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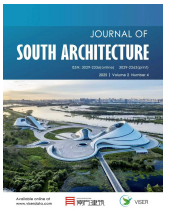

Performance Evaluation and Optimization Path of Industrial Land in Districts and Counties

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ABSTRACT: The inherent scarcity of land drives an inevitable shift in land resource utilization from "incremental expansion" to "stock optimization". Industrial land is the primary carrier of urban production functions and a key focus for optimizing stock space in districts and counties within the context of territorial spatial planning. Through a comprehensive review of relevant literature and practical experience, this study clarifies and extends the conceptual framework of the development potential of stock industrial land, providing a theoretical foundation for the revitalization of underutilized industrial land. It constructs an integrated framework for macro-scale performance assessment and micro-scale classification of inefficiency types of industrial land, offering categorized guidance for enhancing the quality and efficiency of the "three-level and five-category" industrial land system, and providing methodological references for district- and county-level redevelopment of stock underutilized industrial land as well as sustainable urban development decision-making in the new development stage. Furthermore, the study explores multi-scenario implementation paths and full life-cycle management mechanisms for the redevelopment of underutilized stock industrial land, providing support and assurance for the intensive and efficient utilization of construction land.

KEY WORDS: territorial spatial planning; stock industrial land; three levels and five categories; performance evaluation; optimization path

Introduction

Under the guidance of the concept of ecological civilization, territorial spatial planning in the new era actively addresses various conflicts among spatial resources, and fulfills the requirements of high-quality development through spatial development, protection, replacement, and renewal[1]. The scientific rationality of territorial spatial allocation, with land as the core resource element, is an important guarantee for improving the quality of China's economic development and promoting its sustainable growth [2]. The inherent scarcity of land dictates that, with the continuous rise of urbanization, the stock of unused land will steadily decline, while demand for land use will grow. Accordingly, the vast stock of urban space, as the most expansive "blue ocean" in territorial spatial planning, must inevitably be subject to potential tapping and urban renewal. As the reform of territorial spatial planning advances, the city construction model dominated by incremental planning is gradually being replaced by stock-oriented planning. "Strictly controlling increments and revitalizing stock" has become the core approach to achieving high-quality development. To improve the rationality of intensity in urban construction land development and utili-

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zation, attention must be paid to potential tapping in urban land use [3].

Industry is the driving force and foundation of urban development[4]. Industrial land, as an important carrier of urban production functions, is the key target for potential tapping in existing space. During the period of rapid urbanization, local governments sought development through investment promotion policies featuring low or even zero land prices. Consequently, the spatial structure of cities changed along with rapid land expansion. Meanwhile, shifts in industrial planning and environmental protection policies, coupled with the finite lifecycles of enterprises and the lack of effective exit mechanisms, led to a series of issues such as a high proportion of industrial land, inefficient utilization, and irrational spatial distribution [5, 6]. With the continuous advancement of new-type urbanization, promoting the redevelopment of underutilized industrial land within cities has become an inherent requirement for adapting to economic restructuring and optimizing the spatial development and protection pattern of national territory [7]. In current territorial spatial planning practices, it has been observed that cities of all scales—large, medium, and small—maintain a relatively high proportion of industrial land, which also demonstrates greater potential compared to other categories of land use. In recent years, relevant departments of the State Council have successively issued a series of policies and implementation guidelines related to industrial land, such as the "Overall Plan for Comprehensive Pilot Reform of Market-Oriented Factor Allocation" and the "Guidelines for the Implementation of Industrial Land Policies". All of these documents propose improving the efficiency of land factor allocation and addressing in depth the issue of output efficiency for stock industrial land [8]. How to create greater value from limited land resources has become an important direction of exploration for local governments to enhance spatial governance efficiency under the ongoing reform of territorial spatial planning [9].

Research on the evaluation and identification ofunderutilized industrial land and on optimized redevelopment pathways is of great significance for the systematic implementation of territorial spatial planning and for enhancing the efficiency of land resource allocation. Existing studies primarily concentrate on macro- and meso-level efficiency evaluations of construction land at provincial and municipal scales, with little refinement to the micro scale of industrial parcels, thereby limiting their ability to provide effective evidence for constructing rational and orderly pathways of stock industrial land optimization and renewal [10]. Meanwhile, domestic studies on the renewal of stock industrial land generally exhibit the characteristics of emphasizing conceptual frameworks over practical application and focusing on major cities while neglecting smaller towns, tending either toward theoretical construction or toward case studies in the central districts of first-tier metropolises [11]. Because they possess strong fiscal capacity, relatively mature policy mechanisms, and well-developed institutional foundations, large cities usually adopt government-led approaches such as repurchasing underutilized land for redevelopment as the main mode of urban renewal. However, such approaches provide limited direct guidance for ordinary small towns where financial resources are tight and supporting policies remain in exploratory stages. This study seeks to summarize and synthesize existing theoretical research and practical experience on underutilized industrial land redevelopment, aims to construct a performance evaluation and optimization framework for existing industrial land at the district and county level with broad applicability, thereby providing systematic operational guidance for ongoing industrial land renewal efforts across regions.

1 Local models of underutilized industrial land redevelopment

Since 2016, based on the implementation requirements and guiding principles of the former Ministry of Land and Resources' "Guiding Opinions on Deepening the Redevelopment of Inefficient Urban Land (Trial)", provinces and cities have proposed different implementation approaches forunderutilized industrial land redevelopment according to their respective industrial land-use characteristics. In practical applications, most provinces and cities adopt a similar approach to determine the redevelopment potential of underutilized industrial land in urban areas—namely, identifying and assessing potential

sites based on the results of special investigations on underutilized urban land. This process involves conducting an inventory survey of existing construction land using data from the national land survey to obtain information on the quantity, distribution, and industrial types of underutilized urban land in the areas. The sites planned for redevelopment are then marked on remote sensing images and planning maps to establish a database of underutilized land. In terms of organizational modes for underutilized industrial land redevelopment, local practices vary slightly, but they can generally be categorized into three types: government-led redevelopment, redevelopment by original landowners, and redevelopment involving market participants (Table 1).

