

Spatiotemporal Evolution Characteristics and Planning Strategies of Population and Construction Land in Shrinking Chinese Counties

Weiping Cao, Su Wang, Han Tao

College of Architecture and Urban Planning, Tongji University
529788416@qq.com

Abstract:

This study focuses on the contradiction between population loss and construction land expansion in China's shrinking counties. It explores the spatiotemporal change patterns of permanent population, urban population and construction land through three time sections: 2000, 2010 and 2020. On this basis, the decoupling model is used to further analyze the degree of coordinated development of population and construction land in shrinking counties, summarize its characteristics and causes, and compare them with international shrinking cities. Planning strategy recommendations are proposed to optimize the human-land relationship and promote coordinated and sustainable development.

Keywords

population and construction land relationship; urban shrinkage; spatial-temporal evolution; coordinated development; Planning strategy

1. Introduction

1.1 Research background

1.1.1 The universality and challenges of the shrinking county phenomenon in China

Against the backdrop of accelerating global urbanization and cities entering the post-growth era, China is experiencing extensive population mobility and reconstruction of spatial development. Due to factors such as unbalanced regional development, in sharp contrast to the continued expansion of large cities, the shrinking of China's counties is gradually becoming an undeniable reality in the process of new urbanization. According to the China County Statistical Yearbook, between 2010 and 2020, many of the country's counties (cities) experienced a continuous loss of permanent population, with the Northeast and central mountainous areas being particularly significant. This shrinking phenomenon not only reflects the objective law of population agglomeration in developed coastal areas and high-level cities, but also exposes the deep-seated contradiction between the county development pattern and spatial resource allocation (Wu and Sun, 2017).

1.1.2 The particularity of China's county shrinkage phenomenon compared with international shrinking cities

The phenomenon of urban shrinkage is common in Western developed countries, but China's urban shrinkage phenomenon is significantly different from that of Western developed countries. On the one hand, unlike Western developed countries, urban shrinkage occurs in the mature stage of urbanization development. For example, in developed countries such as the United Kingdom and the United States, the shrinkage of population and idle housing land are developing in the process of urban deindustrialization and suburbanization. (Yang, Wu Wang etc, 2021) China's urban shrinkage phenomenon occurs in the rapid urbanization development cycle. A large number of people flow out of county towns and move to large cities, resulting in widespread shrinkage of county towns. The slowdown in China's urbanization growth in recent years will further aggravate the phenomenon of urban shrinkage (Yang, Long, Yang etc 2015). On the other hand, the shrinkage phenomenon in Western developed countries is the "double shrinkage" of population and construction land, while China has a more widespread contradiction between population shrinkage and construction land growth (Sang, Pan, Zhang etc, 2024). The transfer and flow of population and the corresponding changes in construction land continue to affect the allocation efficiency of urban construction resources. To achieve high-quality urbanization development, it is necessary to coordinate the evolution and coordination relationship between population and construction land, and promote the rational use of resources and sustainable development.

1.2 Research Questions

Many scholars have conducted research on the phenomenon of urban shrinkage in China, but most of them focus on the prefecture-level cities in some regions, with few nationwide studies and insufficient long-term analysis of county-level units. At the same time, most studies focus more on the phenomenon of population shrinkage

itself, ignoring the contradiction between population decline and increase in construction land, and insufficient analysis of the spatiotemporal heterogeneity of the response to human-land relations. Relevant planning strategies do not make targeted distinctions between shrinking cities in different regions and development types across the country. Therefore, based on the above contradictions and gaps, this study takes the spatiotemporal evolution pattern of population and construction land in shrinking county-level cities in China, the analysis of coordination degree, and the analysis of classified planning strategies as the main research issues.

1.3 Research framework and technical route

This study first clarifies the universality of the development of shrinking cities in China and its uniqueness from the Western country. Then, it takes county-level cities in China with shrinking population as the research object, selects three time sections of 2000, 2010 and 2020, uses spatial statistical tools to deeply analyze the spatial characteristics of the evolution of their population and construction land, and comprehensively analyzes their development coordination. It classifies and summarizes the coordination types and development trends of the relationship between people and land in shrinking counties in different regions, analyzes their influencing factors by category, and proposes planning optimization strategies based on international shrinking cities comparisons.

2. Research area and methods

2.1 Research area

More than 1,848 county-level units (excluding urban districts) with available data across China were selected as the research scope, and county-level cities that had a county-level permanent population and whose permanent population increased by no more than 20,000 people between 2000 and 2020 were defined as "county-level shrinking cities shrinking counties". A total of 280 research objects were selected. They are distributed throughout the country.

