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Rural Transformation and Land Use Transition in Southern Jiangsu (1980–2020): Phased Co-Evolution from an Institutional Perspective

Changjun Jiang, Chang Xu, Hao Li and Fei Hou *

College of Public Administration, Shandong Agricultural University, Tai'an 271018, China; 90025029@sdau.edu.cn (C.J.)
* Correspondence: fengfei1218@126.com

Abstract

Advanced urbanization promotes the continuous cross-flow of urban–rural elements. The coupling between rural transformation and land-use spatial reconstruction has become a key topic in urban–rural integration and rural revitalization. Focusing on southern Jiangsu, a typical highly urbanized region in China, this study uses long-term land-use datasets from the Chinese Academy of Sciences to examine land-use transfer areas of diverse land types across stages. It clarifies the connotations of rural transformation and land-use spatial reconstruction, builds an interactive-mechanism framework, and explores their phased evolutionary coupling characteristics. The results indicate that rural natural, economic, social, and policy factors, together with multi-source urbanization forces, jointly reshape land space. Reciprocally, adjustments in land structure, function, and layout constrain and steer transformations in rural industries, settlements, and social forms. From 1980 to 2020, southern Jiangsu's land-use reconstruction underwent initial, rapid, and stable phases. Agricultural production space declined continuously while urban–rural living spaces expanded steadily, with obvious stage-divergent land conversion features. Rural transformation experienced four successive stages generally matching the three land-use phases, with distinct land–space and human–land conflicts in each stage. Against rapid high-level urbanization, few studies have systematically untangled their phased coupled evolution from a long-time-series perspective. This study reveals the internal evolutionary logic of rural human–land systems in highly urbanized regions and offers theoretical support and regional practical references for territorial pattern optimization, rural land system reform, and sustainable rural development.

Keywords: rural transformation; land use transition; formation logic; evolutionary relationship; southern Jiangsu

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1. Introduction

Over four decades have passed since China's reform and opening up, and the country has entered a stage of rapid urbanization and industrialization [1]. It is important to review the prominent problems emerging from this process. Highly urbanized regions have strong absorptive capacity. Rapid economic growth has driven the migration of rural residents to cities and towns, and urban expansion has squeezed the original development space of rural areas [2,3]. China's urbanization and industrialization are at a medium-to-high level, but rural development has not seen changes in the urbanization patterns established in the

early days of the People's Republic of China. The outflow of superior rural resources to urban areas continues to accelerate. Further, there has been an overall downward trend in the total number of villages across the country. In 2005, there were 2.7091 million natural villages and 549,000 administrative villages nationwide; by 2019, the counts dropped to 2.3629 million natural villages and 493,000 administrative villages, with both types of villages shrinking year by year. On average, 13,800 natural villages and 3700 administrative villages disappear every year.

The land use structure and spatial layout of rural areas have entered a new era of transformation and reconstruction. Rural development requires appropriate adjustments, requiring transformation across different dimensions of rural development, such as industrial structure, production modes, community structure, and organizational structure [4,5]. Academics generally agree on the core concepts underlying rural transformation. However, rural transformation and development can only be realized by adjusting the structural composition and spatial allocation of land use patterns. This reality is consistent with the multifunctional characteristics of land that meet human needs for production, living, and other activities.

Rural transformation and the spatial allocation of land use interact and correspond to each other [6]. In regions with mature rural transformation, economic development eventually reaches a bottleneck and is restricted by the spatial allocation of land resources. This makes the optimization of land use spatial allocation an essential measure. China's Land Administration Law, promulgated in 2019, states that "We shall make scientific and coordinated arrangements for functional spaces including ecological, agricultural and urban spaces in an orderly manner, optimize the structure and layout of territorial space, and improve the quality and efficiency of territorial space development and protection." This marked a shift in China's territorial development from an economy-led development model to a spatial coordination model centered on sustainable development. China's economic growth has recently slowed, raising significant societal uncertainties. Population plays a driving role in economic growth [7,8]. China has relaxed its population control policies, but the effects have not been significant. Land is a similarly important production factor. Given decelerating economic growth, land resources have become more valuable, highlighting their prominent economic attributes. Sustainable development in the new era requires intensifying the consolidation of rural land resources, increasing land use efficiency, and fully and efficiently utilizing land resources. This requires the effective spatial reconstruction of land use; optimizing the structural composition of land types and their spatial layout is a core measure for rural transformation.

Topics regarding the spatial reconstruction of land use during rural transformation are closely tied to rural revitalization and urban–rural integration strategies, which are being implemented nationwide in China. A series of policy practices have been launched, including the revitalization of idle homesteads and rural houses [9]; the trading of urban and rural construction land quotas [10]; rectification of illegal housing construction on cultivated land; and the reform of the separation of rural land ownership, contracting rights, and management rights [11]. These reforms help foster a new type of urban–rural relationship and advance integrated urban–rural development. This paper uses southern Jiangsu as an empirical case to clarify the interactive mechanism between rural transformation and land spatial reconstruction and analyze their phased coupling and evolutionary laws. This study builds upon prior work on rural land transition by examining coupled human–land dynamics in southern Jiangsu, with empirical analysis limited to explicit land-use changes. This study enriches the theoretical work on rural human–land systems and offers practical references for regional territorial spatial optimization and coordinated urban–rural governance.

The general objective of this paper is to reveal the interactive mechanism between rural transformation and land-use transition in southern Jiangsu. The specific objectives are as follows: (1) to clarify the conceptual connotations and logical links between rural transformation and land-use transition; (2) to identify the phased characteristics of land-use transition from 1980 to 2020; and (3) to clarify the evolutionary relationship between rural transformation and land-use transition. Two core research questions are put forward in this study: How do rural transformation and land-use transition interact in highly urbanized regions? What phased characteristics do they exhibit under long-time-series evolution? This paper is structured as follows. Section 2 introduces the study area, data, and methodologies. Section 3 elaborates the conceptual connotations and interactive logic. Moving to empirical analysis, Section 4 analyzes the spatiotemporal characteristics of land-use transition. Building on this evidence, Section 5 explores their phased coupled evolutionary relationship. Section 6 is the discussion, while Section 7 presents the conclusions.

2. Materials and Data Sources

2.1. Study Area

Southern Jiangsu is the abbreviation for the southern region of Jiangsu Province, China, and constitutes one of the key hubs within the Yangtze River Delta Economic Zone (Figure 1). As the birthplace of the "Southern Jiangsu Model", the study area of this paper covers approximately 28,000 square kilometers, encompassing five prefecture-level cities: Nanjing, Suzhou, Wuxi, Changzhou, and Zhenjiang. Characterized by the interactive dynamics among urbanization, industrialization, and rural development, this region serves as an ideal testbed for theoretical research in rural geography. All land-use datasets were aligned to the latest administrative boundaries. This procedure eliminated biases arising from historical administrative adjustments.