Table 1 Comparison of scope and modes of underutilized industrial land redevelopment at national and provincial levels

	Scope of Underutilized Industrial Land Redevelopment	Modes of Underutilized Industrial Land Redevelopment
Former Ministry of Land and Resources (2016)	(1) Industrial land used for prohibited or phased-out industries as specified in national industrial policies; (2) Land failing safety production or environmental protection requirements; (3) Land for "upgrading from secondary to tertiary industries"; (4) Areas with scattered layout and outdated facilities that are designated for reconstruction in plans	(1) Reconstruction and development by state-owned land use right holder; (2) Reconstruction and development of collective construction land in urban villages; (3) Land with structure to be optimized through industrial transformation and upgrading; (4) Concentrated, large-scale development; (5) Construction for strengthening public facilities and livelihood projects
Jiangsu Province (2016)	(1) Land not in line with industrial policy guidance, safety production, or environmental protection requirements; (2) Land with phased-out, redundant, or overcapacity industries; (3) Land with scattered layout and inefficient land use; (4) Land with irrational use or low output efficiency; (5) Land not meeting the conditions of state-owned construction land transfer contracts	(1) Government-led redevelopment; (2) Redevelopment by original landowners; (3) Redevelopment involving market participants; (4) Comprehensive renovation and improvement
Sichuan Province (2017)	(1) Land prohibited or to be phased out according to industrial policies and documents such as the "Catalogue for Guiding Industry Restructuring", the "Catalogue of Items for Which the Land Use Is Restricted", and the "Catalogue of Items for Which the Land Use Is Prohibited"; (2) Land identified by authorities as failing safety production or environmental standards; (3) Land for "upgrading from secondary to tertiary industries"; (4) Land with utilization intensity and input-output levels significantly below relevant standards or contractual agreements	(1) Government reclaims land use rights for redevelopment; (2) Redevelopment by original state-owned land use right holder in ways like self-development, joint ventures, equity participation, or transfer; (3) Market entities conduct concentrated, contiguous development: acquire adjacent plots through public procedures, then apply for concentrated redevelopment
Henan Province (2018)	(1) Industrial land used for prohibited or phased-out industries as specified in national industrial policies; (2) Land failing safety production or environmental protection requirements; (3) Land where buildings and structures pose serious safety hazards; (4) Land listed in municipal, county (district) industrial layout adjustment plans, pending relocation, or for "upgrading from secondary to tertiary industries"; (5) Land with low utilization intensity or land output rate	(1) Industrial upgrading and transformation to optimize land use structure; (2) Redevelopment involving original state-owned or collective land use right holders and other market entities; (3) Market entities acquiring adjacent plots for concentrated, contiguous development

(Continued)

	Scope of Underutilized Industrial Land Redevelopment	Modes of Underutilized Industrial Land Redevelopment
Tianjin Municipality (2020)	(1) Industrial land used for prohibited or phased-out industries as specified in national industrial policies; (2) Land failing safety production or environmental protection requirements; (3) Land for "upgrading from secondary to tertiary industries"; (4) Areas with scattered layout and outdated facilities that are designated for reconstruction in plans	(1) Government-led redevelopment: redevelopment according to current policies; (2) Market-led redevelopment: original land right holders redevelop independently or through investment cooperation, but their investment share must not be less than 51%
Shandong Province (2020)	(1) Industrial land used for prohibited or phased-out industries as specified in national industrial policies; (2) Land failing safety production or environmental protection requirements; (3) Land for "upgrading from secondary to tertiary industries"; (4) Areas with scattered layout and outdated facilities that are designated for reconstruction in plans; (5) Control indicators such as investment intensity, plot ratio, and land-based output intensity are significantly below local industry averages; (6) Land identified based on the list of "restricted development" enterprises according to the "per-mu output efficiency" performance evaluation reform	(1) Government reclaim land for redevelopment: plots planned for residential, urban infrastructure, or public facilities are reclaimed or purchased according to law; (2) Original land use right holder redevelop: through self-development, joint ventures, equity participation, or transfer; (3) Original rural collective economic organizations redevelop: urban village collective construction land may be redeveloped independently or with social investors; (4) Market entities redevelop: open bidding is conducted to determine market entities to acquire adjacent plots and implement concentrated, contiguous development
Zhejiang Province (2021)	(1) Land not conforming to planning purposes, or requiring implementation of "retreat from secondary, advance tertiary"; (2) Land failing safety production or environmental protection requirements; (3) Land classified as prohibited or phased-out at national and provincial levels; (4) Land with utilization intensity or input-output level significantly below construction land control standards; (5) Land occupied by outdated industries or struggling enterprises that needs to be vacated from use	(1) Government-led redevelopment; (2) Market entity redevelopment: acquire adjacent plots through transfer and apply for concentrated development; (3) Original land-use rights holder develops the land independently: a redevelopment plan shall be formulated, submitted for approval in accordance with procedures, and implemented upon approval. (4) Original collective economic organization develops independently or cooperatively

Although policy guidelines forunderutilized land redevelopment have been successively introduced at the provincial and municipal levels, the implementation of industrial land rectification and upgrading at the district and county level still faces a series of challenges. These mainly include: (1) identification of the scope of underutilized industrial land redevelopment is incomplete; (2) connotation of the redevelopment potential of stock industrial land is outdated; (3) An integrated implementation framework spanning from policy guidance to operational guidelines has yet to be established for the identification of underutilized land. Regional standards remain inconsistent, and the involvement of multiple departments renders data collection and survey work highly labor- and cost-intensive; (4) market entities show limited willingness to participate in the redevelopment or land exchange of certain plots due to financing difficulties and low expected economic returns; (5) high expectations of land value appreciation among original land use right holders result in substantial funding requirements for government land acquisition and reserve, potentially exceeding the fiscal capacity of local governments; (6) the relevant legal and policy framework remains incomplete, and there is limited exploration of localized safeguard mechanisms for implementation, including remediation, upgrading, and subsequent management [12].

