Identification of Vacant Land in Industrial Parks in Nanjing City and its Governance Strategies

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Abstract: At present, the development of industrial parks in China is undergoing acritical period of transformation. The presence of vacant land is ill aligned with thegoal of high-quality development. Therefore, there is a need to deepen understandingof the spatial characteristics, formation mechanisms, and revitalization strategies forvacant land in industrial parks. This study introduces a methodology and technicalapproach for identifying and evaluating vacant land, which is applied to 15 selectedindustrial parks at or above the provincial level in Nanjing. The research revealsthat vacant land in Nanjing's industrial parks demonstrates characteristics of perfora.tion and dynamic evolution. The management of landscape needs further optimizationBased on these findings, the paper proposes categorized and graded redevelopmentstrategies for vacant land. It advocates for the establishment of a multi-departmentalcollaborative intervention system to create high-quality industrial spaces that can ac-commodate newproduction needs.

Keywords: industrial park;vacant land;identification and evaluation;governancestrategy; Nanjing

China's industrial parks are currently at a critical stage of transformation and development. Due to the previously extensive land development model, the number and scale of idle land within parks have been continuously increasing, resulting in the waste of valuable land resources, which contradicts the goal of high-quality park development. However, such idle land also represents potential resources for future redevelopment. In 2023, the Nanjing Municipal People's Government issued a revised version of the Implementation Plan for Promoting the High-Quality Utilization of Industrial Land. This plan explicitly stipulates that new district-level construction land quotas must be directly linked to the activation of idle and inefficient land, raising the requirements for managing idle land in industrial parks. The urgency and necessity of redeveloping idle land have become increasingly apparent. Guided by this policy, Jiangning District of Nanjing actively carried out comprehensive inspections and evaluations of idle land. Starting in December 2023, the district successively disclosed a total of 48 idle land parcels, demonstrating the government's strong commitment to revitalizing existing land resources. Against this backdrop, effectively identifying and evaluating idle land in industrial parks, as well as conducting in-depth studies on its development characteristics and formation mechanisms, will serve as a critical approach for future park governance. These efforts will contribute to providing high-quality industrial spaces to support the development of new productive forces.

Land vacancy is a significant issue in every country[1]. The concept of idle land encompasses various interpretations. International scholars[2] primarily focus on vacant land and brownfields. Vacant land is broadly defined, including underdeveloped, abandoned developed land, and spaces perceived negatively due to their underutilization. These spaces are often small in size [3], fragmented in shape[4], have indistinct boundaries [5], and are unevenly distributed geographically [6], making their redevelopment particularly challenging. Brownfields, on the other hand,

generally refer to idle industrial land that is often polluted [7], with research emphasizing its market redevelopment value [8]. In China, research on idle land is often linked to spatial efficiency [9]. On one hand, idle land is widely regarded as a type of inefficient land use [10] and can be identified using models and methods designed for low-efficiency land [11]. Through the redevelopment of industrial parks, the continuous optimization of land utilization efficiency can be achieved [12–14]. On the other hand, idle land in China's industrial parks exhibits a certain degree of complexity and distinct characteristics [15–16]. These include features such as premature development and the coexistence of overall growth with localized contraction [17–18], making it a transitional phenomenon driven by proactive government intervention during periods of transformation [19–20].

Overall, research on idle land at home and abroad has distinct focuses. International studies mainly address vacant land and brownfields, while domestic studies concentrate on inefficient land use, with limited specialized research on "vacant-type" inefficient land. Additionally, existing studies on idle land largely remain at the level of phenomenon identification, lacking in-depth exploration and comprehensive evaluation. Insufficient attention has been given to the development characteristics of idle land in China's industrial parks, and its underlying mechanisms require further investigation. Therefore, constructing a rational system of identification and evaluation methods for idle land, along with technical approaches, and selecting empirical case studies to analyze land characteristics and optimization strategies, holds significant theoretical and practical value. This can help promote the optimal allocation of land resources, improve land utilization efficiency, and drive high-quality development of industrial parks.

1 Causes and Identification Methods of Idle Land

1.1 Classification and Formation Mechanism of Idle Land

The emergence of idle land is a result of the combined influence of governments, enterprises, and markets during specific stages of development. From the perspective of land types, idle land in industrial parks can be categorized into two main types： Undeveloped Construction Land: This refers to "approved but not built" land, including officially designated idle land and halted construction or production sites not yet recognized as idle land. However, "approved but not allocated" land does not fall within this category. Such land is considered unused idle land, typically caused by excessive land supply or improper development practices. Abandoned Idle Land: Also known as abandoned industrial land, this refers to land and its facilities that have been idle for over a year due to production suspension, leaving them in a state of abandonment or semi-abandonment①. The causes of such idle land are more complex, often linked to enterprise relocation, bankruptcy, or industrial obsolescence. To some extent, abandoned idle land is a byproduct of industrial parks eliminating outdated capacities and pursuing industrial transformation and upgrading.

From the perspective of temporal and spatial evolution, the development of idle land is closely tied to the lifecycle of enterprises and industrial parks [21]. The land-use behaviors of individual enterprises dictate the formation and evolution of idle land at the plot scale. In the early stages

of enterprise expansion, land is often developed incrementally, gradually utilizing previously idle land. During the decline phase, enterprises exit, leaving behind abandoned idle land. Similarly, the lifecycle of industrial parks also influences the dynamics of idle land. Changes in land use by enterprises at scale determine the evolution of idle land at the park level. Throughout different development phases—framework development, infill development, and contraction—land shortages and idle land alternately occur, influencing each other. This process is shaped by the economic efficiency of individual plots, while the overall efficiency of an area significantly determines the extent of idle land in the park. Additionally, factors such as location conditions, planning policies, park types, and leading industries affect the formation and evolution of idle land, with varying mechanisms leading to both commonalities and differences in idle land characteristics across parks.

