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Interpretation of Hot Spots in Wuhan New Town Development and Analysis of Influencing Factors Based on Spatio-Temporal Pattern Mining

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Abstract: The construction of new towns is one of the main measures to evacuate urban populations and promote regional coordination and urban–rural integration in China. Mining the spatio-temporal pattern of new town hot spots based on multivariate data and analyzing the influencing factors of new town construction hot spots can provide a strategic basis for new town construction, but few researchers have extracted and analyzed the influencing factors of new town internal hot spots and their classification. In order to define the key points of Wuhan's new town construction and promote the construction of new cities in an orderly and efficient manner, this paper first constructs a space-time cube based on the luminous remote sensing data from 2010 to 2019, extracts hot spots and emerging hot spots in Wuhan New City, selects 14 influencing factor indicators such as population density, and uses bivariate Moran's index to analyze the influencing factors of hot spots, indicating that the number of bus stops and vegetation coverage rate are the most significant. Secondly, the disorderly multivariate logistic regression model is used to analyze the influencing factors of emerging hot spots. The results show that population density, vegetation coverage, road density, distance to water bodies, and distance to train stations are the most significant factors. Finally, based on the analysis results, some relevant suggestions for the construction of Wuhan New City are proposed, providing theoretical support for the planning and policy guidance of new cities, and offering reference for the construction of new towns in other cities, promoting the construction of high-quality cities.

Keywords: urban hot spots; spatio-temporal pattern mining; space-time cube; bivariate Moran's index; disorderly multivariate logistic regression model

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1. Introduction

Under the background of economic development and rapid urbanization, the built-up environment of big cities has been continuously expanded, and the population scale has expanded rapidly. By the end of 1990s, problems such as space constraint and reduced operation efficiency appeared in big cities such as Beijing and Shanghai. In order to expand urban space, evacuate urban populations, and optimize urban structure, the construction of new cities with the core concept of pursuing ideal cities, seeking regional coordination, urban–rural coordination, and interpersonal harmony has become a widespread concern [1]. COVID-19, which broke out at the end of 2019, shows that excessive agglomeration can easily cause big cities to face difficulties in the face of emergencies, and scientific and reasonable urban layout structure can help to enhance urban resilience [2,3].

The construction of new cities in China aims to solve the "big city disease" and meet the needs of urban space expansion. In the process of establishing and supervising the implementation of the territorial space planning system, its significant value in regional spatial coordination, urban construction quality, and social harmony development should be fully demonstrated [4]. However, due to the lack of theoretical research and practical experience accumulation, the construction of new cities in China has led to issues such as "ghost cities" and "lying cities", indicating a series of practical problems such as disorderly development, insufficient driving force, and poor quality [4]. Scientific research and development guidelines are necessary for the investment in new urban construction.

Urban hot spots are regions with the densest population and geographic elements and the highest frequency and intensity of human activities; they are also the most dynamic areas driving urban development [5]. In the initial stages of new city construction, massive infrastructure construction is required, involving significant amounts of investment. To enhance the efficiency of capital utilization, it is necessary to study the development laws of new urban areas and hot spots, identify the most promising value areas, and prioritize the construction projects that significantly promote the formation of hot spots. Urban hot spot research, especially the emerging hot spot research using spatio-temporal pattern mining technology, is helpful to find the most significant development hot spots of new cities [6]. Combined with correlation analysis, it can further analyze the key factors affecting the formation of hot spots, guide the construction funds to invest in the most critical factors in potential hot spots, and is expected to improve the utilization efficiency of funds and promote the rapid development of new cities and the formation of reasonable urban structure.

Hubei is a significant province in central China, and Wuhan is its capital city. The planning of Wuhan new town, promulgated in 2023, spans some areas of Wuhan and Ezhou. Wuhan new town is an effective measure to relieve the high-density population in the central city of Wuhan, and it is also the core area of the "Wuhan-Ezhou-Huangshi-Huanggang" urban belt. The development and construction of Wuhan new town is a very significant recent work for Wuhan City, Ezhou City, and even Hubei Province. How to plan the hot spot areas of key investment and invest in key projects efficiently in the early stage of new town construction is an urgent problem that needs to be studied.

By studying the temporal and spatial patterns of hot spots and emerging hot spots in Wuhan new town and their influencing factors, this paper provides development suggestions for promoting the construction of the new town efficiently and in an orderly fashion, and it has great research significance for the future policy formulation, economic development and residents' life development of the new town.