2 Connotation of the redevelopment potential of stock Industrial land

Built-upunderutilized industrial land in urban areas constitutes the primary component of the redevelopment potential of stock industrial land. In 2015, the former Min-

istry of Land and Resources defined underutilized industrial land as "non-idle land whose current input-output intensity, floor area ratio, building density, industrial type, and production operation conditions do not meet industrial and urban development needs, yet still possess significant potential for adjustment and utilization." At present, there is still no universally accepted academic definition of the scientific connotation of underutilized industrial land. However, the concept is generally examined across multiple dimensions, including industrial orientation, external manifestation, output efficiency, utilization intensity, environmental protection and energy performance [13-15]. He Fang et al. proposed that the identification of underutilized industrial land should reflect the characteristics of comprehensive multi-departmental management, encompassing 6 categories: low efficiency due to idle or shutdown, low efficiency in development and utilization, low efficiency in input/output, low efficiency in industrial orientation, low efficiency in contract, low efficiency in functional allocation [16]. Based on the principle of land conservation, QU Zhongqiong summarized the connotation of underutilized industrial land into 3 aspects: low efficiency in land output, low utilization rate of industrial land, and insufficient function in social service [17]. Internationally, a similar concept to underutilized industrial land is the "brownfield". The two share four comparable characteristics: (1) In terms of physical form, they are previously developed lands that are currently idle, abandoned, or awaiting redevelopment; (2) In terms of economic performance, they have low productivity or fail to meet the requirements of regional dominant industries to be developed, with indicators such as total output value, profit, and tax revenue falling short of contractual obligations; (3) In terms of spatial efficiency, they feature disordered and underutilized layouts, with low indicators of land use intensity such as factory building density, floor area ratio, and fixed-asset investment; (4) In terms of environmental benefits, they are characterized by high energy consumption, high pollution, and high risk, and fail to meet relevant regulatory standards [18-20].

The incorporation of approved-but-unsupplied and idle land into the stock under the "increment-stock linkage" mechanism, together with the removal of legal barriers to the market entry of rural collective operational construction land, extended the spatial connotation of the potential exploitable in stock industrial land[21]. In 2018 the "Notice of the Ministry of Natural Resources on Improving the 'Increment-Stock' Linkage Mechanism for Construction Land" stipulated that approved-but-unsupplied and idle land should be included as stock indicators in calculations. Regions with large amounts of such land would see reduced allocations of new construction land, and subsequent annual quotas would be rewarded or reduced based on the completion of land disposal tasks. In the past, academic and planning circles often associated the redevelopment of underutilized land with "Three-Old Redevelopment" and "Urban Renewal" [22]. The discussion typically focused on the performance evaluation and low efficiency identification of already developed industrial land, while paid insufficient attention to unsupplied and undeveloped land. Furthermore, the *Notice of the Ministry of Natural Resources, the National Development and Reform Commission, and the Ministry of Agriculture and Rural Affairs on Ensuring and Regulating Land Use for the Integrated Development of Primary, Secondary, and Tertiary Industries in Rural Areas* issued in 2021 stipulated that large-scale and highly industrialized projects should be located in industrial parks, and sizable agricultural product processing projects should be concentrated within urban development boundaries. For a long period, the lack of adequate control over land outside urban development boundaries has led to scattered and underutilized development of rural collective operational construction land. Given the widespread overextension of construction land quotas, small towns must explore a more compact and efficient model for reconstructing urban-rural industrial spaces [23]. However, most national and provincial guidelines for investigating and redeveloping low-efficiency stock land focus primarily on urban areas, and little research is conducted for this in rural regions [24]. Consequently, many districts and counties still lack policy guidance for the redevelopment of low-efficiency collective industrial land in rural areas.

This study examines each stage of the full life cycle

of industrial land and includes all non-high-quality industrial spaces throughout the processes of land approval, allocation, and construction within the scope of the redevelopment potential of existing industrial land. These spaces are classified into four major categories: approved but unsupplied industrial land, supplied but undeveloped industrial land, underutilized industrial land in urban areas, and underutilized industrial land in rural areas (Figure 1).

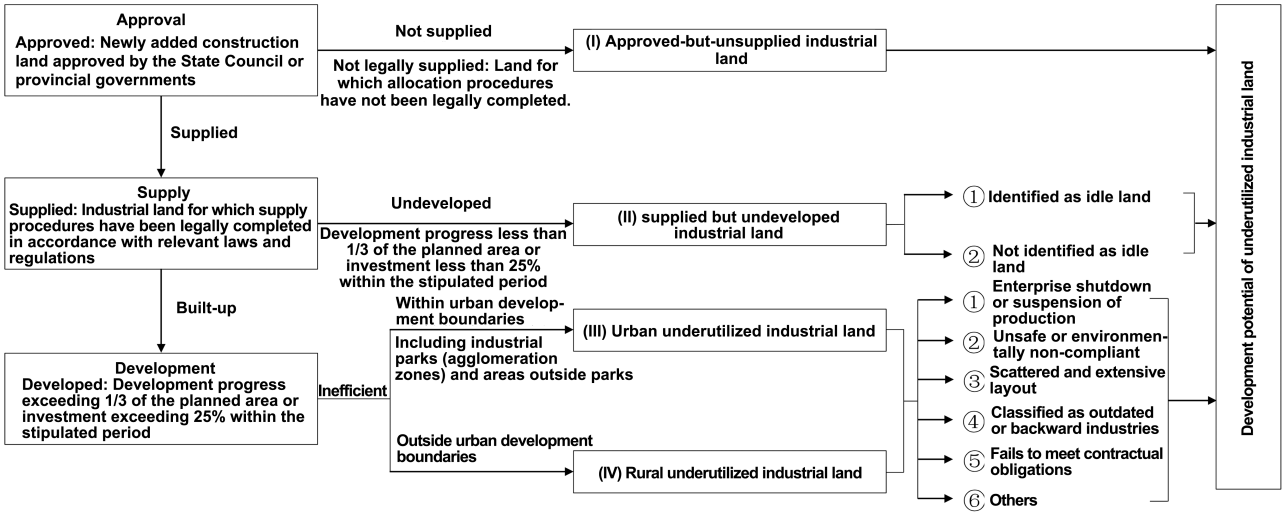
3 Evaluation and optimization pathway of industrial land use performance