1.2 Construction of Identification and Evaluation Methods for Idle Land

To analyze the characteristics of idle land in industrial parks, a systematic method for identifying and evaluating idle land needs to be established, comprising two main steps: identification and evaluation. The technical process is shown in Figure 1. In the identification phase, the process involves determining identification criteria, selecting methods, establishing databases, and refining and validating results [22]. This can be simplified into four steps: data processing, basic identification, first-round correction, and second-round correction. First, satellite imagery is clipped and processed to determine idle land identification standards based on factors such as land scale and spatial characteristics. Second, by referencing mainstream identification methods in academic research [23-24] and considering study scope, precision requirements, and data availability, visual interpretation of satellite imagery is adopted for basic identification. The results are then recorded in an idle land database, creating a spatial vector database and corresponding attribute table. Subsequently, a multi-source data calibration method is used for first and second-round corrections, ultimately generating refined identification results for idle land.

Based on the identification results, this study develops an evaluation index system to assess the spatial characteristics of idle land. Drawing from spatial analysis and landscape pattern analysis methods, indicators such as idle land rate, proportion of abandoned idle land, landscape shape index (LSI), mean patch size (MPS), and patch density (PD) are selected. ArcGIS is used as a technical tool to evaluate idle land, summarizing its spatial development characteristics across different dimensions. Furthermore, by incorporating time-series data and land-use efficiency evaluations, the study comprehensively analyzes the development characteristics and evolutionary mechanisms of idle land.

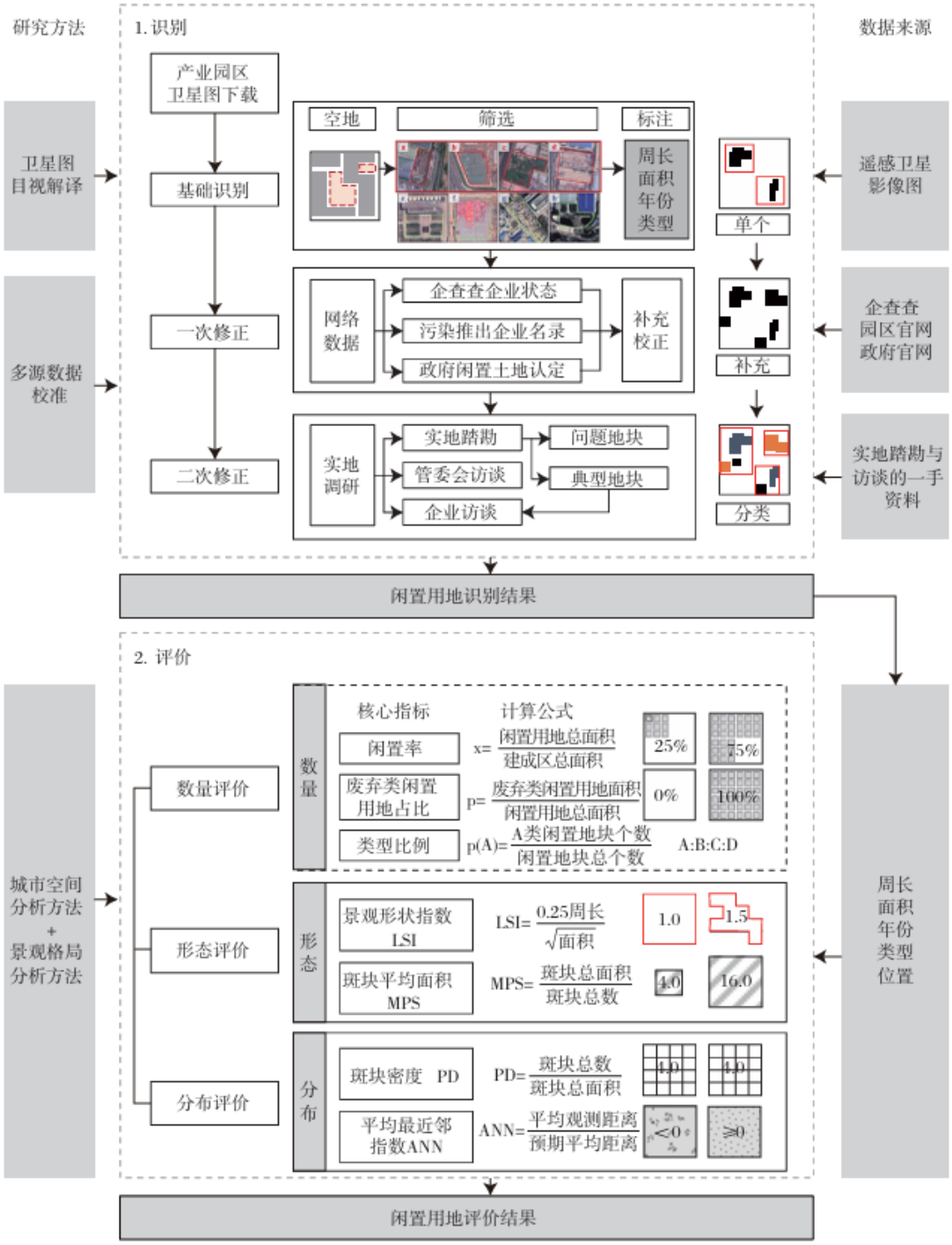

Fig.1 Technical pathway for identifying and evaluating vacant land of industrial parks

2 Identification and Evaluation of Idle Land in Nanjing Industrial Parks

2.1 Case Selection and Study Scope

As a vital spatial carrier for advanced manufacturing and new productive forces, Nanjing's industrial parks started development relatively early and exhibit a high level of quality, making them representative case studies. Additionally, as a leading economic region along China's eastern coast, Nanjing's industrial parks are at the forefront of facing challenges related to land idleness and transformation. Therefore, studying idle land in Nanjing's industrial parks provides

insights into the characteristics, complexities, and uniqueness of China's economic development. The governance experiences derived from this study may also serve as valuable references for the development of other industrial parks. To ensure consistency in statistical standards and similarity in development contexts, this study selects two representative types of industrial parks in Nanjing as the primary research subjects: Economic and Technological Development Zones (ETDZs) and High-Tech Industrial Development Zones (HTIDZs), comprising a total of 15 parks (Table 1). These include 2 national-level ETDZs, 1 national-level HTIDZ, 8 provincial-level ETDZs, and 4 provincial-level HTIDZs.

