.34 million to 1.46 million from 1995 to 2020, with an annual average growth of 0.37%. However, the residential land area fluctuated slightly before 2005, and then, over the next five years, a significant decrease in the number of rural settlements resulted from the demolition and reform of the reclamation areas. After 2010, due to the return of the population, the number of rural settlements slowly began to grow.

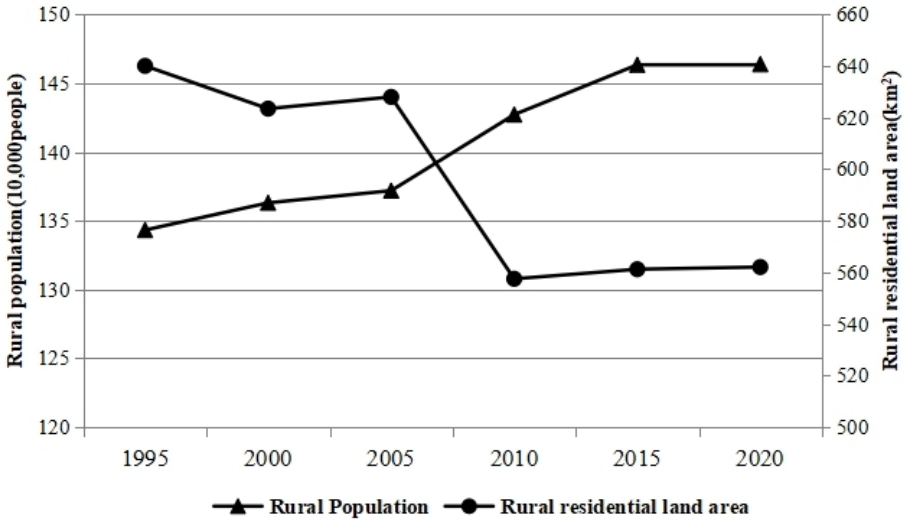


Figure 7. Changes in rural population and residential land in reclamation areas of state-owned land system in Heilongjiang Province.

3.2.2. Spatial Characteristics

As the Global Moran's I for rural population and residential land area in the reclamation areas of the state-owned land system for 1995–2020 did not pass the test, in order to better characterize the extent of change in population and residential land area, the ArcGIS standard deviation classification method was used to divide the population and residential land area into three different levels—high speed, medium speed, and low speed—and map the distribution of average annual change rates for the rural population and residential land area in reclamation areas of the state-owned land system in Heilongjiang Province from 1995 to 2020 (Figure 8).

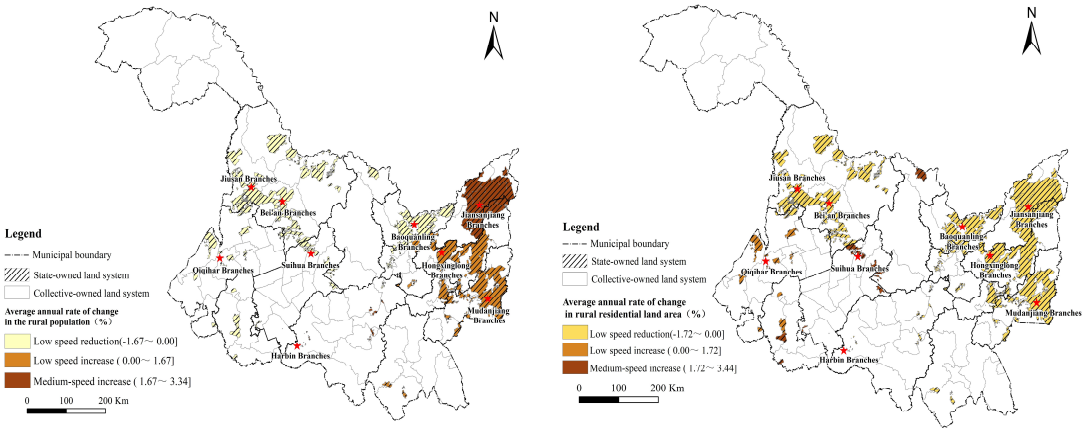


Figure 8. Distribution of rural population and residential land in reclamation areas of state-owned land system in Heilongjiang Province.

