Optimizing Land Resource Allocation and Functional Configuration in High-Tech Industrial Parks: A Case Study of Chengdu Xinchuan High-tech Innovation Park

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Abstract:
Amid China's ongoing initiatives to enhance industrial land efficiency and promote urban upgrading, high-tech innovation parks emerge as crucial policy zones driving urban economic development. These parks are increasingly integrated into the fabric of urban districts, reflecting their growing role as key components of city functions. This paper specifically examines Chengdu Xinchuan High-tech Innovation Park, exploring strategies for managing land resource allocation and efficient supply to support the park's swift and transformative development. An analysis of the functional configurations from exemplary parks like Shenzhen Nanshan High-Tech Park, Shanghai Zhangjiang Hi-Tech North Park, and Chengdu Tianfu Software Park informs the proposed optimization for Chengdu Xinchuan. The initial planned distribution of 32% residential, 28% industrial, and 40% commercial functions is recalibrated to 32% residential, 43% industrial, and 25% commercial. This adjustment is aimed at creating a more balanced development conducive to both economic vitality and community sustainability. Drawing on the successes of these benchmark parks, the study outlines a tailored functional ratio scheme, providing actionable insights and strategic guidance for similar transformations in other urban high-tech industrial parks.

keywords: Functional optimization, High-tech innovation parks, Benchmark analysis, Land function

1.Introduction

The rapid economic transformation of China over the past few decades has been significantly influenced by the strategic development of high-tech industrial parks (Hu, 2007). These parks are pivotal in fostering innovation, attracting foreign investment, and catalyzing regional development. The Chinese government's emphasis on upgrading industrial structures and enhancing technological innovation capabilities has further propelled the evolution of these parks (Zhang and Wu, 2012). In Chengdu, the push towards establishing a high-tech zone reflects broader national trends aimed at integrating advanced manufacturing and information technology industries. Chengdu's strategic location in southwestern China adds to its potential, positioning it as a gateway for technological and economic interactions between China and South Asia.

Chengdu's commitment to technological advancement is exemplified by the development of Chengdu Xinchuan High-tech Innovation Park. Launched as part of a larger initiative to transform the region into a center for technological innovation, the park is designed to support cutting-edge industries such as IT, biotechnology, and new energy. This development is underpinned by China's national policies advocating for

the intensive use of industrial land, which aims to optimize land use efficiency and support sustainable urban growth (Tu, Yu, and Ruan, 2014).

Since its inception, Chengdu Xinchuan High-tech Innovation Park has made significant strides in attracting high-tech firms and contributing to the region's economic growth. However, the park faces several challenges that hinder its potential to become a leading innovation hub. One of the primary issues is the mismatch between land supply and the specific demands of high-tech industries. This misalignment often leads to inefficient land use and underutilization of available resources, which can stifle the growth of resident companies and reduce the park's overall competitiveness.

Another significant challenge is the functional imbalance in land use, where the proportions of land designated for industrial, residential, and commercial uses do not optimally support the park's goals. This issue is exacerbated by rigid planning policies that fail to adapt to the dynamic needs of high-tech enterprises, which require flexible environments that can rapidly adjust to technological advancements and market changes.

This study aims to address these challenges by:

1. Analyzing the current land allocation and functional configuration at Chengdu Xinchuan High-tech Innovation Park to identify core issues in land management and usage efficiency.

2. Benchmarking against successful high-tech parks nationally to derive actionable insights and best practices that could be adapted for Chengdu Xinchuan.

3. Proposing strategic interventions to optimize land resource allocation and functional configuration, ensuring that the park not only meets the current needs of its tenants but is also poised for future growth and innovation.

The ultimate goal is to redefine the urban space within Chengdu Xinchuan High-tech Innovation Park to better serve its function as a catalyst for technological innovation and economic development, contributing to the broader objectives of Chengdu's urban and economic planning strategies.

