

Article

Study on the Evaluation of Urban Park Landscape Pattern Index and Its Driving Mechanisms in Nanchang City

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Abstract: Urban planning is often influenced by industrial and construction activities, leading to a lack of attention to the planning and construction of urban parks, which results in prominent spatial layout problems. Urban parks, as an important part of the urban green space system, play a significant role in improving the ecological environment, promoting urban economic development, and enhancing the daily living standards of the people. As a typical representative of China's second and third-tier cities, Nanchang's analysis of the evolution process of urban landscape patterns has reference significance for other similar cities in China. This paper is based on the theoretical foundations of landscape ecology, human geography, and urban planning, and analyzes the evolution of the park landscape pattern in the central urban area of Nanchang from 1999 to 2019 from the perspective of urban context, revealing the driving mechanisms. It provides important references and bases for the further optimization and construction development of the park landscape pattern in Nanchang. The results show that the park area and number in the central urban area of Nanchang have significantly increased, with the overall layout evolving from "central aggregation" to "core aggregation in each area", and from "central scarcity, more on the periphery" to "inward concentration, outward diffusion". However, the distribution of various types of parks is uneven, and there is a lack of green corridor links between parks. The park landscape pattern is driven by multiple factors such as natural factors of urban context, socio-economic factors, urban construction factors, historical policies, and related planning, which can have positive or negative effects. Incorporating relevant urban factors into the park planning system analysis can promote the benign development of urban context and park landscape layout, thereby achieving the "parkification" of the city.

Keywords: urban park; landscape pattern; driving forces; urban planning



Citation: Deng, X.; Zhou, Y.; Sun, N. Study on the Evaluation of Urban Park Landscape Pattern Index and Its Driving Mechanisms in Nanchang City. *Sustainability* **2024**, *16*, 4132. <https://doi.org/10.3390/su16104132>

Academic Editor: Derk Jan Stobbelaar

Received: 4 March 2024

Revised: 19 April 2024

Accepted: 26 April 2024

Published: 15 May 2024



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1. Introduction

The continuous advancement of urbanization has led to a constant expansion of urban population and size. The pursuit of interests without restraint and blind expansion has resulted in severe homogenization among cities, lacking regional characteristics [1–3]. At the same time, the process of industrialization has led to a significant encroachment of urban green spaces by buildings, and the reduction in green space areas has greatly impacted the living environment [4]. As a moderately prosperous society is comprehensively built, people's demands for the quality of living environments are gradually increasing [5]. Urban green spaces have immense ecological, economic, and social benefits and are a major indicator of a city's competitiveness. Improving urban greening is an important means to advance the construction of urban ecological civilization [6,7]. Chinese cities are in a period of rapid evolution and great instability, with many newly built urban parks not yet mature. Researching the landscape patterns of urban parks and optimizing the spatial layout and structure of urban parks to maximize the comprehensive functions of green spaces is of great significance for coordinating the relationship between urban

development and environmental construction and achieving scientific and sustainable urban development [8]. The spatial layout, area, and number of urban parks directly affect the development of recreational activities for urban residents. Only by valuing the ecological environmental protection and planning and construction of urban parks can the quality of the living environment be greatly improved [9]. However, early urban planning was often influenced by industry and construction, leading to a lack of attention to the planning and construction of park urban parks. Parks were often built in conjunction with industrial projects, neglecting the serviceability of parks to residents, resulting in prominent spatial layout issues [10]. To further restore the connectivity and ecological benefits of urban parks and address the imbalance and disproportionate spatial scale of urban park layouts are urgent issues to be resolved in the development of second and third-tier cities in China [11].

Currently, research scholars primarily focus on the dynamic analysis of urban land use and landscape patterns [12–15], but studies addressing the mechanisms driving urban park landscape patterns from the perspective of urban context are rare. This study approaches the topic from the perspective of the urban context, exploring its correlation with park patterns through natural factors, socio-economic and urban construction, as well as historical policies and planning. The research is grounded in several disciplinary theories, including landscape ecology, human geography, and urban planning theory [16–18]. Landscape ecology provides the scientific basis for understanding the structure, function, and changes in urban landscapes, emphasizing the importance of spatial patterns and ecological processes, crucial for assessing ecological connectivity and biodiversity within urban parks. Human geography explores how human behavior and cultural practices influence landscape forms, aiding in identifying the socio-economic factors and cultural values that drive changes in the design and use of urban parks. Urban planning theory integrates these ecological and humanistic insights into a practical framework, guiding the strategic design and management of urban spaces to enhance livability, sustainability, and functionality. Together, these theories enrich our understanding of how urban parks evolve and can be planned and managed to meet ecological goals and community needs, providing a comprehensive approach to urban environmental management and policy formulation. This study, based on urban context landscape research and urban park landscape pattern studies, analyzes existing studies to uncover that “urban context” theory in China started relatively late, with research mainly covering the protection of urban historical and cultural districts [19], the shaping of urban spatial features [20], and urban form management [21]. Landscape studies based on urban context focus on inheriting, continuing, and protecting urban context within landscape design, emphasizing and articulating the connotations of urban context and evaluating the value of its elements, thus providing a foundational framework for the impact factors of urban context in this study. The research on landscape patterns discusses the service level structure and spatial layout characteristics of urban park landscapes, proposing strategies and measures for the ecological optimization of urban park green spaces [22,23]. In the study of the evolution of urban park landscape patterns, existing research mainly focuses on the application of landscape pattern indices to quantitatively assess the structural changes in parks and green systems during urbanization [24]. These studies show that urban parks not only beautify the urban environment and provide recreational spaces but also play a significant role in ecosystem services, enhancing community interaction, and mitigating urban heat island effects. By integrating GIS 10.2 technology and tools like Fragstats 4.2, scholars can analyze and compare the spatial distribution and morphological changes in park green spaces over different periods. For instance, some studies focus on how optimizing the spatial configuration and connectivity of parks can enhance their ecological benefits [25]. Additionally, changes in socio-economic data enable researchers to gain a deeper understanding of the impacts of urban expansion, population growth, and economic development on urban park patterns. In urban park landscape pattern research, landscape pattern indices (LPis) and Geographic Information System (GIS) technology are key tools [26]. Landscape

pattern indices describe the structure and function of landscapes through metrics like patch density, edge density, and uniformity index, aiding in assessing the fragmentation and connectivity of park systems [27]. GIS 10.2 collects and analyzes geospatial data, mapping the location and size of parks, and studying their spatial relationships with other urban elements [28]. Additionally, integrating remote sensing technology can monitor changes in urban green spaces, capturing rapid changes during urbanization. Researchers also use a combination of qualitative and quantitative methods through socio-economic studies and GIS 10.2 analysis, to fully understand the drivers of landscape changes. Model simulations like the CA-Markov model and geographically weighted regression are used to predict future landscape changes, providing a basis for urban planning. The comprehensive application of these methods not only enhances the accuracy of the research but also provides practical strategies for urban green space planning, helping researchers better understand and address the challenges of rapid urbanization. In the study of the driving mechanisms of urban park landscape evolution, researchers use various methods to analyze the causes of these changes. These methods include spatial analysis techniques, such as GIS 10.2 and remote sensing, which provide precise spatial data on landscape changes [29]; statistical modeling, such as regression analysis and multivariate statistics, used to determine the impact of various factors on landscape pattern changes [30]; system dynamics models, such as cellular automata and system dynamics models, which help simulate and predict the dynamics of landscape patterns [31]; ecological process simulations, using landscape ecology models to study how natural and human factors affect landscape patterns through ecological processes [32].

Nanchang is a typical representative of China's second and third-tier cities, capable of reflecting some common issues and development trends in the evolution process of park landscape patterns during urbanization in these cities. The study of Nanchang can provide beneficial references and insights for other similar cities. This article, based on landscape pattern indices and partial least squares regression analysis methods, quantitatively analyzes the evolution of park landscape patterns in the central urban area of Nanchang from 1999 to 2019, using time-section data from different periods to study the dynamic changes in park green landscape patterns. It associates landscape pattern indices with quantified urban context factors to determine the intensity of driving forces. In response to the pattern development issues in the evolution of park landscape patterns in the central urban area of Nanchang indicated by the research results, corresponding countermeasures and suggestions are proposed, providing important references and bases for the further optimization and construction development of Nanchang's park landscape pattern.

2. Materials and Methods

2.1. Overview of the Study Area

The research scope of this paper covers the central urban district of Nanchang City, which includes seven administrative regions: the Economic Development Zone, East Lake District, Qingshan Lake District, High-tech Zone, Honggutan District, West Lake District, and Qingyunpu District. The scope of the central urban area encompasses regions that centrally bear the city's dominant functions, aligned with the urban spatial layout, and development scale set forth in the city's master plan, and after evaluating urban land. Based on these principles, the range of Nanchang's central urban area is defined as starting from Changli and Maiyuan in the west, reaching Yao Lake in the east, initiating from Changnan Avenue in the south, and ending at the North Second Ring Road in the north. This demarcation focuses on the connection between natural landscapes, water bodies, and historical urban districts, covering a total research area of 35,500 hectares, as shown in Figure 1. As the core area, the central urban district is a focal point for urban planning and management. Studying the parks within this central district is representative and can more accurately reflect the development trajectory and evolution process of urban parks [33]. This study uses the range data of the central urban area sourced from the National Bureau of Statistics (<https://www.stats.gov.cn/> (accessed on 1 October 2023)).