2.2 Data Source

The county population data comes from the fifth, sixth and seventh national census data in 2000, 2010 and 2020, and the construction land data comes from the China Urban Land Cover Remote Sensing Monitoring Dataset (CN-LUCC) produced and released by The Data Center for Resources and Environmental Sciences, Chinese Academy of Sciences (RESDC) (Xu,Liu,Zhang etc,2018)

2.3 Research Methods

2.3.1 Standard Deviation Ellipse

Standard deviation ellipse is a spatial statistical method widely used to describe the spatial distribution characteristics of geographical elements, and depicts the centrality, spread, directionality and other spatial morphological characteristics of geographical elements. This study constructs the standard deviation ellipse of urban construction land in shrinking cities in counties across the country from 2000 to 2010 and from 2010 to 2020 to analyze the spatiotemporal evolution pattern of construction land.

2.3.2 Change coupling mode measurement

This study constructs a decoupling model of shrinking cities in counties based on the elasticity coefficients of urban population and urban construction land area in counties from 2010 to 2020.

$$F=\Delta P/\Delta L$$

Where F is the elasticity coefficient, ΔP and ΔL are the ratios of the change rate of urban population to the change rate of urban construction land in a certain period, reflecting the coordinated relationship between urban population change and construction land change. According to the positive and negative change rates of urban population and construction land(Yi,Wang,Zhang etc,2023), as well as the value of the elasticity coefficient, the decoupling type of human-land relationship can be further established to judge the current status and trend of human-land relationship.

3. Characteristics of the spatiotemporal evolution of population and construction land in shrinking counties

3.1 Characteristics of population shrinkage

3.1.1 Spatial distribution pattern of total population in counties

As can be seen from the figure 1, the shrinking counties development in China are mainly concentrated in the Northeast, Sichuan Province, Hubei Province, Hunan Province in the upper and middle reaches of the Yangtze River, and Fujian Province and Guangdong Province in the southeast coast.

In terms of total volume, the total population of shrinking counties showed a straight-line downward trend in the two decades from 2000 to 2020, with the total population dropping from 110.665 million in 2000 to 86.232 million, which was significantly reduced in all regions of the country. Among them, the total population base of shrinking counties in the Northeast, Central and Western regions is large, and the reduction is the largest. The total population in the Northeast region has decreased by more than 10 million in 20 years. It is the region where the urban shrinkage phenomenon in my country has occurred most profoundly and extensively, and is experiencing a large-scale population outflow; the total population of shrinking counties in the eastern region is small. Due to the high level of economic development and small county gaps, the population mobility changes are relatively slow. Overall, the total population of shrinking counties in all regions of the country showed a more obvious decrease between 2010 and 2020, and the population shrinkage phenomenon further intensified.

