The Distribution of Spatial Landscape and Its Impact on Residents During the Transformation of Industrial Cities

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Abstract. This study takes Shenyang, a former industrial base in China, as its research subject. Based on GIS technology, open-source remote sensing imagery, and statistical data, it explores the urban spatial landscape reconstruction under government-led transformation and its impact on residents' quality of life. The study finds that Shenyang achieved dual benefits during the transformation period: the green space ratio in the built-up area increased from 25.73% to 40.74%, and the per capita park green space area increased by 161.3%. Simultaneously, industrial land did not shrink but rather increased by 104.75%, showing a clear suburban reconstruction and breaking the traditional perception that transformation equals "deindustrialization." Along with spatial reconstruction, residents' per capita disposable income, housing area, and life expectancy significantly improved, and unemployment improved. The study indicates that government-led "eastward relocation and westward construction" and industrial restructuring can effectively balance ecological restoration in the central area with industrial agglomeration in the suburbs. However, the potential risk of ecological pressure shifting to the suburbs still needs to be considered to promote the long-term sustainable development of industrial cities.

Keywords: Transformation of old industrial cities, spatial landscape reconstruction, GIS, quality of life, Shenyang.

1. Introduction

Industrialization has brought significant change in the cityscapes and ecology. In addition to that, various stages of development have affected the psychology of the people living in those cities. For instance, this research focuses on the city of Shenyang located in China, which has experienced industrialization. The use of Geographic Information Systems (GIS) is used to make comparisons of the impact of industrialization on the environment of the city as well as its influence on the well-being of people living there.

The industrialization process has produced much heterogeneous spatial data such as surface temperature, building density, vegetation, and various kinds of land use type. It is not just about "deindustrialization," but more of the process of land use change and infrastructure replacement. The existing studies have only examined the process of environmental restoration or economic efficiency from a one-dimensional perspective.

Shenyang, China, is a typical case of industrial cities, which is considered the "Ruhr of the East." In the post-industrial stage, Shenyang is faced with a totally new situation of transformation. With the help of the Soviets, Shenyang developed a full-scale heavy industrial system. Now, according to the government policy of "retreat from secondary industry and advance to tertiary industry," Shenyang tries to preserve the building density but pursue functional mixing. Various features of Shenyang as an industrial city make a good case for environmental study under the industrialization model.

This study utilizes GIS spatial analysis technology, combined with remote sensing imagery and land use data, to analyze the spatial changes in Shenyang during its industrial transformation. A standardized remote sensing analysis workflow was constructed using open-source remote sensing imagery to analyze the characteristics of green space reconstruction in Shenyang. Simultaneously, using income before and after the transformation as evidence, the study explores the correlation between environmental changes and social well-being under different systems, providing practical insights for the ecological restoration of industrial cities. This low-cost, reproducible workflow can

effectively identify differences in green space reconstruction patterns in industrial cities under different institutional backgrounds, providing a reference for environmental monitoring in similar cities.

2. Case Selection and Research Area

Shenyang City is located in central Liaoning Province, with geographical coordinates of 122°25′ to 123°48′ east longitude and 41°11′ to 43°02′ north latitude. The Hun River flows through the city from east to west. The city has a total area of approximately 12,860 square kilometers and a resident population of approximately 9.276 million in 2026 (official statistics at the end of 2025, released in May 2026). Shenyang was chosen as a case study based on the following four considerations. First, its typicality. Shenyang was a key industrial base developed by the state during the First Five-Year Plan period, forming an industrial system centered on equipment manufacturing, aircraft industry (such as Shenyang Aircraft Industry Group), and steel smelting. Industrial land has long dominated the city's space. The pressure of transformation is also an undeniable factor. As a city heavily reliant on a single industry, Shenyang faced severe post-industrial transformation pressures after the 1990s, including comprehensive challenges such as industrial decline, environmental pollution, and declining employment. The specific policy juncture is also important. In 2002, Tiexi District launched the "Eastward Relocation and Westward Construction" project, and in 2003, the Northeast Revitalization Strategy was elevated to a national policy, providing an ideal window of opportunity for studying the transformation of government-led industrial cities. Finally, data availability needs to be checked. As the provincial capital, Shenyang has relatively complete statistical data, and remote sensing imagery data is available, facilitating long-term quantitative analysis.