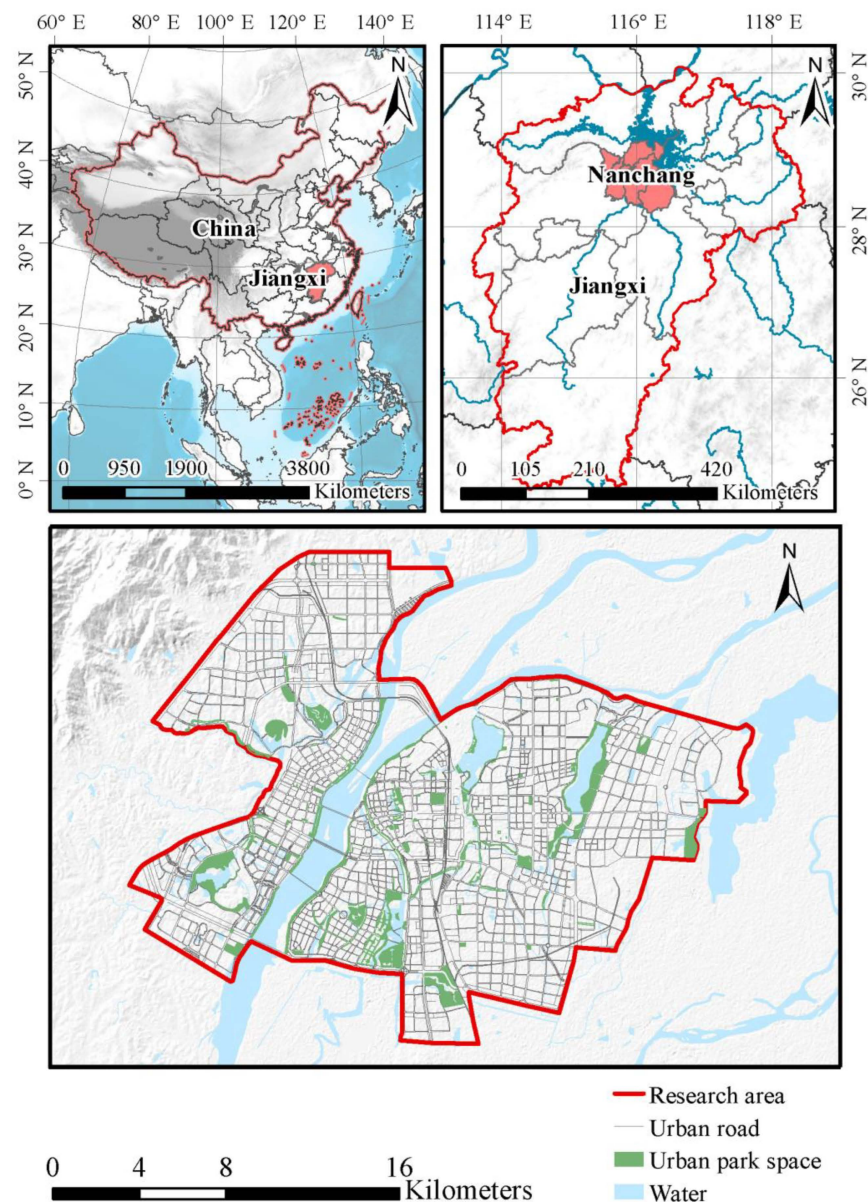


Figure 1. Map of the Research Area.

2.2. Data Sources and Preprocessing

2.2.1. Establishment of Park Database

Through the dynamic analysis of park construction in Nanchang, it was found that the city's parks entered a rapid development stage starting in the year 2000. Parks from five years: 1999, 2004, 2009, 2014, and 2019 were selected for analysis. This article collects statistical data within the study period, including overall urban planning, green space system planning, and park planning, sourced from the Jiangxi Provincial People's Government website (<http://www.jiangxi.gov.cn/> (accessed on 1 October 2023)), combined with actual field research to establish a vector database. Additionally, according to standards published by the Ministry of Construction, parks in Nanchang are categorized into four types: comprehensive parks (P1), community parks (P2), specialized parks (P3), and pleasure parks (P4), as shown in Table 1.

Table 1. Types of urban park landscapes and their characteristics.

Major Categories	Category Code Minor Categories	Category Name	Content	Remarks
G11		Comprehensive Park	Rich in content, suitable for all kinds of outdoor activities, with well-developed recreational and supporting management service facilities.	Should be larger than 10 hectares.
G12		Community Park	Independently located, with basic recreational and service facilities, mainly serves the nearby residents of a specific community for daily leisure activities.	Should be larger than 1 hectare.
G13		Specialized Park	Green space with specific content or form, with corresponding recreation and service facilities.	
	G131	Zoo	Under artificial breeding conditions, off-site conservation of wildlife, conducting scientific research such as animal breeding, and for popular science, viewing, and leisure activities, with well-developed facilities and interpretative signage.	
	G132	Botanical Park	Engaged in botanical scientific research, species introduction and domestication, plant conservation, and for viewing, leisure, and educational activities, with well-developed facilities and interpretative signage.	
	G133	Historic Park	Reflects the representative garden art of a certain historical period that requires special protection.	
	G134	Site Park	Formed mainly around significant sites and their background environments, having a demonstrative significance in site protection and display, and features cultural and leisure functions.	
	G135	Amusement Park	Set up independently, with large amusement facilities, in a good ecological environment. The greening ratio should be greater than or equal to 65%.	
	G139	Other Specialized Park	Besides the above types, green spaces with specific thematic content, mainly including children's parks, sports and fitness parks, waterfront parks, memorial parks, sculpture parks, and scenic parks within urban construction lands, urban emperor parks, and forest parks, etc.	The greening ratio should be greater than or equal to 65%.

Table 1. *Cont.*

Major Categories	Category Code Minor Categories	Category Name	Content	Remarks
G14		Pleasance Park	Apart from the various parks mentioned above, independently used land, smaller in scale or diverse in shape, convenient for residents to enter nearby, with certain recreational functions.	The width of strip gardens should be greater than 12 m; The proportion of green space should be greater than or equal to 65%.

Source: The author organized the classification standards for urban park green spaces based on the “Urban Green Space Classification Standards” (CJJ/T 85-2017) [34] issued by the Ministry of Construction.

2.2.2. Construction of Urban Context Driving Mechanism

Urban context is the inner expression of urban development, embodying the soul and characteristics of a city [35]. The evolution of the park landscape pattern in the central urban area of Nanchang is influenced by various urban context factors, dividing the urban context driving mechanisms into qualitative and quantitative driving forces. Qualitative driving forces are summarized as historical policy and urban planning factors, while quantitative driving forces are divided into natural, socio-economic, and urban construction factors. Among them, data on average annual temperature come from the National Meteorological Science Data Center (<http://data.cma.cn/> (accessed on 1 October 2023)), average annual precipitation data from the Jiangxi Provincial Department of Water Resources (<http://slt.jiangxi.gov.cn/> (accessed on 1 October 2023)), and elevation and slope data from Earthexplorer—USGS (<https://earthexplorer.usgs.gov/> (accessed on 1 October 2023)). Socio-economic and urban construction data are sourced from the Nanchang Municipal Bureau of Statistics (<http://tjj.nc.gov.cn/ncstjj/index.shtml> (accessed on 1 October 2023)).

2.3. Research Methods

The research methods used in this study primarily include literature review, combined quantitative and qualitative comparative analysis, ArcGIS 10.2 technology, and landscape pattern index analysis. Specifically, the analysis of the evolution of the park landscape pattern in Nanchang City is based on landscape ecology theory. Appropriate landscape pattern indices are selected, and technologies from the Fragstats 4.2 software platform and ArcGIS 10.2 are used to obtain changes in indices and patterns over different time periods. Additionally, for the analysis of the urban contextual driving mechanisms in Nanchang City, based on theories of human geography and urban planning, a qualitative analysis of urban contextual factors affecting the evolution of park landscape patterns is conducted. The SIMCA-P 14.1.0 combined with partial least squares regression equations, is used for quantitative analysis of these urban contextual factors in the evolution of park landscape patterns.

2.3.1. Analysis of the Evolution of Park Landscape Patterns in Nanchang

Geographic Information Systems (GIS) are a crucial component of geospatial information technology. ArcGIS is used for image data preprocessing and spatial analysis, such as cropping, projecting, raster extraction, raster calculation, reclassification, and creating attribute tables [36,37]. In this study, ArcGIS 10.2 was utilized to preprocess and statistically analyze the foundational information of parks from different periods and types. It visualizes the spatial analysis of park landscape patterns and establishes a vector database, providing a more systematic and intuitive revelation of the overall characteristics of park spatial distribution [38,39].

Quantitative research methods for landscape patterns mainly include spatial statistical methods [40], the landscape index method [41], and the fractal analysis method [42]. Landscape indices are quantitative indicators that reflect the composition and spatial

mosaic of landscape patterns, representing a high condensation of landscape pattern information [43]. Based on relevant domestic and international studies and considering the actual characteristics of the study area, this research has selected the following landscape pattern indices for a quantitative analysis of the evolution of urban park landscape patterns in Nanchang using the Fragstats 4.2 software platform technology [44,45]:

Number of Patches (NP): The number of patches at the type level equals the total number of patches of a certain type in the landscape; at the landscape level, it equals the total number of all patches in the landscape. The formula is as follows:

$$NP = n_i \quad (1)$$

In the above formula, n_i is the total number of patches of type i .

Patch Type Area (CA): The area of a patch type equals the sum of the areas of all patches of that type (in m^2) converted to hectares (in ha), which is the total area of that patch type. The formula for patch type area is as follows:

$$CA = \sum_{j=1}^n a_{ij} \left(\frac{1}{10000} \right) \quad (2)$$

In the above formula, j is the number of patches, ranging from 1 to n , and a_{ij} is the area of the j th patch of type i .

Mean Patch Area (MPS): At a specific patch type level, it equals the total area of that type divided by the number of patches; at the entire landscape level, it equals the total landscape area divided by the total number of different type patches. It can also indicate the fragmentation level of the landscape, and its changes can reflect richer ecological information about the landscape.

$$MPS = \frac{CA}{n} \quad (3)$$

In the above formula, CA is the patch area, and n is the number of patches.

Patch Density (PD): Refers to the number of patches of a certain landscape type per 100 hectares. It reflects the degree of landscape fragmentation and also the degree of spatial heterogeneity of the landscape. The higher the value, the higher the degree of fragmentation, and vice versa.

$$PD = \frac{n_i}{A} (10000) (100) \quad (4)$$

In the above formula, n_i is the total number of patches of type i , and A is the landscape area (in hm^2).