2.Literature Review

2.1 Industrial Land Use Policies in China

The transformation of industrial land use policies in China has been profound over the last few decades, reflecting the nation's shift towards a more sustainable and economically productive use of its urban and peri-urban land. The Chinese government has introduced several policies aimed at promoting the efficient use of industrial land, particularly in the context of rapid urbanization and the growing need for innovation-driven economic zones. Notably, the "National Land Use Policy" (2008) and subsequent amendments emphasize the intensive and efficient use of industrial land. These policies support the development of high-tech parks by stipulating that such areas must incorporate sustainable practices and efficient land use to foster innovation while minimizing environmental impacts (Ministry of Natural Resources of the People's

Republic of China, 2008).

Further reforms were introduced with the "Guidelines on Promoting the Economical and Intensive Use of Land" (2015), which set specific targets for the utilization rates and densities of industrial parks. These guidelines are designed to ensure that new developments, like Chengdu Xinchuan, align with national sustainability objectives while supporting high-tech industries (Ministry of Natural Resources of the People's Republic of China, 2015).

2.2 Case Studies on Land Resource Management in High-tech Zones

Several high-tech zones in China and globally offer valuable insights into effective land resource management practices. For instance, the Suzhou Industrial Park and the Shanghai Zhangjiang High-tech Park have been highlighted for their innovative approaches to land use and management. These parks have implemented mixed-use development strategies that integrate residential, commercial, and industrial spaces, allowing for greater functional integration and resource efficiency (Holländer, Wu and Duan, 2009).

Examining high-tech zones within Asia provides valuable insights into the effective management of land resources. Alongside China's Suzhou Industrial Park and Shanghai Zhangjiang High-tech Park, Singapore's One-North is a leading example of a science park that exemplifies best practices in land resource management. One-North has been designed to be a hub for research, innovation, and entrepreneurship, integrating business parks, biomedical sciences, and infocomm technology zones. The park's development strategy has prioritized flexibility in land use and zoning to adapt quickly to the needs of dynamic sectors, enhancing its appeal to international and local companies (Yuen, 2016).

In Japan, the Tsukuba Science City represents another significant case of strategic land use. Tsukuba's planning framework was designed to facilitate close interaction between research institutions and private companies, fostering collaboration and innovation. The city's layout includes dedicated spaces for different scientific fields, residential areas, and commercial services, creating an integrated environment that supports both professional and personal needs of its community.

In Europe and America, examples such as the Research Triangle Park in North Carolina, USA, and the Cambridge Science Park in the UK demonstrate the importance of flexible land use policies that adapt to the evolving needs of high-tech companies. These parks focus on creating environments that foster collaboration and innovation while providing the necessary infrastructure to support high-tech development (Bakouros, Mardas and Varsakelis, 2002).

2.3 Impact of Functional Configuration on Urban Development

The configuration of land use functions within high-tech zones significantly impacts urban development. Properly balanced functional areas can lead to enhanced economic performance, improved environmental sustainability, and increased quality of life for residents and workers within the zone. Research has shown that the integration of green spaces, residential areas, and commercial services within industrial parks not only

supports sustainability but also boosts the attractiveness and competitiveness of these areas (Qu et al, 2015). In Chengdu Xinchuan, the challenge lies in optimizing this functional mix to match the specific needs of high-tech industries while supporting urban development goals. Effective functional configuration can facilitate better traffic management, reduce environmental stress, and create more livable urban spaces, contributing positively to the broader urban fabric of Chengdu (Yang Wu and Dang, 2017).

3.Research subjects and methods

3.1 Background Of Chengdu Xinchuan High-Tech Innovation Park

The Chengdu Xinchuan High-tech Innovation Park, located in the Chengdu High-tech Zone, integrates industrial, residential, and commercial functions (Figure 1). Since its establishment in 2012, the park has attracted numerous industries, primarily focusing on information technology, biotechnology, and new materials. In 2018, the policy document titled "Several Policies for Further Relieving the Non-Core Functions of Central Urban Areas and Enhancing the Quality of Urban Capacity in Chengdu" was issued. This policy mandates further optimization of land use functions in central urban areas, promoting the reform of industrial land supply side, and accelerating the improvement of land use efficiency and management levels.