As can be seen from the diagram, the average annual rural population of each branch in reclamation areas of the state-owned land system, as well as the changes in residential land, were distributed in three tiers—low-speed reduction, low-speed increase, and medium-speed increase—and both were mainly characterized by low-speed reduction. The rural population reduction areas were concentrated in the central plains, including Jiusan, Bei'an, Qiqihar, Suihua, Baoquanling, and Harbin Branch, and the average rate of decrease was 0.56%. The most obvious area of decrease in residential land was in the eastern part of the province, such as Jiansanjiang, Baoquanling, and Mudanjiang branches, as well as Jiusan and Bei'an branches, where the average reduction rate was 0.75%. Overall, due to the rapid development of agricultural mechanization in the plains, demand for agricultural labor has declined, and the rural population and number of settlements have been declining. However, the eastern branches, such as Jiansanjiang, Hongxinglong, Mudanjiang Branch, are dominated by paddy crops, while the level of agricultural mechanization is rising rapidly, and the industrial chain of agricultural services around rice cultivation has been prolonged. The need for a high-quality labor force has simultaneously increased with the population. At the same time, in order to promote the concentration of population and industry, then promote the development of urbanization, the reclamation areas of the state-owned land system have vigorously implemented old district demolition, overall relocation, and other policies to guide the population and industry to the farm centers. In this way, the spatial layout of the land used by the population and settlements can be coordinated, improving the efficiency of land-use and achieving population–land harmony.

3.3. Decoupling Relationships between the Rural Population and Rural Residential Land

3.3.1. Overall Characteristics of Decoupling Relationships

Figure 9 shows the decoupling relationships between the rural population and residential land area under different land systems. The analysis shows that, for 1995–2020, 69 research units in areas under the local government jurisdiction of Heilongjiang province were negatively decoupled, accounting for 89.61% of the total county-level units. The proportions of strongly negative and weakly negative decoupled counties were 44.16%

and 45.45%, respectively. These cities were concentrated in the Songnen Plain, and the hilly areas of the Daxing'anling Mountains recorded the highest population migration rate. There are six research units that were decoupled, and the rural residential land area changed in coordination with the rural population. Only two research units were in a decaying coupled state, balanced by population changes.