Largest Patch Index (LPI): Equals the proportion of the largest patch of a certain type to the total landscape area. The landscape patch index helps determine the landscape's modality or dominant types, etc. The size of its value determines the dominant species, the richness of internal species, and other ecological characteristics within the landscape; its changes can alter the intensity and frequency of disturbances, reflecting the direction and strength of human activities.

$$LPI = \frac{\max(a_1 \cdots a_n)}{A} (100) \quad (5)$$

In the above formula, n is the number of patch types, and A is the landscape area (in hm^2).

Landscape Shape Index (LSI): similar to the patch shape index, but calculated at the entire landscape scale, it measures the shape complexity of a certain type of patch by calculating the deviation of its shape from a circle or square of the same area.

$$LSI = \frac{0.25 \sum_{k=1}^m e_{ik}^*}{\sqrt{A}} \quad (6)$$

In the above formula, m is the number of patch types, and A is the landscape area (in hm^2).

Aggregation Index (AI): Based on the length of the common boundary between same-type patch pixels. When there is no common boundary between all pixels of a type, the aggregation degree of that type is the lowest; when the common boundary existing between all pixels of a type is maximized, the maximum aggregation index is achieved. The aggregation index examines the connectivity between patches of each landscape type. The smaller the value, the more dispersed the landscape.

$$AI = \left[\frac{g_{ii}}{\max \rightarrow g_{ii}} \right] (100) \quad (7)$$

In the above formula, g_{ii} is the number of similar adjacent patches of the corresponding landscape type.

Shannon Diversity Index (SHDI): At the landscape level, it equals the negative sum of the area ratio of each patch type multiplied by its natural logarithm. SHDI = 0 indicates the entire landscape is composed of a single patch type; an increase in the SHDI suggests an increase in patch types or a more balanced distribution of various patch types within the landscape. The Shannon diversity index is widely used in community ecology to detect diversity, reflecting landscape heterogeneity and is particularly sensitive to the uneven distribution of various patch types within the landscape.

$$SHDI = \frac{-\sum_{i=1}^m (P_i^* \ln P_i)}{\ln m} \quad (8)$$

In the above formula, m represents the number of patch types and is the area ratio occupied by the i th type of patch, and $\ln m$ is the maximum diversity index.

2.3.2. Analysis of Urban Context Driving Mechanism

The Partial Least Squares Regression (PLSR) model belongs to the multivariate statistical regression model, focusing on the analysis of spatiotemporal changes in land use and its driving factors [46]. Quantitative factors of urban context driving forces are used as independent variables in the model, while park area and overall landscape pattern indices serve as dependent variables. The regression model is constructed using SIMCA-P software, and the precision of the driving mechanism is verified to validate the regression's rationality, accuracy, and predictiveness [47], thereby exploring the impact of the urban context driving mechanism on the evolution of the park landscape pattern. The basic formula of the Partial Least Squares Regression (PLSR) [48] model is as follows:

$$Y = b_0 + \sum_{i=1}^n b_i X_i + \varepsilon \quad (9)$$

In the above formula, Y is the dependent variable (target variable); b_0 is the intercept term; X_i is the i th independent variable; b_i are the corresponding regression coefficients; ε is the error term.

Testing the precision of the driving mechanism verifies the regression's rationality. In the model constructed with SIMCA-P software, the value of Q^2 (cross-validation) is obtained through cross-validation. When $Q^2 \geq 0.0975$, it indicates that the regression model's robustness meets the requirements. The value of R^2Y (goodness of fit) represents the model's fit. When $R^2Y > 50$, it indicates that the regression model has high accuracy.

and predictiveness. The value of *VIP* (variable importance in the projection) reflects the importance of the independent variables relative to the dependent variable in the model. When $VIP > 1$, it indicates a very relevant relationship between the independent and dependent variables, with higher values signifying the greater importance of the independent variable relative to the dependent variable [49].

3. Results

3.1. Analysis of Overall Feature Evolution

Using the ArcGIS 10.2 platform, an attribute database for urban park types in the central urban area of Nanchang was established. Based on this, the classification numbers of urban parks from 1999 to 2019 were statistically analyzed, resulting in a spatial distribution of the parks for each period as shown in Figure 2. Referencing research standards for green space landscape patterns in many large and medium-sized cities in China, and considering the characteristics and scale of urban parks in the central urban area of Nanchang, urban park patches were divided into four levels: patches smaller than 1 hectare were classified as small patches; patches between 1 to 10 hectares as medium patches; patches between 10 to 50 hectares as large patches and patches larger than 50 hectares as extra-large patches. The spatial distribution of park patch levels for each period is shown in Figure 2.

Using the spatial query and statistical functions of ArcGIS 10.2, an analysis was conducted on the overall characteristics of the changes in the number and area of parks, as well as their distribution, in the central urban district of Nanchang from 1999 to 2019. The results are presented in Table 2 and Figure 3.

Table 2. Statistical table of various types of urban parks in the central urban area of Nanchang during the study period.

Year	Statistical Indicators	Comprehensive Park	Community Park	Specialized Park	Pleasance Park	Total
1999	N (Pieces) *	3	1	3	5	12
	A (hm ²) *	39.32	1.99	101.12	14.38	156.81
	AR (%) *	25.07	1.27	64.49	9.17	100.00
2004	N (Pieces)	5	1	4	13	23
	A (hm ²)	192.62	1.99	105.76	50.89	351.26
	AR (%)	54.84	0.57	30.11	14.49	100.00
2009	N (Pieces)	8	4	9	31	52
	A (hm ²)	212.17	84.36	257.13	138.05	691.71
	AR (%)	30.67	12.20	37.17	19.96	100.00
2014	N (Pieces)	12	7	16	40	75
	A (hm ²)	477.48	92.82	557.35	162.80	1290.45
	AR (%)	37.00	7.19	43.19	12.62	100.00
2019	N (Pieces)	17	12	21	75	125
	A(hm ²)	707.68	113.83	594.53	373.04	1789.08
	AR (%)	39.56	6.36	33.23	20.85	100.00

* N: Number; A: Area; AR: Area Ratio.

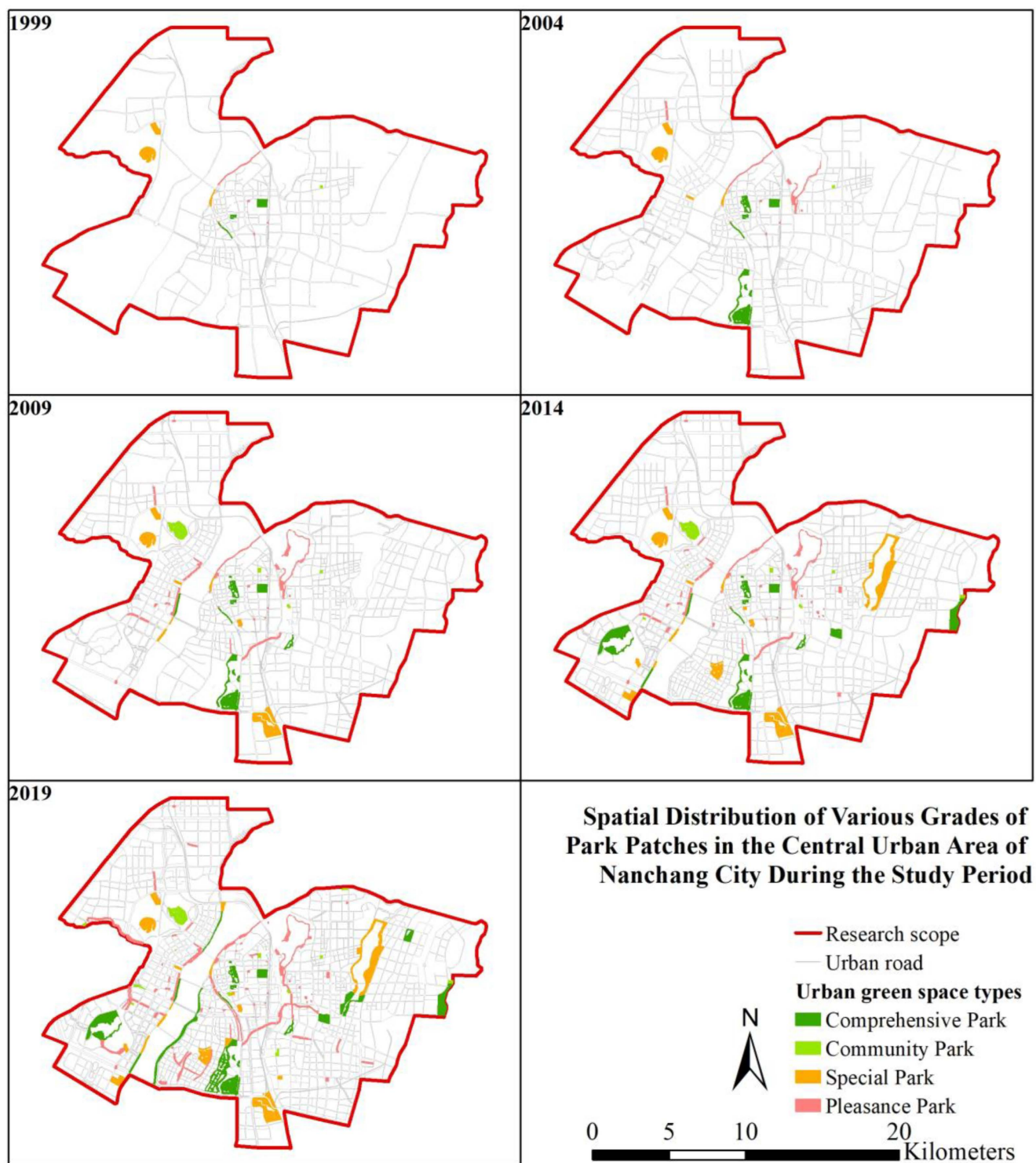


Figure 2. Spatial distribution of various grades of park patches in the central urban area of Nanchang city during the study period.