3. Data Sources

The data sources for this paper are presented in Table 1, and all data are authentic and reliable.

Table 1. Data sources

Data Type	Specific content	Time range	Use
Remote sensing images	omap	2023	Land use classification and change monitoring
Statistical data	Shenyang Statistical Yearbook	2002-2023	Green space ratio, per capita park green space area
Spatial data	OpenStreetMap, Overpass Turbo	2023	Spatial distribution of industrial land
Policy text	Government Work Report	2002, 2023	Income, life expectancy and other indicators of people's livelihood

4. Key Findings

4.1. Green Space Expansion and Ecological Improvement

Shenyang City has achieved remarkable results in green space construction during its transformation period. According to the statistics in Fig. 1, the green space ratio of the built-up area increased from 25.73% in 2002 to 40.74% in 2023, with a relative growth rate of 58.35%; Fig. 2 shows that the per capita park green space area increased from 5.61 square meters to 14.65 square meters, with a relative growth rate as high as 161.3%.

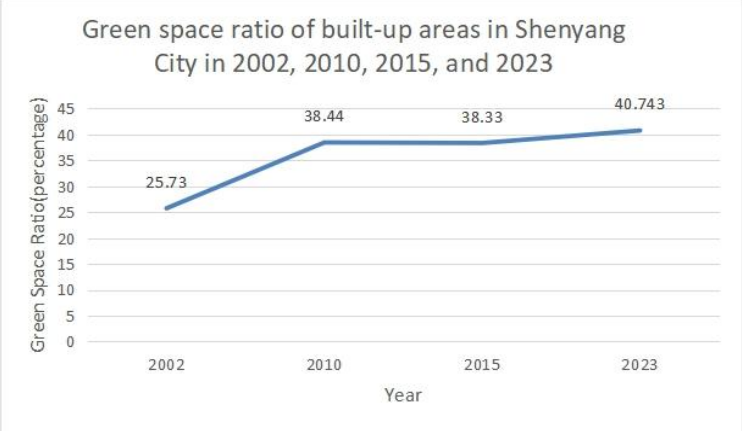


Fig. 1 Line chart of green space ratio of built-up areas in Shenyang City in 2002,2010,2015, and 2023) (Photo/Picture credit: Original).

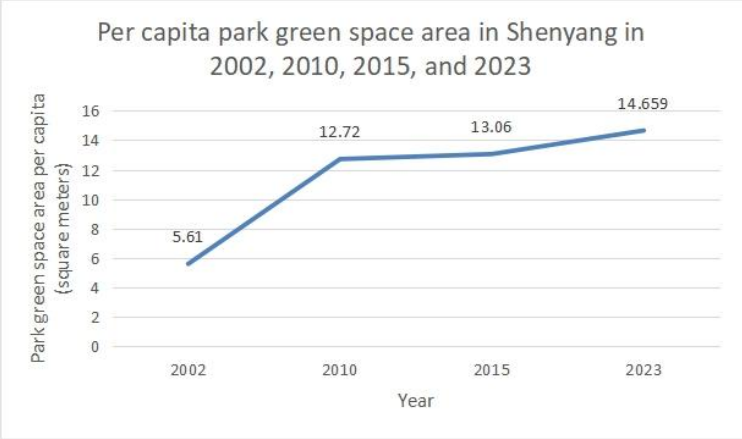


Fig. 2 Line chart of per capita park green space area in Shenyang in 2002,2010,2015, and 2023 (Photo/Picture credit: Original).