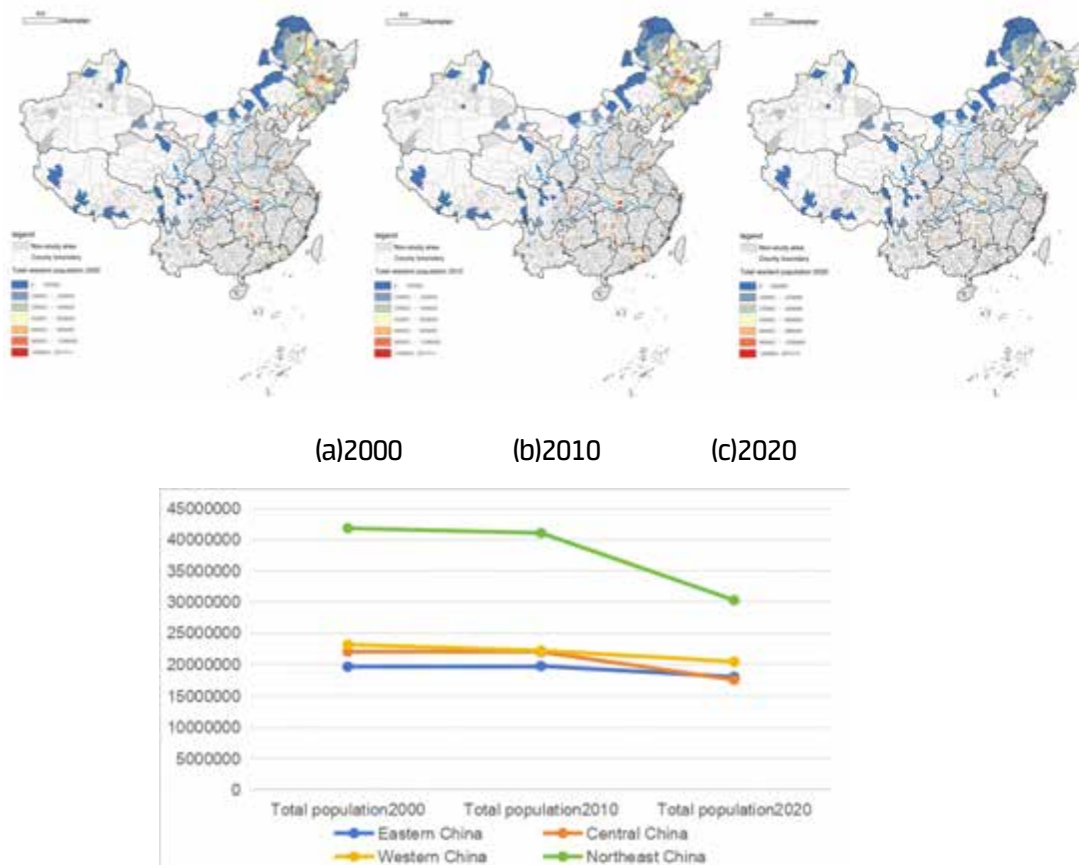


Figure 1 Spatial and Temporal Pattern of Total Population Changes in Shrinking Counties in China

3.1.2 Spatial distribution pattern of urban population

The figure 2 shows that from 2000 to 2020, the urban population of shrinking counties in China first increased and then decreased. The total urban population eventually increased from 33.806 million in 2000 to 40.231 million in 2020, and the changes in various regions across the country were different. Among them, the number of urban residents in the Northeast and Central regions first increased and then decreased, showing an overall downward trend. The urban population in shrinking counties decreased significantly, and the population loss was more serious. It is the most important shrinking development region in China. The urban population in the western and eastern regions continued to increase. The growth rate of the urban population in shrinking counties in the eastern region gradually slowed down after 2010. The urban population in the western region continued to increase. This is largely due to the fact that the economic and urbanization development in the western region lags behind other regions. It is still in the stage of converting rural population into urban population on the spot, which has led to a certain increase in the urban population.

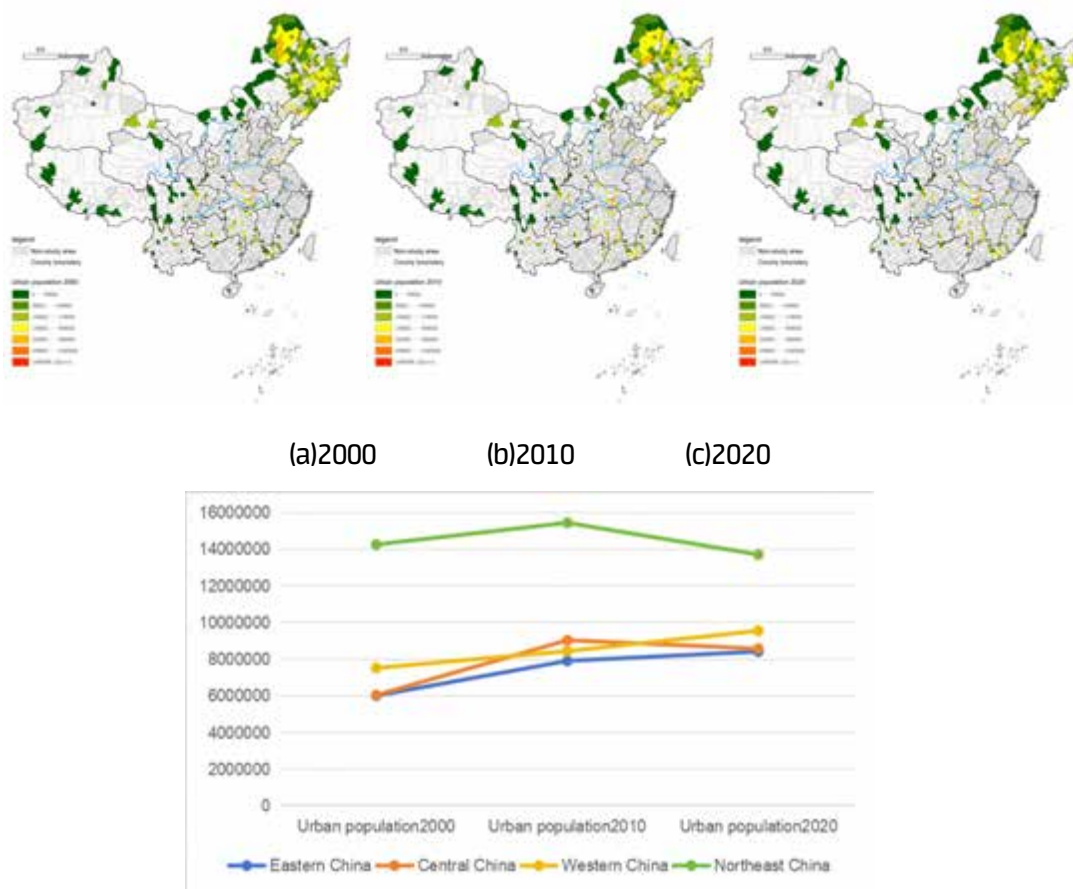


Figure 2 Spatial and Temporal Pattern of Urban Population Changes in Shrinking Counties in China