According to Table 2 and Figure 4, the area and number of parks in the central urban area of Nanchang have continuously increased from 1999 to 2019. The number of parks rose from 12 in 1999 to 125 in 2019; the total area of parks expanded from 156.81 hectares to 1789.08 hectares, more than ten times the area in 1999, showing a remarkably rapid growth trend with an average annual growth rate of 12.94%. During the study period, the number, area, and area percentage of parks of each type underwent significant changes. Among

them, comprehensive parks grew at a stable rate of 2, 3, 4, and 5 every five years. Given their more comprehensive service functions compared to other parks, comprehensive parks, acting as landmark public service green spaces, reflect the era's characteristics in Nanchang; hence, their area remained in the lead despite the less pronounced increase in number. The growth of community parks was relatively slow, with an increase of 3, 4, and 5 every five years after 2004. Due to their service range, functions, and target users often being limited to the surrounding residential population, their area has remained small with modest growth. Specialized parks added five parks in each period after 2004, with a stable growth rate. The completion of the Nanchang Zoo in 2011 and the Aixi Lake Scenic Area in 2014 led to a more than doubling of the area of specialized parks between 2009 and 2014. The most significant change was observed in pleasure parks, with their number in 2019 being 15 times that of 2014, related to Nanchang's construction of waterfront pleasure parks and street green space gardens in the later stages of urban planning.

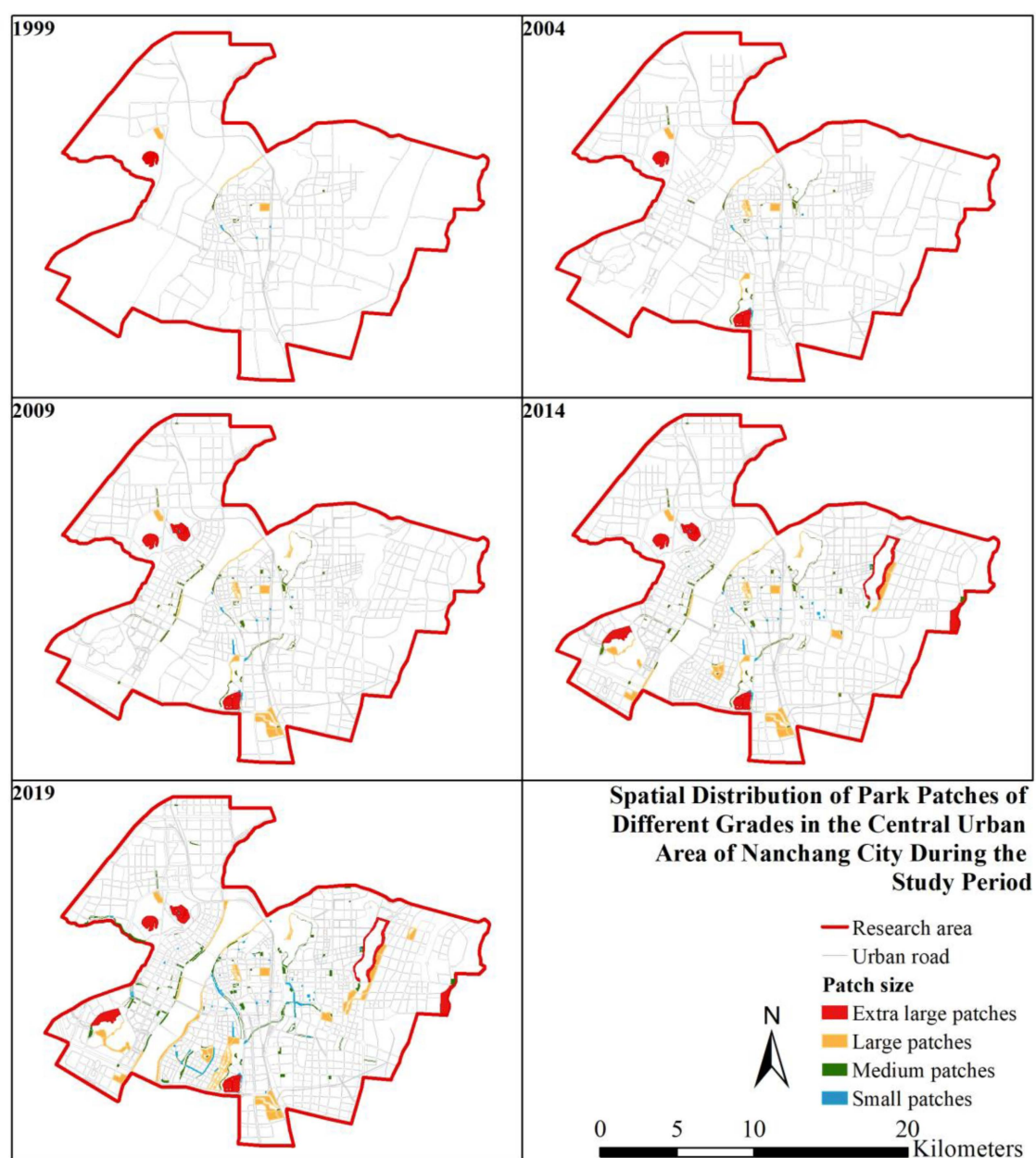


Figure 3. Spatial distribution of park patches of different grades in the central urban area of Nanchang city during the study period.

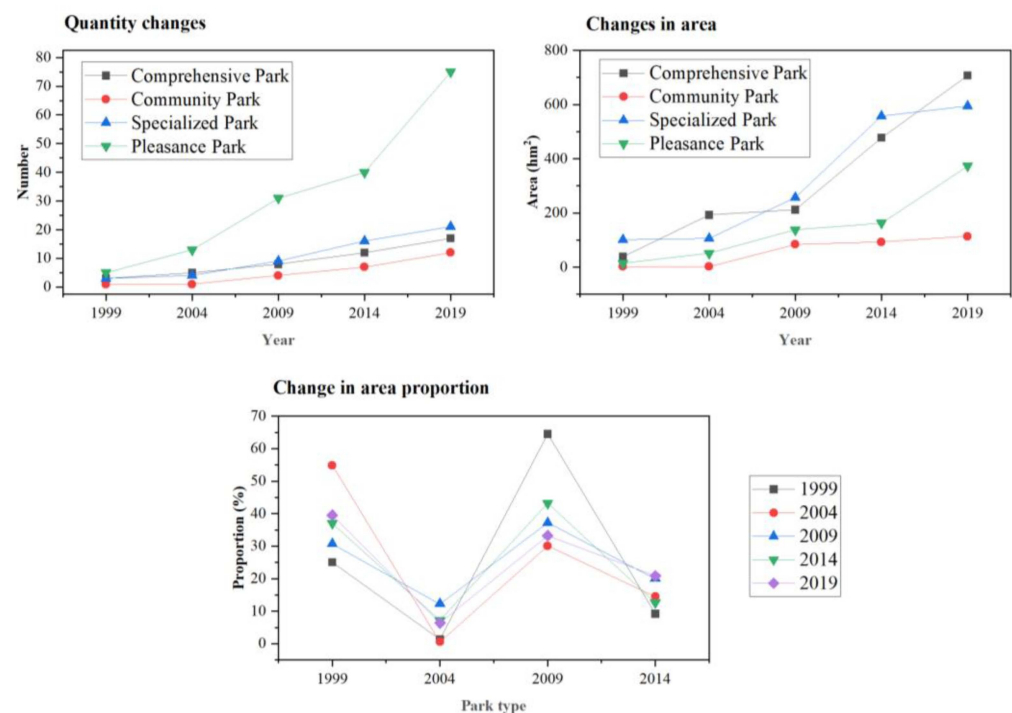


Figure 4. Comparative diagram of the changes in various types of urban parks in the central urban area of Nanchang City during the study period.

Combined with Figure 3, the evolution of the park's spatial pattern reveals an overall layout of “concentrating inward and expanding outward”. As the old city renovation plan in Nanchang progressed, the planning of parks in the old city became part of the city's renewal. Due to the limited available area in the old city, which is particularly suitable for the construction of community parks and pleasance parks, many were located near residential areas, office buildings, and waterfront green spaces, often displaying a “scattered” layout before 2009. With the city's expansion, the government began planning new district park constructions. To ensure ecological sustainability, since 2009, the city has built several large comprehensive parks and specialized parks such as wetland parks, botanical gardens, zoos, and pleasance parks, incorporating natural water resources. From the overall park layout perspective, between 2014 and 2019 green corridors were mainly composed of pleasance parks connected to different types of parks, emphasizing the connectivity and continuity between city parks.

3.2. Analysis of Landscape Pattern Evolution

To study the overall pattern changes in various types of parks, important landscape pattern indices were selected based on relevant domestic and international research methods, combined with the actual characteristics of the study area, to study their change features.