3.1 Classification of industrial land by scale

There are objective differences in the utilization performance of stock industrial land across different scale levels. Higher-level industrial parks, being generally larger in area and benefiting from stricter entry thresholds, more complete supporting facilities and greater policy incentives, exhibit significantly higher land productivity than lower-level ones[25]. In order to propose targeted land-use renewal schemes from the perspective of overall territorial coordination and balance, it is necessary to conduct classified evaluations based on a macro-level assessment of the entire territory. Drawing on industrial land renewal practices in cities such as Shanghai and Suzhou, and based on the current scale distribution of industrial parks nationwide, the stock industrial land within districts and counties can be classified into a three-tier system comprising industrial bases, industrial communities, and industrial blocks (Figure 2). Industrial bases refer to large-scale industrial parks or clusters located within the jurisdiction of development zones or high-tech zones at the district or county level. The total land area generally exceeds 4 km^2. Industrial communities refer to industrial parks or clusters at the municipal level or above, that are situated outside industrial bases. Their area is typically greater than 1 km^2. Industrial blocks refer to smaller industrial parks below the municipal level, and other scattered industrial lands located outside industrial bases and industrial communities. Empirical evidence shows that in most regions, the output efficiency of industrial land is highest in industrial bases, followed by industrial communities, and lowest in industrial blocks. Under current resource constraints, the overarching principle is that industrial bases and communities within the urban development boundary should focus on prioritized development and optimization, whereas industrial blocks outside the boundary should focus on clearance, relocation, and improvement.

3.2 Macro-scale evaluation of industrial land use performance

A comprehensive evaluation is conducted at both the overall regional (macroscopic) level and the three-tier classification of industrial land use. The objective is to gain an intuitive understanding of the current efficiency of urban industrial land through a multidimensional factor profiling approach, identify the relative strengths and weaknesses of the industrial bases and communities, and thereby coordinate and balance the spatial layout of industrial land within districts and counties to more effectively guide the relocation and renewal of industrial sites. Based on existing theoretical research and planning practices related to industrial land evaluation methods[26-28], this study constructs an indicator system comprising five criterion dimensions: economic efficiency, land use intensity, accessibility and industry-friendliness, innovation and collaboration, and ecological efficiency (Table 2). Under each criterion, more than three representative indicators are selected. The number of "+" signs represent the relative importance of each indicator—the greater the number of "+" signs, the higher its weight in performance evaluation and the greater its priority in consideration. If it is necessary to assign specific weights to the indicators under each criterion and calculate a comprehensive performance score for a particular industrial base or community, methods such as the Delphi method, Analytic Hierarchy Process (AHP), or Entropy Weight Method can be adopted [29]. However, it should be noted that excessive dimensionality reduction or normalization may obscure important original attributes [30]. In many cases, qualitative judgments derived from multidimensional quantitative indicators may provide more intuitive and effective insights than the results of composite index calculations. Therefore, this study focuses primarily on the logic of macroscopic performance evaluation and the application of evaluation results within the system framework for industrial land optimization and renewal, while simplifying technical processes such as weight calculation as much as possible to better meet the practical needs of district- and county-level redevelopment of stock industrial land.



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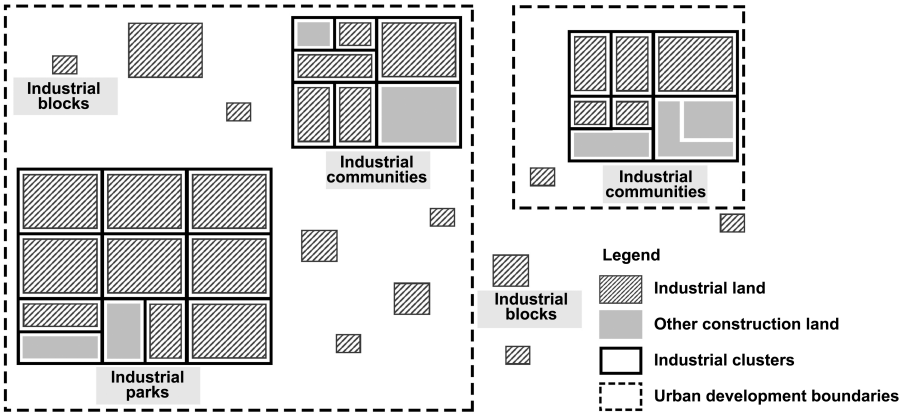

Figure 2 Classification ofndustrial and cale at istrict and ounty evel

3.3 Micro-scale identification of underutilized land use types by enterprises

Identifying and classifyingunderutilized land use by enterprises at the micro scale serves to establish a clear baseline, fully explore the redevelopment potential of the land, and facilitate phased, targeted management of different types of enterprises by relevant authorities. In current planning practice, the estimation of underutilized land use potential often relies directly on specialized survey and assessment data from administrative authorities. However, due to the involvement of multiple stakeholders, the lists of underutilized land submitted by local governments are usually limited in both number and scale. A scientifically sound, rational, and straightforward evaluation indicator system is the foundation for assessing the intensive utilization and high-quality development of industrial enterprises [31]. To avoid inaccuracies in specialized survey results and to enhance the relevance of evaluation outcomes, this study simplifies the composite scoring method used in previous underutilized land identification research into a single-factor integrated evaluation approach.