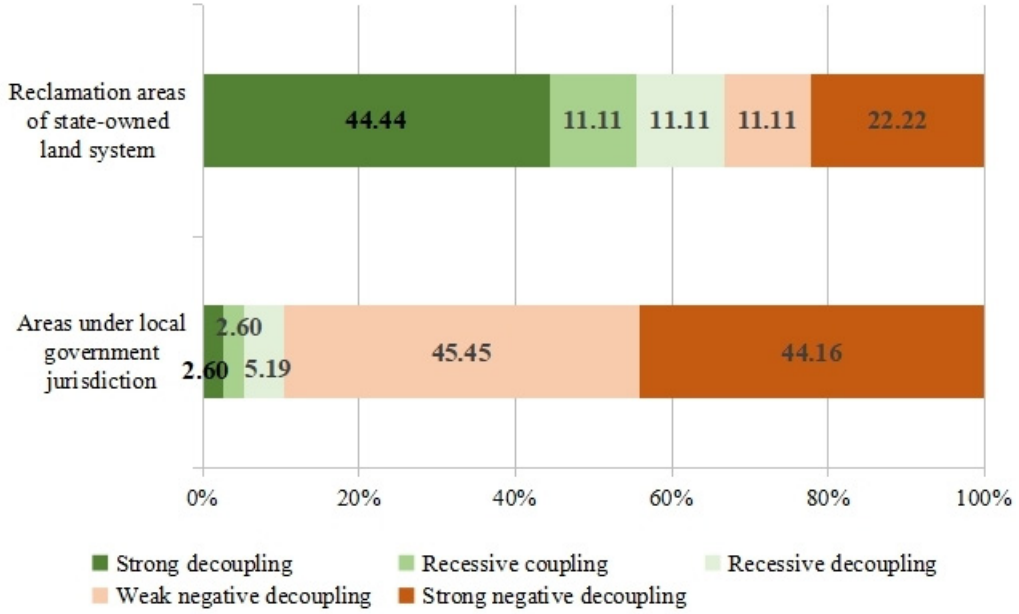


Figure 9. Decoupling system map for different land systems.

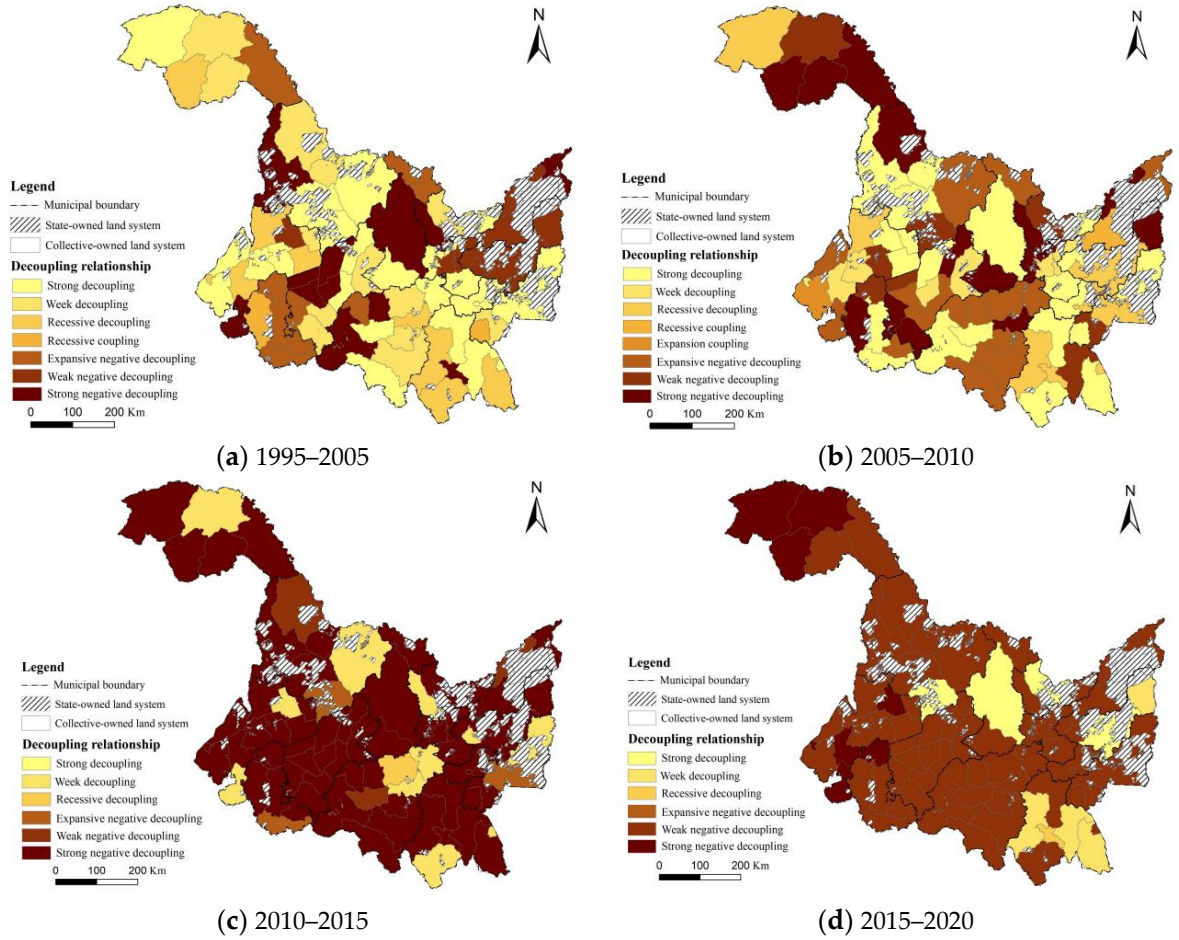
For 1995–2020, in reclamation areas of the state-owned land system, five branches were in decoupling, three in negative decoupling, and one in decaying coupling. These accounted for 55.56%, 33.33%, and 11.11% of all state-owned research units, respectively. The decoupling status of the branches was concentrated in the eastern area, and the change in population–land relationships tended to be coordinated.