2. Literature Review

Space-time pattern mining can analyze data distributions and patterns in spatial and temporal environments, with its dataset visualization assisting in visualizing data stored in space-time NetCDF cubes (in 2D and 3D forms) and filling missing values before cube creation. In ArcGIS Pro, space-time pattern mining includes tools such as the space-time cube, new space-time hot spot analysis, local outlier analysis, and time-series clustering. Hagerstrand [7] first proposed using the space-time cube model to represent geographical phenomena over time [8]; this was later further researched by Rucker, Szego, and others [9]. The space-time cube is a spatiotemporal data model that integrates temporal, spatial, and attribute information of geographic phenomena, enabling data reconstruction, the tracking of spatiotemporal changes, and the prediction of development trends [10], ensuring the continuity of spatiotemporal data [11].

The space-time cube is widely used in spatio-temporal research. Purwanto [12] and Mo et al. [13], respectively, used the space-time cube model to determine the spatio-temporal patterns of novel coronavirus infections in East Java, Indonesia, and China, analyzing the trends of hot spots to assess the development of the epidemic. Song, Y. [14], based on the space-time cube model, visualized 10 years' worth of hourly traffic flow data on highways

in Utah, USA, analyzing the traffic flow and development trends on highways. Cheng, Z.Y. [15], combined the space-time cube, spatial autocorrelation, and emerging hot spot analysis methods to explore the spatio-temporal evolution characteristics of traffic accidents

Research on the space-time cube in China began in 1997, focusing mainly on improvements and applications of spatiotemporal data models. In recent years, the space-time cube has been widely applied in various fields such as urban transportation and land research [16]. For example, Hong [17] extracted the spatiotemporal patterns of traffic congestion points in Chengdu using the space-time cube model. Xia [18] proposed a spatiotemporal data model based on forest data, and Chen [19] analyzed the spatial and temporal hot spot performance of housing prices in the central urban area and suburbs of Nanchang using the space-time cube model. However, the urban cube model is rarely applied to urban hot spots, the main aspect of urban development.

At present, the research on hot spots is mostly focused on first- and second-tier cities, such as Shanghai [4] and Wuhan [20]. There are also studies on the horizontal comparative analysis of the spatial pattern of hot spots in several cities. For example, in 2022, based on the OD trajectory of taxis, the distribution and influence patterns of hot spots in China, Shanghai, Beijing, and Wuhan were compared and analyzed [21]; then, based on the comparison, the differences of spatial patterns of different cities and different factors of development momentum were obtained. There are also cities that study the evolution of regional hot spots on a larger scale from the perspective of time development, based on past data. For example, some studies have selected the Beijing-Tianjin-Hebei region of China as a research object to analyze the development results of economic hot spots [22,23]. Generally speaking, the existing studies pay more attention to the construction and development of first-tier and second-tier cities, and they pay less attention to the construction of new cities.

In terms of research methods for urban hot spots, traditional urban hot spot research mostly collects data on urban hot spots and population distributions by means of on-the-spot investigations and interviews. However, the rapid development of technologies and products such as global positioning system (GPS), Weibo, and WeChat has yielded a large number of data sources for urban research and provided data and technical bases for urban hot spot research. At present, a large number of scholars have used social media sign-in data [8,24], taxi track data [7], and other big data to study urban hot spots. With the development of deep learning technology, many studies have also used circular neural networks [25] and improved spectral clustering [9] to predict urban hot spots.

In the field of new city research, current literature primarily focuses on directions such as policy governance [26], industrial analysis [27], and transportation planning [28]. The research by Xu Yanfei and Qin Peng [26] emphasizes the key role of national new districts in national strategy, proposing strategies to optimize the development path of new districts through balanced empowerment and legal empowerment to achieve high-quality development goals. Jing An and Wang Roncheng [29] evaluated the integration of industry and city in Zhoushan Archipelago New District and Qingdao West Coast New District through the coupling coordination degree model, pointing out that the initial development of the two new districts was unbalanced; however, the level of industry–city integration improved later, highlighting the importance of development control strategies tailored to local conditions for new districts. Yang Xiyu [30], taking Yang'an's new district as an example, discussed the comprehensive transportation planning of new cities from the perspective of urbanization, proposing strategies such as the coordinated development of transportation and industry, green transportation systems, urban–rural integration, humanized transportation facilities, and intelligent transportation systems, providing new ideas for new city transportation planning. Overall, there is a lack of analysis from the perspective of hotspots regarding the positive and negative factors of new city construction. Furthermore, in urban hotspot research, literature mainly focuses on built-up urban areas [31] or urban agglomerations [32], with less attention given to new cities. Therefore, there is almost a blank slate in domestic research on the factors influencing the development hotspots of

new cities, and there is an urgent need for research in this area to provide scientific and rational guidance for the construction of new cities.