Tab.1 Case selection of industrial parks at or above the provincial level in Nanjing

类型	园区名称
国家级经济技术产业开发区	南京经济技术开发区、江宁经济技术开发区
国家级高新技术产业开发区	南京高新技术产业开发区
省级经济技术开发区	江苏南京生态科技岛经济开发区、南京浦口经济开发区、南京雨花经济开发区、南京江宁滨江经济开发区、南京化学工业园区、南京六合经济开发区、江苏溧水经济开发区、江苏高淳经济开发区
省级高新技术产业开发区	南京徐庄高新技术产业开发区、南京白下高新技术产业园区、南京白马农业高新技术产业开发区、江苏省高淳高新技术产业开发区

Data sources: the Department of Commerce of Jiangsu Province, China Development Zone Audit and Announcement Catalog (2018 Edition), and the official website of the People's Government of Jiangsu Province

It is found that the actual built-up area of most industrial parks is much smaller than their planned area and control area. In order to improve the accuracy and comparability of the evaluation of idle land in the parks, this study further restricts the scope of the study to the contiguous built-up area within the planning area of industrial parks2 , rather than the administrative boundary or planning scope, and excludes a large area outside the built-up area that is "granted but not built". The study further limits the scope of the study to the contiguous built-up area within the industrial park planning area ② instead of the administrative boundary or planning scope, and excludes the large "undeveloped" land outside the built-up area. By visual interpretation of satellite maps, areas with more than 100 hm^2 of developed land are identified as built-up areas, and discrete sites within 100 m of the edge of the built-up area are also included in the study, taking into account the enclave and fragmentation of some built-up land.

2.2 Identification Criteria and Steps

Taking into account the methodology system for identifying and evaluating unused land established above, and considering the actual situation of Nanjing, the systematic identification of unused land in the park will be carried out according to the two steps of basic identification and multi-source data calibration.

2.2.1 Identification Criteria and Basic Identification

Considering the identification accuracy of idle land in the existing studies and the average size of industrial enterprises in Nanjing, this study combines fieldwork to determine a set of standard

thresholds (Table 2), i.e., the identification accuracy is greater than or equal to 1hm² , the duration of idleness is over 6 months, and summarizes 8 common types of vacant land (Fig. 2), of which the cases that can be identified as idle land include: (a) bare soil without vegetation cover; (b) idle land covered by green film; (c) idle land covered by green film; (d) idle land covered by green film; (e) unused land covered by green film; (f) idle land covered by green film. (a) bare land without vegetation cover; (b) unused land covered by green film; (c) barren plots with overgrown grass; and (d) abandoned hardened land where garbage and other debris are piled up. Situations that cannot be considered as idle land include: (e) planned landscaped green space; (f) sites under construction and quasi-construction sites; (g) parking lots and large equipment storage yards; and (h) forested land, lakes, or farmland. Based on the above type criteria, this study classifies the identified unused sites into four categories: bare soil and bare land, green film-covered land, overgrown land, and abandoned hardened land. The determination of idle land is centered on whether the land use status is idle or not, rather than whether the land parcel has been built or what level of building density has been reached.

维度	具体标准	识别方法	数据来源
规模标准	大于等于 1 hm^2	基于目视解译的基础测量	Google Earth 历史影像
时间标准	闲置状态满 6 个月	基于目视解译的跟踪研究	
功能标准	见图 2	基于目视解译的标准比对、实地调研	

Tab.2 Criteria for identifying vacant land based on visual interpretation of satellite images

Fig.2 Standard legends for identifying vacant land

In order to facilitate the subsequent analysis and unified management of unused land, the data of identified unused land are entered into the database and labeled with information such as their precise location, perimeter, area, type and year of identification. Meanwhile, special land parcels that are difficult to identify, have fuzzy boundaries or disputed types are marked for subsequent calibration of multi-source data.

2.2.2 Multi-source data calibration

The calibration process consists of two rounds: the first round is to verify the business status of enterprises whose registered addresses are located in industrial parks according to the enterprise filing data on websites such as “Enterprise Cha Cha”, with the purpose of supplementing the abandoned idle land that cannot be identified by visual interpretation of satellite maps; the second round of correction is to confirm the disputed parcels through field surveys and multi-party validation, with the specific methods including enterprise interviews, management committee interviews, etc. The purpose is to make comprehensive judgments on special parcels such as blurred boundaries and disputed types marked in the identification. The second round of amendment is mainly to confirm the disputed land parcels through field survey and multi-party verification, the specific methods include enterprise interview, management committee interview, etc. The purpose is to make comprehensive judgment on the special land parcels marked in the identification, such as blurred boundaries and disputed types. The above two rounds of correction can not only supplement and correct the identification results of visual interpretation, but also summarize and judge the core problems and development needs of unused land from the perspective of enterprises through field visits to the park.

2.3 Recognition and Evaluation Results

Taking December 2022 as the time point, this study identifies and evaluates in detail about 200 km^2 of built-up land in 15 provincial-level and above industrial parks in Nanjing. The results show that a total of 379 idle sites were identified, and the overall idle rate of built-up areas in industrial parks reached 13.42%. Among them, the abandoned type of idle land accounted for the highest proportion, which was 18.27%. Further analysis, the proportion of 4 types of idle land such as bare soil and bare land, green film covered land, overgrown land and abandoned hardened land is 27:18:47:8 From the point of view of the shape of the land:the average area of the patches of idle land is 7.37 hm^2, but 48% of the area of the idle plots is less than 4 hm^2, which contains the edge of the area of the smaller corners of the land, the sandwich land; the average value of the landscape shape index is 1.14, which indicating that the boundary irregular shape of idle plots is more complex and characterized by fragmentation; the average patch density is 1.85, reflecting the trend of discrete distribution of idle land as a whole.