In the context of this policy framework, the land management strategies of Xinchuan urgently require reevaluation. Currently, under the management of floor area ratio (FAR), Chengdu Xinchuan High-tech Innovation Park still has a potential total buildable volume of 14.687 million square meters. According to statistics, the scale of buildable new-type industrial buildings is estimated to be between 8.75 and 9.5 million square meters, residential buildings between 3.6 and 5.14 million square meters, and commercial buildings between 0.7 and 1.45 million square meters. This data demonstrates significant flexibility in land use adjustment.

Figure 1. Construction Status of Chengdu Xinchuan High-tech Innovation Park

3.2 Research Approach

This study employs a case comparative analysis method to investigate the development trajectories and land management strategies of high-tech industrial parks with successful operational experiences. It aims to summarize and collate the functional configuration combinations and proportions used across different parks, deriving general principles of spatial requirements for high-tech industrial parks. Based on these findings, the study proposes land use configuration strategies for Chengdu Xinchuan High-tech Innovation Park.

3.3 Method of Case Selection

This study selects parks for comparison based on their similarities in function (focusing on high-tech industries), challenges (urban integration and sustainable development), and their successful experiences in overcoming these challenges through innovative land use planning. Chengdu Xinchuan High-tech Innovation Park, with a land area of 10.34 km^2, was ultimately chosen for analysis alongside three other cases: Shenzhen Nanshan High-Tech Park(11.52km^2), Shanghai Zhangjiang Hi-Tech North Park (12.13km^2), and Chengdu Tianfu Software Park (9.55km^2). These comparisons aim to draw actionable insights based on the similarities and distinctive approaches of each park.

4. Case Study Analysis

4.1 Shenzhen Nanshan High-Tech Park

Shenzhen's Nanshan district, home to the renowned Shenzhen High-Tech Industrial Park, represents a model of successful high-tech park development through distinct phases of growth. There are three stages of development as follows.

Firstly, in initial industrialization phase (1985-1996), the Shenzhen Science and Technology Industrial Park, the predecessor of Shenzhen Nanshan High-Tech Park, rapidly achieved industrialization through a strategy known as "three supplies and one compensation". This phase focused on drawing in investment and technology through favorable policies, creating a somewhat isolated development model with designated land separating it from surrounding cities. Secondly, in rapid construction and innovation gathering phase (1996-2006), the High-tech Park shifted its focus towards aggregating innovative resources and fostering leading enterprises. This was a time of intensive land and industrial park development, seamlessly integrating property development with industrial expansion. The approach evolved from solely enhancing physical infrastructure to cultivating a comprehensive environment that supported all aspects of high-tech industry growth. And thirdly, in world-class park development phase (2006-present), the emphasis has been on promoting industrial transformation and upgrading to enhance indigenous innovation capabilities. The park's relationship with surrounding cities has become increasingly centered on human capital needs. This intercity collaboration extends to urban services such as university campuses, commercial centers, high-end residential areas, and the Shenzhen Bay Sports Center, significantly strengthening the integrated urban service framework that supports the

high-tech park.

Today, Nanshan hosts major companies like Tencent and Huawei and has developed a robust ecosystem that supports innovation across various sectors including telecommunications, biotechnology, and digital media. The park's enduring success is attributed to its strategic location, superior infrastructure, and the thoughtful integration of commercial and residential areas which enhance the livability for employees and their families (Cheng et al., 2014). This approach to functional mix and land use optimization provides valuable insights into creating a sustainable and integrated urban environment conducive to high-tech development.

The land use within the Shenzhen Nanshan High-Tech Park has been meticulously categorized to highlight the functionality of different areas as shown in Figure 2. Spanning an extensive site area of 11.52 square kilometers, the park features a total built-up area of 22.36 million square meters. It is predominantly designated as M0 new-type industrial land, accounting for 67% of the total area, which underscores its focus on fostering cutting-edge technological and industrial development. Additionally, commercial and residential lands make up 3% and 30% of the area respectively.