This paper selects Wuhan New City as the research area, aiming to explore its hot spots and emerging hot spots. By selecting various indicators closely related to life, economy, transportation, and other aspects to analyze and judge future development factors, this paper aims to clarify the significant influencing factors of hot spots and emerging hot spots and better guide the construction process of Wuhan New City. To avoid inaccurate analysis results due to city data being affected by the COVID-19 pandemic, this paper focuses on the years 2010 to 2019 for the study of Wuhan New City. Based on the night-light remote sensing data of Wuhan New City, this paper extracts the spatiotemporal distribution characteristics of hot spots and combines them with multi-source data such as POI, GDP, and population to further analyze the influencing factors of hot spots in Wuhan New City. Furthermore, through the space-time cube model, this paper extracts the emerging hot spot categories of Wuhan New City from 2010 to 2019 and uses unordered multinomial logistic regression to extract and summarize the significant influencing factors of each type of emerging hot spot. Finally, based on the above analysis results and the development orientation and status quo of Wuhan New Town, this paper puts forward relevant suggestions for the future development focus, strategic direction, and development path of Wuhan New Town, and it provides theoretical and practical reference value for the construction of new towns in other provinces, cities, and regions in China under the background of high-quality urbanization and emphasis on spatial layout optimization.

3. Study Area and Data

3.1. Study Area

The article selects Wuhan New City as the research scope. As shown in Figure 1, Wuhan New City is located between Wuhan and Ezhou cities, spanning both cities. The planned area of Wuhan New City is approximately 719 square kilometers, situated at the geographical center of Wuhan, Ezhou, and Huangshi. Therefore, it enjoys obvious location advantages.

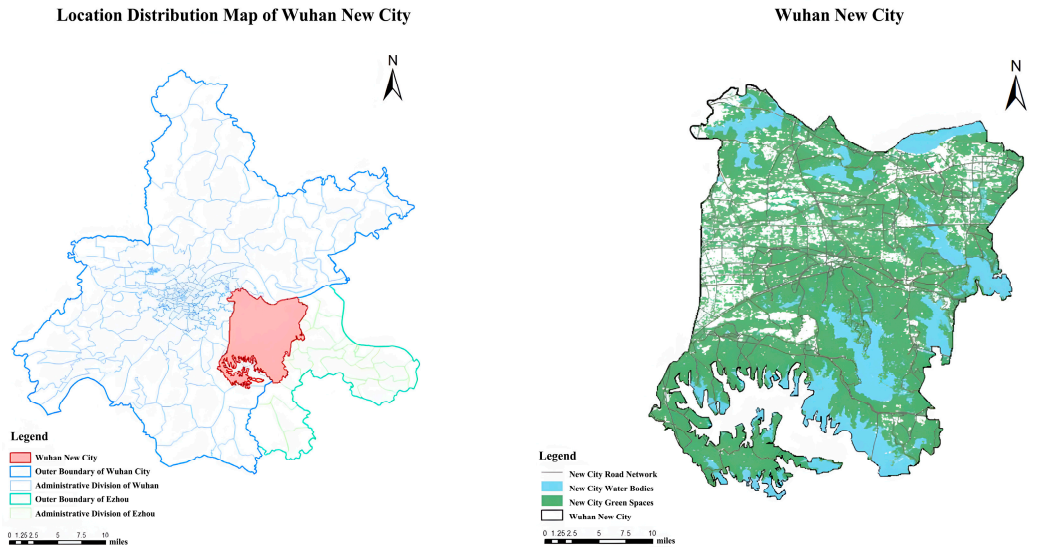


Figure 1. Study area.

Wuhan New City boasts superior ecological resources with high-quality blue and green ecological spaces, including natural conservation areas such as Jiufeng Mountain, Wusi Lake, and Honglian Lake, as well as lake development control areas. Meanwhile, it is undergoing rapid population growth and vigorously promotes "industry–city integration" and the development of high-tech digital industries. Its proximity to Wuhan Optics Valley

facilitates the focused development of industries such as optical technology and storage chips. Thus, Wuhan New City holds significant strategic planning status and considerable development potential. As the research area of this article, from the perspective of urban hot spots, it is possible to extract rapidly developing areas in Wuhan New City and analyze the reasons and driving forces behind them, which is of positive research significance.

Currently, Wuhan New City faces a series of practical problems, such as unreasonable infrastructure layout, inconvenient transportation (including the metro), insufficient road density, inadequate public service facilities, the coexistence of developing hot spots, and difficulty attracting resources from outside Wuhan. It urgently requires guidance through urban hot spot research to promote the orderly and coordinated development of Wuhan New City.