According to Table 3, Figures 2 and 5, the analysis of the evolution of park patch characteristics over 20 years shows that the number and area of parks in the central urban area of Nanchang have continuously increased, with the number of pleasance parks and the area of comprehensive parks changing most significantly. The change in the largest patch index indicates that the dominance of specialized parks is gradually decreasing, suggesting that human disturbances have a significant impact on specialized parks. The largest patch indices of various types of parks are gradually converging, indicating that the government's construction efforts for different types of parks in the central urban area of Nanchang are relatively even, and planning is moving towards balanced development. During the study period, the landscape shape index of various types of parks generally increased, indicating that the shapes of park patches have become more complex, and the dispersion in spatial

distribution has increased, spreading outward. From the analysis of park fragmentation evolution, the patch density can reflect the fragmentation degree of various types of parks, with the changes in pleasure parks being the most obvious. Between 2009 and 2014, pleasure parks mainly showed a regional distribution with high integrity. After 2014, intensified urban construction and city expansion drove the layout of pleasure parks, worsening their fragmentation degree. The comprehensive park is the only type with a decreasing patch density during the study period, indicating that comprehensive parks are still mostly distributed in densely populated central areas, showing a centrally concentrated pattern. From the analysis of park connectivity evolution, the aggregation index can reflect the connectivity of various types of parks. The overall increase in the aggregation index of pleasure parks is significantly higher than that of other types of parks, consistent with the situation reflected by their patch density with the most dispersed distribution and the poorest connectivity. The aggregation degree of specialized parks decreases year by year due to their marginal spatial distribution, low aggregation, and connectivity. From the analysis of park diversity evolution, the Shannon diversity index can reflect the diversity of landscape types and also the richness of the landscape structure and the balance of spatial layout in the area. The overall Shannon diversity index of parks in the central urban area of Nanchang increased during the study period, with a decline only from 2009 to 2014 due to the dispersion in spatial distribution caused by the construction of new large parks around the urban area. Gradually, Nanchang's park types have become more complex and diverse, enhancing biodiversity and showing a positive trend in green space construction and balanced spatial development.

Table 3. Statistical table of urban park landscape pattern indices for central Nanchang City during the study period.

Year	Type of Park	Patch Number	Patch Type Area (hm ²)	Mean Patch (hm ²)	Patch Density (No·km ²)	Largest Patch Index	Landscape Shape Index	Aggregation Index	Shannon's Diversity Index
1999	P1 *	5	39.32	7.86	3.18	20.06	3.24	96.36	0.91
	P2 *	1	1.99	1.99	0.64	1.31	1.14	98.95	
	P3 *	3	101.12	33.71	1.91	42.55	2.81	98.17	
	P4 *	5	14.38	2.88	3.18	7.32	7.49	82.42	
2004	P1	16	192.62	12.04	4.55	24.58	7.95	94.95	1.00
	P2	1	1.99	1.99	0.28	0.58	1.10	99.21	
	P3	6	105.76	17.63	1.71	19.00	3.21	97.83	
	P4	16	50.89	3.18	4.55	3.57	12.65	83.41	
2009	P1	21	212.17	10.10	3.04	12.50	9.40	94.18	1.31
	P2	5	84.36	16.87	0.72	10.66	3.83	96.88	
	P3	15	257.13	17.14	2.17	9.66	5.83	96.96	
	P4	62	138.05	2.23	8.97	1.86	20.07	83.52	
2014	P1	30	477.48	15.92	2.33	7.35	9.87	95.92	1.18
	P2	8	92.82	11.60	0.62	5.72	4.19	96.65	
	P3	32	557.35	17.42	2.48	8.46	10.00	96.16	
	P4	77	162.80	2.11	5.97	0.99	20.47	84.49	
2019	P1	46	707.68	15.38	2.57	5.30	15.45	94.55	1.23
	P2	13	113.83	8.76	0.73	4.12	5.25	95.96	
	P3	36	594.53	16.51	2.01	6.11	10.43	96.12	
	P4	221	373.04	1.69	12.36	1.53	30.45	84.63	

* P1: Comprehensive park; P2: Community park; P3: Specialized park; P4: Pleasure park.

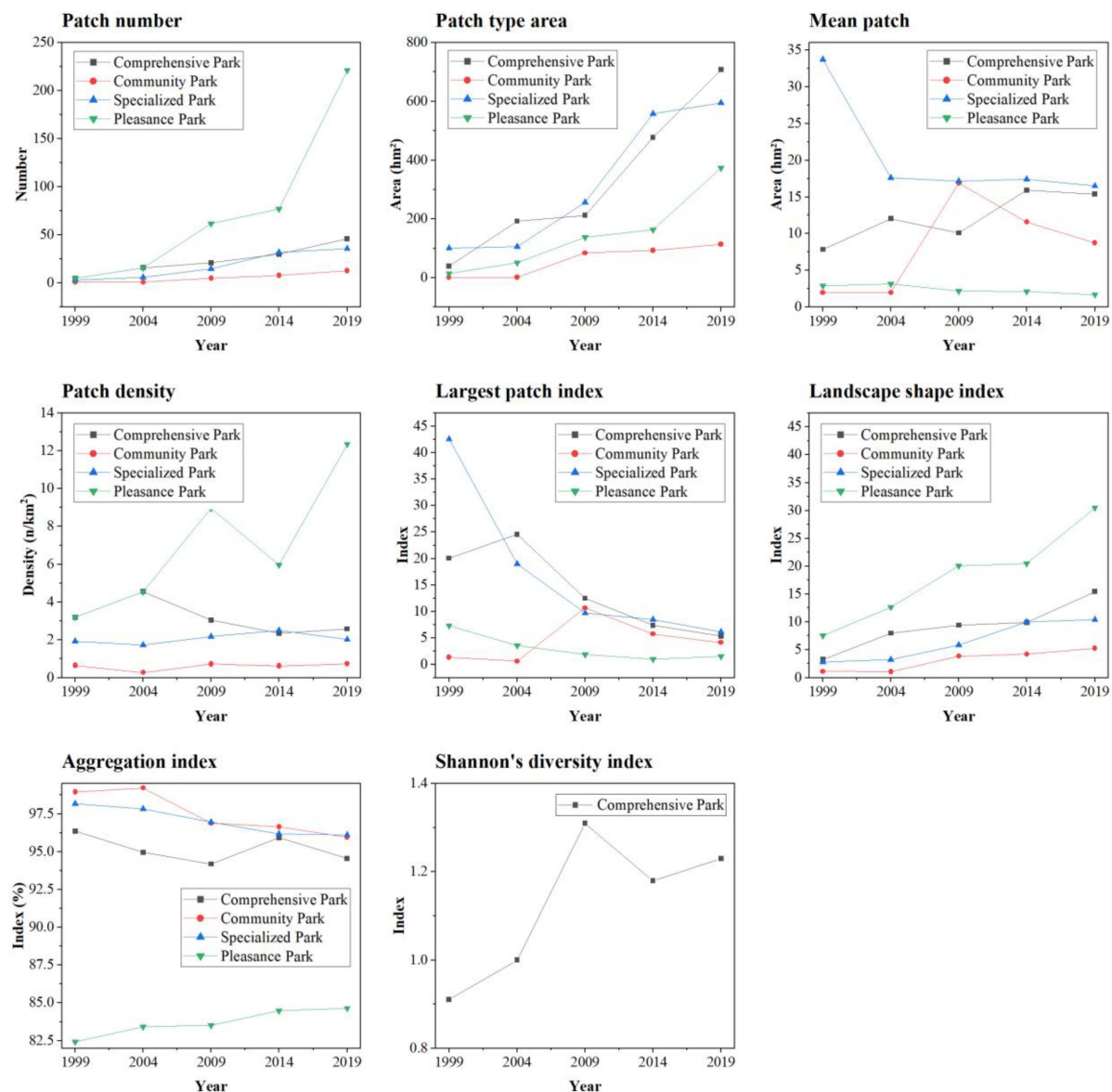


Figure 5. Comparative chart of changes in park landscape pattern indices in the central urban area of Nanchang city during the study period.

3.3. Analysis of Urban Context Driving Forces

As the city rapidly develops, the urban context continually changes. Over longer timeframes and larger spatial scales, natural conditions have a certain impact on the evolution of the landscape pattern of urban parks; over shorter timeframes and smaller spatial scales, socio-economic factors and urban construction cause direct changes to the landscape pattern of urban parks; especially within the central urban area, urban historical policies and related planning play a decisive guiding role [50].

3.3.1. Analysis of Qualitative Driving Force Factors

The qualitative driving forces of the urban context mainly include urban historical policies and related planning. Table 4 is the table of urban green space construction activities in Nanchang City. This table summarizes the goals, start times, achievement times, relevant historical policies, and long-term planning initiatives aimed at enhancing urban green spaces in Nanchang City.

Table 4. Urban green space construction activities in Nanchang City.

Goal	Start Time	Achievement Time	Historical Policies and Planning	Long-Term Planning
International Garden City	2001	2006	“Nanchang City Urban Greening Plan” “Nanchang City Urban Ecological Environment Protection Plan” “Nanchang City Urban Environment Comprehensive Treatment Plan” “Nanchang City Urban Traffic Development Plan” “Nanchang City Urban Tourism Development Plan” “Nanchang City Plan for Becoming a National Model City for Environmental Protection”	“Nanchang City Master Plan (2001–2020)”
National Garden City	2002	2007	“Nanchang City Water Functional Area Planning” “Nanchang Ecological City Construction Planning” “Nanchang City National Garden City Implementation Plan” “Nanchang City Park Regulations” “Nanchang City Star-rated Park Evaluation Methods”	“Nanchang City Comprehensive Environmental Quality Standards Planning (2005–2010)” “Nanchang City Land Use Master Plan (2006–2020)”
National Forest City	2004	2015	“Nanchang National Forest City Construction Master Plan” “‘Forest Urban-Rural Areas, Garden Nanchang’ Construction Project Implementation Detailed Rules” “‘Forest Urban-Rural Areas, Garden Nanchang’ Construction Implementation Opinions” “Opinions on Fully Implementing the Forest Chief System”	“Nanchang Forest City Construction Master Plan (2011–2020)” “Nanchang City Short-term Construction Plan (2011–2015)”
National Ecological Garden City	2005	Not Achieved	“Nanchang City Urban Greenway Construction Planning” “Nanchang City Ancient and Famous Trees Protection Management Methods” “Nanchang City Urban Low Impact Development Planning” “Jiangxi Province Forest Park Regulations”.	“Nanchang City Urban Green Space System Planning (2015–2020)” “Nanchang City Ecological Environment Protection Planning (2016–2020)”
National Park City	2018	Not Achieved	“Interim Measures for the Operation and Management of Urban Park Supporting Service Projects” “Jiangxi Wetland Park Management Measures” “Guiding Opinions on Establishing a System of Nature Reserves Centered on National Parks” “Jiangxi Province 2023 Urban Park and Green Space Open Sharing Pilot Work Plan” “Jiangxi Province 2023 ‘Pocket Park’ Construction Work Plan”	“Nanchang City Park System Development Plan (2021–2035)” “Nanchang City Master Plan (2016–2035)”