The identification of industrial enterprisesunderutilizing land ("inefficient enterprises" hereinafter) can be categorized into five fundamental dimensions: green, efficiency, quality, equity, and safety: (1) Industrial enterprises within ecological red-line zones should be gradually withdrawn or replaced. As Environmental Impact Assessments (EIAs) can predict environmental impacts through qualitative and quantitative analysis, enterprises encroaching on ecological red lines or failing to pass EIA acceptance are identified as inefficient enterprises in green dimension; (2) The operational efficiency of industrial enterprises significantly affects their future market expansion, their capacity to provide employment, and the overall development of

local society. Output per unit of land serves as the fundamental metric for assessing how efficiently enterprises utilize resources; (3) The long-term high-quality development of enterprises is largely contingent upon the cultivation and support of local industrial policies. Industrial enterprises outside dominant sectors and with poor management performance, in their efforts to reduce fixed costs, often fail to make intensive and efficient use of land; (4) Tax revenue per unit of land directly reflects the capacity of industrial enterprises to assume social responsibilities and obligations, and also indirectly indicates the equity with which they utilize land resources for production and operation and bear the associated costs; (5) The purpose of a safety evaluation is to identify potential hazards, assess their severity and consequences, and propose effective control measures prior to establishing safety provisions. Accordingly, whether an enterprise has completed and passed the safety evaluation constitutes a key indicator in the safety dimension. Based on individual indicators enterprise data from various industrial parks, a five-layer recursive judgment logic is established to successively screen and classify enterprises into five categories: green-deficient, efficiency-deficient, quality-deficient, equity-deficient, and safety-alert enterprises. These classifications are then matched to corresponding underutilized industrial land (Figure 3). The specific classification criteria and judgment logic for inefficient enterprises can be adjusted according to local conditions and practical needs.

Table 2 Optional indicators for performance evaluation of stock industrial land at district and county level

Criterion	Optional Indicator	Unit	Effects	Importance
Economic Efficiency	Industrial land output value per unit area	CNY10,000/km^2	Positive	+ + + + +
	Industrial land tax revenue per unit area	CNY10,000/km^2	Positive	+ + + + +
	Proportion of above-scale industrial enterprises	%	Positive	+
	Other related indicators	...	...	...
Land Use Intensity	Comprehensive plot ratio of industrial land	%	Positive	+ + + +
	Fixed asset investment per unit area of industrial land	CNY10,000/km^2	Positive	+ + + +
	Idle land rate of industrial land	%	Negative	+ +
	Other related indicators	...	...	...
Accessibility and Suitability for Industry	Employment per unit area of industrial land	Persons/km^2	Positive	+ + + +
	POI density of public service facilities	Numbers per km^2	Positive	+
	Accessibility	-	Positive	+
	Other related indicators	...	...	...
Innovation and collaboration	Proportion of planned strategic emerging industries output	%	Positive	+ + +
	Proportion of high-tech enterprises	%	Positive	+ + +
	Spatial agglomeration of industrial enterprises	-	Positive	+ +
	Other related indicators	...	...	...
Eco-Efficiency	Electricity consumption per unit industrial output	10,000 kWh/10,000 RMB	Negative	+ +
	Water consumption per unit industrial output	10,000 tons/10,000 RMB	Negative	+ +
	Wastewater generated per unit industrial output	10,000 tons/10,000 RMB	Negative	+
	Solid waste generated per unit industrial output	10,000 tons/10,000 RMB	Negative	+
	Other related indicators	...	...	...

3.4 Framework for Industrial Land Optimization and Renewal

The management of industrial parks and industrial land primarily involves the Natural Resources Commission, the Economic and Information Technology Commission, the Development and Reform Commission, and the Commerce Commission. Although each department has distinct regulatory emphases, their authorities overlap. Thus, in the new round of optimization and renewal of stock industrial land, it is necessary to enhance integration and coordination to ensure smooth and controllable decision-making and implementation[32]. Given the shortage of new construction land quotas in many districts and counties, the unsustainability of the previous model of rapidly advancing development and demonstration zones, and the near absence of a policy foundation for stock land renewal, this study adopts a territory-wide perspective to coordinate industrial land layout and calculate renewal costs under multiple scenarios, and constructs a full-process, implementation-oriented framework for industrial land optimization and renewal (Figure 4). The specific pathways are as follows:

(1) Overall performance assessment atthe macro level: Based on data from the Third National Land Survey (the 3rd Survey), appropriate indicators are selected from five criterion dimensions to comprehensively evaluate the utilization performance of industrial land across the entire district or county. By benchmarking against other districts in the same city or the national level to form a macro strategic assessment. Then conduct classified evaluations of industrial land-use intensity across different scales to identify inefficient, wasteful, or poorly planned industrial parks as priority areas for renewal and optimization.

(2) Drawing on enterprise survey data provided by government departments such as the Economic and Information Technology Commission and the Development and Reform Commission, and taking into consideration of regional characteristics and data availability, this study identifiesthe types of inefficient enterprises. Through methods such as POI crawling, the list of inefficient enterprises is spatially matched with industrial park land-use survey data, thereby clarifying the enterprises requiring enhanced supervision or planned withdrawal, and providing direction for efficiency improvement and targeted guidance in subsequent industrial land renewal.