3.3.2. Spatial Characteristics of Decoupling Relationships

Taking 2005, 2010, 2015, and 2020 as the time sections, the Tapio elasticity coefficient of the rural population and residential land change under the different land systems of Heilongjiang Province was calculated in different periods to determine the decoupling status (Figure 10). Overall, the proportion of decoupled units with the characteristics of coordinated population–land relationships in areas under local government jurisdiction decreased. The ratio of decoupled units decreased from 58.44% in 1995–2005 to 12.99% in 2020 (Table 4). For 1995–2020, the proportion of strongly decoupled units decreased sharply, by 6.49%. The ratio of negative decoupling units increased during the study period, from 38.96% in 1995–2005 to 87.01% in 2020. Among them, the strong negative decoupling of research units accounted for only 15.58% in 1995–2005, then slowly increased to 18.18% in 2005–2010 and rapidly increased to 76.62% in 2010–2015. By 2020, 77.92% of the research units had turned to weak negative decoupling, and population–land contradictions had eased but were still severe.

Compared to the local government jurisdiction, the proportion of decoupling branches in coordinated population–land development in reclamation areas of the state-owned land system first increased during the study period. The share for 1995–2005 was 66.67%, which increased to 88.89% for 2005–2010 and gradually decreased after 2010 to 33.33% by 2020 (Table 5). The highest percentage of strongly decoupled branches was 44.44% in 1995–2005, which increased to 66.67%, followed by a sharp decline beginning in 2010, reaching 11.11% in 2020. However, with population loss after 2010, the share of branch offices in negative decoupled states first decreased and then increased by 33.33% in 1995–2005, 11.11% in

2005–2010, and 66.67% in 2020. Among them, the share of strong negative decoupling branches decreased from 33.33% in 1995–2005 to 0% in 2010 and then increased to 44.44% year-on-year. Thus, changes in population–land relationships in reclamation areas of the state-owned land system were more coordinated than under the collective-owned land system (Figure 11).



(**a**) 1995–2005 (**b**) 2005–2010

(**c**) 2010–2015 (**d**) 2015–2020

Figure 10. Distribution of decoupling between the rural population and residential land areas under local government jurisdiction.

Table 4. Statistics for decoupling status in areas under local government jurisdiction, 1995–2005.