3.2 Changes in construction land

3.2.1 Dynamic changes in the total amount of urban construction land

In terms of total amount, the area of urban construction land in shrinking counties across the country increased from 2584.21 square kilometers in 2000 to 3949.86 square kilometers in 2020, with a growth rate of 52.8%. The changes in the area of construction land in shrinking counties in different regions of the country vary greatly (Figure 3). Except for the western region, the growth rate of construction land in other regions has slowed down after 2010. The slowdown in the growth rate of construction land in the northeast region may be related to the transformation and development of industry, the slowdown of urban economic growth, and the large-scale population loss; the counties in the more developed eastern and central regions may gradually enter the stock development period, and the speed of urban land construction and development will slow down. The western

region is still in the process of accelerated development, and the area of urban construction land is accelerating. The large-scale growth of urban construction land has formed a paradox with the shrinking population, and it presents an unbalanced and contradictory development state in different regions.

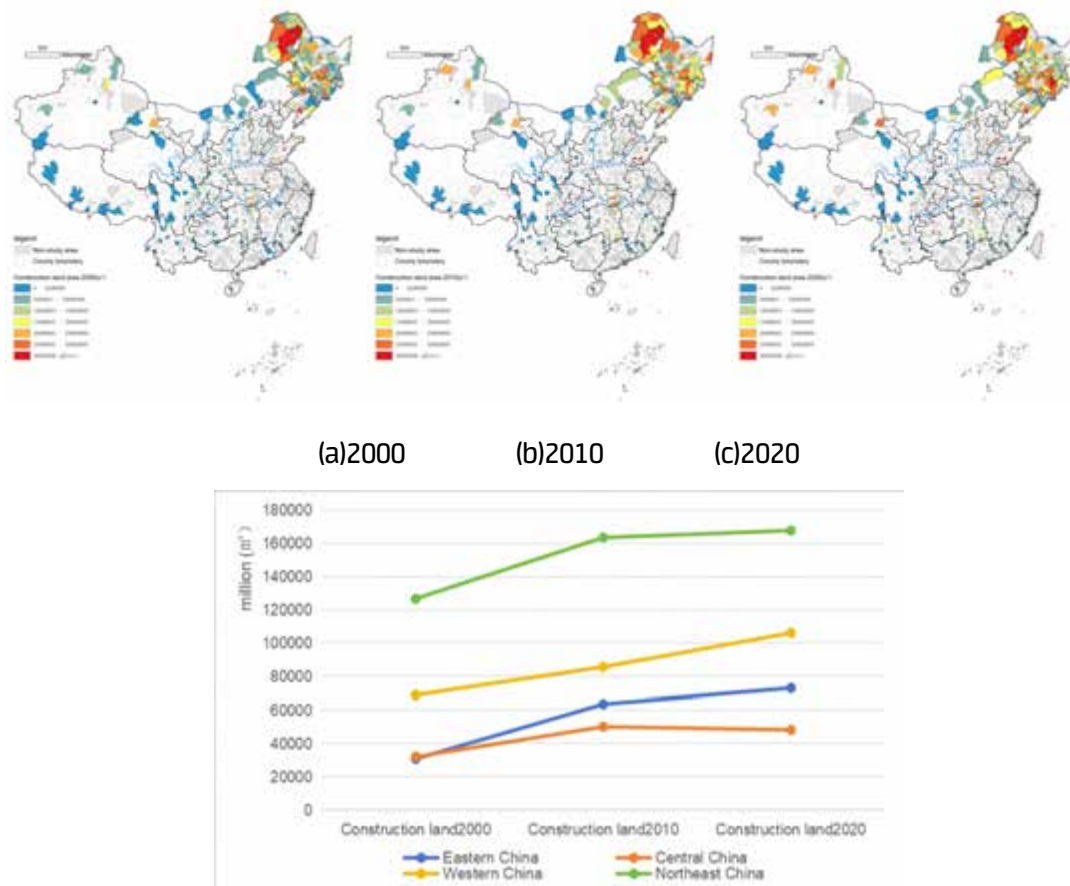
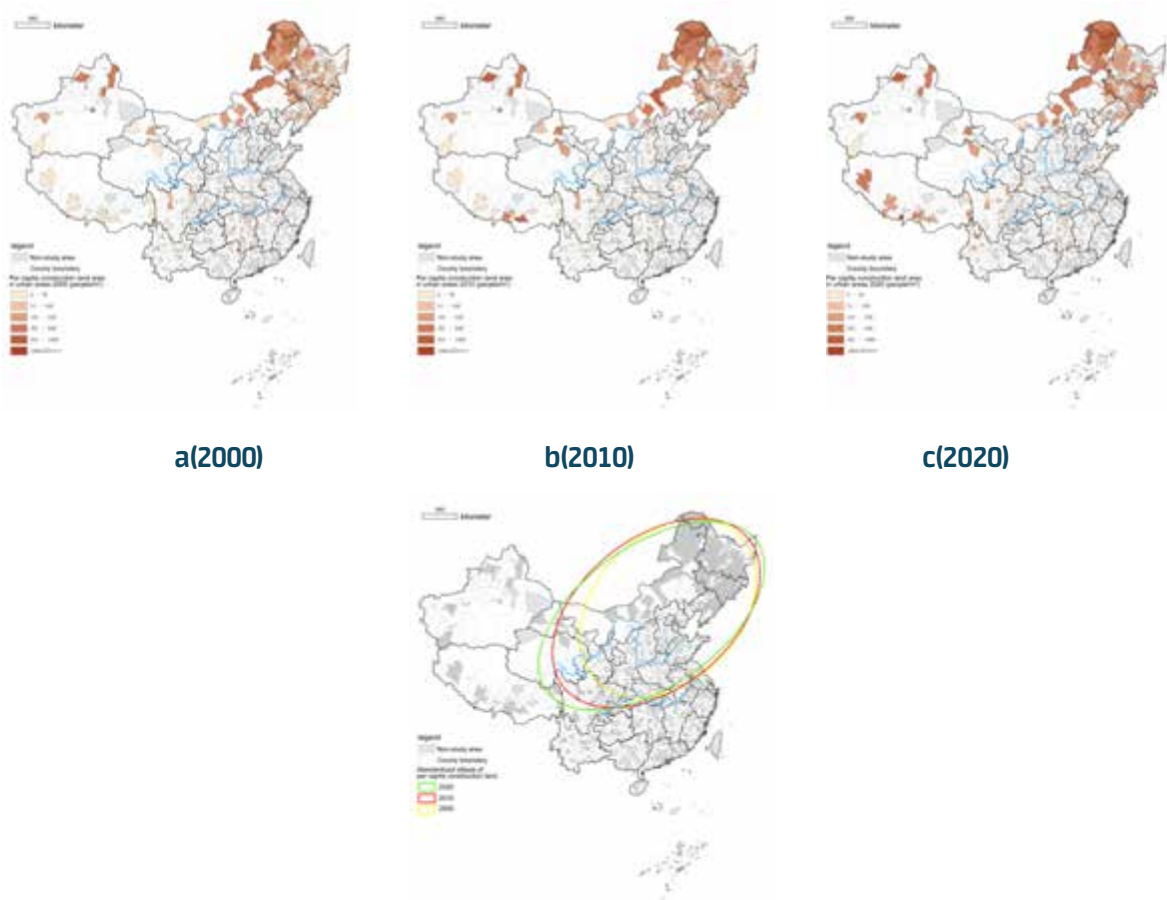


Figure 3 Spatial and Temporal Pattern of Urban Construction Land Changes in Shrinking Counties in China

3.1.2 Dynamic changes in the average amount of urban construction land

As can be seen from the figure 4, the per capita construction land in shrinking counties across the country has been growing over the past 20 years, with the average value increasing from 76.4 square meters per person in 2000 to 98.2 square meters per person in 2020. This is related to the continued growth of construction land while the population in shrinking counties is declining. It can be seen that the uncoordinated development of the relationship between people and land in shrinking counties is likely to cause resource waste and unsustainable development problems. During this period, the centre of gravity of urban per capita construction land area continued to move toward the central and western regions. The northeast region with vast land and sparse population is the main area of population loss. The per capita construction land area is large, and there is obvious waste of resources. The change direction of construction land and urban population in the central region is relatively consistent, but the growth rate of construction land is still faster than the growth rate of population, resulting in an increase in per capita construction land area. The western region is still in a rapid urbanization development stage, and the construction land area is increasing rapidly. In addition, the local towns have limited attraction to the population, and the population growth lags behind the growth of county construction land. The per capita construction land area continues to expand. The eastern region is densely populated, construction land is tight, and the per capita construction land area is growing slowly. There is a spatial mismatch between the per capita construction land area in county towns and the economically developed and more densely populated regions in China. The problem of uncoordinated development of population and construction land needs to be optimized and solved urgently.