Specifically, the spatial distribution of abandoned land in 15 provincial-level and above industrial parks is shown in Figure 3 As of December 2022, the idle rate of each park ranges from 4.86% to 28.73%. There is a large difference in the proportion of abandoned idle land in different parks, which is closely related to the age of establishment and development stage of the parks. The average area of the patches of idle land within each park ranged from 2.25hm^2-15.71hm^2, of which the average area of idle plots in Nanjing Chemical Industry Park was nearly eight times that of Nanjing Eco-technology Island Economic and Technological Development Zone. The evaluation results of landscape shape index and patch density show that the degree of fragmentation of idle land in different parks is different, which directly affects the difficulty of their respective remediation. Finally, at the park level, unused land is generally characterized by discrete or random distribution, yet there are localized clustering phenomena within specific zones within the park.

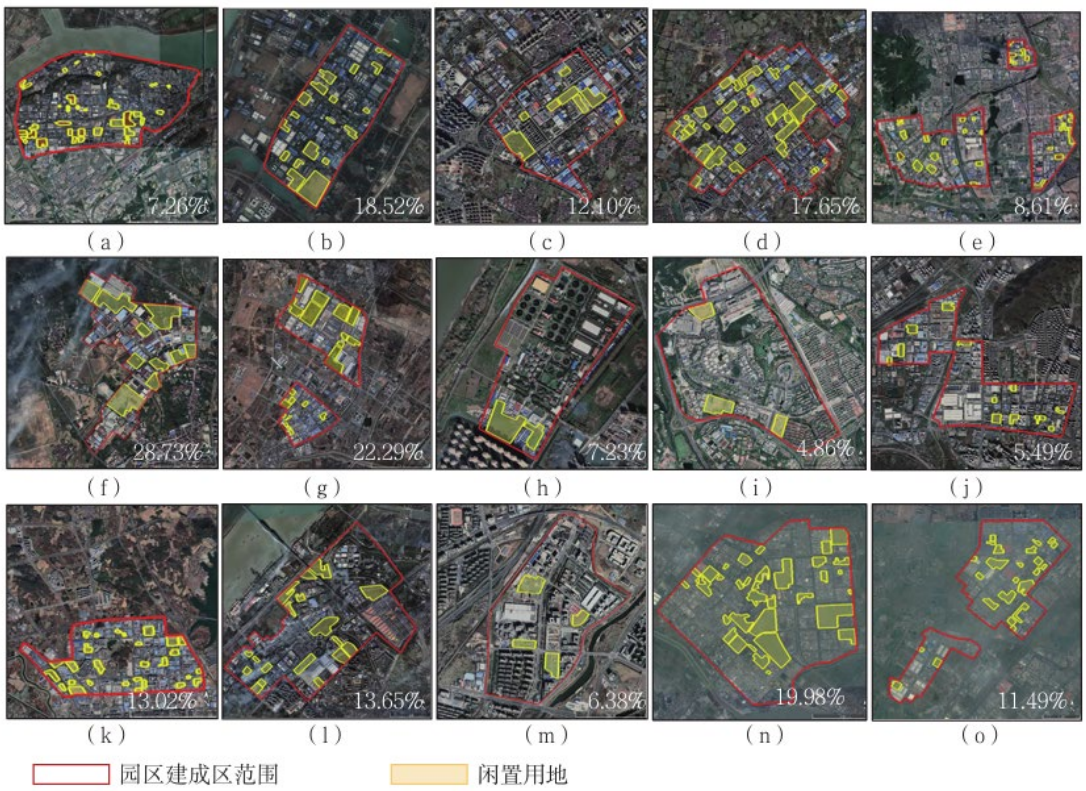

Fig.3 Identified vacant land in 15 industrial parks in Nanjing (December 2022)

Note: a. Nanjing Economic Development Zone, b. Binjiang Development Zone, c. Gaochun High-tech Zone, d. Gaochun Economic Development Zone, e. Jiangning Economic Development Zone, f Baima Agricultural Park, g. Pukou Economic Development Zone, h. Ecological Science and Technology Island Economic Development Zone, i. Xuzhuang High-tech Zone, j. Nanjing High-tech Zone, k. Lishui Economic Development Zone, l. Yuhua Economic Development Zone, m. Baiche High-tech Zone, n. Nanjing Chemical Industry Park, o. Liuha Economic Development Zone

3 Characterization of idle land in Nanjing industrial parks

According to the evaluation results of the unused land in industrial parks in Nanjing, we analyze its spatial distribution characteristics and development and evolution laws from both spatial and temporal dimensions, study the impact of unused land parcels on the benefits of the area from the perspective of the land parcels, and analyze the typical parcels in combination with the actual development status of the parks, and finally summarize the current status of the wind and landscape management of the unused land parcels and the current situation problems.

3.1 Spatial distribution: cellularization

“Honeycombing” refers to the spatial phenomenon that unused land units are embedded in the urban land texture like a ‘honeycomb’ [9,25], which is the most intuitive feature of the spatial distribution of unused land in industrial parks. Specifically, honeycombing has different manifestations at different scales. At the urban scale, the degree of idle land in different industrial parks is different, and the idle rate of the parks shows the distribution state of “circling”; at the park scale, the distribution of idle plots has a posterior agglomeration, and is mostly concentrated in the fringe areas of the parks and the posterior areas; at the parcel scale, the idle

land is often found in the interior of the large parcels, which results in the “holeization” of the utilization of the parcels. This has resulted in the utilization of land parcels being “porous” and “hollowed out”.