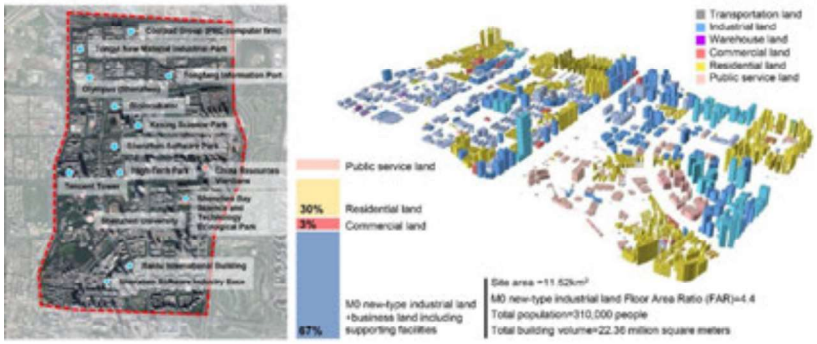

Figure 2. The proportions of different land use functions in Shenzhen Nanshan High-Tech Park

4.2 Shanghai Zhangjiang Hi-Tech North Park

Located in the Pudong district, Shanghai Zhangjiang High-tech Park is often referred to as China's Silicon Valley. Since its inception, the park has undergone several pivotal development phases as follows.

The period from 1992 to 1995 constituted the initial setup phase. The Park was meticulously planned, outlining the functional composition and zoning of the technology area. It established biopharmaceuticals, electronic information technology, and optomechatronics as the three leading industries. The construction of the park's incubators began, and expert and advisory committees were formed to guide development. Then, the period from 1995 to 1999 marked the Consolidation Phase for Zhangjiang. During these years, the area encountered substantial challenges in

attracting investments. In response, the municipal government strategically pivoted to emphasize high-tech development, designating the park as a national biopharmaceutical and technology industry base in Shanghai. This strategic shift included the establishment of national key laboratories, which laid the essential groundwork for the subsequent development of a comprehensive national science center. From 1999 to 2005, during the Aggregation Phase, Zhangjiang witnessed a significant integration of industry, education, and research. The establishment of an industrial base development and operation service company and the completion of a large-scale integrated circuit manufacturing base marked major milestones. Additionally, the groundwork was laid for the burgeoning cultural and creative industries. This phase seamlessly transitioned into the Upgrade Phase from 2005 to 2012, where Zhangjiang was among the first to propose the "Triple Services Strategy" in development zones, which included development and operation, integrated services, and industrial investment. This strategic evolution continued into the current phase, beginning in 2012, where Zhangjiang has been designated as a National Independent Innovation Demonstration Zone. This phase accentuates the dual engines of "function and innovation," rapidly integrating these elements into the park's development agenda, ensuring continual progress and enhancement of its industrial and research capabilities.

Throughout these phases, Zhangjiang High-tech Park has been instrumental in advancing China's pharmaceutical and IT industries. The Park benefits from strong governmental support and boasts a comprehensive service system that promotes research and development activities. Its development has been characterized by a strong emphasis on research and development facilities, which are complemented by residential and commercial spaces designed to foster a balanced work-life environment. The park's planning has been particularly effective in facilitating collaboration between research institutions and businesses, which has been a key factor in its success (Zhang and Wu, 2012).

Similarly, the land use within the Shanghai Zhangjiang Hi-Tech North Park has been carefully analyzed to ascertain the functionality of different areas, as depicted in Figure 3. The Park spans a total site area of 12.13 square kilometers and features a total built-up area of 10.16 million square meters. The distribution of land types includes 74% allocated to M0 new-type industrial land, 5% to commercial land, and 21% to residential land.