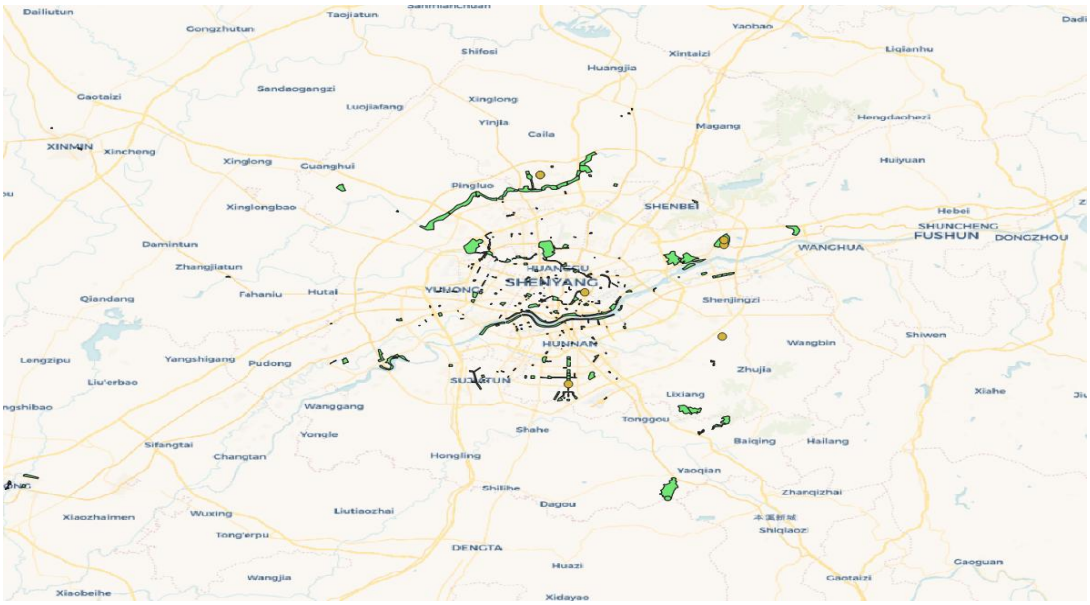


Fig. 3 2023 Shenyang City Green Space GIS Image (Photo/Picture credit: Original).

As shown in Fig. 3, the relocation and renovation of Tiexi District began in 2002, accelerating green space construction, but the overall green space ratio remained relatively low citywide. In 2010, after years of relocation and reconstruction, the opening of Metro Line 1 stretched the city's framework outwards, and a preliminary green space network was formed, increasing the green space ratio to 38.44%. In 2015, Hunnan New Area developed rapidly, implementing afforestation and

greening projects, stabilizing the green space ratio at 38.33%. Most recently, in 2023: a mature "one river, two banks" pattern was formed, with the green space ratio exceeding 40%, showcasing the latest transformation achievements. The renovation of the Hunhe River urban section's waterfront green space constructed a composite corridor of "ecological buffer + citizen recreation," forming the main framework of Shenyang's "one river, two banks" green space. By combining idle green spaces along the waterfront to revitalize recreational spaces, we can balance ecological protection with the needs of citizens for waterfront activities and achieve synergistic effects of multiple ecosystem services [1].

Recent changes can be summarized as follows:

1. The park system has become increasingly comprehensive. Dozens of large and medium-sized parks have been built or renovated, and over 3,100 pocket parks have been created. The service radius coverage of park green space activity areas has reached 87.58%, a significant increase compared to 2021. This has effectively addressed the shortcomings of uneven green space distribution, basically achieving "green views from every window and parks at every doorstep."

2. The spatial pattern has been comprehensively optimized. A park layout has been formed, characterized by "large parks anchoring specific areas, pocket parks scattered throughout streets and alleys, and the Hun River waterfront connecting the entire region." Hundreds of kilometers of slow-moving paths have been newly built or renovated, tens of millions of flowers have been planted, and nearly 3 million square meters of exposed ground have been cleaned up, incorporating northern regional cultural elements and an all-age-friendly concept.