From the urban scale, the degree of idleness of industrial parks in different locations varies, and the overall distribution of industrial parks shows the characteristic of “circling”, which is manifested in the fact that the closer the parks are to the city center, the lower the idleness rate and the higher the land use efficiency, while the parks in the edge of the city have a high idleness rate and a low land use efficiency. It can be roughly divided into three circles (Figure 4): the idle rate of the parks in the first circle, i.e. the center circle, is less than 10%, the idle rate of the parks in the second circle is about 10%-15%, and the parks with an idle rate of more than 15% are distributed in the third circle. This “stratified” distribution based on the location difference is basically consistent with the development intensity of urban construction land, and is also influenced by the life cycle of parks and park policies. The distribution of unused land in different circles shows an obvious difference of “center and periphery”. The results show that the average size of idle land patches in industrial parks in the center of the city is small and fragmented, while the average size of idle land patches far away from the center is large and regular.

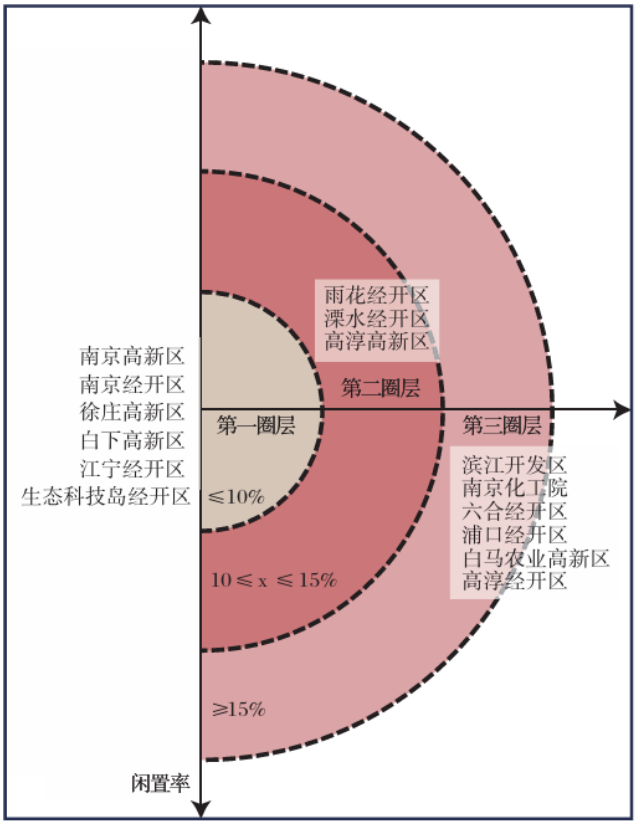

Fig.4 Circles of vacancy rates

Within the parks, the distribution of unused land has a post-aggregation nature. A high proportion of unutilized idle land often appears in the second phase development area of industrial parks, which is closely related to the development stage of the park. Take Nanjing Economic Development Zone as an example: the northeast cluster represented by Sinopec Jinling Branch has a higher degree of development maturity, higher land use efficiency and lower idle

rate; the northwest cluster of Xingang High-tech Park has a lower idle rate due to the concentration of technology companies and electrical manufacturing enterprises; and the idle land in the zone is concentrated in the late development area south of the railroad.

At the parcel level, idle land in industrial parks has the typical characteristic of “cellularization”, i.e., it appears within larger parcels and tends to be distributed far away from roads. This is complementary to the development sequence of industrial enterprises, because enterprises usually prioritize the development and construction on the side of the road [26], i.e., “close to the edge of the use”, which leads to the formation of idle land in the space abandoned by enterprises within the parcel, resulting in the “cellularization” and “sandwiching” of the parcel utilization. This has resulted in the “honeycombization” and “sandwichization” of land use. Similarly, in Nanjing Chemical Industry Park, unused land in larger parcels appears and gathers, showing a continuous trend; if the accessibility of the parcels is improved through the optimization of the road network in the future, this kind of “honeycomb” land will be in a position to carry out secondary development.

3.2 Spatio-temporal Evolution: Dynamic Changes and Mutual Transformation

Idle land is not an inherent property of land, and all land in the industrial park may become idle temporarily for some reasons, which indicates that idle land has a certain degree of dynamic change (Figure 5). Meanwhile, the idle time can be long or short, the earliest redevelopment can be achieved in 1-2 years, or the idle time can last for decades; and it is the dynamic evolution of idle land that drives the continuous updating and optimization of the land in industrial parks.

Fig.5 Evolution of the abandoned vacant land

Idle land is divided into two main categories: unutilized and abandoned, with the former

indicating that the site has been in an undeveloped stage and the latter indicating that the site has been developed but is currently idle. There is a significant difference in the proportion of idle land in the abandoned category in each zone. From an overall point of view, the average proportion of abandoned land in Hi-tech Zone is 45%, which is significantly higher than the average level of 15% in Jingkai Zone, indicating that the industrial land in Hi-tech Zone has a higher turnover rate, and is more active in land turnover and redevelopment. Specifically, the development stage of different zones is different, for example: Xuzhuang Hi-Tech Zone's abandoned idle land accounted for as high as 100%, all idle land are developed but abandoned type; Nanjing Economic and Technological Development Zone's abandoned idle land accounted for 52%. In contrast, all idle sites in Nanjing Eco-Tech Island and Pukou Economic and Development Zone are of the unutilized type, mainly because these zones are still in the early stage of development and have abundant land reserves, even if some of the land has not yet been converted from non-construction land.