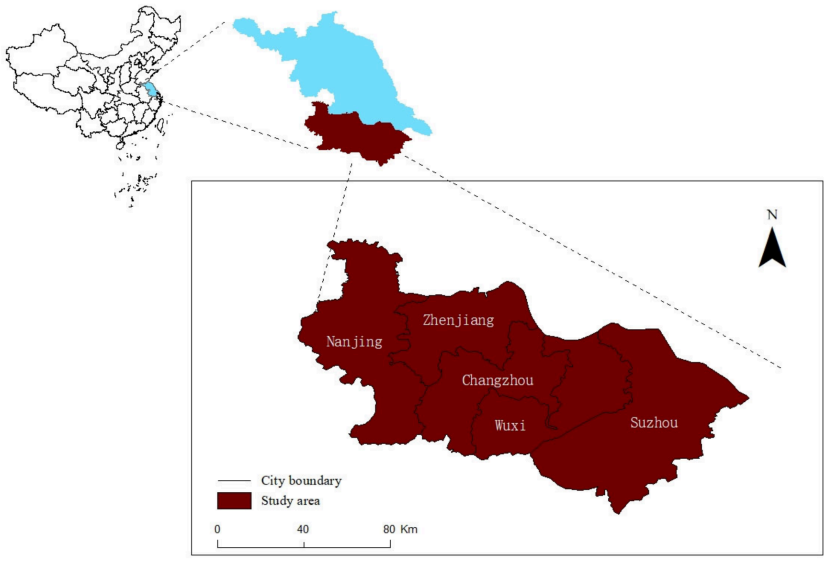


Figure 1. Study area.

2.2. Land Transition Matrix

This paper uses the land-use spatiotemporal transition matrix to directly present the research results. The formula is as follows:

$$S = \begin{Bmatrix} s_{11} & \cdots & s_{1n} \\ \cdots & \cdots & \cdots \\ s_{m1} & \cdots & s_{mn} \end{Bmatrix} \quad (1)$$

In the formula, S refers to the land-use area transition matrix for southern Jiangsu. s_{mn} is the area transformed from land-use type m to type n between two consecutive study periods. The land-use transfer matrix was generated using ArcGIS 10.8.

2.3. Data and Sources

The multi-period remote sensing monitoring dataset of land use in southern Jiangsu adopted in this study is obtained from the Resource and Environment Science and Data Center, Chinese Academy of Sciences, with a grid resolution of 30 m × 30 m. The publicly released overall classification accuracy of this dataset exceeds 90%, and the corresponding Kappa coefficient is higher than 0.80. On the basis of clarifying urban and rural land use functions, this paper constructs a transformation table of urban–rural land use function types to identify the relationships among urbanization factors, rural transformation, and the functional transition of rural land use in southern Jiangsu (Table A1).

3. Conceptual Connotations and Interactive Logic

3.1. Connotations of Rural Transformation and Land Use Transition

From the 1970s to the 1990s, the research focus of rural geography shifted from rural physical space construction to the study of rural social structures and economic development. Since then, the evolutionary process of rurality and rural restructuring has become a core research theme [12,13]. In the Chinese context, scholarly understanding of rural transformation remains fragmented, with no universally unified definition. Existing studies differ substantially in their analytical priorities. Long (2012) focuses on macroscopic restructuring of rural socio-economic forms and territorial spatial patterns, placing greater emphasis on land use and territorial reconstruction [14]. In comparison, Yang et al. (2015) adopt a holistic perspective that highlights multi-dimensional village-level progress covering economy, society, ecology, and culture; however, their framework pays less attention to structural institutional changes [15]. In contrast, Liu (2007) concentrates on micro socio-economic structural transitions reflected in industrial, employment, and urban–rural relational shifts [16]. These divergent definitions reflect different research scales and analytical perspectives, and none can fully capture the long-term, institution-driven rural evolution of southern Jiangsu. Synthesizing their strengths while fitting the regional context, this study defines rural transformation as a dynamic evolutionary process featuring shifts in rural regional economic structures, social formations, and spatial patterns, which integrates the temporal and spatial dimensions of rural socio-economic development.

Western neo-liberal perspectives on rural restructuring [17] emphasize market-driven deagrarianization and the commodification of rural space. These classical frameworks were developed under market-dominated institutional contexts and differ substantially from the state-led and policy-guided rural transformation observed in southern Jiangsu. Post-productivist transition theory [18] depicts the shift from productivist agriculture toward rural consumption, recreation, and multifunctionality. While this framework provides a valuable reference, the long-term evolutionary trajectory of southern Jiangsu cannot be simply categorized as a standard post-productivist transition; instead, it manifests a hybrid pathway shaped by industrialization and policy interventions.

Land resources act as the development carrier for rural areas, possessing natural attributes and human-shaped economic attributes. Land use transition is a key research field in human geography and economic geography, facilitating the coordination of human–land relations and high-quality regional economic development. It can be divided into explicit and implicit forms [19,20]. Explicit land use transition refers to visible quantitative and spatial changes of land systems, embodied in adjustments to the quantity, area, proportion, and spatial distribution of various land types. In contrast, implicit land use

transition denotes the invisible qualitative evolution of land spatial systems, reflected in shifts in land function, land use intensity, land property rights, management modes, and land–socio-economic factor matching. It constitutes the long-term goal of territorial spatial planning and rural development and accumulates from continuous explicit layout optimization. Maximizing comprehensive land use efficiency balances development efficiency and equity in resource distribution [21,22]. An unbalanced land-use structure hinders the multifunctional release of land, reduces factor-input efficiency, and leads to lagged implicit transitions with mismatched land functions and imperfect land management systems.

Rural transformation represents holistic macro-level changes in rural economic, social, and spatial systems, while land use transition serves as its concrete spatial carrier. Flows of urban–rural factors drive rural socio-economic transformation; development demands are translated into land use transition via land resource allocation. In turn, land use transition reshapes industrial layouts, living environments, and urban–rural spatial patterns and facilitates in-depth rural transformation. The two processes are mutually coupled and co-evolve synergistically. It should be noted that the interactive feedback described in this conceptual framework represents theoretically inferred mechanisms, rather than causal effects empirically identified in this study.

3.2. Driving Forces and Objectives for Rural Land Evolution in Southern Jiangsu

Rural transformation is not driven by a single factor but represents a comprehensive spatial outcome from the coordinated evolution of multiple elements. It involves the iterative upgrading of rural endogenous elements (economy, social culture, and labor production), as well as the transition of rural areas from a closed system under urban–rural segmentation to an open system for urban–rural integration. Accordingly, this study regards rural transformation as a systematic socio-economic and cultural process. Alongside strengthened urban–rural linkages, urbanization factors continuously couple with rural territorial systems. To adapt to changing urban–rural relations and upgraded rural socio-economic conditions, rural land use undergoes systematic adjustments in quantity, structure, and spatial pattern.

China has long been an agricultural country with a prominent small-scale peasant economy [23]. Such national conditions create pressure for the transfer of surplus rural labor. Traditional agriculture generates limited industrial value, and farmers' employment demands shift alongside socio-economic development. From the perspective of induced institutional innovation theory, factor-product relative price changes and technological progress drive institutional transition. Farmers' pursuit of maximum labor income constitutes a key endogenous driver of rural transformation [24]. Consistent with Petty–Clark's Law, lower agricultural labor productivity pushes rural labor into non-agricultural sectors for higher wages. Agriculture is characterized by long production cycles, slow technological renewal, and diminishing returns, while industry delivers faster technological progress and higher returns [25,26]. Accordingly, rural industrialization represents a typical feature of rural transformation in highly urbanized regions.

