Impacts of Village Transformation on Rural-Urban Integration Based on Land Use Change–Taking Suzhou City as an Example

Shuting Zhang, Yasi Tian, Jiamin An
Suzhou University Golden Mantis School of Architecture, Jiangsu, China

Abstract: Against the backdrop of rapid advancement of new industrialization and urbanization, coupled with surging demand for land resources, land use change has emerged as a key factor driving village transformation and facilitating urban-rural integration. However, the impact mechanisms between urban-rural integration and the evolution of rural land use, as well as how they influence rural transformation and development, remain unresolved scientific issues.

From the perspective of urban-rural integration, this study takes Suzhou City as a case to explore the mechanism by which land use change affects urban-rural integration through village transformation. It constructs an evaluation system for urban-rural integration development level encompassing spatial, economic, and social integration dimensions. Using the Analytic Hierarchy Process (AHP), it assesses the spatio-temporal characteristics of urban-rural integration in Suzhou's districts and counties from 2010 to 2020. Regression analysis reveals that land use change-driven village transformation exerts a positive promoting effect on urban-rural integration.

Results indicate that optimized land use drives the transformation of village functions, thereby enhancing the efficiency of urban-rural resource allocation. Nevertheless, regional imbalance and insufficient land use efficiency remain constraining factors. Based on this, a synergistic path of land use optimization and village transformation with Suzhou characteristics is proposed. This study clarifies the interaction mechanism among land use change, village transformation, and urban-rural integration, providing theoretical support and policy insights for regional coordinated development and rural revitalization.

Keywords: Land use change; Village transformation; Urban rural integration; Industrial living ecological land

1. Introduction

New industrialization and urbanization have reshaped urban-rural relations, with land use change driving regional development and spatial restructuring. China has prioritized urban-rural coordination since the 18th CPC National Congress, yet integration challenges remain. Rural areas are integral to urban-rural systems, where land transitions reflect socioeconomic shifts [1]. Urban-rural integration (URID) promotes bidirectional factor flows and spatial optimization, with villages facilitating land transformations [2]; the rural-urban gradient views land as a multifunctional continuum [3]. Suzhou, a Yangtze River Delta core city with 81.93% urbanization by 2020, offers a key case for studying these dynamics [4].

International research on village transformation focuses on labor migration, global-local interactions, and territorial governance. Domestic studies have advanced URID measurement—including Li et al.'s coordination indicators, Si et al.'s evaluation system, Tan Lin et al.'s spatial reconstruction framework, and Liu and Liu (2025)'s work on land use efficiency [5]. However, gaps exist in linking land use change, village transformation, and integration mechanisms, spatio-temporal dynamics, and optimization pathways. This study addresses these via a "land use-village transformation-integration" framework, multi-dimensional evaluation, and Suzhou-based empirical analysis using AHP and regression.

In summary, this study clarifies their interaction mechanisms in Suzhou to support regional coordination and rural revitalization.

2. Research Methods and Data Sources

2.1 Overview of the Study Area

Suzhou is located in Jiangsu Province, China (Figure 1), comprising 5 urban districts and 4 county-level cities. Its 2022 population reached 12.91 million with 82.12% urbanization rate, exceeding the national average. Land use during the study period featured construction land expansion, farmland reduction, and ecological land optimization, reflecting industrializati7on-driven village transformation.