3.2. Data Sources

3.2.1. Basic Data

The primary data for this article consist of information on population, gross domestic product (GDP), road networks, and land use. GDP (which stands for gross domestic product and measures the total value of goods and services produced within a country) along with population distribution data serve as critical indicators for analyzing socio-economic development and regional planning. However, these indicators are traditionally based on administrative divisions, which limits their use for spatial statistics and calculations. To address this issue, the article utilizes kilometer-scale spatial grid data for GDP and population from the Resource and Environmental Science Data Center. This data has been processed by the Institute of Geographic Sciences and Natural Resources Research and is provided by the Research Department of the Chinese Academy of Sciences. According to a unified standard, the study area is divided into several pixels. Since kilometer-scale spatial grids conform to the basic size of residential areas and are not affected by administrative divisions, a size of 1 km $\times$ 1 km is chosen as the size of a single pixel. Based on the corresponding years, this article calculates the average GDP, total population, green area, water area, and other data for each grid within the land use range. Each pixel has an identifier and multiple attribute values, and assigning data to each grid as attribute values can be useful for subsequent spatial analysis, visually reflected on maps.

At present, the method of analyzing urban data based on spatial grids has been widely used in contemporary geography research, and the grid data of GDP or population are used as social factors for urban research [29,33]. For example, in order to optimize the allocation of road traffic, some studies put forward a spatial grid calculation method, constructed a variety of spatial grids with different scales, and combined them with geographically weighted regression to analyze the balanced allocation and optimization of road traffic [34]. Urban analysis based on grids is a relatively new method, which is used in this paper to lay the foundation for the statistics of subsequent data.

3.2.2. Point of Interest (POI) Data

As publicly available geographic information data, the spatial distribution and temporal evolution trend of POI not only reflects the heterogeneity between different regions of the city but also indicates the development of a certain urban function. Therefore, choosing POI as the index of influencing factors of hot spots can better reflect residents' basic living needs and facility guarantees of residents.

Each type of POI used in the study was obtained separately based on the Amap application programming interface (API) using Python (https://lbs.amap.com/, accessed on 1 February 2024). The categories of points of interest include dining services, shopping facilities, lifestyle services, sports and leisure facilities, medical services, hotels, scenic spots, commercial buildings, residential areas, government and social organizations, internal transportation facilities, external transportation facilities, financial facilities, enterprises, and educational and cultural venues. Based on the needs determined by the influencing factors of urban hot spots, this study identified transportation-related POIs such as subway

stations and bus stops, as well as infrastructure and lifestyle service-related POIs such as scenic spots, road facilities, public facilities, healthcare services, and government agencies as the five major categories for subsequent factor analysis. Finally, counting the number of each type of POI in each grid as one of the grid's attribute values facilitates further analysis.

3.2.3. VIIRS Remote Sensing of Night-time Light Emissions

The noctilucent remote sensing data can comprehensively reflect the development of human beings, the intensity of development, and the scope and region of hot spots. According to the literature, the noctilucent remote sensing data has a realistic reflection on regional GDP, production and living development level [31], urban layout, expansion and scale [32], population activities, and active areas [27], so this paper chooses noctilucent remote sensing data as the overall representation of hot spots in Wuhan New Town.

The chosen dataset in this study is VIIRS Nighttime Light Data, which includes a day/night band (DNB) sensor. Its dynamic range covers nearly seven orders of magnitude from full daylight scenes to moonlit clouds. Compared to DMSP/OLS, VIIRS/DNB enhances the spatial resolution, thereby improving the ability to monitor and quantify night-time brightness [35,36]. Therefore, it is more suitable as the foundational data for hot spot extraction. The data for Wuhan City and Ezhou City from 2010 to 2019 were obtained through NOAA and subsequently processed using ArcGIS 10.2 to extract the remote sensing of night-time light emissions for Wuhan New City (As shown in Figure 2). Since the brightness values for remote sensing of night-time light emissions range from 0 to 255, facilitating subsequent processing, a linear transformation was applied to the remote sensing of night-time light emission brightness values. After transformation, the average remote sensing data for each grid were computed as the basis for subsequent data analysis.