Rural transformation and the evolution of urban–rural relations mutually reinforce one another. Urban–rural relations refer to the interactive ties of mutual influence and restriction between cities and villages [27]. Marxist theory holds that urban–rural relations shape social changes, and one goal of rural transformation is to break rural areas' subordinate status relative to cities. In the early reform and opening-up period, rural transformation largely constituted passive adaptation driven by urban siphoning effects. In the new era, narrowing urban–rural gaps and the rising livelihood demands of farmers have shifted rural transformation toward a balanced pattern featuring two-way free flow of urban–rural factors. As the core spatial carrier of rural transformation, land experiences continuous

optimization in its types, structure, pattern, and utilization modes under factor flows, which provides spatial support for rural transformation. In turn, land-use restructuring further deepens rural transformation and generates a coupled evolutionary relationship. Drawing on the above logic and characteristics of highly urbanized regions, this study constructs an interactive framework for rural transformation and land-use spatial restructuring in southern Jiangsu (Figure 2).

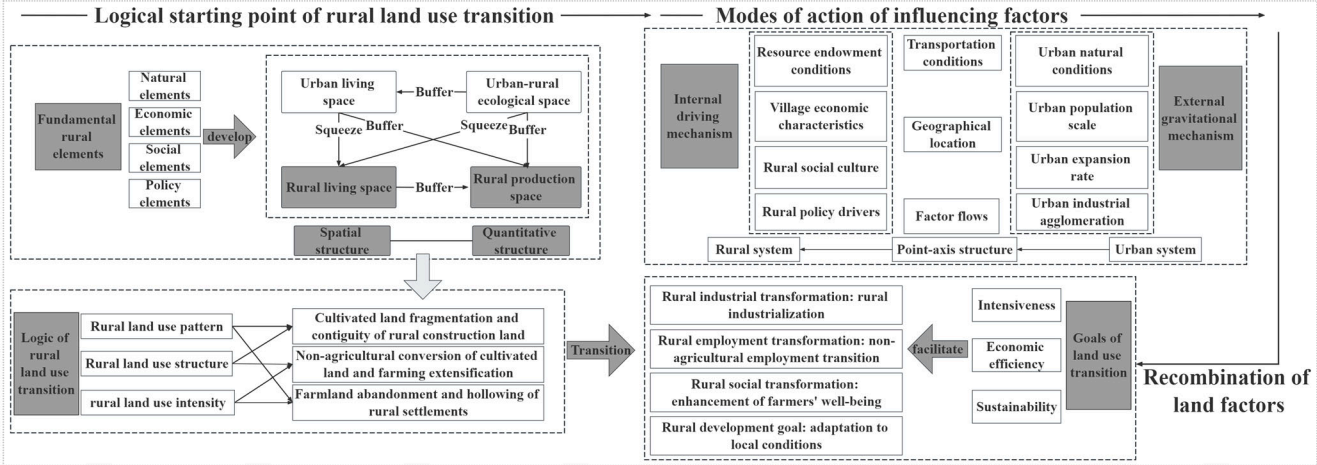


Figure 2. Interactive framework between rural transformation and rural land use transition.

3.2.1. Development of Rural Factors and Rural Land Use Transition

Four categories of basic factors support rural development and jointly drive the evolution of rural land use patterns: natural, economic, social, and policy. Natural factors are the foundation of rural development. Natural resources interact and restrict one another through material circulation and energy exchange, making them preconditions that constrain the spatial restructuring of land use. Natural endowments determine land cover and land distribution. Topographic features (e.g., elevation, slope, and terrain) govern the spatial layout of farmland, rural industrial land, and infrastructure. The arrangement of all types of production and construction land depends on natural conditions.

The combination of economic factors is a core force driving rural transformation. Technological advances fuel rural industrial expansion, and the proportion of land occupied by mines, factories, and industrial projects continues to increase in highly urbanized regions [28]. Industrial agglomeration leads to development zones, and the iteration of industrial structures leads to adjustments in the structure and spatial layout of rural land use.

Social factors reshape rural settlement patterns. Historical culture and clan ties once led to the agglomeration of villages with similar cultural backgrounds [29,30]. Rural transformation has changed the traditional rural social order and lowered clan restraints. Farmers' work and daily lives now transcend village boundaries, and changes in population and social structures continuously restructure the layout of residential and production land in rural areas.

Policy factors are critical instruments for coordinating urban and rural land allocation. Examples of land system policies include land expropriation, rural homestead management, and the market entry of rural collective commercial construction land. These have provided safeguards for land-lost farmers, provided new land for the market, and explored compensation for the voluntary withdrawal and transfer of homesteads for farmers who settle in cities [31,32]. These policies significantly shape the spatial restructuring of rural land use.

3.2.2. Urbanization and Rural Land Use Transition

Since its reform and opening up, China has experienced rapid socio-economic growth, accelerated urbanization, and industrial upgrading [1], promoting rural economic development. Nevertheless, agricultural population migration and rapid rural land conversion for non-agricultural purposes have triggered urban–rural segmentation and structural contradictions. Urbanization exerts dual effects on the evolution of rural territorial systems. This paper distinguishes two forms of urbanization: external urbanization and internal rural urbanization.

External urbanization focuses on urban built-up areas, representing the transition from a traditional agriculture-dominated rural society to a secondary- and tertiary-industry-oriented urban society driven by productivity growth, technological progress, and industrial restructuring. China's conventional urbanization relies heavily on land-based spatial expansion supported by capital, technology, and industrial growth [33,34]. It directly squeezes rural production and living spaces. With land urbanization advancing, peri-urban rural settlements and farmland are converted into urban construction land, reducing the cultivated land area. China implements the cultivated land requisition–compensation balance system [35], requiring farmland occupiers to approve non-agricultural construction to reclaim farmland of equivalent quantity and quality. This policy reshapes rural internal land-use patterns.

Rural transformation involves the evolution of internal elements in rural territorial systems, manifested as the urban-like transition of rural factors. Rural urbanization refers to the household registration shift of agricultural populations to non-agricultural status [36,37], alongside the transformation of scattered villages into concentrated town-style residential zones. Large-scale rural land consolidation relocates dispersed villages to residential quarters in towns, with the original village construction land reclaimed as cultivated land. However, residential relocation raises farmers' time and distance costs for farming.

Local governments have promoted large-scale farming to improve agricultural productivity [38], yet policy outcomes are unsatisfactory. As rural laborers migrate for off-farm jobs, cultivated land use in traditional villages changes dramatically. Mismatches between land transformation and local contexts cause extensive and underutilized farmland in some regions. Temporal misalignment between homestead policies and rural transformation also leads to rural settlement hollowing. Powered mainly by rural industrialization, rural urbanization acts as a major pathway of rural transformation in highly urbanized regions [39,40]. Rural industrialization converts large tracts of cultivated land into industrial and warehousing land, increasing the proportion of non-agricultural land, while expanding transport land further fragments farmland. Rural transformation causes spatial restructuring of rural land use, which calls for coordination between rural elements and land use to support rural revitalization.