3. Ecological benefits have continued to emerge. The number of days with excellent air quality has remained stable at over 300 days for five consecutive years, reaching 328 days in 2025, with an excellent air quality rate of 89.9%. The green space system has played an important role in improving the urban microclimate, enhancing biodiversity, and increasing citizens' sense of well-being. The layout of green spaces is significantly affected by the built environment, with older, densely populated residential areas having the strongest demand for micro-green spaces. Simply relying on building new parks is insufficient to bridge the gap between the north and south, and between new and old urban areas. Continuously promoting the transformation of micro-green spaces is a long-term and effective means to continuously improve living conditions and increase the service radius coverage of parks.[2]

4.2. Changes in Industrial Land Use

Contrary to the expected policy of "shifting from secondary to tertiary industries," Shenyang did not experience deindustrialization. Instead, it witnessed a spatial restructuring of industrial land use and suburban expansion. Fig. 4 shows that the city's industrial land area increased from 69.54 square kilometers in 2002 to 142.38 square kilometers in 2023, representing a relative growth rate of 104.75%, meaning that the industrial land area doubled in twenty years.



Fig. 4 Line chart of industrial land area in Shenyang in 2002,2010,2015 and 2023 (Photo/Picture credit: Original).

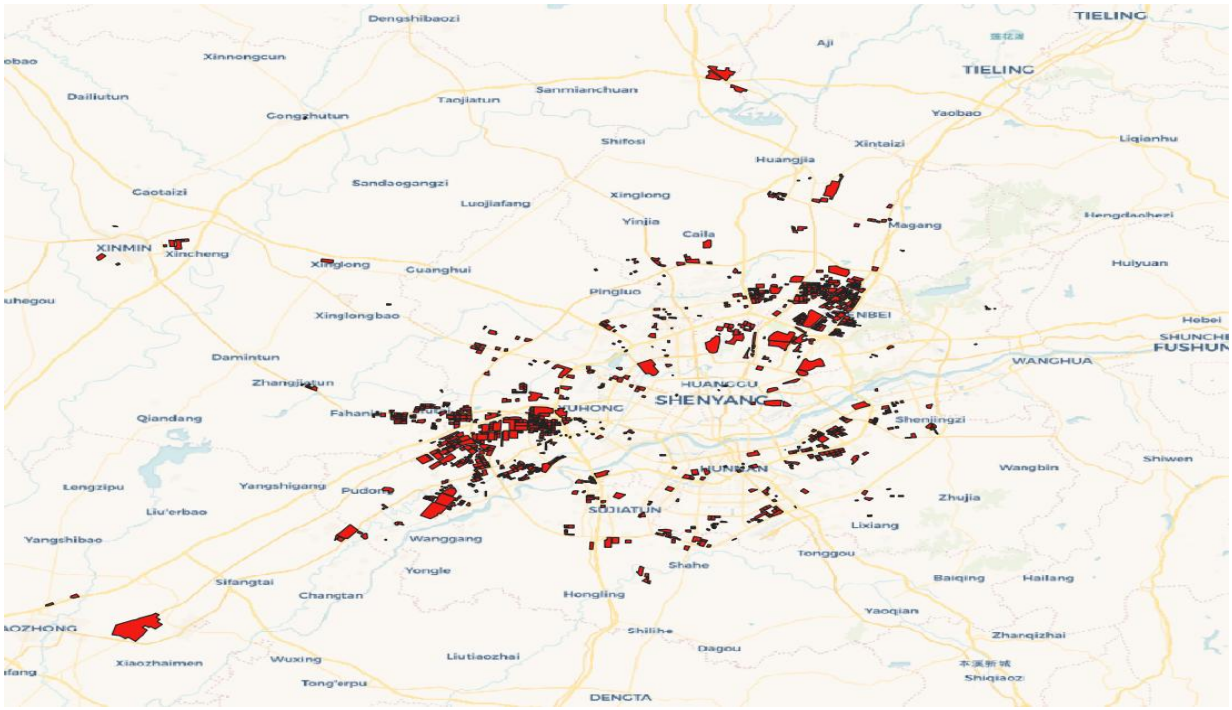


Fig. 5 GIS image of industrial land in Shenyang in 2023 (Photo/Picture credit: Original).