(3) Formulation of land renewal schemes: Based on the results of the macro-level performance assessment and micro-level inefficiency identification, and from the perspective of overall spatial optimization, three fundamental principles are established: maintaining total volume, promoting clustering, and enhancing quality. To develop and improve supporting policy mechanisms for industrial land renewal in a context-specific manner, explore multiple scenario-based renewal schemes, verify them against existing plans and the "three control lines," and complete cost-benefit accounting to evaluate the feasibility of implementation.

4 Design of the implementation mechanism for industrial land optimization and renewal

4.1 Categorized guidance for "three levels and five categories" of industrial land

Based on the three-level scale system of industrial land and the distribution characteristics of the five categories ofunderutilized land, multiple renewal and revitalization approaches are adopted to enhance quality and efficiency. (1) For underutilized industrial land within industrial bases and industrial communities, on-site renewal is prioritized. High-efficiency enterprises should be retained, and the supporting facilities within the parks should be gradually improved through micro-renovations. Emphasis should be placed on strengthening the supervision of approved but unused land and tapping into the potential of stock land indicators. The efficiency targets per unit of land for industrial bases should be higher than those for industrial communities. The transformation of "industry-to-industry" can be combined with "industry-to-commercial" and "industry-to-public" transformations, upgrade from secondary to tertiary industries to facilitate the industrial restructuring and the integration of industry and urban functions. (2) Industrial blocks within industrial clusters should prioritize industrial-to-industrial renewal, phasing out low-end industries while supporting and upgrading advanced ones, so as to promote industrial transformation and upgrading. The strategy is to advance the integration of industrial parks and the relocation of industries in an orderly way, or to abolish certain parks, gradually transferring industries into qualified industrial communities, thereby freeing up construction land quotas. The methods for improving the efficiency of land use by inefficient enterprises in industrial com-

munities are generally the same with those used in industrial communities, but the land-use efficiency targets can be slightly lower. (3) Scattered rural industrial blocks should, in the near term, focus on comprehensive remediation, while in the medium to long term, depending on development needs, they should be adjusted into land reserve and development zones, thereby transforming their land-use function. Rural industrial land that encroaches on ecological protection zones or farmland protection zones must be prioritized for withdrawal, while industrial land in other areas should be gradually phased out in accordance with policy.

Among the five categories of low-efficiency enterprise land: (1) green-deficient enterprises located within permanent ecological protection zones must strictly comply with control requirements. Where rigid control elements cover more than 50% of the total land area, the enterprise land must be reclaimed and restored to green use; (2) for efficiency-deficient enterprises, the main strategy is partial renovation and selective demolition/reconstruction to support expansion and upgrading. Heavy industry enterprises should not simply increase land-use intensity, while light industry enterprises may selectively adopt multi-story industrial building models[33]; (3) for quality-deficient enterprises, guidance should be provided to utilize existing land and facilities or to eliminate outdated capacity to free space for technological upgrading; alternatively, the space may be reallocated to high-tech enterprises or large-scale industrial enterprises, thereby supporting the development of higher-quality firms; (4) for equity-deficient enterprises, emphasis should be placed on encouragement, guidance, and differentiated management. Enterprise classification results are to be applied more deeply, with differentiated urban land-use tax reductions or exemptions implemented according to the level of contribution to local public finance. Projects that significantly enhance tax revenue per unit of land are to be given priority in land allocation; (5) safety-alert enterprises are to be managed by establishing a standardized institutional environment and conducting safety evaluations in strict accordance with national or industry standards. Enterprises with safety risks shall be ordered to rectify or, if necessary, be compelled to exit.

4.2 Economic evaluation of multi-scenario industrial land renewal schemes

The spatial pattern of scattered industry is uneconomical and unsustainable, whereas a specialized and concentrated industrial geography is conducive to regional economic development and to strengthening regional competitiveness[34]. In practice, the single policy goal of "moving industry into parks" is insufficient for guiding the optimization and restructuring of industrial space. Furthermore, highly concentrated spatial patterns are difficult to implement in many districts and counties. Therefore, local governments must acknowledge the partial rationality of existing conditions and seek more realistic optimization strategies. Under the guiding principles of "maintaining total volume, promoting clustering, and enhancing quality", the possible coordinated optimization patterns for district- and county-level industrial land can be divided into three types: "large-scale concentration," "small-scale clustering," and "small clustering with moderate park integration" (Figure 5). Economic costs for each scenario can be calculated based on expected planning-period indicators, and the results can be combined with the local socioeconomic context to select the most appropriate scheme.

This study compares and evaluates the three industrial land renewal schemes to achieve a balance between short-term economic costs and long-term social development benefits. (1) "Large concentration" model: All industrial blocks outside the main industrial clusters are relocated and fully incorporated into industrial bases. This model entails extremely high short-term economic costs for land relocation. Currently, local district and county finances are often insufficient to support it, and issues such as insufficient development incentives for townships and rising unemployment may arise. (2) "Small clustering" model: Scattered rural industrial blocks are integrated by relocating them to nearby industrial bases or industrial communities within their corresponding towns or subdistricts. Multiple small parcels within the same industrial cluster are merged into larger blocks to achieve moderate clustering. This model, based on current conditions, involves only a small scale of land withdrawal and thus entails low economic and social costs. However, as the overall industrial spatial layout remains relatively dispersed, indicators such as output value per unit of land and tax revenue per unit of land are unlikely to meet planning expectations. (3) The "small clustering + moderate park"

scheme involves relocating all small industrial blocks surrounding industrial bases and consolidating them into the base, while vacating certain scattered industrial blocks in towns and rural areas and incorporating them into nearby industrial communities. This model balances the advantages and disadvantages of the previous two schemes. Through a dynamic balance of land relocation and the addition of new land, it simultaneously considers planning feasibility and long-term development benefits, making it the preferred approach for most districts and counties.