3.2.3. Influencing Factors and Objectives of Land Use Transition

Rural land use transition is shaped by internal rural factors and external urban development characteristics. Internal resource endowments, socio-economic conditions, historical culture, and policies directly drive adjustments to the quantitative and spatial structure of rural land use. Population, industry, and resource flows in the context of external urbanization further complicate land use transitions. Southern Jiangsu has a dense urban system. Towns of different scales have distinct developmental characteristics. This leads to hierarchical disparities in their capacity to absorb beneficial rural factors and generate radiating effects. Large and medium-sized cities have concentrated industries and abundant employment opportunities. Nearby villages can efficiently capture the economic spillover from these cities, bringing higher returns to farmers engaged in off-farm work [41]. In contrast,

small cities and central towns mostly rely on land expansion for development. They exert unique reshaping effects on the pattern of rural land use transition in surrounding areas.

Beyond the inherent factors of urban and rural systems, spatial media linking the two systems are critical to their interaction. Pole-Axis System Theory posits that settlement nodes at all levels and development axes are formed by transportation, energy, and other infrastructure. These infrastructures attract populations and industries, with a strong agglomeration effect [42]. Castells' Space of Flows Theory aligns with this view. It stresses that transportation and communication infrastructures form a material carrier for factor flows [43]. Hierarchical urban nodes build a diverse radiation functional system. This study draws only on the above core insights of the two theories, rather than adopting their complete frameworks. These two theories have been widely adopted in research on the mechanisms driving rural transformation. They offer theoretical support for analyzing urban–rural factor flows and land use evolution in southern Jiangsu.

The fundamental contradiction between urban and rural development lies in the human–land conflict. As a highly urbanized region, southern Jiangsu has an acute imbalance between land supply and demand. It highlights an urgent need for land use transition and optimization [44]. Given this background, regional land use transition has three core objectives. The first is intensive and economical land use to alleviate land shortages. The second is prioritizing economic benefits to meet the core demand of upgrading rural economic development models. The third is sustainable development by coordinating the layout of construction land and ecological land. Delineating permanent basic farmland and permanent ecological protection spaces facilitates the green and sustainable development of rural areas. Changes in any element within the rural system force adjustments in land use patterns and reshape regional human–land relationships. Rural transformation and rural land-use transition exhibit a coupled and mutually interactive evolutionary relationship.

4. Spatiotemporal Characteristics of Rural Land Use Transition in Southern Jiangsu

4.1. Spatial Characteristics

There has been extensive research on "production–living–ecological (PLE) spaces", with two primary methodological approaches. The first method uses comprehensive social science indicators for evaluation, couples multiple metrics, and calculates PLE space indices within provincial or prefectural-level administrative boundaries [45]. This approach incorporates a wide array of indicators that reflect the attributes of PLE spaces. However, it is less successful in visualizing spatiotemporal variations and leads to complex research questions. The second method classifies distinct spatial types based on land use functions, streamlining research inquiries [46]. However, this approach does not capture long-term dynamic evolution patterns. Furthermore, due to limited data precision, this approach cannot differentiate urban living spaces from rural living–production spaces. This makes it less useful for long-term sequential research on the spatial restructuring of rural land use. For the highly urbanized southern Jiangsu region in particular, conventional PLE space studies prioritize urban living and production spaces, but have not fully considered rural living and production dimensions. In summary, most studies on PLE spaces focus on quantitative measurements and the spatiotemporal evolution mapping of localized areas over short time horizons. There are few long-term comparative analyses of urban and rural land use spaces. Specifically for southern Jiangsu, there are few systematic summaries of spatial transformation patterns and distillation of their underlying endogenous driving mechanisms.

To facilitate in-depth research and explore the critical correlation between rural transformation and land-use function transition given high urbanization, this study classifies

land-use categories in southern Jiangsu into four spatial types based on the classification system of PLE land use and urban–rural land-use functions. The four types of spaces are agricultural production spaces, urban–rural ecological spaces, urban living spaces, and rural living spaces, as illustrated in Figure 3.

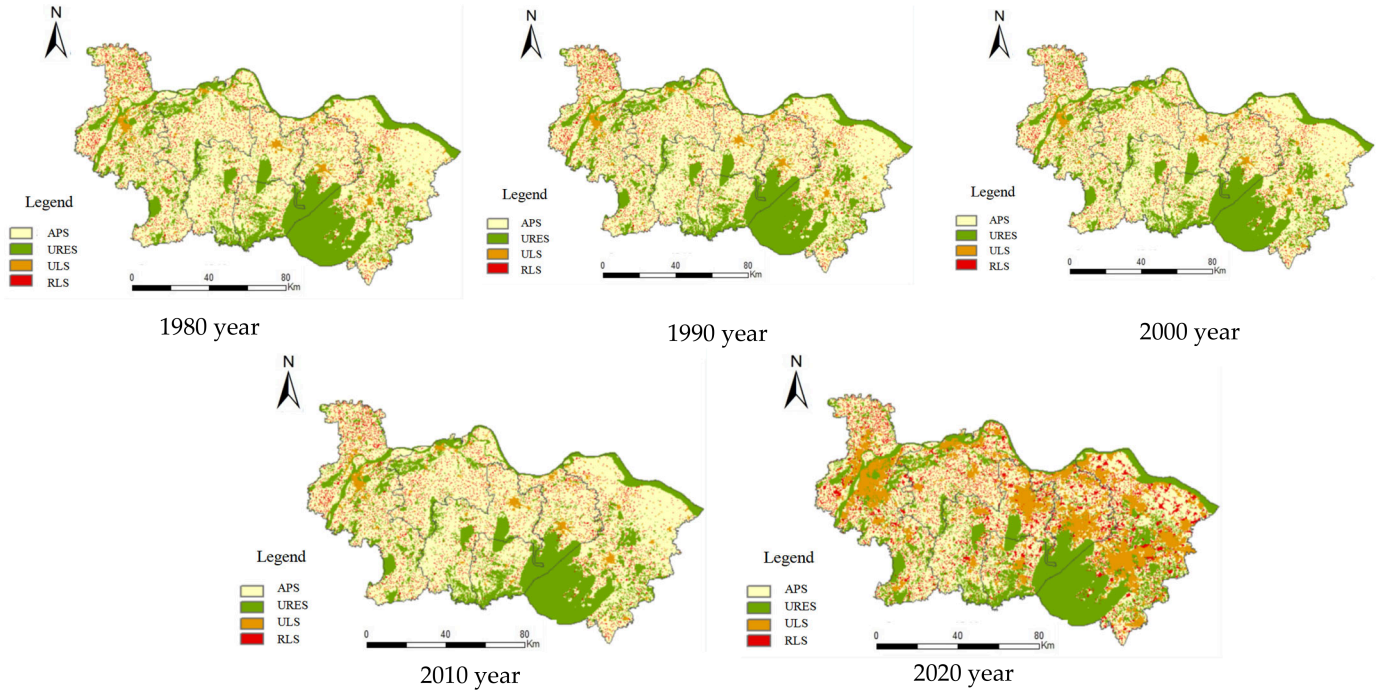


Figure 3. Land classification for urban and rural areas in southern Jiangsu.