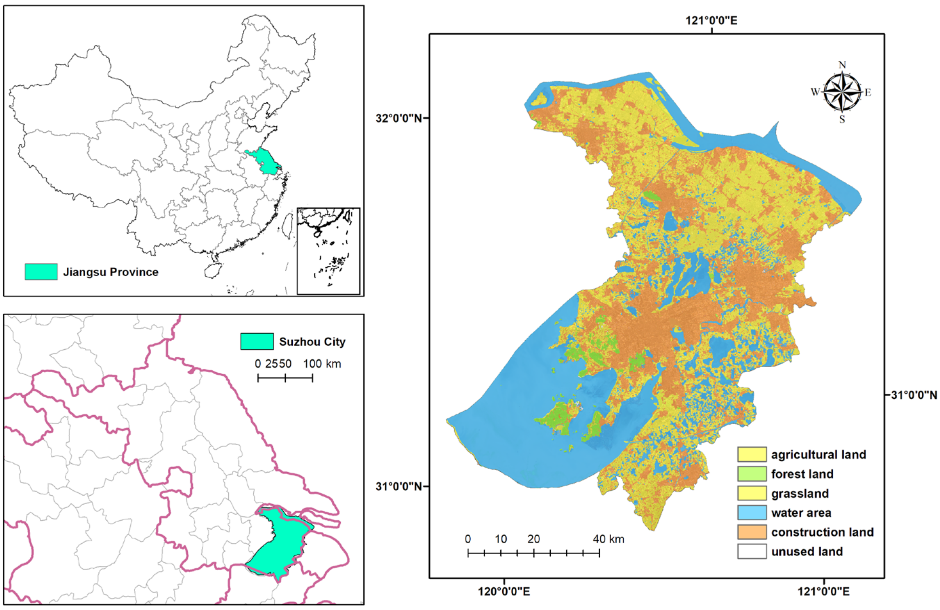

Figure 1: Location of the study area. (Map data from http://bzdt.ch.mnr.gov.cn/)

2.2 Evaluation System Construction

This study constructs a three-level evaluation system for Suzhou's urban-rural integration (Table 1), covering spatial, economic, and social integration dimensions.

Table 1: Comprehensive Evaluation System for the Level of Urban-Rural Integration and Development.

Target Level	Tier 1 Indicators	Tier 2 Indicators	Tertiary Indicators
Urban-rural Integration Development Level	Urban-rural Spatial Integration	Administrative Planning	Level of land urbanization (%)
			Share of urban population
		Infrastructure	Road network density (km/km′)
			Park green space per capita(m)
	Urban-rural Economic Integration	Economic Strength	GDP per capita (billion yuan)
			Per capita public budget revenue of one share (billion yuan)
			Share of secondary and tertiary industries in GDP
		Industrial Interaction	Ratio of non-agricultural industries to agricultural output
			GDP per unit of unit of construction land (million yuan/metric item)
	Urban-rural Social Integration	Social Programs	General public budget expenditure per capita
			Number of practicing (assistant) physicians in health institutions per 10000 persons

2.3 Research Methods

2.3.1Analytic Hierarchy Process (AHP)

Expert scoring determined indicator weights by: 1) Establishing hierarchy (goal-criterion-indicator layers), 2) Constructing 1-9 scale judgment matrix, 3) Calculating weights with consistency check (CR < 0.1). The three first-level dimensions were decomposed into 5 second-level and 11 third-level indicators based on data/logical consistency (Table 2).

Table 2: Comprehensive Evaluation System and Specific Indicators for the Level of Urban-Rural Integration and Development.

Target Level Name	Tier 1 Indicators Name	Tier 1 Weight	Tier 2 Indicators Name	Tier 2 Weight	Tertiary Indicators Name	Tertiary Weight	Indicator Description
Urban-rural Integration Development Level	Urban-rural Spatial Integration	0.4	Administrative Planning	0.5	Level of land urbanization (%)	0.5	Built-up area / Total land area (%)
					Share of urban population	0.5	Urban population density / Rural population density
			Infrastructure	0.5	Road network density (km/km′)	0.5	Road operation mileage / Total land area (km/km)
					Park green space per capita(m)	0.5	-
	Urban-rural Economic Integration	0.3	Economic Strength	0.5	GDP per capita (billion yuan)	0.4	Per capita consumption of urban households
					Per capita public budget revenue of one share (billion yuan)	0.6	Engel's coefficient in urban areas / Engel's coefficient in rural areas
			Industrial Interaction	0.5	Share of secondary and tertiary industries in GDP	0.3	Sum of output value of secondary and tertiary industries / GDP (%)
					Ratio of non-agricultural industries to agricultural output	0.3	Sum of output value of secondary and tertiary industries / Primary industry output value
					GDP per unit of unit of construction land (million yuan/metric item)	0.4	-
	Urban-rural Social Integration	0.3	Social Programs	1	General public budget expenditure per capita	0.6	Public library collection / Total population (books)
					Number of practicing (assistant) physicians in health institutions per 10000 persons	0.4	Share of employees in secondary and tertiary industries / Share of employees in primary industries

2.3.2 Regression Analysis

The model uses the following formula:

$$URF_i = \alpha + \beta_1 LUC_i + \beta_2 VT_i + \beta_3 LUC_i \times VT_i + \varepsilon_i \quad (1)$$

Where URFi is the urban-rural integration index, LUC_i is the land use change index (including the growth rate of construction land and the conversion rate of farmland), VT_i is the village transformation index (including industrial structure entropy and urbanization rate of the population), and ε_i is the random error term.