After the 21st century, aiming to become an “International Garden City”, Nanchang has carried out urban greening activities. Between 2001 and 2006, Nanchang formulated a series of specific plans and policies. The implementation of these planning policies improved the city’s green coverage, protected the ecological environment, enhanced the quality of the urban environment, strengthened the construction of urban transportation and tourism infrastructure, and promoted the development of environmental protection endeavors. Starting in 2002, Nanchang initiated efforts to become a “National Garden City” and officially proposed the plan to strive for the “National Garden City” status in 2005. Nanchang made significant progress in urban greening, with steady advancement in the construction of city parks, leisure greenways, and leisure spaces. Numerous parks of various sizes distributed within the urban area greatly enhanced residents’ sense of belonging and identity. The city’s safety, comfort, and functional satisfaction improved annually, directly promoting the evolution of Nanchang’s park spatial pattern, leading to its inclusion in the National Garden City list for the first time in 2007. Nanchang began efforts to become a “National Forest City” in 2004 and, in 2009, to implement the “Forest Urban-Rural Areas, Garden Nanchang” construction plan, aimed to create a large ecological park in the Qingshan Lake District. The work plan proposed establishing four major ecological conservation areas, including five lakes in the central urban area of Nanchang—Qingshan Lake, Qian Lake, Xiang Lake, Yao Lake, and Aixi Lake—as well as the ecological conservation area along the Ganjiang River. This significantly advanced the development of waterfront and lakeside pleasure parks. In 2015, Nanchang was officially named a “National Forest City”, with the next goal being to become a “National Ecological Garden City”. A series of greening construction plans were formulated to create a “National Ecological Garden City”, strengthening the connection between urban and regional forest ecosystems, improving large-scale forest land systems, and utilizing existing natural resources to construct a number of parks around the urban area. With the introduction of the “Park City” concept in 2018, Nanchang has advanced the construction of urban parks, greenways, and integrated water and green spaces, focusing on connecting parks, greenways, and street green spaces in the evolution of park landscape patterns to achieve the goal of “seeing green space every 300 m and a park every 500 m”.

From 1999 to 2014, the development of parks in Nanchang City was mainly influenced by Nanchang’s master plan, green space system planning, forest city construction planning, land use planning, and short-term construction planning [51]. The “Nanchang City Master Plan (2001–2020)” proposed to highlight the characteristics of a landscape garden city, relying on the natural elements of “one mountain, one river, two streams, and eight lakes” to construct a circular radial urban green space structure in the central urban area, evolving the park landscape pattern to gradually expand from the center to the periphery. Under the guidance of the master plan, the “Nanchang City Land Use Master Plan (2006–2020)” integrated the three major natural ecological resources surrounding the urban area to form a distinctive scenic belt with the Ecological Development Belt along the Ganjiang River as the axis, organically connecting the inner and outer rings of the urban area. To join the ranks of “National Forest Cities”, the “Nanchang Forest City Construction Master Plan (2011–2020)” emphasized the construction of five ecological forest wetland parks in the central urban area of Nanchang, including Aixi Lake, Yao Lake, Xiang Lake, Yuzhou Bay, and Kongmu Lake. The “Nanchang City Short-term Construction Plan (2011–2015)” proposed adding parks to various administrative areas of the urban district, enhancing the construction of street green spaces and small pleasure parks. The “Nanchang Urban Green Space System Plan (2015–2020)” played a direct guiding role in the evolution of the green space landscape pattern. The plan proposed integrating the city’s spatial form and core resources to create a central urban green space system structure that showcases the city’s natural and cultural landscapes. With the Ganjiang River landscape belt at its core, it orchestrated the overall planning and, through the green ring around the urban area, formed an urban green landscape where water and mountains blend. This approach aimed to prevent haphazard urban sprawl and ensure a balanced distribution of various types of

green spaces. The “Nanchang City Ecological Environment Protection Plan (2016–2020)” advocates for the prioritized advancement of park construction in areas such as the Donghu District, Xihu District, and Qingyunpu District. It suggests leveraging natural resources like urban water systems and mountains to build ecological parks in regions including the Ganjiang New District and Honggutan New District. Additionally, in conjunction with urban renewal and transformation efforts, the plan proposed the creation of a number of community parks within old city areas and shantytown renovation projects. These efforts aimed to enhance the living environment quality for residents by employing strategies such as “finding spaces for greenery and replacing illegal constructions with green spaces”.

The area and number of parks in the central urban area of Nanchang City have been further increased with a more rationalized layout and continuously improved green space connectivity. Historical policies and planning provided a basic framework and direction for park construction, determining priority areas, types, and scales for park construction and ensuring the balanced development of the park system. These policies and planning have had a long-term impact on the evolution of Nanchang’s park landscape pattern.

3.3.2. Analysis of Quantitative Driving Force Factors

The quantitative driving force factors mainly include natural factors, socio-economic factors, and urban construction factors. The table conducts partial least squares regression analysis on both park area and landscape pattern indices.

As revealed by Table 5, within natural factors, elevation and slope have a significantly greater impact on the evolution of the park area in Nanchang’s central urban district than average annual temperature and precipitation. Furthermore, they are negatively correlated with this evolution, indicating that parks in the central urban area are predominantly situated in flat, low-elevation regions. The change in pleasure park areas is significantly influenced by elevation, while the evolution of community park areas is closely related to changes in slope, which is consistent with the service nature of pleasure parks and community parks. Pleasure parks are independently located, generally smaller in area and scale, with a large number of waterfront strip pleasure parks distributed in the central urban area conveniently accessible to nearby residents, thus they are usually built on flat land at lower elevations. Community parks are primarily for fitness, sports, and leisure, so they are built on gently sloping terrain. The average annual temperature significantly affects the fragmentation and aggregation of park landscapes; an increase in temperature may reduce the connectivity of parks, possibly related to some greenhouse effect caused by urban construction activities expanding the urban area, leading to a more dispersed distribution of parks with urban expansion. An increase in elevation and slope can increase the fragmentation of park patterns and reduce landscape diversity.

According to Table 6, among socio-economic factors, population, regional GDP, fiscal revenue and expenditure, tourism, and technology all play a positive role in increasing park area. The intensification of urbanization and population growth increases the demand for urban public services, economic development enhances the living standards, and tourism stimulates urban park development, leading the government to invest more funds in the construction, operation, and maintenance of parks. The adjustment of the urban industrial structure has varying effects on different types of parks: the primary industry promotes the increase in the area of comprehensive parks and pleasure parks, while the tertiary industry inhibits the growth in the area of community parks and specialized parks. In terms of landscape pattern evolution, an increase in permanent population, due to different population density distributions in various areas, necessitates dispersed park layouts to meet the accessibility of residents within the service range of parks, exacerbating fragmentation. The imbalance between fiscal revenue and expenditure and per capita income levels across urban regions leads to more concentrated development of pleasure parks and community parks in economic development zones, thus decreasing landscape fragmentation and connectivity. The primary industry, mainly agriculture, forestry, animal husbandry, and fisheries, increases the proportion of output value, promoting a patchy layout of

parks, reducing landscape fragmentation and diversity, and improving connectivity and aggregation. The secondary industry, mainly related to urban construction and housing construction, increases the rate of urbanization, leading to higher landscape fragmentation and diversity, while reducing connectivity and aggregation. The tertiary industry, primarily the service sector, can influence urban planning layouts and land use types, thereby promoting landscape fragmentation and connectivity, and reducing aggregation and diversity.

Table 5. Analysis of park landscape pattern evolution and natural factors driving.

Natural Factors	Area										Landscape Pattern Index					
	Comprehensive Park		Community Park		Specialized Park		Pleasance Park		Division		Connect		Aggregation Index		Shannon's Diversity Index	
	VIP *	RC *	VIP	RC	VIP	RC	VIP	RC	VIP	RC	VIP	RC	VIP	RC	VIP	RC
Average Annual Temperature	0.98	0.28	0.86	−0.07	0.74	0.22	0.94	0.24	1.09	0.01	0.89	−0.65	1.16	−0.63	0.83	0.14
Average Annual Precipitation	0.57	0.16	0.22	−0.11	0.64	0.19	0.16	0.04	0.09	−0.13	0.21	0.08	0.76	0.48	0.65	−0.39
Elevation	1.33	−0.38	1.20	−0.41	1.30	−0.38	1.37	−0.35	1.26	0.15	1.24	0.42	1.09	0.35	1.11	−0.33
Slope	0.97	−0.27	1.33	−0.65	1.16	−0.34	1.11	−0.28	1.11	0.18	1.27	0.57	0.93	0.05	1.29	−0.56

* VIP: Variable Projection Importance; RC: Regression Coefficient. If the VIP value is greater than 1, it indicates that it is an important influencing factor, with larger values having a more significant impact; a positive RC indicates a positive correlation between the driving force and the park landscape pattern, whereas a negative RC indicates a negative correlation [49], the same below.

Table 6. Analysis of park landscape pattern evolution and socio-economic factors driving.