3.3 Benefits of Land Use: Lowering the Average Benefits of Sites

From the perspective of economic benefits, idle land is a land unit with blank benefits, and its cellular distribution in the park space affects the overall benefits of the area. In practice, the land benefits are mostly counted and calculated on the basis of parcels of land as a unit. In practice, the land use benefits are calculated on the basis of the land parcel. The land parcel is an independent land parcel closed by the ownership boundaries, so the boundaries of the idle land parcel do not exactly correspond to the boundaries of the land parcel. In addition to the overall idleness of parcels of land, there are also some idle sites within some parcels of land, which lowers the unit output efficiency of the parcels of land.

Taking a development zone in Nanjing as an example, the characteristics of idle land are revisited from the perspective of parcel efficiency. As of 2022, the current built-up area of this development zone is 13.38 km², of which 2.37 km² is idle industrial land, with an idle rate of 18.52%, which is a high degree of idleness among all development zones above the provincial level in Nanjing. On this basis, the efficiency of the current status quo land is comprehensively evaluated by two indicators, namely, enterprise output value per mu and tax revenue per mu, and the results are categorized into five grades from high to low (Fig. 6). Two characteristics are found: first, 44% of the idle land parcels in the park are distributed within the parcels, indicating that partial idleness of parcels is a common situation. The land use efficiency of such parcels shows two very different directions. On the one hand, when the proportion of idle land reaches a certain level, the overall efficiency of the parcel will be affected, showing inefficient utilization in the efficiency evaluation; on the other hand, within the parcels with higher efficiency, there are also some idle land as future reserve land. Secondly, the idle situation of the whole block of land mainly includes two types, namely, discontinued production and abandonment and approved but not yet constructed. These types of land generally lack tax data, but their ownership relationship is clear, which provides relatively mature conditions for future redevelopment. Further in-depth analysis of the tenure status of the land reveals that only 2% of the idle land is under lease, and only 1.8% of the total 2.62km² of leased land in the park is idle, which indicates that industrial land under lease is generally more intensively utilized and less prone to idleness.

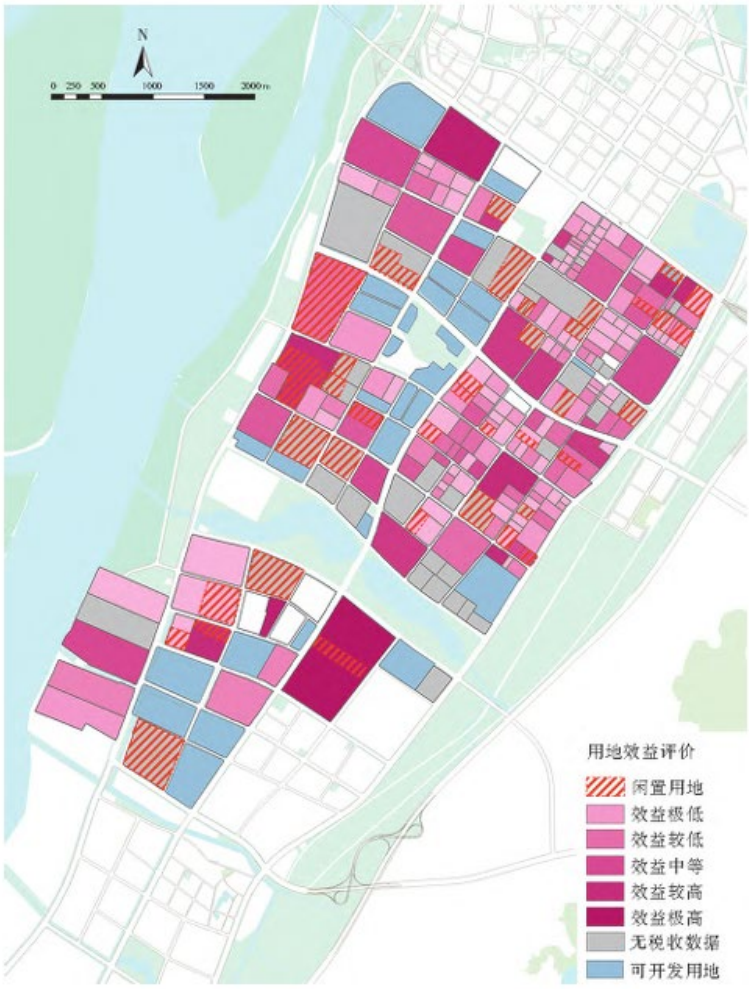

Fig.6 Evaluation of the status and benefit of vacant land in a development zone

3.4 Landscape management: to be improved

In the process of identifying idle land, based on its functional use and landscape status, idle land is categorized into 4 types. The first type of bare soil bare land accounts for about 27.24% of the total type, these lands are idle for a relatively short period of time or have been leveled but not started construction. The second category of green film covered land accounted for about 17.93% of the total type, these sites had been identified and largely managed by covering the surface with a protective film to prevent sand and dust from polluting the urban air environment. The third category of weed-infested land is the most common type of unused land, accounting for 46.55%, which is usually unused for a long period of time and lacks management. The fourth type of abandoned hardened land accounts for only 8.28%, mainly found in utilized but abandoned sites, often accompanied by problems such as debris piling up, dilapidated buildings and even land pollution, and some of them are occupied by neighboring enterprises or managed on behalf of them, with a poor appearance.

Industrial parks in different circles show significant differences in the type of idle land (Table 3). In the first circle immediately adjacent to the urban core, the proportion of green film-covered land is more than half, which indicates that the urban center area has stricter management of the landscape of unused land to reduce the potential impact on the urban landscape; as the distance

from the urban center gets further and further away, the proportion of bare soil and overgrown land gradually increases, especially in the third circle of the park, where overgrown type of unused land accounts for as much as 64% of the total land area, and becomes the region's idle land main type. Meanwhile, the proportion of abandoned hardened land is the highest in the second circle of the city, which has a certain negative impact on the landscape image of the urban fringe area. The differences in the types of idle land in the parks are closely related to the supervision of the parks. According to the regulations of relevant government departments, long-term idle and exposed sites in industrial parks should be covered and maintained by the property rights unit or park management department responsible for laying dust prevention nets or greening. However, in practice, there are differences in the management efforts and approaches of the parks, and some parks lack attention to the supervision of idle sites, resulting in the overall appearance of the parks to be improved. Up to now, Nanjing has not issued any specific management for the management of vacant land and wind appearance control in industrial parks.