2.4 Data Sources

Land use data are derived from the 2010 and 2020 Globeland30 land cover data, interpreted using ENVI5.3; socio-economic data are sourced from the 2010 and 2020 Suzhou Statistical Yearbook and the National Economic and Social Development Statistical Bulletins of Suzhou's various districts and counties; rail transit data is based on official Suzhou Metro data; fiscal revenue and expenditure data is sourced from fiscal transparency information on government websites at all levels; education-related data is sourced from public information released by the Suzhou Municipal Education Bureau.

3. Results and Analysis

3.1 Spatio-temporal Characteristics of Urban-rural Integration in Suzhou City

3.1.1 Time Series Analysis

Standardized operations were performed on the calculated results of each indicator. The data for each tertiary indicator for each district and county in 2010 and 2020 were obtained. Using the 2010 indicator values as the standard, the ratio of the 2020 urban-rural integration indicators to the 2010 values constitutes the urban-rural integration index score. This score reflects the overall change in data under each tertiary indicator between 2020 and 2010. A score closer to 1 indicates a level closer to the average of 2010. From the time series data, if the 2020 evaluation score is greater than 1, it indicates a positive trend in urban-rural integration; conversely, it indicates a trend toward differentiation. Among scores greater than 1, the higher the score, the higher the degree of urban-rural integration. Finally, the scores of the grade indicators are weighted and summed according to the aforementioned framework weights to obtain the overall change score for the first-level indicators (Table 3).

Table 3: Standardized scores for various indicators in each district and county of Suzhou.

District	Spatial Integration Changes	Administrative Planning	Infrastructure	Economic Integration Changes	Economic Strength	Industrial Interaction	Social Integration Changes	Social Programs	Overall Changes
Wuzhong	1.41	1.8	1.01	1.76	2.07	1.44	1.21	1.21	1.45
Wujiang	1.06	1.45	0.67	1.39	1.47	1.31	2.58	2.58	1.62
Taicang	1.06	1.19	0.93	1.95	2.55	1.35	5.79	5.79	2.75
Changshu	0.84	1.03	0.64	1.11	0.95	1.27	1.13	1.13	1.01
Gusu	1.88	1.05	2.7	1.36	1.7	1.01	1.66	1.66	1.65
Zhangjiagang	3.35	0.96	5.74	1.08	1.2	2.28	2.28	1.45	1.99
Kunshan	1.1	1.34	0.86	1.08	2..02	1.67	1.67	1.67	1.45
Xiangcheng	1.54	1	2.07	1.85	1.67	2.02	1.67	1.67	1.67
Huqiu	1	0.87	1.12	1	1	1	2.85	2.85	1.55
Industrial Park	1.06	1.12	1	1	1	1	4.22	4.22	1.99

Longitudinal analysis. From a time series perspective, Zhangjiagang City's comprehensive score for urban-rural integration increased from 1.0 in 2010 to 1.99 in 2020, showing a sustained upward trend over the decade. Among these, the improvement in urban-rural spatial integration was the most significant, with a 2.55-fold increase from 2010 to 2020. This was primarily due to the city's efforts to revitalize idle industrial land, improve the integrated urban-rural transportation network (such as extending urban rail transit to townships), and coordinate the planning of ecological and development spaces.

3.1.2 Spatial Differentiation Characteristics

Horizontal Comprehensive Evaluation. Based on the calculated data, the urban-rural integration development index for all districts and counties in Suzhou City in 2020 was greater than 1, indicating that the urban-rural integration process across the entire region is showing a positive and promising trend. Among them, Taicang City, Zhangjiagang City, and Suzhou Industrial Park stood out, with their urban-rural integration development indices significantly higher than the city-wide average, reflecting that these regions have already formed strong integration momentum in terms of factor mobility, spatial integration, and industrial synergy. In contrast, the urban-rural integration process in Changshu City and other districts and counties lagged behind, with their development indices showing a certain gap compared to leading regions, possibly constrained by factors such as slow industrial structure transformation or insufficient efficiency in spatial resource allocation.

Overall level evaluation. During the 2010-2020 period, the level of urban-rural integration development in all districts and counties of Suzhou City achieved varying degrees of improvement. Taking Zhangjiagang City as an example, its 2020 urban-rural integration composite score reached 1.99, nearly doubling from the 2010 baseline value (1.0).