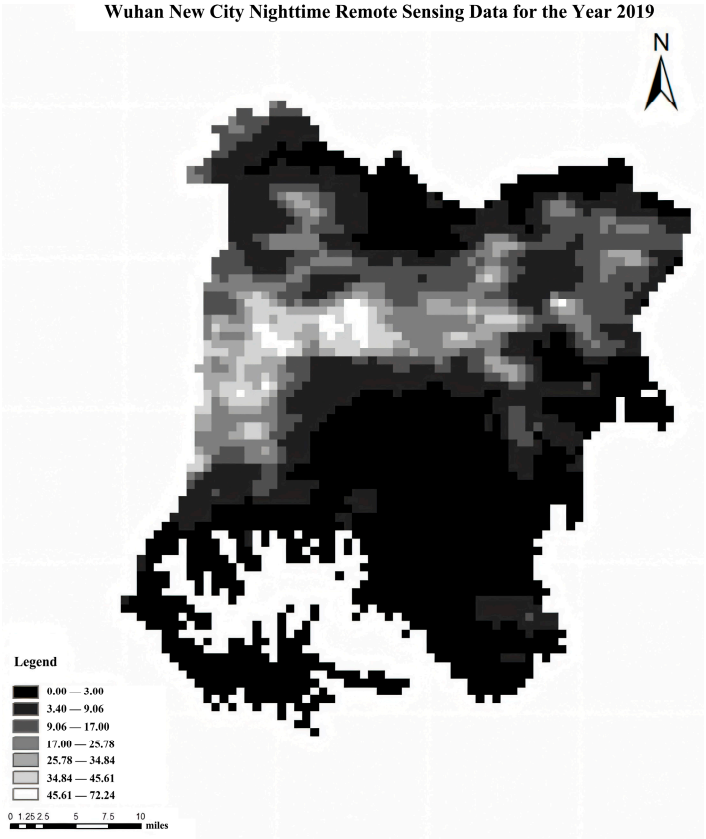
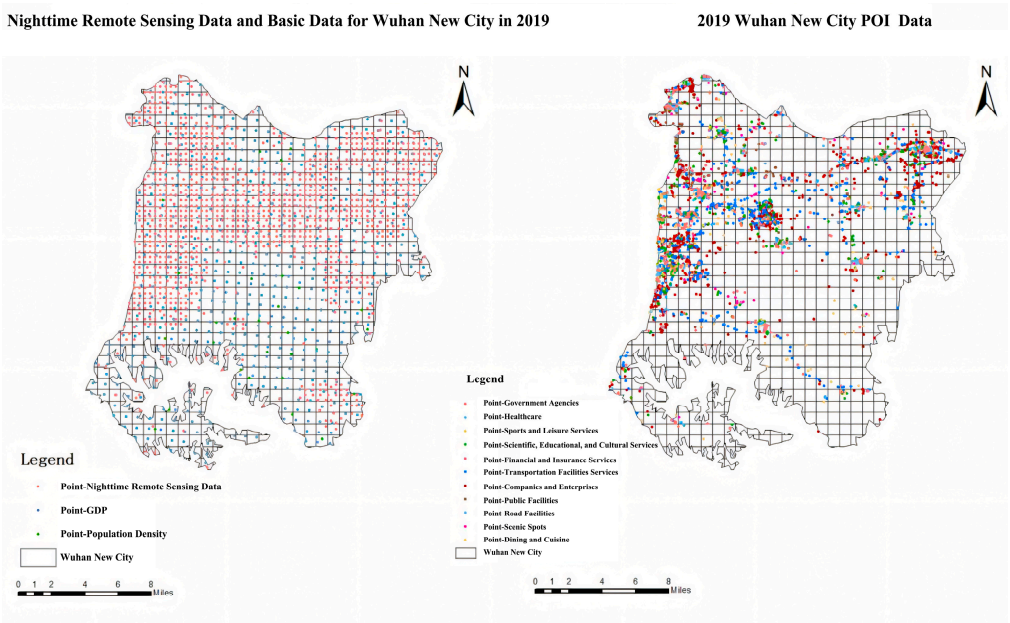


Figure 2. Night-time light remote sensing masking results for Wuhan New City in 2019.

3.2.4. Data Preprocessing

In this study, the night-time raster was first converted into point features with values. The remote sensing of night-time light emissions data was then masked using ArcGIS 10.2 to extract data within the boundary of Wuhan New City. Subsequently, a 1 km × 1 km grid was created. The choice of a 1 km grid was based on two considerations: first, the resolution of the GDP and population data used was 1000 m; second, it aligned with the size of a typical community unit defined in [37] as approximately 160 acres, or roughly an 800 m × 800 m square. Therefore, selecting a 1 km × 1 km grid is more aligned with the residential communities and travel distances within the city.

Next, the average values of night-time points, GDP, population density, number of bus stops, and other indicators were spatially joined to each unit of the grid, resulting in the polygon of Wuhan New City. This information was embedded into the attribute table of each 1 km × 1 km grid unit, as shown in Figure 3. All spatial data were projected into the WGS 1984 UTM Zone 50 N projection coordinate system as the basis for subsequent spatial analysis.



(**a**) (**b**)

Figure 3. (**a**) Remote sensing of night-time light emissions data and basic data for Wuhan New City in 2019 and (**b**) 2019 Wuhan New City POI data.

4. Research Method and Technical Route

4.1. Theoretical Basis

Tobler's First Law of Geography

Tobler's first law of geography, proposed by the American geographer Waldo Tobler in 1970, is a fundamental principle in the field of geographic information science. It articulates the spatial relationships of geographic phenomena with the core idea that "everything is related to everything else, but near things are more related than distant things".