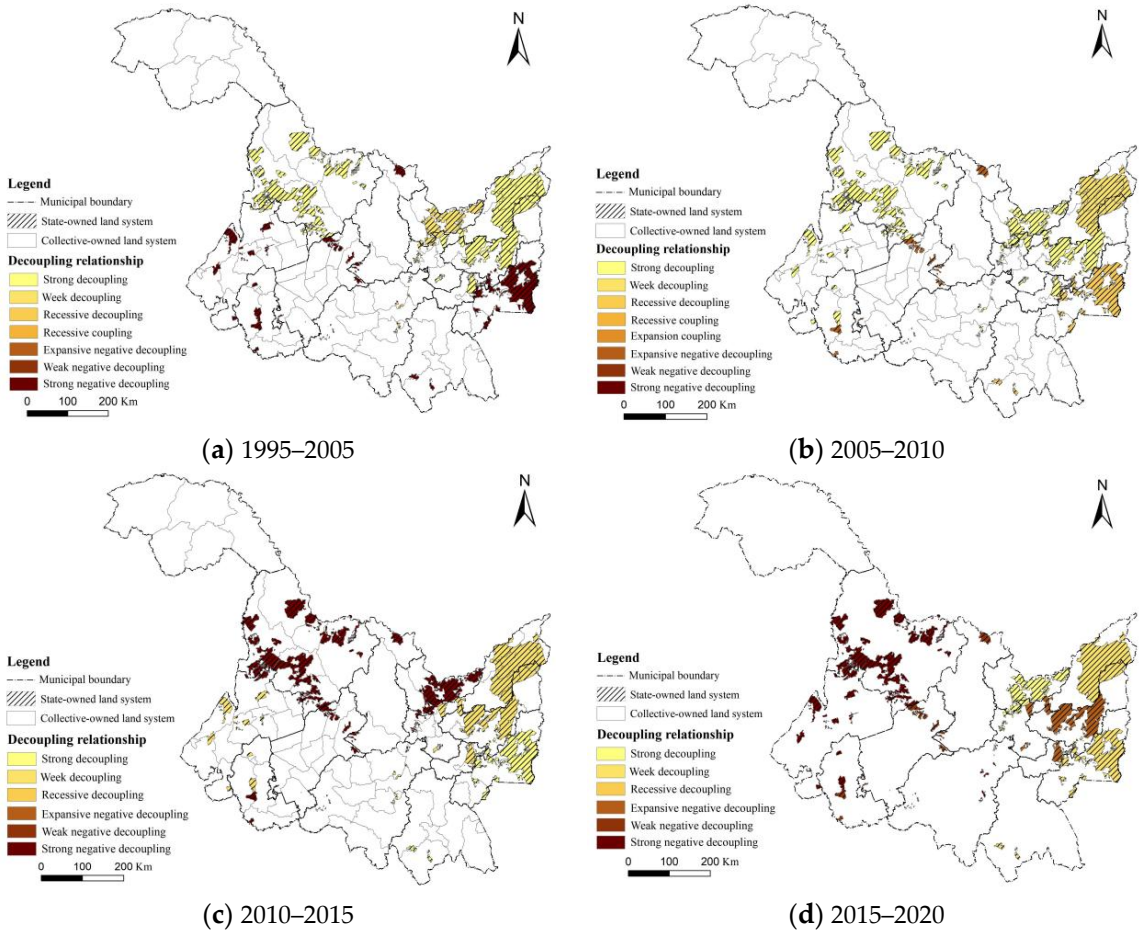
Decoupling Status (From Coordination to Disharmony)	1995–2005		2015–2020	
	Included Units	Percentage/%	Included Units	Percentage/%
Strong decoupling	24	31.17	5	6.49
Weak decoupling	13	16.88	4	5.20
Recessive decoupling	8	10.39	1	1.30
Recessive coupling	2	2.60	0	0.00
Expansion coupling	0	0.00	0	0.00
Expansive negative decoupling	8	10.39	0	0.00
Weak negative decoupling	10	12.99	60	77.92
Strong negative decoupling	12	15.58	7	9.09
Total	77	100	77	100

As for Heilongjiang Province, although the population–land relationships presented negative decoupling in some regions in 1995–2010, the overall relationships between people and land remained more harmonious. However, from 2010 to 2015, the negative decoupling of population–land relationships developed rapidly, and the proportion of counties and

municipalities in a strong negative decoupling state increased dramatically. In 2015–2020, population–land relationships in Heilongjiang Province gradually shifted from strong negative decoupling to weak negative decoupling, due to the implementation of rural revitalization strategies. However, the problem of population–land imbalance remained more prominen.

Table 5. Statistics for decoupling status in reclamation areas, 1995–2005.