An analysis of land-use spatial patterns in southern Jiangsu throughout the study period (1980–2020) shows that agricultural production space (APS) covered the broadest territory across the five cities of southern Jiangsu in 1980. Urban–rural ecological space (URES) was mainly distributed in Changzhou and Suzhou. Urban living space (ULS) only occupied a limited area, mainly in the core urban districts of Nanjing, Changzhou, and Wuxi. Rural living space (RLS) was scattered sporadically. From 1980 to 1990, the distribution of APS, URES, ULS, and RLS remained largely unchanged. From 1990 to 2000, the expansion of ULS and RLS encroached into APS. ULS expanded significantly in Nanjing, Changzhou, Wuxi, and Suzhou, with substantial area growth. Zhenjiang saw no noticeable expansion of ULS. From 2000 to 2010, ULS spread significantly, particularly in Nanjing and Suzhou. RLS changed from being distributed in scattered fragments in the early stage of the study period to small, clustered patches. ULS and RLS took over the area previously occupied by APS. Suzhou was the largest area where APS was converted into ULS. From 2010 to 2020, ULS and RLS continued to squeeze out APS, and the clustered spatial pattern of RLS became more distinct. The most visible impact of urbanization on rural development in southern Jiangsu was the encroachment of ULS on APS and RLS. This squeezing effect was most prominent in Nanjing, Changzhou, and Suzhou over the study period. Zhenjiang has a special location adjacent to the Yangtze River and is on the municipal boundary with Yangzhou. This resulted in local ULS compressing APS and RLS to a far lesser extent compared to other prefecture-level cities.

4.2. Temporal Characteristics

A Sankey diagram was developed to characterize land-use transitions in southern Jiangsu across the study period, as shown in Figure 4 and Table A2. Based on the land transfer flow data, the Sankey diagram of land-use transitions (Figure 5) is plotted to

visualize the conversion pathways among different land types. This Sankey diagram, based on origin only, visualizes land parcels with land-use conversion, excluding parcels where the land-use type remains unchanged. The width of each node represents the area of the corresponding land type involved in land transfer, and the width of flow ribbons denotes the mutual transferred area between different land-use types.

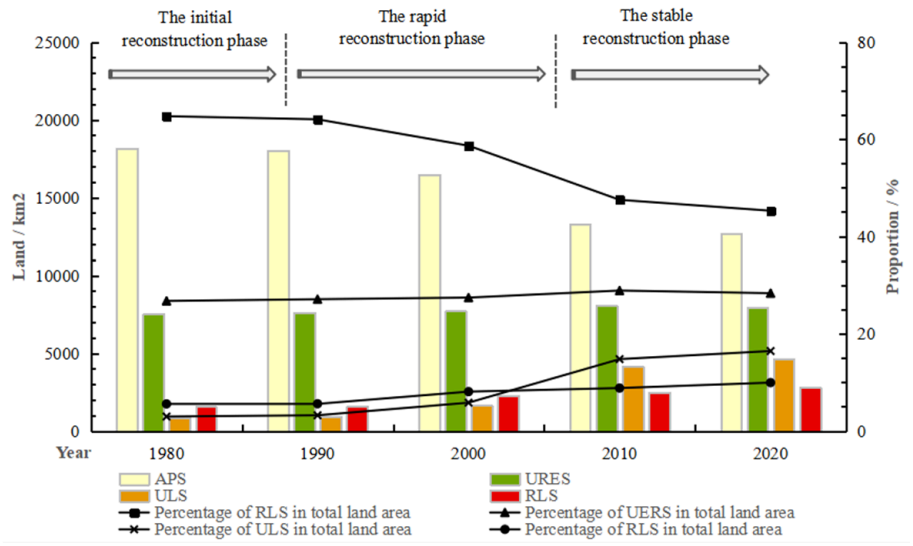


Figure 4. Phased quantitative transitions of the four land-use types in southern Jiangsu.

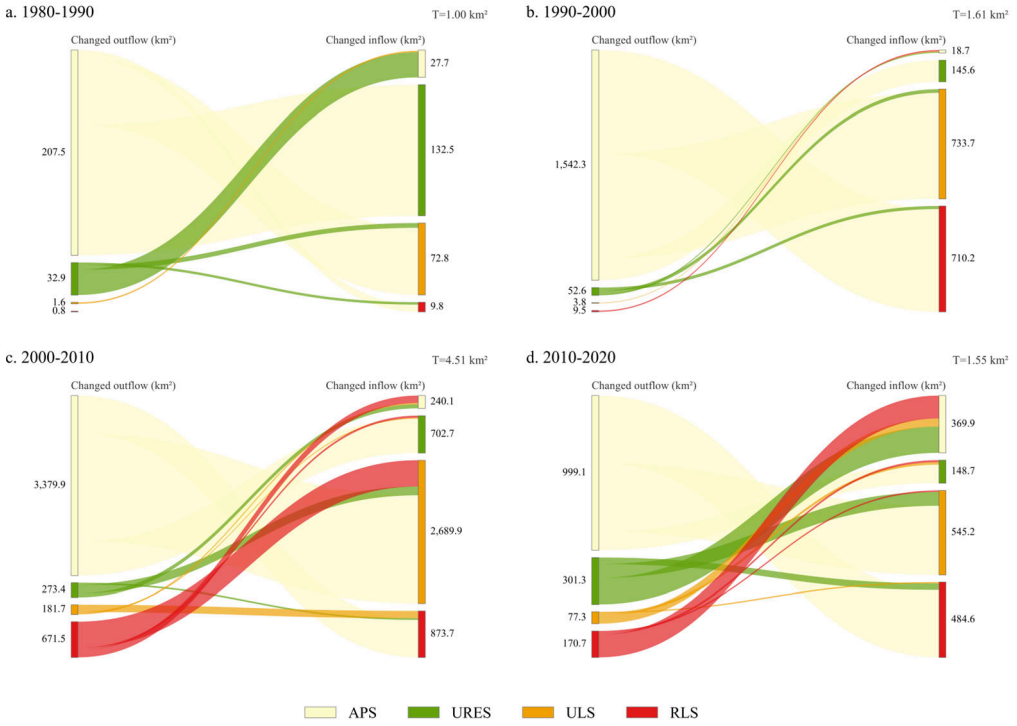


Figure 5. Sankey diagrams of four types of land space transfers in southern Jiangsu. Note: Only converted land is displayed. (**a**) Land use transition during 1980–1990; (**b**) Land use transition during 1990–2000; (**c**) Land use transition during 2000–2010; (**d**) Land use transition during 2010–2020.