Figure 3. The proportions of different land use functions in Shanghai Zhangjiang Hi-Tech North Park

4.3 Chengdu Tianfu Software Park

Chengdu Tianfu Software Park, located in the heart of the Chengdu Hi-tech Zone, epitomizes a strategic approach to high-tech park development through clearly defined growth phases. Since its official opening in 2005, the park has undergone significant evolution, reflecting the broader ambitions of China's software and service outsourcing industries. Initially, from 2005 to 2007, it focused on establishing a strong foundational structure to rapidly cultivate a professional environment conducive to software development and IT outsourcing. This initial growth phase enabled the park to quickly attract major companies, leveraging Chengdu's burgeoning status as a tech hub. In the next phase, from 2008 to 2011, the park expanded its infrastructure from 800,000 square meters to over 1.3 million square meters, diversifying its industry mix to include business software, digital entertainment, and telecommunications. This expansion facilitated an ecosystem that supports both large corporations and small-medium enterprises. The most recent phase, from 2012 to the present, has centered on sustainability and internationalization. The Park has focused on creating a sustainable and culturally vibrant environment that attracts international investments, enhancing global connectivity and cultural offerings to improve the quality of life for its 30,000 employees and foster a balanced work-life environment.

The land use distribution within Chengdu Tianfu Software Park is detailed in Figure 4. Spanning a site area of 9.55 square kilometers, it is the smallest in size among the three cases discussed. Despite its smaller area, the park boasts a significant total building volume of 17.94 million square meters, ranking just behind Shenzhen Nanshan High-Tech Park. In terms of land allocation, 62% is dedicated to M0 new-type industrial land, underscoring its focus on technological and industrial development. Additionally, commercial land makes up a modest 3%, while residential land comprises 35% of the park. This layout strategically balances industrial growth with residential and commercial spaces, enhancing the overall functionality and livability of the area.

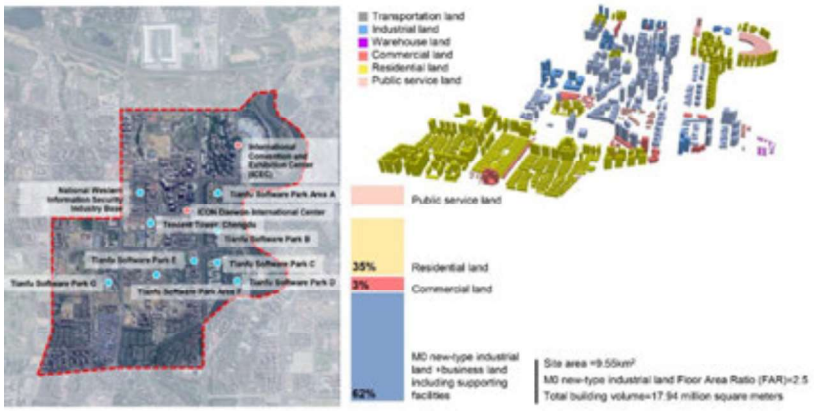

Figure 4. The proportions of different land use functions in Chengdu Tianfu Software Park

4.4 Summary

Although there are clear differences in the total building volumes among the three case study areas, the proportion of industrial, residential, and commercial land use demonstrates a general pattern (Figure 5). M0 new-type industrial land generally accounts for about 60%-75%, residential land comprises 20%-35%, and commercial land falls within the range of 3%-5%. This pattern provides a reference of successful experiences for the functional distribution in Xinchuan.

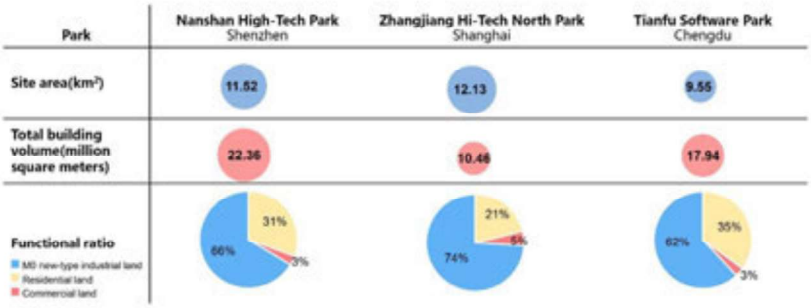

Figure 5. Comparison of land function proportions in the three high-tech industrial parks