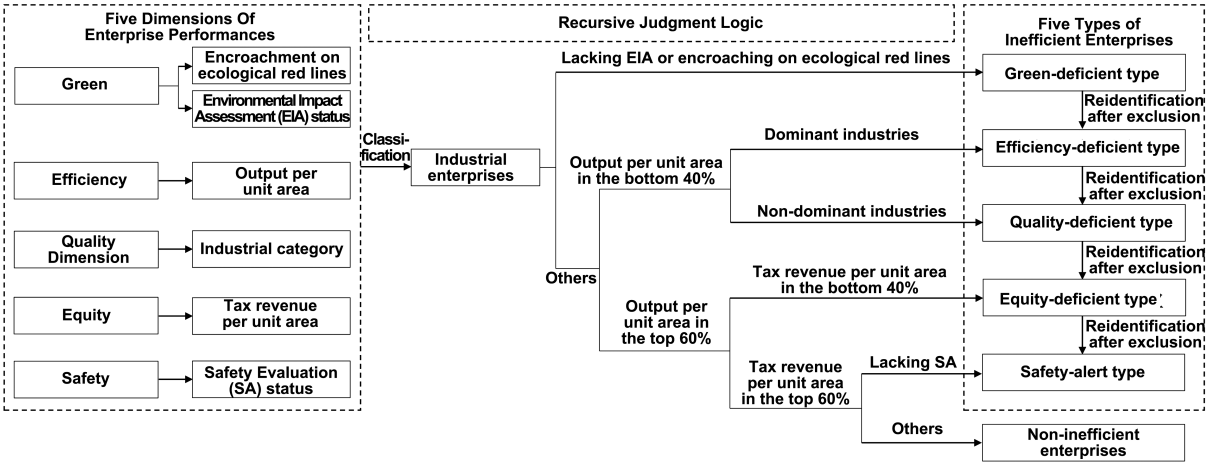

Figure 3 Recursive logic for identifying five categories of inefficient enterprises

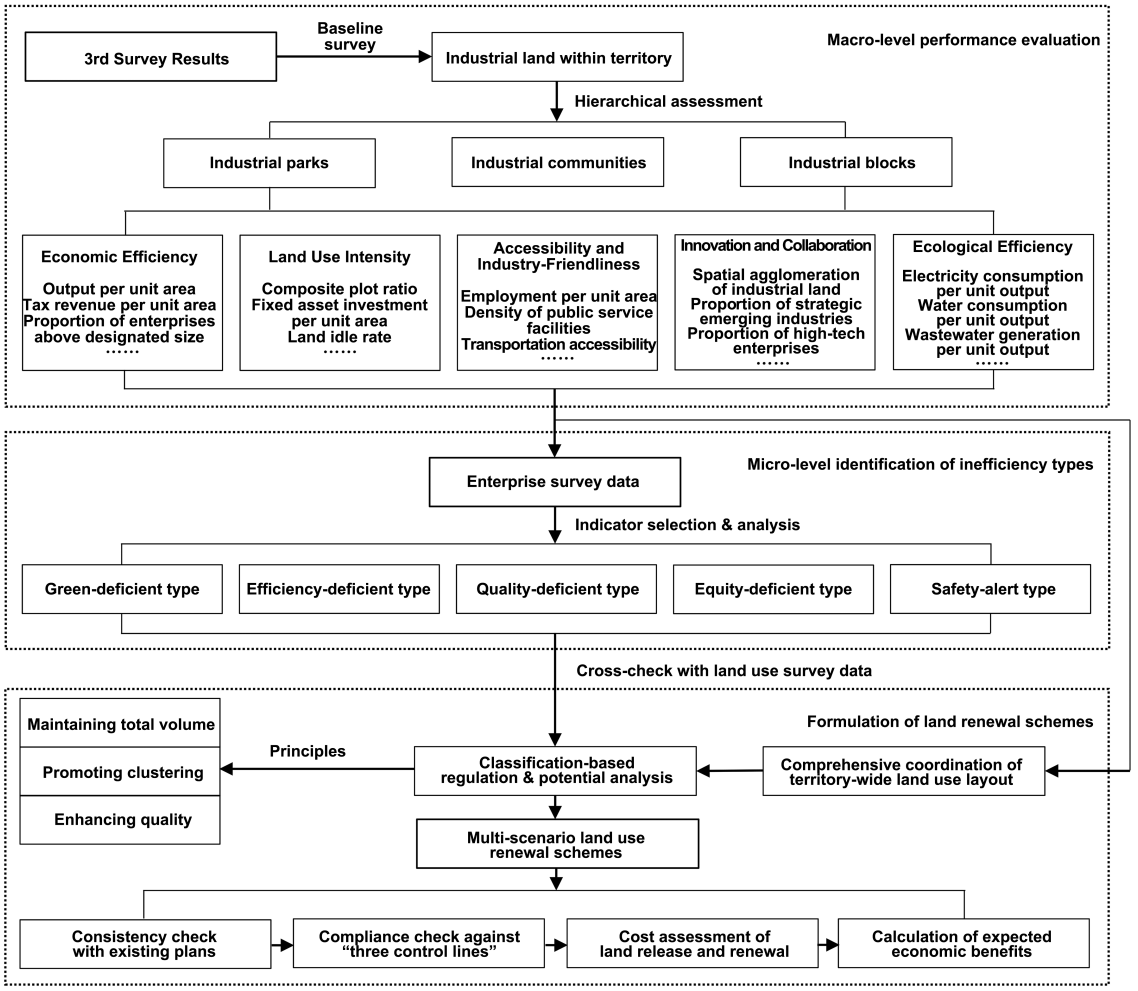

Figure 4 Framework for stock industrial land optimization and renewal in county level

4.3 Full lifecycle management mechanism for industrial land

Pre-supply management stage: The land-use approval process should be optimized, and strict entry thresholds for industrial land enforced. Clauses must be clarified regarding project construction, property self-holding requirements, performance bond supervision, and enterprise default responsibilities, with enterprises required to sign the corresponding performance agreement. The policy pilots flexible-term land transfers, considering market demand and the relatively short life cycle of industrial enterprises. Drawing on advanced regional practices, it sets an initial lease period, with renewal permitted if conditions are met upon expiry. In principle, the land-use term for general industrial projects should not exceed 20 years.