(1) Initial stage of urban–rural land use restructuring in southern Jiangsu (1980–1990)

There was little conversion of the four land use spaces from 1980 to 1990. APS decreased by approximately 200 km^2, accounting for only 0.7% of the total regional land area. This decrease accounted for 85% of the total reduced area of all land types. Figure 4a

shows that APS was mainly converted into URES and ULS; the area that changed to RLS was negligible at only 7.28 km^2. Socio-economic development in southern Jiangsu was in its infancy, and the primary industry dominated the economy. In this specific historical backdrop, the urban–rural land-use spatial structure remained stable, and land-use functions were relatively homogeneous.

(2) Significant restructuring stage of urban–rural land use in southern Jiangsu (1990–2010)

The most significant transformation of urban and rural land use in southern Jiangsu occurred from 1990 to 2010. There were prominent mutual conversions among the four types of spaces and a shift in land spatial patterns. In terms of overall area, APS decreased sharply from 18,000 km^2 in 1990 to 13,340 km^2 in 2010, representing a total decline of 26%. Both rural and urban living spaces expanded rapidly. RLS grew from 1600 km^2 to 2500 km^2, which was a 56% increase; ULS saw even greater expansion, increasing from 900 km^2 to 4100 km^2, with a growth rate exceeding 300%; its proportion of total land area rose from 3.21% to 14.77%.

Industrialization in southern Jiangsu accelerated continuously during this period, and the region's socio-economic output ranked among the nation's top-tier high-income areas. There was a simultaneous emergence of urban sprawl, booming township enterprises, and a surge in rural residential construction. The original agricultural land supply did not meet the demand for urban and rural construction, pushing the entire region into a phase of intensive land-use restructuring. To further describe internal land transfers, this period is split into two sub-periods, 1990–2000 and 2000–2010, with land flow discrepancies illustrated in Figure 5b and Figure 5c, respectively. From 1990 to 2000, township industries grew across the region, accompanied by a parallel expansion of urban construction and rural residential land. APS transferred into other forms, with 690 km^2 converted to RLS and 705 km^2 converted to ULS. This meant that the occupation of cultivated land by the two types of living space was comparable in scale.

After 2000, regional development priorities shifted toward the large-scale expansion of central urban areas, bringing a visible shift in land conversion. APS generally transitioned to urban construction: 2000 km^2 of agricultural land was transformed into ULS, compared with the 700 km^2 that was transformed into RLS. There was a clear integration of urban and rural spaces, as massive amounts of rural construction land were absorbed by cities; roughly 500 km^2 of RLS was further converted into ULS. Local rural land reclamation also occurred, with 140 km^2 of RLS restored to APS. Bidirectional conversion between urban and rural spaces and within rural territories was a core characteristic of rural land restructuring in this sub-period.

(3) Stabilized stage of urban–rural land use restructuring in southern Jiangsu (2010–2020)

Overall quantitative changes in regional land use were low from 2010–2020. The share of APS as part of the total land area dropped from 47.51% in 2010 to 45.26% in 2020, which was a decrease of 2.25%. The proportion of RLS rose from 8.82% to 9.94%, and the proportion of ULS rose from 14.77% to 16.44%. The share of URES remained steady at roughly 28.50%, with little fluctuation. Observations from the Sankey diagram (Figure 5d) show active internal land conversions despite the superficial stability. Following the trends of the second sub-period of the significant restructuring stage, a total of 370 km^2 of land was converted into APS between 2010 and 2020, representing the largest inflow supplement to APS across all study periods. This newly supplemented APS originated from 170 km^2 of URES and 150 km^2 of RLS. Nevertheless, considerable APS was simultaneously transferred to RLS and ULS, and outflow exceeded inflow, so APS still experienced a net reduction. RLS expanded by 480 km^2; this new area was primarily converted from APS.

In summary, there were three distinct stages of land-use transition across different periods in southern Jiangsu: the initial restructuring stage (1980–1990), the significant restructuring stage (1990–2010, subdivided into Phase I: 1990–2000 and Phase II: 2000–2010), and the stabilized restructuring stage (2010–2020). Based on transfer patterns originating from APS and RLS, rural land spatial restructuring from 1980 to 2000 (covering the initial restructuring stage and Phase I of the significant restructuring stage) was primarily driven by transitions away from APS. In contrast, rural land spatial restructuring from 2000 to 2020 (encompassing Phase II of the significant restructuring stage and the stabilized restructuring stage) was jointly shaped by the transformation of both APS and RLS. During this later period, the conversion destinations of APS, RLS, and ULS became more balanced, and the patterns of rural land spatial restructuring grew increasingly intricate.

5. The Evolutionary Relationship Between Rural Transformation and Rural Land-Use Transition in Southern Jiangsu

This paper considers the policy context, economic development conditions, and phased transfers of four types of spatial land use in southern Jiangsu over 40 years to explore the dynamic evolutionary relationship between rural transformation and rural land-use transitions (Figure 6). In the early stage of rural industrialization, there were many enterprises that were small-scale and had a scattered layout; industrial development did not fundamentally drive the large-scale spatial restructuring of regional land use. From the late 1970s to the early 1980s, the Sunan Model centered on Suzhou, Wuxi, and Changzhou took shape, relying on its superior geographical location. The model centered on the rural collective economy [47], prioritizing rural industry and the construction of small towns, with market regulation as the primary approach. It realized the non-agricultural transformation of populations and land by developing township and village enterprises.