As Fig. 5, the changes in industrial land use in Shenyang have three key characteristics: spatial transfer, industrial succession, and policy-driven. Industrial land has migrated from the central urban area (Tiexi Old Town) to the suburbs. Spatial data extracted by Overpass Turbo shows that industrial land is mainly distributed in the southern Tiexi District (including the Economic and Technological Development Zone), Sujiatun District, and Hunnan District. While traditional manufacturing industries are relocating, emerging industries are clustering in suburban industrial parks. The Shenyang Economic and Technological Development Zone has taken over the equipment manufacturing enterprises relocated from Tiexi District, and at the same time introduced emerging industries such as automobiles and aerospace. Finally, "moving east and building west" is not a simple industrial transformation, but a spatial relocation of industry under the leadership of the government. Through policy tools such as land swaps, tax incentives, and infrastructure support, the "relocation and upgrading" of industrial capacity has been achieved. The spatial diffusion of industries can be gradual, hierarchical, or even leapfrog. In the early stages, it is generally gradual. The spatial diffusion of industries in Shenyang is still in its early stages of development. The diffusion between industries is mainly gradual, that is, enterprises in the urban area diffuse to the suburbs [1]. This finding corrects the perception that "transformation of old industrial bases equals deindustrialization." Government-led transformation can achieve a balance between "spatial optimization" and "industrial preservation." The central urban area gains space for ecological improvement and functional upgrading through industrial relocation, while the suburbs achieve industrial agglomeration and economies of scale through the construction of industrial parks.

The Shenyang government prioritizes public green spaces and supporting facilities for old communities by coordinating and guiding the relocation of industrial land; at the same time, it innovates industrial land policies, appropriately retaining suitable manufacturing land to prevent singular real estate development. Relying on the spatial reconstruction of industrial land, the urban landscape structure is optimized, the gap in public space resources between the old and new urban areas is narrowed, and the living environment of residents is continuously improved [3]. The renewal of industrial land in Tiexi District, Shenyang, adheres to the concept of "weaving the city," utilizing the industrial idle land released by relocation to build a continuous green space system and slow-walking corridors; relying on the old factory buildings and railway relics along the Weigong Canal, an industrial culture green corridor is created. Land use adjustment is no longer limited to the conversion of land use nature, but rather coordinates ecological restoration, landscape construction,

and community renewal, promoting the benefits of industrial land transformation directly to the grassroots level and systematically improving the quality of life of residents in old areas [4].

4.3. Changes in Residents' Quality of Life

Table 2. Data of change in residents' quality of life

Category | Year Percentage	Per capita disposable income (yuan)	Average living space per person (square meters)	Life expectancy (years)	Number of unemployed (in ten thousands)
2002	7050	19.12	73.56	13.9
2023	47455	34.1	80.27	8.6
Growth percentage	573.12%	78.35%	9.12%	-38.13%

Table 2 shows that improvements in income and housing were the most significant. Per capita disposable income increased by 573.12%, reflecting the dual effects of economic transformation, industrial upgrading, and housing commercialization. Per capita living space increased from 19.12 square meters to 34.1 square meters, directly related to the large-scale shantytown renovation in Tiexi District (1.46 million square meters) and real estate development in the new district. However, it should be noted that income growth is partly due to inflation, and the actual increase in purchasing power needs to be adjusted using the price index.

Life expectancy increased by 9.12%, which is related to green space expansion and air quality improvement. Health improvements were relatively moderate and may be influenced by complex factors such as dietary habits, an aging population, and the allocation of medical resources. There may be a 3-5 year time lag between green space expansion and health benefits.