(d) standard deviation ellipse of per capita construction land area
Figure 4 The Spatiotemporal Evolution of Per Capita Construction Land Area

4 Analysis of the coordinated relationship between shrinking county population and construction land

4.1 Construction of a decoupling model for human-land relationship

Based on the analysis of the spatiotemporal evolution of shrinking urban population and construction land in the previous study, the changes in population and construction land during 2010-2020 are more diverse, which can better reflect the dislocation and disharmony of human-land relationship. In order to further measure the mismatch relationship between shrinking urban population and construction land, this time period is selected to analyze the decoupling relationship between shrinking county population and construction land changes. According to the provisions of China's "Urban Land Classification and Planning Construction Land Standards" on per capita construction land indicators and related research by other scholars, the types and trend standards of the decoupling relationship between urban population and construction land are formulated as follows.

Figure 5. Types of the Decoupling Relationship Between Urban Population and Construction Land

decoupling type		ΔP	ΔL	F	human land relationship status
decoupling	strong decoupling	$\Delta P < 0$	$\Delta L > 0$	$F < 0$	Population decreases, land use increases
	weak decoupling	$\Delta P > 0$	$\Delta L > 0$	$0 < F < 0.8$	increase at the same time, the growth rate of land use is greater than the growth rate of population
	weakening decoupling	$\Delta P < 0$	$\Delta L < 0$	$F > 1.2$	decrease at the same time, the land use slowdown is smaller than the population slowdown
negative decoupling	strong negative decoupling	$\Delta P > 0$	$\Delta L < 0$	$F < 0$	Population increases, land reduction decreases
	expansion negative decoupling	$\Delta P > 0$	$\Delta L > 0$	$F > 1.2$	increase at the same time, the land use growth rate is lower than the population growth rate
	weak negative decoupling	$\Delta P < 0$	$\Delta L < 0$	$0 < F < 0.8$	decrease at the same time, land use slowdown is greater than population slowdown
connection	expansion Connection	$\Delta P > 0$	$\Delta L > 0$	$0.8 < F < 1.2$	Relatively synchronous increase
	declining Connection	$\Delta P < 0$	$\Delta L < 0$	$0.8 < F < 1.2$	Relatively synchronous decrease

A corresponding analysis of shrinking counties across the country found that there is a clear correlation between the shrinkage of counties and the decoupling development of the relationship between people and land, resulting in three types of decoupling of the relationship between people and land: negative decoupling type, connection type and decoupling type (Figure 6). The negative decoupling type includes a strong negative decoupling mode with population growth and reduction in construction land, an expansion negative decoupling mode with both urban population and construction land increasing, and the growth rate of construction land being lower than the growth rate of urban population, and a weak negative decoupling mode with both urban population and construction land decreasing, and the deceleration of construction land being higher than the deceleration of population. From 2010 to 2020, county units of this type of decoupling accounted for about 31.7% of the total, and nearly half of the counties' urban construction land area exceeded the national standard. Under the trend of population shrinkage, these areas should continue to maintain slow growth and negative growth in construction land to further optimize and coordinate the relationship between people and land. The connection type includes a pattern of relatively synchronous growth and decrease of urban population and construction land, which is a type of relatively harmonious human-land relationship. From 2010 to 2020, such county units accounted for about 5.2% of the total. Only very few counties were in such a good state of human-land relationship. More than half of the shrinking counties were in the third decoupling type of unharmonious human-land relationship, indicating that the human-land relationship in shrinking county units is more likely to be out of balance.