Decoupling Status (From Coordination to Disharmony)	1995–2005		2015-2020	
	Included Units	Percentage/%	Included Units	Percentage/%
Strong decoupling	4	44.45	1	11.11
Weak decoupling	1	11.11	2	22.22
Recessive decoupling	1	11.11	0	0.00
Recessive coupling	0	0.00	0	0.00
Expansion coupling	0	0.00	0	0.00
Expansive negative decoupling	0	0.00	1	11.11
Weak negative decoupling	0	0.00	1	11.11
Strong negative decoupling	3	33.33	4	44.45
Total	9	100	9	100



(**a**) 1995–2005 (**b**) 2005–2010

(**c**) 2010–2015 (**d**) 2015–2020

Figure 11. Distribution of decoupling between the rural population and residential land areas in reclamation areas.

4. Discussion

4.1. Analysis of Differences in Different Land Systems

Coordinated development of the population and land is the basis and prerequisite for sustainable development in a region [28]. The movement of people between urban

and rural areas is an essential channel for reconfiguring elements in all sectors of the national economy. Rural population movements are closely linked to rural land systems, and different land systems affect local population movements differently.

First, there were significant differences in land and population management systems in the reclamation area of the state-owned land system and areas under the jurisdiction of local governments. In Heilongjiang Province, the reclamation area presented two characteristics in land and population management. On one hand, the unified management of urban and rural land was observed. In accordance with the development of modern agricultural industries and the requirements of people's lives, state-owned farms may plan, expropriate, adjust, and supervise the land (including residential land) in the name of the state under the supervision of the higher government in order to achieve the unified management of urban and rural land and promote synchronous adjustment of the economy, population, and land. On the other hand, the unified management of urban and rural household registration was also observed. The current population of state-owned farms is mostly workers and their families, and household registration is managed in a unified manner by the central farm. In this way, all laborers enjoy equal opportunities and environment, resulting in a low rate of population loss in the region [29]. As a result, this can coordinate the spatial and temporal relationships between the population and residential land areas, improve the efficiency of land utilization, and avoid idle and wasted land.

However, areas under the jurisdiction of local governments in Heilongjiang implement a dual system, including an urban–rural dual land system and an urban–rural dual household registration system, which have a certain inherent correlation [30]. China's early household registration system controlled the movement of people, while the early homestead system limited the movement of homestead use rights. They work together to maintain social stability. However, the resulting dual structure of urban and rural land and household registration also seriously blocked the flow of the rural population. After the reform and opening up in 1978, with the rapid development of the social economy and the reform of the rural household registration system, the rural population could move into the city through the way of schools, housing, and doing business; however, the focus of the reform of the rural land system is only on the land contract management system, while the reform of the homestead system is rarely involved [31]. As a result, large numbers of rural outbound people cannot leave their homesteads, and new rural households still need to be deployed in more homesteads, resulting in significant challenges regarding the optimization of rural settlements.

At the same time, differences in the industrial structure, income levels, and social services brought about by different land and population management systems further contribute to differences in population–land relationships between the reclamation area of the state-owned land system and areas under the jurisdiction of local governments. Areas under the jurisdiction of the local government are dominated by farming, and the development of the secondary and tertiary sectors has lagged. Simultaneously, with the continuous improvement of agricultural mechanization, the demand for an agricultural workforce has been declining. A large amount of surplus labor goes into the city, mainly in the secondary and tertiary sectors [32]. Combined with the low social security coverage and the low level of benefits available in rural areas, resulting in low living standards and poor quality of life, farmers who go out no longer return to rural life or work, resulting in rural hollowing out [33]. In contrast, with the development of the social economy since 2005, reclamation areas of state-owned land systems have shifted fixed asset investments from agriculture to the service industry, and the number of tertiary industry practitioners has rapidly increased by 55,000 people. Furthermore, public service systems in state-owned land systems are set up directly within farms, where the population has direct access to a high standard of living and high-quality services. At the same time, workers in the state-owned land system can continue to use land, carry out large-scale farming, develop specialty agricultural products, and increase their income sources. This facilitates the intensive use of land in the region and helps to achieve "in-situ urbanization" [34].