Socio-Economic Factors	Area										Landscape Pattern Index					
	Comprehensive Park		Community Park		Specialized Park		Pleasance Park		Division		Connect		Aggregation Index		Shannon's Diversity Index	
	VIP	RC	VIP	RC	VIP	RC	VIP	RC	VIP	RC	VIP	RC	VIP	RC	VIP	RC
Pop. *	1.06	0.11	1.08	0.31	1.04	0.07	1.05	0.11	1.05	0.23	1.11	−0.29	0.94	−0.34	1.08	0.20
GRP *	1.09	0.12	1.02	0.30	1.08	0.37	1.08	0.12	0.91	−0.03	1.01	−0.22	0.89	0.38	0.88	0.08
GDP/Cap *	1.08	0.12	1.07	0.38	1.09	0.39	1.07	0.11	0.93	−0.01	1.04	−0.28	0.92	0.38	0.91	0.11
Rev. *	1.09	0.12	0.97	0.15	1.06	0.30	1.08	0.12	0.88	−0.04	0.97	−0.11	0.84	0.34	0.85	0.04
Fin. Exp. *	1.08	0.12	0.98	0.23	1.05	0.30	1.08	0.12	0.87	−0.04	0.97	−0.16	0.82	0.31	0.85	0.04
Pri. Ind. % *	0.99	−0.11	1.08	0.04	1.03	0.04	0.94	−0.10	1.20	−0.35	1.12	0.07	1.07	0.50	1.15	−0.24
Sec. Ind. % *	0.15	0.02	0.91	0.18	0.66	0.43	0.43	0.01	1.44	0.46	1.01	−0.25	1.24	−0.44	1.56	0.41
Tert. Ind. % *	1.03	0.11	1.07	−0.64	1.00	−0.50	1.05	0.11	0.86	0.28	0.97	0.40	1.30	−0.98	0.82	−0.03
Tourists *	0.99	0.11	0.85	0.01	0.90	0.24	1.06	0.13	0.83	0.10	0.85	−0.04	1.07	−0.61	0.80	−0.04
Tech. Turn. *	1.07	0.12	0.94	0.14	1.02	0.24	1.08	0.12	0.86	−0.39	0.94	−0.10	0.78	0.24	0.84	0.01

* Pop.: Resident Population; GRP: Gross Regional Product; GDP/Cap: GDP per Capita; Rev.: Revenue; Fin. Exp.: Financial Expenditure; Pri. Ind. %: Proportion of Primary Industry Output Value; Sec. Ind. %: Proportion of Output Value of the Secondary Industry; Tert. Ind. %: Proportion of Output Value of the Tertiary Industry; Tourists: Number of Tourists; Tech. Turn.: Technology Turnover.

From Table 7, it can be seen that among urban construction factors, the increase in the overall society's fixed asset investment has driven urban construction, thereby significantly increasing the area and number of parks. Among these, real estate development investment, which is a part of the overall society's fixed asset investment, has promoted the construction of comprehensive parks, community parks, and pleasance parks in the surrounding areas after the reduction in the public fund loan interest rate in Nanchang in 2015. However, the replacement of land use to higher-yield land types may inhibit the development of specialized parks. The urban greening coverage rate, garden green spaces, and the area of public green spaces can reflect the overall level of urban greening. Among these, the area of urban garden green spaces does not include specialized park-type green spaces, thus potentially restraining the growth in the area of specialized parks. Additionally, increasing the coverage area of greenery can lead to an overall increase in park areas. In terms of landscape pattern evolution, urban construction factors have a more significant impact

on landscape aggregation. The increase in real estate development investment causes the park layout to disperse, reducing aggregation. The improvement in the overall level of urban greening inhibits landscape connectivity and aggregation, but the continuous optimization of urban greening space development has enhanced park diversity. Improved accessibility between parks due to convenient transportation means that parks are more densely distributed in areas with developed road networks, thereby increasing landscape aggregation, which reduces landscape diversity in the same area.

Table 7. Analysis of park landscape pattern evolution and urban construction factors driving.

Urban Construction Factors	Area										Landscape Pattern Index					
	Comprehensive Park		Community Park		Specialized Park		Pleasance Park		Division		Connect		Aggregation Index		Shannon's Diversity Index	
	VIP	RC	VIP	RC	VIP	RC	VIP	RC	VIP	RC	VIP	RC	VIP	RC	VIP	RC
Total FAI *	1.04	0.18	1.02	1.35	1.01	0.18	1.05	0.18	0.86	0.00	0.94	−0.11	1.06	0.19	0.78	0.24
RE Dev. Inv. *	1.01	0.18	0.90	0.35	0.99	−0.18	1.06	0.18	0.88	0.13	0.91	0.13	1.01	−0.54	0.86	0.18
Urban Garden Area *	1.04	0.18	0.95	−0.23	1.00	−0.46	1.07	0.18	0.88	0.15	0.96	−0.15	1.01	−0.70	0.88	0.26
Public Green Area *	1.05	0.18	0.99	−0.89	1.01	0.14	1.04	0.18	0.89	0.18	0.96	−0.15	1.00	−0.31	0.79	0.07
Urban Green Cov. *	0.82	0.14	1.22	0.80	0.91	0.43	0.83	0.14	1.48	0.88	1.29	−0.68	0.99	−0.57	1.39	0.98
Total Road Length *	1.02	0.18	0.88	−0.34	1.06	0.53	0.93	0.16	0.85	−0.11	0.89	0.05	0.91	1.20	1.14	−0.76

* Total FAI.: Fixed Asset Investment in the Whole Society; RE Dev. Inv.: Real Estate Development Investment; Urban Garden Area: Urban Garden Green Space Area; Public Green Area.: Public Green Area; Urban Green Cov.: Urban Green Coverage; Total Road Length: Total Length of Roads.

4. Discussion

4.1. The Impact of Evolution Characteristics and Driving Mechanisms on the Park Landscape Pattern in the Central Urban Area of Nanchang City

The landscape pattern of urban parks directly influences the recreational activities of residents [52]. To analyze the relationship between the urban park landscape pattern and various influencing factors and to explore the driving mechanisms behind the evolution of urban parks, this section summarizes the impact of the evolution characteristics and driving mechanisms on the park landscape pattern in the central urban area of Nanchang City, based on the quantitative analysis results of the evolution of the park landscape pattern from 1999 to 2019.

The overall layout of parks in the central urban area of Nanchang City shows an evolutionary trend from “central aggregation” to “core aggregation in each district”, and from “central scarcity, more on the periphery” to “concentrating inward and expanding outward”. Comprehensive parks are more concentrated in the area east of the Ganjiang River, with fewer distributions in the west. Community parks are arranged in a “scattered” layout, specialized parks in a “marginalized” distribution, and pleasance parks have the most severe fragmentation, showing a “dispersed” layout. The overall layout is uneven, and the lack of green corridor links between parks prevents the integration of surrounding ecological resources into the urban greening development [53]. Old urban areas face a shortage of urban park resources, insufficient per capita greening, traffic congestion, and a lack of parking and other supporting facilities; new urban areas have a homogeneity issue with park types, lack of urban identity and distinctive regional characteristics, varying accessibility, and a lack of support from the public transportation system [54,55].

The park landscape pattern is driven by multiple factors including urban context natural factors, socio-economic factors, urban construction factors, and historical policies and related planning. Natural factors impact the park pattern over a long-term evolution process, where slope and elevation directly affect park site selection and land use types. Among socio-economic factors, economic progress stimulates an overall increase in urban park areas, with the permanent population and the primary and secondary industries being

important factors affecting the landscape pattern. The three basic industry types have either a positive promotion or a negative inhibition effect on different types of parks and the overall landscape pattern. Among urban construction factors, an increase in fixed asset investment and the rapid rise of the real estate market have led to significant attention for urban ecological space, thus greatly increasing park area. Parks are an important part of the greening system, making urban green coverage one of the most important influencing factors in urban construction factors.

As the impact of social integration and community design on the evolution of park landscape patterns deepens, the number of pleasure gardens in the central urban area of Nanchang continues to rise. The layout of these pleasure gardens closely mirrors the urbanization process, indicating that pleasure gardens are likely to be a trend in future urban park development. This is because they require less space and are relatively simpler to implement compared to comprehensive parks. Moreover, urban parks, as part of public spaces, facilitate interaction and communication among members of different communities. Designing inclusive parks provides a gathering place for residents of various ages, cultural backgrounds, and social strata, thereby fostering integration and establishing social relationships within communities. Community participation plays a crucial role in the planning and design of urban parks. Engaging residents in the design and planning of parks not only enhances the applicability of the parks and meets the actual needs of the residents but also strengthens their sense of belonging and responsibility towards the community environment.

4.2. Recommendations for Optimizing the Urban Parks Landscape Pattern in the Central Urban Area of Nanchang City

Nanchang is currently undergoing a rapid phase of urban morphological evolution. Many new urban areas are still in the early stages of planning. Leveraging local conditions and inheriting historical culture, the overall urban plan aims for a balanced and coordinated development of the city's structure. The plan provides guiding suggestions for the future layout of parks in Nanchang's central urban area. Figure 6 overlays the layout of park spaces in the central urban area from 2019 with the distribution of park spaces in the planning documents to produce a map of newly planned park spaces. This map shows the government's efforts to optimize the layout of urban green spaces by constructing an interconnected network of "parks + greenways". This network aims to link major city parks through greenways, thus increasing the overall amount of greenery to achieve the goal of "seeing green space every 300 m and a park every 500 m".

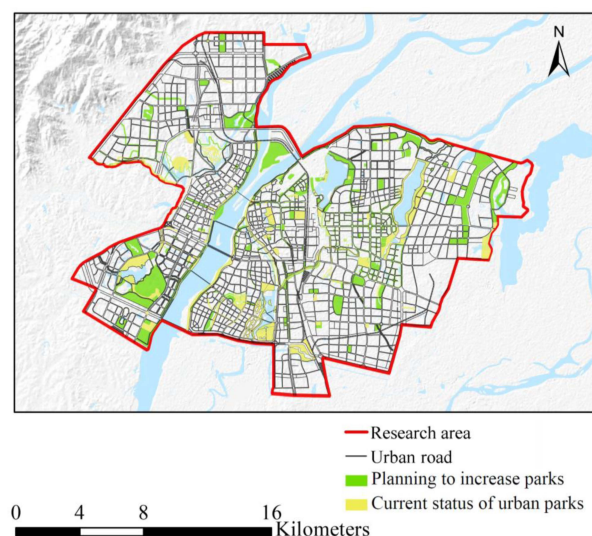


Figure 6. 2019 Distribution Map of Newly Planned Park Spaces in Nanchang Central Urban Area.