Post-supply supervision stage: A full life-cycle regulatory information platform should be developed, incorporating functions such as land transfer contract management, supervision of project commencement and completion, and evaluation of compliance with indicators like construction progress and achievement of production capacity. Strengthen continuous supervision and whole-process management by conducting annual project evaluations and addressing cases of non-compliance or default. The department responsible for introducing the project takes the lead in supervising whether enterprises fulfill their contractual obligations, and conducts an annual review and evaluation of project performance for the previous year. For projects that violate performance agreement commitments, the project introduction departments and the Natural Resources Bureau shall, according to the nature of the breach, propose measures such as requiring the payment of liquidated damages or reclaiming land-use rights and associated buildings.

Rights exit stage: Based on the results of performance evaluations, diversified methods of land withdrawal should be explored. While enterprise interests are fully considered, differentiated land revitalization policies should be explored, such as government buyback, land replacement or transfer, and transformation with capacity expansion. Enterprises revitalizing existing land stock may, based on project performance evaluation results, be reported to the district/county government, which will collectively decide the proportion of land value increment fees to be collected for capacity expansion. The compulsory withdrawal of project land-use rights shall be strengthened. For projects that fail to meet the performance indicators set forth in the land transfer contract, the transferee's breach of contract liability will be pursued in accordance with the contract, up to and including the recovery of land-use rights.

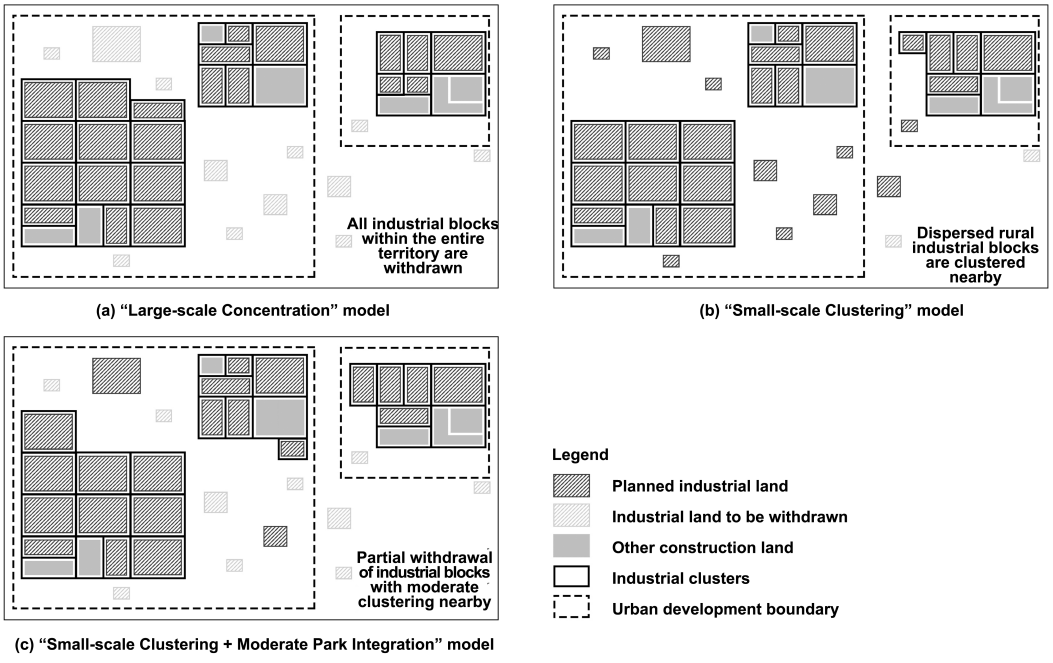

Figure 5 Three patterns for industrial land layout renewal

Conclusion

Revitalizing existing land resources, particularly through the optimization, redevelopment, and efficient utilization ofunderutilized industrial land, is an important means of coordinating and optimizing the national land development-protection pattern, promoting sustainable and high-quality economic development, and constitutes the inevitable choice for transformation in the new era. This study, drawing on local practical experience, expands the understanding of the exploitable potential of stock industrial land in the new era. It proposes an industrial land evaluation index system based on data from the Third National Land Survey and local enterprise surveys, enabling both macro-level performance assessment and micro-level identification of inefficiency characteristics of industrial land at the district and county levels. On this basis, multi-scenario industrial land renewal strategies are proposed, aiming to provide practical and operable references for widespread industrial land renewal at the district and county levels. It should be noted that although this study constructs a full-process system framework for optimizing and redeveloping stock industrial land by integrating macro- and micro-scale analyses, thus avoiding the fragmented limitations of previous studies that focus only on a single aspect or type of underutilized industrial land, there remains a lack of in-depth exploration into the operational mechanisms and dynamic evolution of stock industrial space, particularly the mechanisms generating underutilized land. Moreover, achieving quality enhancement, efficiency improvement, and long-term sustainable development of industrial land requires the integration of interdisciplinary theories and methods from urban and rural planning, economics, management, geography, and sociology, to facilitate the organic coordination of multiple objectives. These aspects need to be further supplemented and refined in future research.

Sources of Figures and Tables

All figures and tables in this paper are prepared by the authors.

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