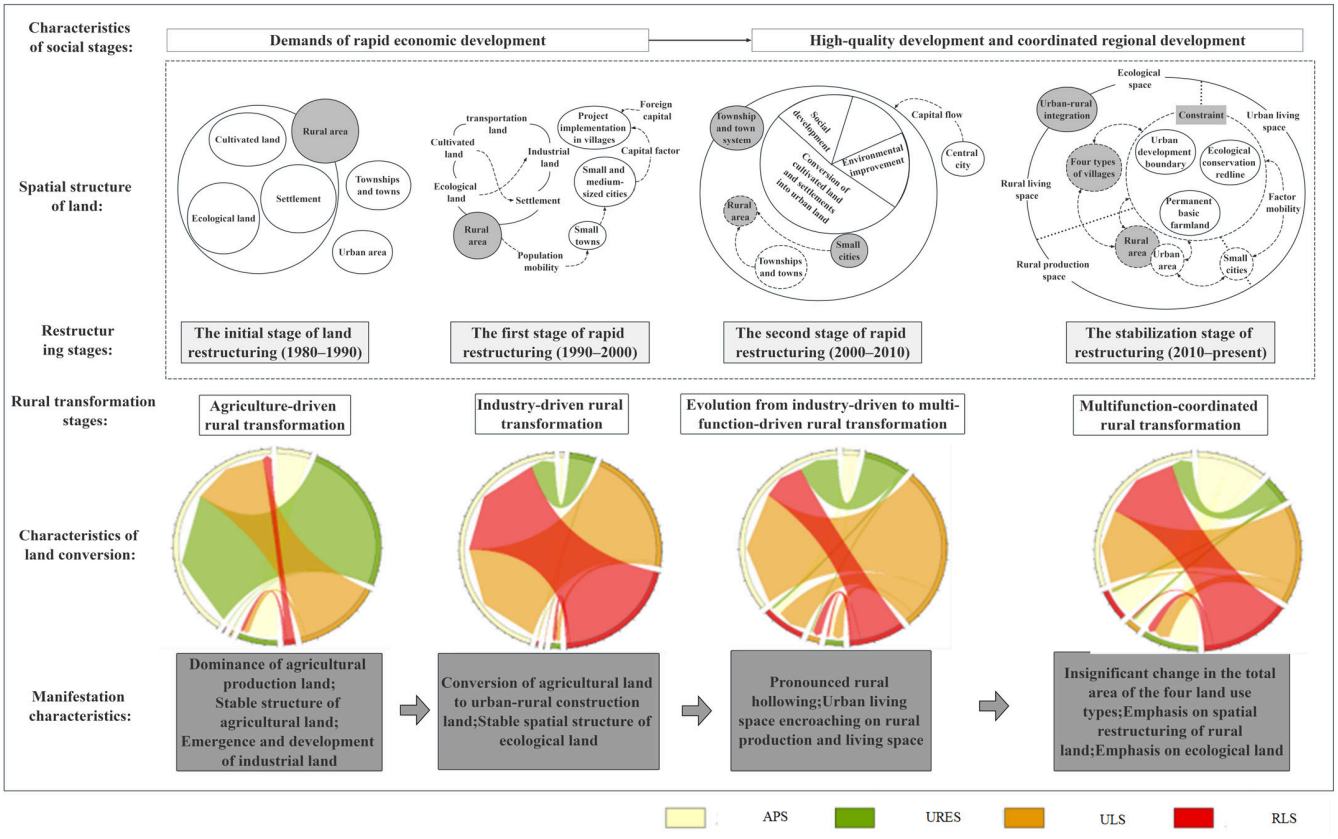


Figure 6. Evolution characteristics of rural transformation and land-use transition.

From 1980 to 1990, agricultural production space was the primary source of land-use reduction, yet the overall magnitude of land transformation remained modest. Agricultural land still occupied a dominant share of the regional territory. Rural southern Jiangsu was in the initial phase of low-level industrialization and urbanization. The restructuring of rural land use was primarily driven by the advancement of rural industrialization; external urbanization had only a small impact on rural land patterns. Rural southern Jiangsu was relatively developed compared with other regions in China, but there was a clear developmental divide between villages and central towns. Township and village enterprises were confined within the radiation scope of central towns, and primary industry remained the dominant rural sector. The land use pattern remained in a traditional village form dominated by residential and agricultural spaces.

In the 1990s, the establishment of the socialist market economy comprehensively deepened economic reforms and urban–rural interactions, accelerating urbanization. Southern Jiangsu benefited from the development dividends of Pudong's development and opening up, gradually forming an industrial park system centered on Suzhou, Wuxi, and Changzhou. The park included national-level development zones, high-tech zones, and export-processing zones. Urban economic scale and construction land expanded continuously, and new-type small towns sprang up rapidly. The regional employment labor structure experienced significant restructuring, and the industrial system completed the shift from being agriculture-dominated to being industry-dominated [48,49]. Rural industrialization in southern Jiangsu accelerated, driven by the policy of introducing industrial projects into villages and the continuous inflow of foreign capital.

Urban living spaces squeezed agricultural production spaces and rural living spaces, while rural living spaces continuously encroached upon farmland. From 1990 to 2000, substantial amounts of agricultural production space were transferred to both urban and rural living spaces. During this phase of rural land use restructuring, endogenous rural development and external urbanization factors jointly drove the transformation of agricultural land and reshaped the regional land use pattern. However, a lack of supporting policy guidance led to the unregulated expansion of urban and rural construction land. This resulted in fragmented agricultural land and the scattered layout of urban and rural industrial land. Interaction and coupling between various urban–rural spaces improved in this period, yet the urban–rural dual structure persisted, with unidirectional flow of production factors.

After the year 2000, the urban–rural relationship in southern Jiangsu shifted from segregation to integrated development. Guided by the Scientific Outlook on Development, government departments in southern Jiangsu implemented a development model of industry supporting agriculture and cities driving villages, gradually establishing a multi-level circulation system of urban–rural capital factors covering small and medium-sized cities, towns, and administrative villages.

From 2000 to 2010, many agricultural laborers in southern Jiangsu migrated to urban areas, mostly to local county seats and central towns. This led to the hollowing out of rural residential homesteads. Unlike Phase I of rural land-use transition, urban living spaces continued to encroach on agricultural production spaces in Phase II. Portions of rural living spaces were reconverted into agricultural production spaces, accompanied by the notable expansion of urban–rural ecological land. During this period, the development orientation of villages in southern Jiangsu transformed from pursuing sheer economic growth to pursuing sustainable development. Continuous optimization and adjustment of social construction land and ecological land diversified the spatial restructuring of rural land use.

As the government prioritized high-quality development and coordinated regional development, the rural land-use transition in southern Jiangsu entered a stable stage. The region has continuously optimized urban–rural relations and implemented policies on demarcating permanent basic farmland [50], urban development boundaries, and ecological protection red lines [51]. The goal of this has been to address the unbalanced distribution of urban and rural resources and uncoordinated local rural development triggered by rapid urbanization. The measures lock in the scale of regional agricultural and ecological spaces and ensure land for grain production and ecological conservation. The rural land system has also been the subject of in-depth reforms. The market entry of collectively owned operational construction land and reforms on rural homesteads have effectively revitalized land resources and channeled urban capital into rural areas.

Compared with Phase II of the rural land-use transition, the total volume change of the four types of land spaces in the stable stage has been mild; however, the two stages are evolutionarily connected. From 2010 to 2020, some land was restored to agricultural production spaces from urban–rural ecological spaces and rural living spaces, alongside limited conversion from urban living spaces to rural living spaces. Nevertheless, a substantial amount of agricultural production space was still diverted to construction land, resulting in its net decline across this period. Phase II was characterized by significant changes in land quantity and spatial patterns, whereas the stable stage featured continuous optimization and adjustment of the land-use spatial structure formed in the previous phase.

6. Discussion

Rural transformation is a multi-dimensional socio-economic process involving industrial restructuring, social reconstruction, settlement evolution, and institutional change. Constrained by multi-source data availability, rural transformation in this paper is mainly interpreted through historical policy narratives and phased socio-economic contextual analysis, rather than a comprehensive quantitative indicator system. Therefore, we focus on revealing the coupled and mutually interactive co-evolution between rural transformation and land-use transition, rather than claiming empirical evidence for bidirectional causal effects. In addition, this study only conducts quantitative measurement of explicit land-use transition, whereas implicit land-use transition is merely discussed conceptually without empirical operationalization.

Rural industrialization facilitates local development, yet it may deepen intra-rural disparities and environmental harm. Such challenges appeared in southern Jiangsu during the township enterprise boom. The cultivated land requisition–compensation balance system reshaped rural land patterns. Scholars worry that the system cannot fully guarantee the quality of reclaimed land [52]. The Sunan Model delivered great economic gains. It also created unintended costs, including land fragmentation and scattered industrial pollution.