The core concepts of the theory are:

(1) Spatial correlation: This refers to the interrelationship of geographic phenomena in space. Tobler's first law of geography emphasizes that geographically proximate entities often have stronger relationships and similarities, while those that are further apart have weaker relationships. This paper illustrates that hotspot areas within a city often have close ties with their neighboring areas.

(2) Spatial autocorrelation: Autocorrelation refers to the correlation between the values of the same variable at different locations, with spatial autocorrelation specifically

referring to this correlation in geographic space. Positive spatial autocorrelation means that the values of variables at nearby locations are similar, while negative spatial autocorrelation indicates that the values are different. Each area within a city has its unique geographical characteristics and functional positioning. In the summary discussion, it is important to respect and utilize this spatial heterogeneity. Through reasonable land-use planning and functional zoning, the optimization and enhancement of urban functions can be promoted.

Tobler's first law of geography is an important and foundational theory in the field of geography. It reveals the basic spatial patterns of geographic phenomena and provides theoretical support and methodological guidance for research in geographic information science, spatial analysis, and related fields. In practical applications, by analyzing spatial autocorrelation, a more scientific understanding and resolution of complex issues in various fields such as urban planning, ecological and environmental protection, and public health can be achieved.

4.2. Research Method

4.2.1. Space-Time Cube Mode

Hagerstrand introduced the concept of time into spatial data and first proposed using the space-time cube model to represent the changes of geographical phenomena over time. The space-time cube model, based on the traditional method of expressing geographic objects in two-dimensional space, adds a one-dimensional time axis to represent the changes of geographic entities or phenomena over time [8] (see Figure 4). By creating a space-time cube, it is possible to visualize and analyze spatiotemporal data through methods such as time series analysis and spatiotemporal pattern analysis. The data structure created includes three dimensions: x, y, and t, where x and y represent spatial positions and t represents time. Each column in the space-time cube has a fixed position in both space and time, with parameters such as location ID, time step ID, and attribute value. Columns covering the same area share the same location ID, and columns with the same duration share the same time-step ID. The count value of each column reflects the number of events or records occurring at the corresponding location within the relevant time step interval [19].

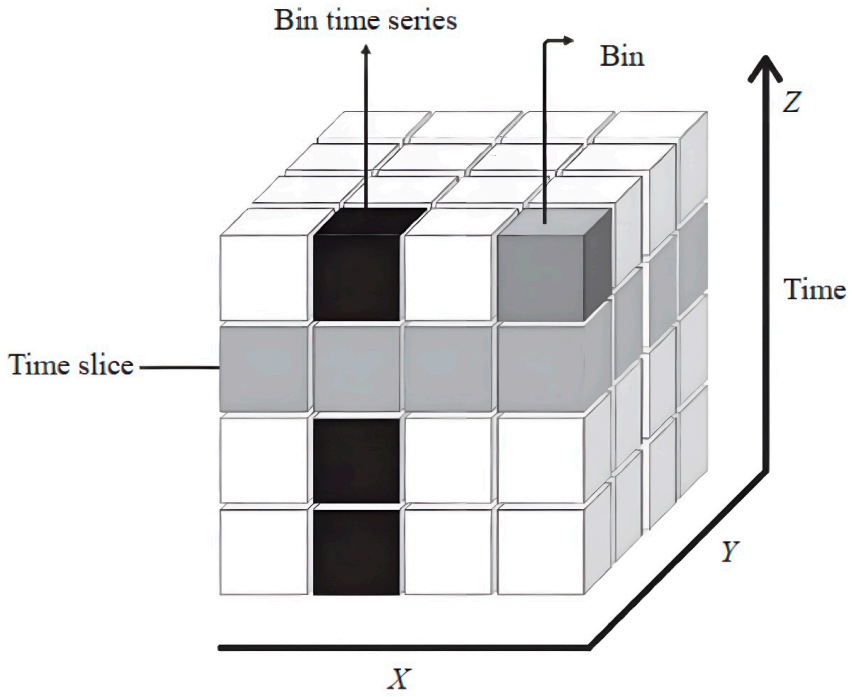


Figure 4. Space-time cube model.

4.2.2. Emerging Hot and Cold Spot Analysis

The primary objective of analyzing emerging hot and cold spots is to identify trends within the data, such as the discovery of new, intensified, diminished, or dispersed hot and cold spots. The main process is outlined in Figure 5.