5. Strategies and Recommendations

Considering the successful strategies employed by benchmarked parks, it is recommended to strategically reallocate resources within Chengdu Xinchuan High-Tech Innovation Park to foster its development into a leading high-tech hub (Figure 6). To achieve a more optimal functional mix, it is advised to adjust property function allocation to 60-75% for 'Industry + Office', which should include accommodation and small commercial support facilities. Residential areas should then comprise 25-35%, with retail space occupying 3-5% of the total area. Additionally, adjustments in the building ratio are necessary, aligning with the successful innovation parks' experiences

to significantly increase the share of industrial space. This includes accommodating up to 10% of the industry space for service facilities as ancillary rooms, which enhances functionality without overwhelming the industrial character. The proposed changes would maintain the residential space at 470.7 million square meters, increase industrial space from 398.9 million to 631.0 million square meters, and decrease commercial space from 589.5 million to 356.3 million square meters. Finally, the comparison of total building volume by land use type for Xinchuan Park before and after adjustments is shown in Figure 7.

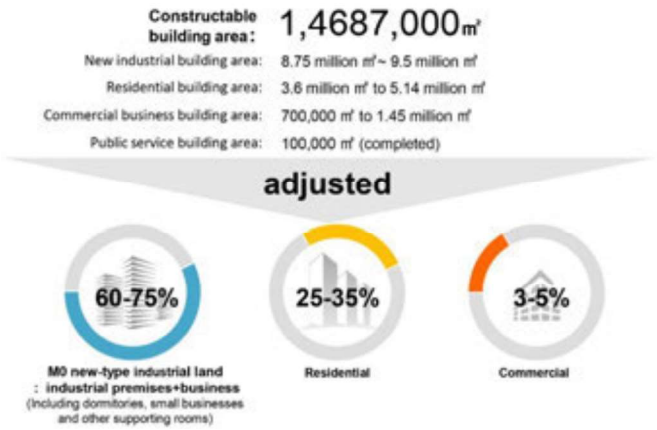

Figure 6. Schematic diagram of land functional ratio adjustment for Chengdu Xinchuan High-tech Innovation Park

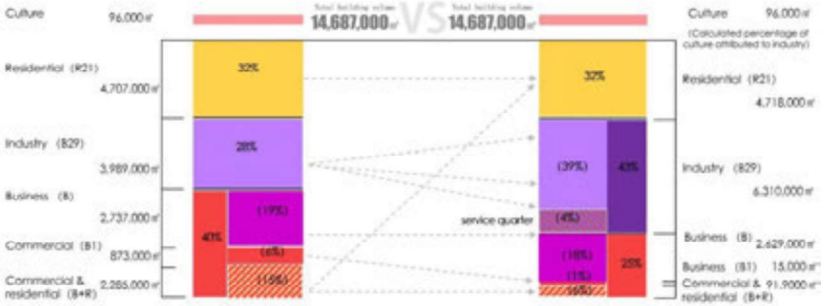

Figure 7. Comparison before and after adjustment of total building volume by land use type

6. Conclusion

This paper analyzes the functional configurations of successful parks such as Shenzhen Nanshan High-Tech Park, Shanghai Zhangjiang Hi-Tech North Park, and Chengdu Tianfu Software Park to derive general principles for land use functional ratios in high-tech industrial parks. It concludes that industrial land typically comprises 60%-75%, residential areas account for 20%-35%, and commercial spaces make up 3%-5% of

these parks. These findings provide empirical guidelines for adjusting the land use layout in Chengdu Xinchuan Innovation Technology Park, aiming to facilitate its transition from a traditional industrial area to an integrated urban district. As a result, this study redefines the urban space of Chengdu Xinchuan High-Tech Innovation Park by adjusting the original planning of 32% residential, 28% industrial, and 40% commercial functions to 32%, 43%, and 25% respectively. This adjustment better positions the urban space to serve as a catalyst for technological innovation and economic development. Although the derived ratios are based on successful parks, the limited number of comparative cases means these guidelines are not yet universally validated and require further substantiation.

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