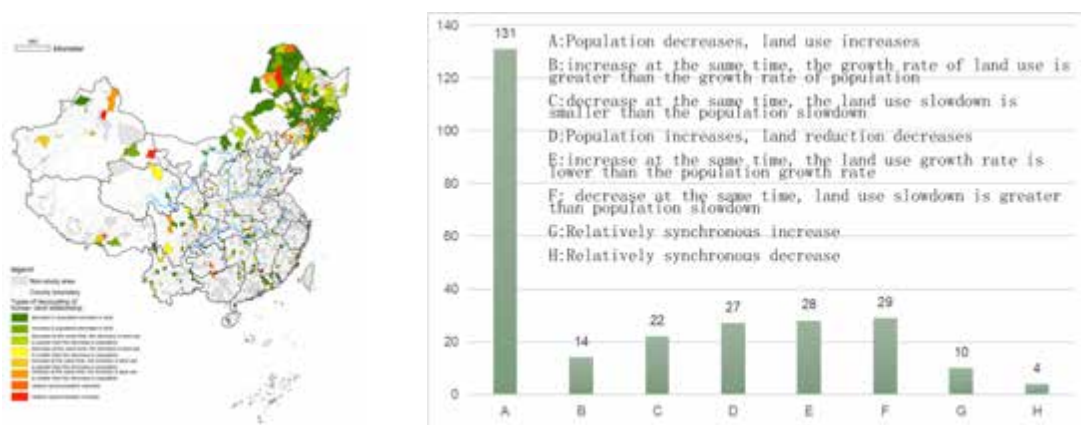


Figure 6. Space distribution of the decoupling relationship between urban population and construction land

4.2 Analysis of the uncoordinated human-land relationship of “decreasing population and increasing construction land” in shrinking counties

In the decoupling type of human-land relationship presented by most shrinking counties, three different development models have been formed according to the different rates of change of urban population and construction land area. From 2010 to 2020, this type of shrinking county units has the largest number, accounting for 49.3% of the total, and is widely distributed. It is more concentrated in the three northeastern provinces, Hebei Province, Hunan Province, Sichuan Province, Yunnan Province and Guangdong Province. These areas are the main areas facing population shrinkage problems. Among them, the development gap between counties in Hebei Province, Hunan Province and Sichuan Province is large. The counties with strong decoupling of human-land relationship in these areas are mostly in the “depression area around the provincial capital”. The urban population in shrinking counties is continuously transferred to large cities in the province or larger cities around them due to the siphon effect, resulting in the continuous loss of urban population in counties. At the same time, compared with the developed eastern coastal areas, these regions are still in the process of accelerated urbanization and have a strong driving force for construction and development. Some government-oriented investments have led to the continued expansion of construction land, resulting in a resource contradiction of reduced population and increased land. The three northeastern provinces are the areas with the most concentrated shrinking counties in China. They are facing the pain of transformation and development of traditional resource-based industries. Many counties still retain a large amount of inefficient industrial land, which has formed a driving force for population outflow. The lag in industrial transformation has caused a mismatch in land space. At the same time, the phenomenon of “reduced population and increased land” is common in counties with shrinking populations, and is also affected to a certain extent by land finance and local administrative management factors. With the loss of county population and the continuous reduction of tax revenue, many governments tend to expand land transfer to maintain finances, and then ignore the current population situation and continue to accelerate infrastructure investment, which has led to the continuous expansion of land use, becoming an institutional cause of the contradiction between people and land in shrinking counties.

This type of county should correctly deal with the current situation of its own population outflow, accelerate the transformation of development mode, reduce population outflow and attract population return by improving competitiveness; make full use of existing construction land and stock land, reduce large-scale development of construction land, and avoid waste of resources (Figure 7).

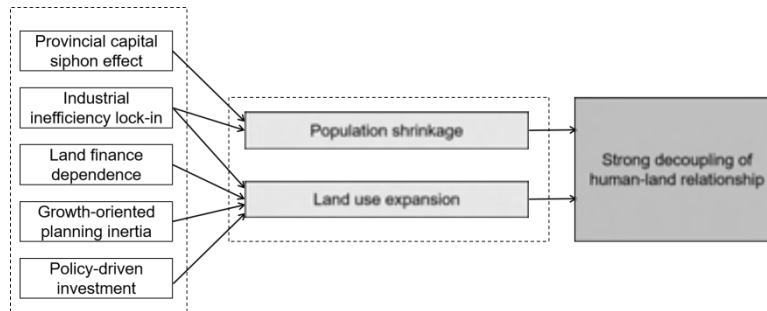


Figure 7. Space Distribution of the Decoupling Relationship Between Urban Population and Construction Land .

The second is the weak decoupling mode in which both urban population and construction land grow, and the growth rate of construction land is greater than the growth rate of urban population. From 2010 to 2020, the number of shrinking county units of this type accounted for about 5.28% of the total, mainly distributed in the eastern part of Liaoning Province, Yunnan Province, Xinjiang and Tibet Autonomous Region. These counties are mostly located in frontier border areas and ecologically fragile areas, and are prone to passive urbanization. Ecological immigration and poverty alleviation relocation have brought a certain increase in population and construction land, and the failure of related supporting facilities and industries to follow up simultaneously can easily lead to vacant new homes. Counties in these areas should strictly abide by the ecological red line, reduce the ecological damage caused by construction and development, and reasonably determine and implement construction indicators in immigration and relocation to avoid waste of resources.