4.2. Countermeasures for Optimal Management of Rural Residential Land

In recent years, the Chinese government has vigorously promoted urban–rural integration development and put forward the idea of promoting urban–rural development. The National New Urbanization Plan and the Rural Revitalization Strategy are concrete methods guided by this idea. Therefore, it is necessary to eliminate the stereotype of the urban–rural dual system and focus on urban–rural interactions. Although some progress has been made regarding the reform of the land system and related household registration system, the overall framework and management policy cannot solve the current development challenges [35]. Therefore, it is necessary to break down barriers to the urban–rural dual structure under the collective-owned land system through policies such as "the linkage of increase and decrease of construction land" and "new-type urbanization", in order to balance increased urban construction land with reduced rural construction land [36]. At the same time, land system reform in rural areas should focus on the withdrawal of idle homesteads and the recovery of abandoned settlements, strengthening the land-use policy for the reclamation of hollow villages [37], improving the intensification and efficiency of residential land, and continuously optimizing urban and rural settlements.

Second, it is necessary to promote coordinated development between urban and rural areas by optimizing the industrial structure and improving the level of public services [38]. This includes promoting the development of tourism or animal husbandry with rural characteristics and encouraging the local employment of surplus agricultural labor [15]. In addition, investment in rural construction funds should be strengthened, and the source and proportion of funding should be gradually adjusted. Various kinds of financing combined with social capital and financial support may make up for the deficiency of financial support, provide security for rural public service construction, and promote rural infrastructure construction and public service levels.

Finally, it will be necessary to promote the integration of state-owned and collective-owned land systems in urban and rural development, talent, industry, and infrastructure to make use of the overall advantage of collaborative action [39]. Simultaneously, we should leverage convenient transportation, more employment opportunities, and comfortable living conditions to attract the outside population, increase the investments made by urban residents, and achieve coordinated population–land development.

5. Conclusions

Population and land are two core elements of rural regional development, and coordinated development of these two elements is the foundation and premise of sustainable development in rural areas. Under the different land systems in Heilongjiang Province, the different evolutionary states of the rural population and residential land area indicate the unique influence of the land system on population–land relationships. Therefore, it is of great theoretical and practical significance to study the relationships between people and land from the perspective of the land system. Based on the theory and method of decoupling, this study investigated the relationships between the rural population and residential land under different land systems in Heilongjiang Province from 1995 to 2020. Different land and household management systems have arisen as a result of the specific land ownership systems in the areas under local government jurisdiction and reclamation areas of the state-owned system. This has led the rural population to decline at a faster rate than residential land in areas under local government jurisdiction; furthermore, the spatial agglomeration of the population is weaker, that of resident land is stronger, and the contradiction between population and land is sharp. However, rural and residential areas presented strong decoupling in reclamation areas of the state-owned land system, declining populations, and increasing residential land areas, indicating that the relationships between people and land are more harmonious. In the reclamation area of state-owned farms, population and residential areas presented strong decoupling, with an increase in population and a decrease in residential land, which was most notable in the eastern part of the reclamation area. In this way, land use was found to be more efficient, and

population–land relationships were more harmonious. Therefore, a single urban–rural structure in the state-owned land system is more helpful in terms of promoting population concentration and efficient land use. In the future, we must encourage urban–rural interactions, take advantage of the coordination and cooperation between the two land systems, build a rational and practical exit mechanism for rural homesteads, and promote the optimization of rural residential land to ensure that the land pattern of rural residents is compatible with the modernization of agriculture and rural areas and the development of urban–rural integration.

The coupling and coordination of population–land relationships are complex issues, and the characteristics and problems related to the relationships between rural people and land differ significantly between regions. The points proposed in this study present some limitations. Future research should include an in-depth and comprehensive discussion of the drivers that influence population–land relationships. Furthermore, indicators such as size, transport, and public services should be selected to obtain more comprehensive, granular, and targeted data while analyzing the number, structure, and change trends of the rural population, combined with the will of farmers, to propose better adjustment measures.

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