3.2 Mechanisms Driving Village Transformation Through Land Use Change

3.2.1 Land Function Transformation

From 2010 to 2020, Zhangjiagang City experienced a decrease in water areas and an increase in living spaces; in Xiangcheng District and the lakeside areas of Kunshan City, water areas decreased, and production spaces began to concentrate; in Wuzhong District and Gusu District, unused land decreased; and in Xiangcheng District, the Industrial Park, and Kunshan City, living spaces increased significantly.

During the study period, Suzhou used 47,000 hectares of farmland for construction, mainly concentrated in villages surrounding industrial parks, promoting the transformation from "agricultural villages to industrial villages,".

3.2.2 Transformation of industrial-living-ecological land Use

This study categorizes land use data within the ArcGIS layers into production space (farmland); living space (construction land); ecological land (orchards/forests, grasslands, water bodies); and unused land (Figure 2).

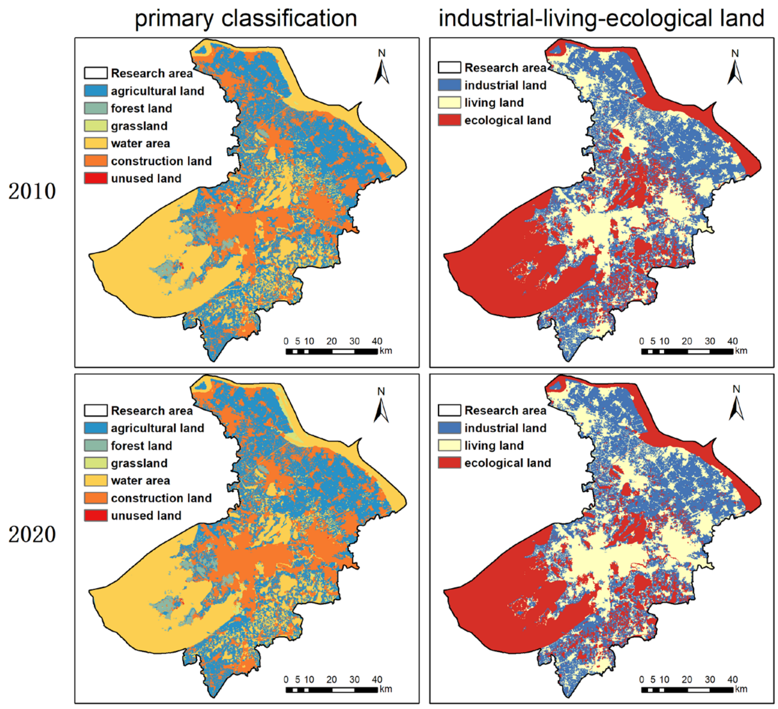

Figure 2: Primary land use classification and industrial-living-ecological land map of Suzhou in 2010 and 2020. ((Map data from http://bzdt.ch.mnr.gov.cn/))

Overall, the land use structure in Suzhou City underwent a significant transformation between 2010 and 2020 (Figure 3): the areas of production space (arable land) and ecological space (orchards/forests, grasslands, and water bodies) decreased by 125.77 square kilometers and 132.45 square kilometers, respectively, while living space (construction land) expanded at an average annual rate of 26.29 square kilometers. This change aligns closely with the development logic of "spatial restructuring - functional transformation" in Suzhou's new urbanization process, reflecting the structural shift of land resources toward urban development spaces driven by industrialization.