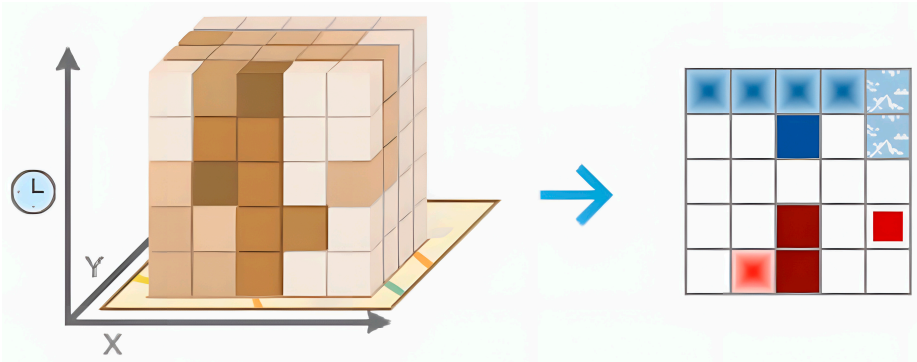


Figure 5. Theory of emerging hot spot analysis.

The analysis begins by utilizing the aggregate points to create a space-time cube tool as input. Subsequently, the Getis-Ord G_i* statistic is computed for each cube in the space-time cube (hot spots analysis). Once the analysis of emerging spatio-temporal hot spots is completed, each cube in the space-time cube contains associated z-scores, *p*-values, and categorized hot spot cubes, as illustrated in Table 1.

Table 1. Significance explanation of emerging hot and cold spots.

Gi-bin	Z Score	*p* Value	Confidence (%)	Hot Spot (or Cold Spot)
3 or (−3)	>+2.58 (or less than −2.58)	<0.01	99	Hot spot (or cold spot)
2 or (−2)	>+2.58 (or less than −2.58)	<0.05	95	Hot spot (or cold spot)
1 or (−1)	>+2.58 (or less than −2.58)	<0.1	90	Hot spot (or cold spot)
0	−1.65 < z < 1.65	>0.1	-	Not statistically significant

According to the significance, hot spots and cold spots are distinguished for each year. Subsequently, the Mann–Kendall method is used to evaluate and analyze the development trends of hot spots and cold spots. Finally, various emerging hot and cold spot patterns are obtained, as shown in Table 2. This study primarily focuses on hot spots, and cold spots are not included in the research content.

Table 2. Types and definitions of emerging hot and cold spot patterns.

Pattern Name	Definition
No pattern detected	Without statistical significance
New hot spot	The last time step becomes a statistically significant hot spot, which was not statistically significant before
Consecutive hot spot	Up to 90% of the cubes are statistically significant hot spots, and statistically significant hot spots exist continuously with no interruption before the final time step
Strengthened hot spot	90% of the time steps (including the final time step) are statistically significant hot spots, with an overall increase in cluster intensity and statistical significance
Persistent hot spot	90% of the time steps are statistically significant hot spots, with no significant trend in cluster count intensity
Diminishing hot spot	90% of the time steps (including the final time step) are statistically significant hot spots, with an overall decrease in cluster intensity and statistical significance
Sporadic hot spot	Up to 90% of the time steps are statistically significant hot spots, but the hot spots are sporadic and not statistically significant cold spots

Table 2. *Cont.*

Pattern Name	Definition
Oscillating hot spot	Up to 90% of the time steps are statistically significant hot spots, and the last time step of statistically significant hot spots has a history of being statistically significant cold spots
Historical hot spot	At least 90% of the time steps are statistically significant hot spots, and the most recent time period is not a hot spot
New cold spot	The last time step becomes a statistically significant cold spot, which was not statistically significant before
Consecutive cold spot	Up to 90% of the cubes are statistically significant cold spots, and statistically significant cold spots exist continuously with no interruption before the final time step
Strengthened cold spot	90% of the time steps (including the final time step) are statistically significant cold spots, with an overall increase in cluster intensity and statistical significance
Persistent cold spot	90% of the time steps are statistically significant cold spots, with no significant trend in cluster count intensity
Diminishing cold spot	90% of the time steps (including the final time step) are statistically significant cold spots, with an overall decrease in cluster intensity and statistical significance
Sporadic cold spot	Up to 90% of the time steps are statistically significant cold spots, but the cold spots are sporadic and not statistically significant hot spots between time steps
Oscillating cold spot	Up to 90% of the time steps are statistically significant cold spots, and the last time step of statistically significant cold spots has a history of being statistically significant hot spots
Historical cold spot	At least 90% of the time steps are statistically significant cold spots, and the most recent time period is not a cold spot

In general, the emerging hot spot analysis is a combination of the Getis-Ord G_i* statistics and Mann–Kendall trend test, which first identifies spatial clusters within a time period and then evaluates and classifies the temporal development trends of these spatial clusters. The specific formula is as follows:

$$G_i^* = \frac{\sum_{j=1}^{n} w_{i,j}x_j - \overline{X}\sum_{j=1}^{n} w_{i,j}}{S\sqrt{\frac{\left[n\sum_{j=1}^{n} w_{i,j}^2 - \left(\left(\sum_{j=1}^{n} w_{i,j}\right)^2\right)n-1}{n-1}}} \quad (1)$$

$$\overline{X} = \frac{\sum_{j=1}^{n} x_j}{n}$$

$$S = \sqrt{\frac{\sum_{j=1}^{n} x_j^2}{n} - \left(\overline{X}\right)^2}$$

where x_j represents the value of feature j, $w_{i,j}$ denotes the spatial weight between feature i and j, and n is the total number of features.