The phased land-use transition of southern Jiangsu can be further contextualized through cross-regional comparison with East Asian and European peri-urban cases. The rural transformation trajectory of southern Jiangsu shares partial similarities with East Asian cases, including South Korea's Saemaul Undong [53] and rural industrialization in Taiwan, China [54], where local industrialization drove rapid land-use restructuring. Unlike these East Asian models dominated by grassroots industrial growth, southern Jiangsu experienced a phased transition from township enterprise expansion to coordinated land regulation after 2010. This stable adjustment stage echoes European peri-urban experiences: the Dutch Green Heart policy and Italian campagna urbanizzata both reflect human–land conflicts amid intensive urbanization. Compared with global patterns [33], southern Jiangsu's land transition is not merely a universal outcome of rapid urbanization but a regionally specific pathway shaped by China's land management and institutional arrangements.

The flow of rural factors to cities occurs spontaneously, while the return of urban factors to rural areas mostly relies on policy incentives. Scholars worldwide have built a sound research system concerning rural transformation and urban–rural integration. Drawing on multidisciplinary theories from geography, sociology, economics, and other disciplines, the literature includes extensive macro and micro studies covering evaluation frameworks, spatial characteristics, and driving mechanisms. However, significant research gaps remain. Most research focuses on macro administrative units, such as provinces and prefecture-level cities, with fewer micro-village-scale investigations and multi-scale comparative analyses. Regionally differentiated modes of land-use restructuring need further refinement. Further, there is a basic analytical framework concerning rural spatial governance, but more research is needed on the interactive mechanisms between rural transformation and land-use transition amid rapid urbanization. Research methods should expand from conventional macroscopic descriptive analysis to more in-depth exploration of evolutionary laws supported by multi-source data integration.

Future research could advance in three dimensions. In terms of scale, scholars should move beyond purely macroscopic perspectives and conduct refined multi-scale analyses using typical village case studies to fill the gap in micro-level research. In terms of driving mechanisms, the push–pull theory could be adopted to systematically describe the internal and external interactive linkages between rural transformation and land use restructuring in highly urbanized regions. This could help reveal the root causes of human–land contradictions and land-use conflicts between urban and rural territories. In terms of research content and methodologies, scholars should explore disparities in land use transition across diverse rural types and developmental stages. Combined with multi-source spatiotemporal analytical tools, long-term follow-up surveys and evolutionary simulation could provide theoretical support for rural spatial optimization and the rational allocation of land resources.

7. Conclusions

This paper studies the typical highly urbanized region of southern Jiangsu, clarifying the conceptual connotations and two-way interactions between rural transformation and land use transition. Using long-term land use datasets spanning 1980 to 2020, this study analyzes the spatiotemporal evolution of four types of spaces in the region: agricultural production spaces, urban–rural ecological spaces, urban living spaces, and rural living spaces. It then identifies their phased coupled evolutionary relationships. The main conclusions are as follows.

Rural transformation and land-use transition present a coupled and mutually interactive co-evolutionary relationship. Our phased historical analysis suggests that basic rural factors covering natural, economic, social, and policy dimensions, together with internal and external urbanization forces, jointly drive the spatial restructuring of land. In turn, the reshaping of land quantity structure, spatial layout, and functions leads to adjustments in regional industries, employment patterns, and settlement forms. This collectively reshapes industry–agriculture and urban–rural ties, with the core objectives of intensive land conservation, high economic efficiency, and ecological sustainability.

Land use transitions in southern Jiangsu from 1980 to 2020 had distinct features across three phases. The period from 1980 to 1990 was the initial transition stage, where agricultural space occupied a dominant position, and the scale of land conversion stayed low. The years 1990 to 2010 saw significant transitions, marked by large expansions in urban and rural living spaces and the persistent non-agricultural conversion of cultivated land. In the early segment of this phase, construction land in both urban and rural areas concurrently encroached on farmland. Urban sprawl became the leading driver in the

later segment, leading to challenges such as rural hollowing and fragmented cultivated land. The period after 2010 started a stable adjustment stage with decelerated overall land conversion. Cultivated land reclamation, ecological conservation, and spatial optimization advanced in tandem, and land governance policies introduced prominent restrictive effects.

Rural transformation and land-use transitions advance in parallel and generate four matched developmental modes. The earliest phase was propelled by agriculture, maintaining the stable traditional residential–agricultural spatial layout of villages. The years 1990 to 2000 saw the introduction of industrial forces, with a unidirectional flow of urban and rural elements and the disorderly expansion of construction land. From 2000 to 2010, development evolved into a model driven by integrated industry and diversified functions; coordinated urban–rural policies fueled the expansion of ecological land. After 2010, the region entered a stage coordinated by multiple factors, where policies and reforms of rural land systems encouraged the balanced optimization of production, living, and ecological spaces.

The fundamental source of conflicts over urban and rural land in highly urbanized regions is the mismatch between the supply and demand of human–land resources. The experience of southern Jiangsu shows that the one-way absorption of rural factors by cities may trigger cultivated land loss and village hollowing. Optimized land spatial restructuring and unimpeded two-way flow of urban–rural production factors are critical to promoting integrated urban–rural development and sustainable rural revitalization. This study carries practical policy implications for public decision-makers and land-use planning. Targeting planners and land administrators in highly urbanized regions, our empirical findings support differentiated land governance. The phased coupling relationship identified in southern Jiangsu provides practical references for idle homestead renovation, construction land quota management, and territorial spatial policy design in economically developed rural areas.

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Appendix A

Table A1. Classification of urban and rural land use in southern Jiangsu province.

First-Level Type	Secondary Type	Classification
1 Cultivated land	Paddy field Dry land	Agricultural production space (APS)
2 Forest land	Wooded land Shrubland Open forest land Other forest land	
3 Grassland	High-coverage grassland Medium-coverage grassland Low-coverage grassland	Urban–rural ecological space (URES)

Table A1. *Cont.*

First-Level Type	Secondary Type	Classification
4 Water area	Rivers and canals	
	Lakes	
	Reservoirs	
	Permanent glaciers and snowfields	
	beach land	
5 Urban–rural, industrial mining, and residential land	Urban built-up area	Urban living space (ULS)
	Rural settlements	Rural living space (RLS)
	Other construction land	ULS
6 Unused land	Sandy land	URES
	Gobi	
	Saline–alkali land	
	Swamp land	
	Bare land	
	Bare rock and gravel land	

Table A2. Area of different land types in various years (km^2).

Area/Year	1980	1990	2000	2010	2020
APS	18,181.24	18,001.37	16,475.19	13,308.58	12,679.37
URES	7516.68	7616.30	7709.27	8095.62	7942.99
ULS	830.12	901.35	1631.24	4138.50	4606.45
RLS	1560.61	1569.56	2270.27	2470.81	2784.69

Note: Summation of land category areas varies across years and may not match the total regional area. These minor discrepancies stem from pixel-level processing, classification, and rounding of raster land-use datasets.

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