圈层	裸土裸地 / %	绿膜覆盖地 / %	杂草丛生地 / %	废弃硬化地 / %
第一圈层平均值	20	54	21	5
第二圈层平均值	23	17	48	12
第三圈层平均值	24	10	64	2

Tab.3 Proportion of vacant land types in different circles

4 Nanjing industrial park idle land governance strategy

In recent years, Nanjing has made remarkable achievements in improving the quality and efficiency of land, but due to historical reasons, there is still a certain scale and number of idle land in industrial parks, which affects the overall efficiency of the land and urgently needs more scientific governance. At this stage, the development of new productivity for industrial space has brought new needs and new opportunities for the revitalization of idle land based on this, this paper puts forward the following two governance strategies.

4.1 Classification and grading to guide the redevelopment of idle land

Unlike incremental planning, the redevelopment of idle land is a complex process, which needs to take into account multiple factors such as land efficiency, property rights, and land types, etc. Therefore, it is necessary to guide the redevelopment of idle land by classification and categorization, which includes determining the focus of governance in the park in a hierarchical manner, and determining the disposal plan of idle land in a categorized manner, and finally guiding the spatial optimization by phases.

First of all, it is necessary to determine the focus of future governance work based on the park's overall development performance and transformation trend, and to grasp the idea of overall disposal of idle land. For industrial parks with high overall development performance, there will be a large demand for land supply in a certain period of time in the future, so the focus should be on land preparation, accelerating the vacating of idle land, and expanding new space for the future industrial development of the park. For industrial parks with low development performance in general, it is presumed that their future low utility land will continue to increase

and be transformed into idle land, so such parks should carry out preventive management of idle land based on the principle of smart contraction. Specifically, firstly, the scale of new idle land should be strictly monitored and linked to the new land supply of the park to ensure that the amount of new construction land in the park each year shall not exceed the amount of new idle land, so as to guide the future industrial land to cluster inward rather than expanding outward. Secondly, a reasonable cordon line for the idle rate should be drawn, so as to guard against the decline of the overall efficiency of the park caused by an excessive amount of idle land.

On the basis of determining the overall development idea of the park, the property rights relationship should be rationalized, and specific idle land should be disposed of in categories to guide the continuous optimization of its spatial use. The main strategy is to consider the type of unused land and property right status, establish a classification and disposal matrix (Table 4), and determine the spatial disposal program for different categories of unused land in combination with the actual situation (Figure 7). For unutilized unused land with single property rights, land preparation should be prioritized, and the government should set compensation standards and recover the state-owned land use rights, especially for larger or adjacent land parcels, which can be used as reserved land for the introduction of major projects in the future. For the unused land with multiple property rights, the government can encourage property rights consolidation and continuous development through neighborhood integration, which will provide the possibility of in-situ expansion of the developing enterprises; or through road division, which will guide the division and utilization of each property rights. For abandoned idle land, enterprises can be encouraged to rent out the whole or part of the idle land; at the same time, land preparation can also be considered for larger land parcels with clear property rights. For abandoned idle land with multiple property rights, the government should encourage enterprises to integrate property rights on their own, allow some temporary uses, and encourage enterprises to jointly build public green areas and public service facilities, and compensate for the plot ratio according to the actual situation.

Tab.4 Categorized strategy matrix for vacant land

分类	未利用类闲置用地	废弃类闲置用地
单产权	土地整备(政府优先回收)	鼓励出租或部分出租
多产权	鼓励邻里整合； 或分割利用	允许部分临时性用途； 鼓励公共绿地和公共服务设施建设

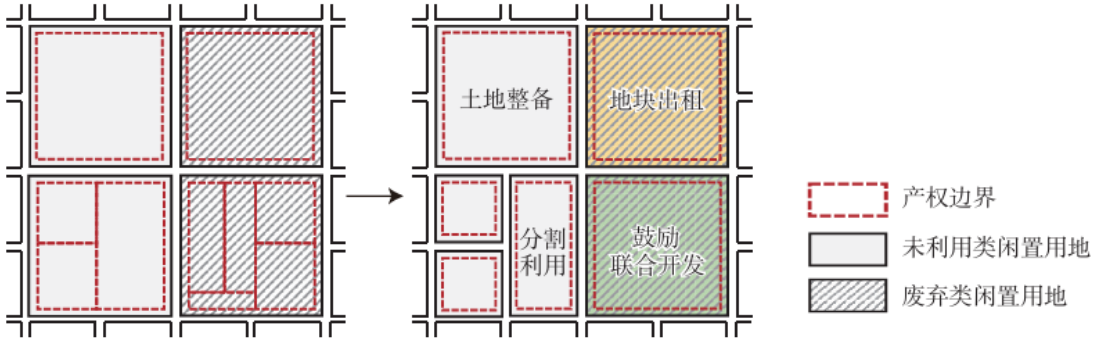

Fig.7 Schematic diagram for optimizing vacant land use

On the basis of categorized disposal, the short-term and long-term values of idle land should be weighed comprehensively, and new functions should be introduced in phases. In the first stage, transitional and temporary functions should be introduced, such as allowing neighboring enterprises to temporarily use idle land as storage, parking and other facilities, or as supplementary support for the leading industries in the park. In the second stage, it is recommended that a professional third-party agency be brought in or a specialized agency be set up in the park to be responsible for land remediation, pollution control and value assessment. This includes carrying out the necessary leveling work on the land, assessing the quality and utilization value of the buildings on the ground, demolishing the buildings with low utilization value, and accurately assessing the market value of the land in order to clarify its market positioning. In the third stage, local governments and park management organizations should set up information platforms to accurately match potential new owners, so as to help unused land to be put on the market smoothly. In particular, for idle land plots with utilizable factory buildings, the platform can assist in matching the use of the land, so as to realize the smooth “inheritance” of the house. The above three phases of the strategy are interlinked, aiming to maximize the utilization efficiency of idle land and minimize the idle time of the land.