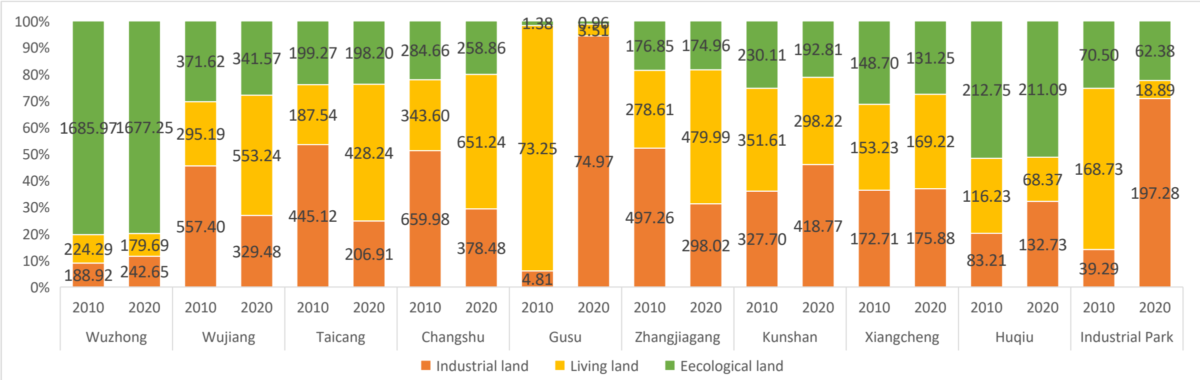

Figure 3: The proportion of industrial land, living land, and ecological land in each district and county of Suzhou City from 2010 to 2020.

The proportion of production space remained at a low level throughout the 2010-2020 period. Production space has been shrinking across all districts and counties, with Kunshan District experiencing the largest reduction (29.48 square kilometers), while Gusu District saw the smallest reduction (1.30 square kilometers). Kunshan District, as the core manufacturing base of the Yangtze River Delta, saw its industrial land area decrease from 36.03% to 32.78% between 2010 and 2020 due to the continuous expansion of industrial platforms. Gusu District, as the core area of Suzhou's ancient city, is strictly restricted by policies protecting historical and cultural cities, with land development primarily focused on renovating existing areas. Additionally, its arable land base is extremely small, resulting in a limited reduction in production space.

In terms of expansion area (Figure 3)., Kunshan District saw the largest increase in living space (67.16 square kilometers), while Gusu District had the smallest increase (1.72 square kilometers). The large-scale expansion of living space in Kunshan District stems from the demand for residential land under the Shanghai-Suzhou urban integration framework; in Gusu District, construction land primarily involves the renovation of existing areas, with very little new living land added. The expansion of living space in Gusu District primarily relies on the redevelopment of low-efficiency land, resulting in limited increases. However, through the integration of cultural spaces and urban functions, the quality of urban-rural social integration has been enhanced.

In terms of reduced area (Figure 3)., Kunshan District saw the largest decrease in ecological space (37.30 square kilometers), while Gusu District had the smallest decrease (0.42 square kilometers). The significant reduction in ecological space in Kunshan District may lead to a decrease in the area of ecological buffer zones around villages, a decline in the ecological service value of farmland ecosystems, and expose shortcomings in ecological sustainability within urban-rural integration.

3.3 Results

The direct effect coefficient of land use change (LUC) on urban-rural integration (URF) is $\beta = 0.23$ ($p<0.01$), indicating that optimizing land use structure can directly promote urban-rural integration. The mediation effect of village transformation (VT) accounts for 37%, with the mediation effect of industrial structure entropy ($\beta = 0.18$) being stronger than that of urbanization rate ($\beta = 0.12$), indicating that industrial diversification has a more significant driving effect on urban-rural integration. The interaction term coefficient between LUC and VT is $\beta = 0.15$ ($p < 0.05$), indicating that land use optimization and village transformation have a synergistic effect, and their joint action can enhance the promotional effect on urban-rural integration.

4. Discussion

4.1 Mechanisms Through Which Land-Use Change Accelerates Urban–Rural Integration

The empirical results confirm that rational land-use restructuring and functional upgrading form a mutually reinforcing loop that accelerates urban–rural integration. Concentrating fragmented farmland into contiguous modern agricultural parks raises land productivity and frees fiscal resources for rural public goods, while the parallel intensification of construction land underpins diversified non-agricultural employment opportunities. The statistically significant interaction term between land-use change (LUC) and village transformation (VT) ($\beta = 0.15$, $p < 0.05$) indicates that land-use optimization unleashes its full integrative potential only when villages simultaneously adjust their industrial and demographic structures.

4.2 Regional Heterogeneity and Path Dependence

A pronounced north–south gradient is evident: Kunshan and Wujiang, endowed with stronger manufacturing bases and more flexible land policies, outperformed northern counties such as Taicang in GDP per hectare by almost 40%. While earlier work by Tan et al. emphasized policy institutions and industrial restructuring as generic drivers of rural spatial reconstruction, the Suzhou case demonstrates that historical path dependence and the maturity of county-level economies condition the strength of these drivers. Areas already integrated into global value chains can convert land dividends into higher-order services and innovation more readily than regions still reliant on primary processing.