The third is the weakening decoupling model in which both the urban population and construction land are reduced, and the deceleration of construction land is less than the deceleration of population. From 2010 to 2020, the number of shrinking county units of this type accounted for about 8.3% of the total, mainly distributed in Heilongjiang Province, Sichuan Province and Shaanxi Province. These regions are relatively backward in economy, lack of self-development, and show a clear shrinking trend. It is necessary to further optimize the use of construction land and reduce resource waste. The above three development models are all facing the spatial mismatch problem of “more land and fewer people”. It is urgent to change their own economic development mode, reduce extensive construction and development, vacate some inefficient land according to the current population situation, and promote the efficient and intensive use of construction land.

5. International Experience and Planning Strategies

5.1 Differences in Shrinking Characteristics

Based on the development characteristics and causes of shrinking cities in county levels in China, there are significant differences compared with other shrinking cities in the world, mainly reflected in the three aspects of economic structure, policy orientation and spatial characteristics.

(1) Differences in Economic Structure

Shrinking cities in European and American countries are mostly due to the process of “deindustrialization”. For example, the relocation of manufacturing industries in the “Rust Belt” cities in the United States has led to a sharp decline in jobs and a continuous loss of population; after the reunification of the two Germanys, the East German region of Germany suffered a structural recession due to insufficient industrial competitiveness. In contrast, the shrinking of Chinese counties is more manifested as a “gradient shrinkage” under the background of “semi-urbanization” - the siphon effect of large cities has led to the outflow of population from counties, but the counties as the outflow of population are still making up for the shortcomings in infrastructure construction, expanding the investment in construction land, and forming a decoupling phenomenon of “reducing population and increasing land”.

(2) Differences in Policy Orientation

European and American countries generally adopt a market-oriented regulation model. For example, the United States acquires abandoned properties for redevelopment through the "Land Bank", and Germany promotes the spatial reorganization of East Germany through federal fiscal transfer payments. The shrinking of Chinese counties is more subject to administrative intervention. The inertia of past growth-oriented planning is likely to lead to continued infrastructure investment. Some local governments still rely on land finance to maintain development.

(3) Differences in spatial characteristics

In terms of macro-spatial distribution, foreign shrinking cities are mainly distributed in industrial urban areas where local resources are exhausted or industries are undergoing transformation. Shrinking counties in China are more widely distributed, including resource-based counties in the northeast, agricultural counties in the central region, and border counties in the west. In terms of micro-spatial shrinkage characteristics, international shrinking cities generally show "hollowing out of central urban areas"; while Chinese urban shrinkage has the characteristics of "decentralized shrinkage": large cities and regional central cities are plump, surrounding counties are shrinking, and the population is moving to provincial capitals and regional central cities. Regional development differences may further aggravate the shrinkage of counties around large cities.

5.2 Planning strategies discussion

By summarizing the international experience in shrinking city governance and the national conditions of China, we can summarize the following planning strategies to deal with the uncoordinated development of the relationship between people and land in shrinking counties.

(1) Change in planning approach

The planning approach should shift from incremental expansion to stock optimization, establish a dynamic linkage mechanism of "population-land use", adjust the construction land indicators according to the elasticity of permanent population changes, optimize the economic construction and development assessment mechanism, and avoid the influence of the inertia of past growth-oriented planning. At the same time, it is necessary to shift from rigid planning control to flexible governance, promote the mixed use of industrial land, and improve the efficiency of construction land use.

(2) Differentiated governance

Based on the different types of county-level shrinkage, differentiated governance should be carried out, and smart shrinkage should be implemented by drawing on international experience. In the face of resource-declining counties in Northeast China, inefficient industrial areas should be "closed, stopped, merged and transferred", and space and construction land resources should be integrated and utilized. Follow-up industries, such as industrial heritage tourism, should be fully developed to inject new momentum into regional development and avoid continued decline. In the face of the population loss in the central provinces, we should shift from the homogeneous layout of construction land and public service facilities to precise allocation, learn from Japan's bus-oriented development to reasonably compress the radius of public services and reduce duplication and excessive construction.

(3) Regional coordinated development

To deal with the problem of county shrinkage through regional coordination and build a "core-contraction" matching mechanism for urban agglomerations, we can achieve complementary development through land quota transactions and regional function decentralization. At the same time, we should also improve the regional infrastructure sharing belt. Ultimately, through smart contraction and transformation, regional coordinated optimization, and the comprehensive construction of a full-chain governance system of "institutional constraints-market regulation-spatial optimization", we can further coordinate the matching of population and construction land and achieve high-efficiency and high-quality sustainable development.

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