4.2 Establishing a multi-sectoral synergistic intervention system

Policy tools play an important role in the renewal of industrial land, but also have a significant impact on the whole process of the formation, development and disposal of idle land.2021 Since 2021, Nanjing has issued documents such as the Implementation Plan on Promoting the High-Quality Utilization of Industrial Land, Measures for the Management of Protective Lines of Industrial Land, Innovative Plans for the Guarantee of Spatial Elements, and a Number of Supporting Policies, and other documents on the intensive utilization of industrial land. to provide guidance. However, the synergy between the current policies and plans needs to be strengthened, failing to form an effective synergy, and the existing policies are mostly focused on a single area such as land supply, lacking a systematic spatial implementation path.

In order to optimize the effectiveness of the management of idle land, it is recommended to build a multi-sectoral synergistic intervention system. First, a working group on the redevelopment of unused land should be set up, with the participation of the planning and resources departments, the industry and information departments and the park management committees, etc., to collect and share data from the industrial enterprise census and the industrial land census on a regular basis, and to conduct continuous monitoring and assessment of unused land, so as to formulate and adjust planning strategies in a timely manner. In addition to sectoral synergies, synergies between spatial planning policies and policies of other sectors should be strengthened. Idle land redevelopment planning should transform practical experience into spatial guiding policies in a timely manner, and form a synergy with land use policy management policies, etc., so that the package of policies can play an overall role in the transfer of ownership, use control and spatial utilization of idle land. For example, in view of the fact that leased land is not easy to become idle, promote the relevant departments to jointly introduce policies to encourage the leasing of idle land, and provide targeted leasing incentive programs for different types of idle land from the perspective of spatial optimization. Secondly, it is also necessary to play a synergistic role in the spatial benefit distribution mechanism for multiple

subjects such as enterprises, parks and governments. The first is to respect the market choice, and incremental planning is different, land redevelopment is to a certain extent the market's initiative behavior, so we must comprehensively consider the development conditions of the land, to improve the efficiency as the goal of promoting the redevelopment of unused land. Second, pay attention to enterprise demand to activate the core of idle land is to tap demand, and enterprise participation is to express demand, the government of different enterprises to match the different needs, integration of enterprise common demand and put forward the solution to maximize the benefits of the final summary of the experience into a relevant policy to promote the third is to strengthen the supervision and management mechanism of the park, it is recommended that through the increase in the collection of land unused management fees, plant unused management fee, in conjunction with the It is recommended to optimize the park's land style and enhance social benefits by increasing the land idle management fee and factory building idle management fee, and formulating detailed functional, environmental and landscape management regulations, etc. to strengthen the supervision of idle land.

5 Conclusion and discussion

Idle land of a certain scale is an inevitable phenomenon accompanying land development. On the basis of existing research, this paper innovatively constructs the identification criteria and evaluation system of idle land in industrial parks, and selects 15 industrial parks above provincial level in Nanjing as empirical cases for evaluation, and finds that their idle land has the characteristics of cellularization in spatial distribution, and cellularization has different manifestations in different scales such as cities, parks and parcels, etc.; in terms of the time dimension, idle land has the characteristics of dynamic change and can be transformed into each other under certain conditions. From the time dimension, unused land has dynamic changes and can be transformed into each other under certain conditions. The formation and development mechanisms of different types of unused land are different, and the existence of some unused land lowers the overall efficiency of the parcel and the area where it is located. At the same time, in order to maintain the overall appearance of the park, the unused land in the park needs more effective and systematic management and supervision.

For Nanjing, which has entered the stage of high-quality development, although incremental expansion is no longer dominant, the city will not experience significant functional decline or structural contraction in the short term either [27]; therefore, the idle land in Nanjing's industrial parks is both a staged phenomenon caused by the mismatch between supply and demand in the process of transitioning from rough to intensive, and a reflection of the local government's proactive approach in the process of optimizing spatial layout and industrial structure Regulation. On the one hand, the generation of idle land is the result of natural selection under the market mechanism, and the land with low efficiency is gradually eliminated, and the constantly released idle land provides new development space and industrial upgrading opportunities for the park, while the park land also maintains the continuity of the market efficiency in the continuous turnover, and on the other hand, the excess or insufficiency of the idle land may affect the overall operational efficiency of the park, and the government will help to avoid the potential risks through moderate intervention and active adjustment. On the other hand, excessive or insufficient idle land may affect the overall operational efficiency of the park, and the

government can help to avoid potential risks through moderate intervention and active adjustment and promote the sustainable and healthy development of industrial parks. Because the formation and development of idle land is subject to the dual roles of the market and policy, the governance of idle land requires the joint efforts of the policy toolbox and the spatial toolbox, including the categorization and grading of unused land to guide the redevelopment of unused land and the establishment of a coordinated multisectoral intervention system. From the identification to the governance of unused land, a more scientific and effective intervention system is needed, as well as a broader empirical test of the future road of unused land governance has just begun.

Notes

①The abandoned idle land mainly includes the idle land of enterprises due to "shutting down and transferring" (i.e., closing down, ceasing operation, merging, and transferring production), the land of "zombie" enterprises in the state of half-stopping production, as well as the land of prohibited and eliminated industries stipulated in the national industrial policy. etc.

② Referring to the definition of "built-up area" in the "Basic Terms of Urban Planning", the built-up area of an industrial park refers to the area where infrastructure construction such as "five passes and one leveling" has been completed, where the existing industrial land is continuous, and where the industrial enterprises have gathered initially.

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