This article correlates the dynamics of park evolution with the development and changes in the urban context, providing important references and a basis for the further optimization and development of the park landscape pattern in Nanchang City. The recommendations are as follows:

4.2.1. Park Landscape Pattern in Nanchang City

Starting from a “point, line, surface” structure, rationally plan the layout of additional parks and effectively enhance existing parks. Utilizing the spatial characteristics of interconnected rivers and lakes in the existing urban area, and relying on urban water bodies integrated with regional cultural characteristics, form a blue and green space park collective that integrates ecology and functionality [56]. Additional comprehensive parks should be built in the “West Ganjiang Area” to strengthen the development of wetland parks; community parks should be planned according to population density in old urban areas using strategies like “vertical greening”, “turning illegal constructions into green spaces”, and “adding green to unused spaces” to enhance the green volume of parks in Nanchang City, improve connectivity, and link various green spaces to form an ecological park network. To meet the needs of residents of different ages, specialized parks should be added in excellent ecological areas such as cross-sections of urban green corridors, based on the service capabilities of specialized parks, and cultural parks and scenic spots should be created relying on historical streets; ribbon pleasure parks built along the water should link other types of parks, combining roads and population density to extensively build pleasure parks along river corridors.

4.2.2. Urban Context Driving Mechanisms

Changes in socio-economic development, urban construction implementation, and policy planning further promote changes in the park landscape pattern. Population size, real estate development, urban industrial structure adjustment, and urban land scale expansion change the park landscape pattern [57]. With the continuous rise in the city’s permanent population, the construction of large municipal parks should be prioritized to address the uneven distribution of urban parks and insufficient service coverage, thereby improving the living environment for urban residents. As the city’s economic income level increases, the government should pay more attention to investment in urban park construction and land allocation, avoiding excessive real estate development. Site selection should consider the existing and planned parks’ service areas to enhance the livability of the area. Although new urban development and expansion also increase the overall green volume of the city, the analysis results of decreased landscape aggregation indicate low connectivity between parks with severe fragmentation. Attention should be paid to areas lacking green volume, increasing effective green connections to form a more rational ecological park network.

4.2.3. Urban Park Related Planning

During the research period, the most important factors influencing the evolution of the park landscape pattern were the city’s master plan and the green space system plan. Nanchang’s master plan established the structural characteristics of a landscape garden city, guiding the urban green space layout in the green space system plan. The results show that the area and number of parks have significantly increased, with the landscape pattern transitioning from unorganized development to rational planning, moving Nanchang’s park construction from “seizing every gap for greening” to “planned greening”. Recently, the “Nanchang City Park System Development Plan (2021–2035)” proposed a development direction from “functional city to garden city to park city”, providing practical and forward-looking guidance for the layout of parks in Nanchang City. In the implementation process, park planning should seek a balance between urban development and ecological space, properly regulate time, space, quantity, area, and structure, and incorporate factors

related to the urban context into the park planning system analysis to promote the benign development of urban context and park landscape layout.

4.3. The Significance of This Study for Urban Park Construction

Previous studies on urban park landscape patterns have primarily focused on the overall layout of urban parks and the dynamic evolution of landscape patterns, including the mechanisms driving these changes [8,14,16,26]. Most of these studies have conducted qualitative analyses to explore the causes of landscape pattern changes, with few involving quantitative analyses of the driving mechanisms from the perspective of urban context. This paper builds on the existing framework of factors influencing urban context to construct a mechanism driven by urban context and uses partial least squares regression models to analyze the correlation between urban context and the evolution of urban park landscape patterns. Compared to previous research, this study stands out in several significant ways. Firstly, whereas most previous research typically covers a ten-year period, our study spans twenty years, providing a more comprehensive dataset for the evolution of urban park landscapes. Secondly, while previous studies mainly focused on qualitative analysis, this study structurally incorporates quantitative factors, resulting in more compelling data-driven conclusions. Lastly, few studies have differentiated among types of parks; this research delves deeper by examining the evolution of different types of parks, thoroughly analyzing the deeper dynamics and mechanisms driving urban park development through the stages of urban growth.

Studying the evolution of park landscape patterns and the urban context-driven mechanisms in Nanchang's central urban area offers crucial insights for the construction of parks in other Chinese cities. By analyzing the historical evolution of park landscapes in Nanchang's central urban area, the study reveals how urban development and park construction interact, showing how urban expansion, population growth, and industrial or commercial developments can propel or constrain the development and layout of parks. This understanding can help other cities anticipate and plan for future changes, ensuring their park systems adapt well to urban development needs. The consideration of urban context, including historical evolution, geographic location, and cultural traditions, significantly impacts park function, design style, and relevance to city life. By integrating local cultural elements and historical features into park design, other cities can learn how to better reflect their urban identity and cultural values in park planning. Furthermore, the study from Nanchang shows how modern technology and methods, like GIS technology and landscape pattern indices, can be used to enhance the ecological functions and social services of parks, improving not only their ecological benefits but also their attractiveness and accessibility to urban residents.

4.4. Uncertainty and Limitations

This paper has achieved some research outcomes in the study of park landscape pattern evolution and urban context-driving mechanisms. However, there are still many uncertainties and limitations in the research process and results.

In the analysis of urban context driving mechanisms, although the importance of natural environment, socio-economic, and urban construction factors has been clarified, the specific driving mechanisms and their interrelationships might be influenced by a variety of factors. Changes in policy formulation and urban planning, as well as the evolution of social culture, could have complex effects on the driving mechanisms, and these impacts are difficult to fully capture and quantify. Future research could employ more complex modeling methods, including system dynamics models or agent-based models, to better capture the complex relationships between different factors. Furthermore, in-depth studies on policy changes and the long-term impact of social culture on urban context will help to understand their effects on the park landscape. Due to the limitations in the study period, research covering long time spans or extensive areas may not fully consider the impact of local changes and specific events, thus potentially overlooking some key dynamic factors.

Future studies could integrate data across more dimensions and longer time spans to fully understand the complexity of park landscape evolution. Additionally, through in-depth research on specific locations and periods, a more detailed understanding of the impact of local changes and specific events on the park landscape can be achieved. Interdisciplinary research and deep collaboration between urban planning and ecology will help to reveal more comprehensively the impact of urban context on the evolution of park landscape patterns. By exploring these methods and directions, the uncertainties and limitations in the study of park landscape evolution can be better addressed. Future research could also consider combining multi-source data, such as remote sensing, geographic information systems, and field surveys, to obtain more comprehensive and precise information on green space changes.

5. Conclusions

This study utilized technical means such as ArcGIS 10.2, Fragstats 4.2, and SIMCA-P software platforms to analyze the spatial layout of parks and their spatiotemporal changes over five research periods. By integrating quantitative and qualitative analyses, this study explores the impact and direction of natural, socio-economic, urban construction, historical policies, and related planning within the urban context on the evolution of the park landscape pattern. It also examines the evolution mechanisms, thereby providing a reference for optimizing the park landscape pattern and green space planning in the central urban area of Nanchang City.

The results indicate an increasing park coverage rate, but green space patches tend towards complexity and fragmentation, potentially affecting the connectivity and ecological functions of green spaces. Large and extra-large patches are unevenly distributed, while small and medium patches are concentrated inward and spread outward, leading to significant differences in the quantity and morphology of green spaces in the urban center and surrounding areas. Old urban areas have a homogeneous type of urban parks and the uneven distribution of various types of parks results in poor park service performance and ecological function imbalance. These issues reveal that the urban park landscape pattern within the central urban area of Nanchang is undergoing an evolution marked by complexity and imbalance. This situation underscores the need for more comprehensive planning and management to foster the city's sustainable development. The evolution of the park landscape pattern in the central urban area of Nanchang City is influenced by multiple factors within the urban context. Among the natural factors, changes in elevation and slope are significant, with an increase in elevation and slope inhibiting green space area growth. In socio-economic aspects, population growth, economic activities, and industrial structure changes are closely related to urban park areas, promoting their expansion. Urban construction factors, including fixed asset investment, real estate development, garden green space and public green space areas, and road length, directly affect the connectivity, aggregation, fragmentation, and diversity of urban parks. Policy factors such as government focus on urban park construction, strengthening of ecological protection systems, and planning improvements also drive landscape pattern changes. This comprehensive impact of urban context indicates that the evolution of the park landscape pattern in the central urban area of Nanchang City is the result of multiple factors working together, requiring a holistic consideration of natural, social, economic, and policy factors for scientific planning and sustainable development.

Optimizing the park landscape pattern should consider multiple factors within the urban context. Emphasizing the rational utilization of natural environments, such as elevation and slope in planning, can maximize the avoidance of constraints on green space area growth. In socio-economic aspects, focusing on population growth, economic activities, and the evolution of industrial structures can promote the expansion of green spaces and the diversity of layouts. In urban construction, the careful management of fixed asset investment, real estate development, and road construction is necessary to ensure optimal green space connectivity and aggregation. At the same time, the continuous strengthening

of policy measures, focusing on ecological protection systems and park management planning, ensures a policy environment conducive to the sustainable optimization of the park landscape pattern. These comprehensive urban context-driven optimization measures help create more attractive, ecologically balanced, and development-compatible park landscape patterns.

Author Contributions: Conceptualization, X.D.; methodology, X.D.; software, X.D.; validation, X.D.; formal analysis, X.D.; investigation, X.D., Y.Z. and N.S.; resources, X.D. and N.S.; data curation, X.D. and N.S.; writing—original draft preparation, X.D. and Y.Z.; writing—review and editing, X.D., Y.Z.; visualization, Y.Z.; supervision, X.D.; project administration, X.D. and N.S.; funding acquisition, N.S. All authors have read and agreed to the published version of the manuscript.

Funding: National Natural Science Foundation of China (31660231); Jiangxi Province University Humanities and Social Sciences Research Project (JXYKRW-23-8).

Data Availability Statement: The data presented in this study are available on request from the corresponding authors.

Conflicts of Interest: The authors declare no conflicts of interest.

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