4.3 Comparison with Previous Empirical Studies

Effect magnitude. The direct effect of LUC on the urban - rural integration index ($\beta = 0.23$) is slightly lower than the elasticities reported for national panel data by Liu and Liu ($\beta \approx 0.28$), suggesting that Suzhou, already at an advanced integration stage, faces diminishing marginal returns from additional land conversion.

Role of industrial diversification. Our mediation analysis attributes 37% of the total effect to VT, with industrial structure entropy ($\beta = 0.18$) outweighing demographic urbanization ($\beta = 0.12$). This pattern corroborates findings from peri-urban drylands where diversified land-use planning had stronger welfare effects than sheer urbanization rates.

Governance perspective. Whereas studies on Beijing's urban–rural fringe highlight spatial planning as the primary lever for sustainability, the Suzhou evidence points to fiscal feedback loops—specifically, recycling land-lease revenues into rural infrastructure—as an equally decisive factor. This variance underscores the need to tailor governance instruments to local fiscal capacities and industrial stages.

Benchmarking against Pearl River Delta. The "whole-area urbanization" model of Dongguan delivers faster absolute integration gains but at the cost of higher ecological pressure. Suzhou's more incremental, county-led strategy yields steadier gains in social and ecological indicators, aligning with international calls to bridge the rural–urban dichotomy through multifunctional landscape governance rather than wholesale conversion.

4.4 Policy Implications

Layered land-use zoning. Introduce differentiated quotas for agricultural, construction and ecological land that reflect each county's industrial maturity and environmental carrying capacity.

Village-specific transformation packages. Combine land consolidation with targeted industrial incubation (e.g., Agri-tech clusters in northern counties, cultural-tourism complexes in Gusu) to mitigate spatial mismatches in resource allocation.

Fiscal recycling mechanisms. Institutionalize a minimum 30% earmark of land-lease revenue for rural public services, ensuring that land-value appreciation translates into tangible social integration benefits.

4.5 Limitations and Future Directions

The decade-long panel captures medium-term structural shifts but cannot fully reveal rapid post-2020 dynamics such as digital-platform agriculture or carbon-neutral land banking. Future research should couple higher-frequency remote-sensing data with agent-based simulations to trace real-time feedbacks between land markets, village livelihoods and ecosystem services.

5. Conclusion

5.1 Key Findings

This study analyzed the relationship between land use changes and urban-rural integration in Suzhou from 2010 to 2020 and reached the following conclusions: Land use changes significantly promote urban-rural integration by driving the transformation of village functions (in terms of industry, space, and society), with economic integration contributing the most and spatial integration growing the fastest. Regional differences are pronounced, with counties and districts with higher levels of industrialization and innovative land policies (such as Kunshan and Wujiang) exhibiting higher levels of integration; Insufficient land use efficiency and the absence of spatial coordination mechanisms are the primary constraints.

5.2 Policy Recommendations

Establish a "flexible land use" mechanism, implementing "spot land allocation" for industrial villages and piloting "ecological compensation + land swap" for ecological villages; improve the land revenue sharing system, allocating 30% of the proceeds from the entry of collective construction land into the market specifically for rural public services; establish a cross-regional land coordination platform, such as the "Suzhou Urban-Rural Land Use Alliance," to coordinate land indicators and industrial layout across counties and districts.

5.3 Research Limitations and Outlook

This study only analyzed static relationships over a ten-year timeframe. Future research could combine remote sensing time-series data to explore dynamic patterns. Additionally, the ecological effects of land use changes on urban-rural integration (such as carbon sink functions) require further investigation.

References

[1] Liu, H. and Liu, X., Research on the impact of urban-rural integration on rural land use efficiency in China, Frontiers in Environmental Science, 13, 1–17 (2025).

[2] Tan, L., et al., The driving mechanism and path analysis of the coupling development of rural spatial

reconstruction and land use transformation, Natural Resources Journal, 37(7), 1829–1847 (2021).

[3] Multiple Authors, Multifunctional role of land-use planning in peri-urban and urban agricultural drylands: The mediating effect of urbanization level, Journal of Urban Planning and Development, 151(1), 1–12 (2025).

[4] Multiple Authors, Analysis of the sustainable development pathway of urban–rural integration from the perspective of spatial planning: A case study of the urban–rural fringe of Beijing, Sustainability, 17(5), 1857–1875 (2025).

[5] Multiple Authors, Bridging the rural-urban dichotomy in land use science, Journal of Land Use Science, 15(5), 585–591 (2020).