The number of unemployed decreased by 38.13%, but there is a difference in the statistical methods used for "number of unemployed" and "unemployment rate." The 2002 data used laid-off workers, while the 2023 data use registered unemployed workers, limiting comparability. More importantly, the quality of re-employment is uneven—some laid-off workers have entered the service sector, but their income stability and social security coverage are insufficient, posing a risk of "hidden unemployment."

Green space expansion and improved quality of life are synchronous in time, but the causal mechanism is complex. Income growth and housing improvements are mainly driven by macroeconomic policies and the real estate market, and should not be simply attributed to changes in land use. The impact of green space expansion on health is more direct, but there is a time lag effect.

Global theories on the transformation of old industrial bases and empirical research in Shenyang, China, have reached a consensus: the transformation of heavy industrial cities cannot rely solely on industrial upgrading; it must simultaneously promote the reconstruction of the entire spatial landscape. Based on the practices in the Ruhr region of Germany and the Rust Belt of North America, European and American scholars have proposed that brownfield ecological restoration should be carried out systematically, abandoned industrial land should be revitalized in an orderly manner, and priority should be given to converting it into continuous ecological corridors and community open spaces. The process of renewal should avoid single real estate development and ensure that residents of old communities can share the benefits of urban renewal [5].

Empirical studies on Shenyang show that, relying on the "Eastward Relocation and Westward Construction" strategy, Shenyang has initiated the reconstruction of industrial space, continuously reducing the amount of industrial and mining land in the central urban area, and gradually converting the vacated land into public green spaces and public service facilities. The urban landscape has transformed from a single industrial style to a composite pattern of ecology, residence, and culture [6]. After urban renewal entered the stock stage, Shenyang adopted a differentiated renewal strategy, organically revitalizing industrial heritage, using relocated idle land to weave a green space system, creating industrial cultural landscape corridors, and coordinating ecological governance, cultural heritage protection, and improvement of the living environment [7].

By continuously adjusting the spatial landscape distribution, the long-standing problems of "intertwined factories and residences, prominent pollution, and uneven green space" have been effectively solved, the regional ecological environment has been continuously restored, and the nearby leisure space for residents has been expanded, promoting the transformation of the "industrial rust belt" into a livable urban area. Shenyang's practice confirms a feasible path for post-industrial cities: using land space reconstruction to drive the optimization of landscape pattern, ultimately leading to a comprehensive improvement in the quality of life for residents, which can provide a reference model for the transformation of similar old industrial bases in Northeast China [8-10].

5. Conclusion

Shenyang's green space area has increased significantly, leading to improved quality of life for residents. The green space ratio in the built-up area increased by 58.35%, and the per capita park green space area increased by 161.3%. During the same period, data on residents' income, housing, and life expectancy all improved, validating the positive impact of the transformation policies. Furthermore, contrary to popular belief, Shenyang did not experience deindustrialization, but rather the suburbanization of industrial space. The city's industrial land area increased by 104.75%, indicating that industrial capacity was retained and even expanded, resulting in a spatial pattern of service-oriented development in the central urban area and manufacturing clusters in the suburbs. Simultaneously, ecological pressure has shifted from the urban area to the suburbs, posing a risk of pollution transfer. While industrial relocation has improved the environmental quality of the central urban area, suburban industrial parks may face new environmental pressures. Industrial city parks and green spaces can curb the spread of industrial pollution sources, purify the atmospheric environment, promote the networked layout of green spaces, alleviate the fragmentation of green spaces, and build an urban ecological security barrier. The transformation of the park system can connect fragmented habitats, build corridors for biological migration, restore ecosystems damaged by industrial activities, and continuously enhance the biodiversity and ecological resilience of industrial cities. Urban renewal reshapes the urban spatial structure, gathers innovative elements, optimizes the business environment, helps traditional industrial cities break free from development path dependence, and promotes the continuous transformation of old and new growth drivers.

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