4.2.3. Bivariate Moran Index

The bivariate Moran's I has a similar working mechanism to the univariate Moran's I spatial autocorrelation. Bivariate Moran does not analyze the spatial relationship between the variable of interest itself and its surrounding similar variables, but rather examines the spatial relationship between the independent variable and the dependent variable in its vicinity. Similar to the Moran index, this study chooses to use the Queen's case method to calculate spatial weights, assigning a value of 1 to all grid units connected to the analyzed grid unit by edges or corners. The calculation formula for the bivariate global Moran's I is as follows:

$$I_{GB} = \frac{\sum_i \left(\sum_j w_{ij}y_j \times x_i\right)}{\sum_i x_i^2} \quad (2)$$

where I_{GB} is the global bivariate Moran's I coefficient, i represents the i-th feature unit (a fishnet grid), j denotes neighboring units of i, w_{ij} is the spatial weight from j to i (spatial weight matrix), x_i is the value of the independent variable in the analyzed fishnet unit, and y_j is the value of the dependent variable in neighboring units. All variables are standardized, and spatial weights are row-standardized (mean = 0, variance = 1).

The output of the local bivariate Moran index is the local spatial autocorrelation indicator (LISA), which captures the association between the independent value in fishnet unit i and the result value in neighboring unit j. The LISA index generates a scatter plot with four quadrants based on the signs of x_i and $\sum_j w_{ij}y_j$, creating high-high (H-H), high-low (H-L), low-high (L-H), and low-low (L-L) zones (all variables are standardized).

Its formula is

$$I_{LB} = cx_i \sum_j w_{ij}y_j \tag{3}$$

where I_{LB} is the local bivariate Moran's I coefficient, c is a constant proportion factor, w_{ij} is the spatial weight from j to i (spatial weight matrix), y_j is the result value of neighboring units, and x_i is the independent value in the analyzed fishnet unit. All variables are standardized, and spatial weights are row-standardized (mean = 0, variance = 1).

4.2.4. The Unordered Multinomial Logistic Regression Model

Multinomial logistic regression models are mainly divided into ordered multinomial logistic regression models and unordered multinomial logistic regression models. Both types have three or more categories for the response variable. The difference lies in the ordered multinomial logistic regression model, where there is an ordinal relationship among the response variable categories, while in the unordered multinomial logistic regression model, there is no such ordinal relationship among the response variable categories. This paper mainly involves the unordered multinomial logistic regression model, and its calculation formula is as follows [38]:

$$\ln \frac{P(Y=j)}{P(Y=k)} = \theta_j + \sum_{i=1}^{n_1} \beta_{1i}^j AB_i + \sum_{i=1}^{n_2} \beta_{2i}^j SN_i + \sum_{i=1}^{n_3} \beta_{3i}^j PBC_i + \sum_{i=1}^{n_4} \beta_{4i}^j Z_i \tag{4}$$

where k is the reference level; $j \in [1, m]$ and $j \neq k$; P represents probability; j represents the various levels of the dependent variable Y, where $j \in [1, m]$; θ_j represents the intercept term; AB_i represents the i-th row of attitude variables; SN_i represents the i-th row of subjective norm variables; PBC_i represents the i-th row of perceived behavioral control variables; Z_i represents the i-th control variable; and β_{1i}, β_{2i}, β_{3i}, and β_{4i} are the partial regression coefficients corresponding to AB_i, SN_i, PBC_i, and Z_i, respectively.

4.2.5. Construction of Factors Influencing Indicators

Factors influencing regional development levels need to be interpreted from multiple perspectives. Wuhan New City is located between Wuhan City and Ezhou City, with superior geographical conditions. Commercial, industrial, and residential sectors are all in planning and development. Therefore, in order to comprehensively summarize the existing and past factors that may affect the overall development level (As show in Figure 6), this study refers to research on the causes of urban hot spots based on check-in data [39] and articles analyzing the factors affecting economic development hot spots [22]. Combined with the unique location, economic development, and planning background of the new city, five major categories of indicators were ultimately selected, as shown in Table 3:

(1) Basic Indicators

Kilometer grid population and kilometer grid GDP are included. The economic development level and population factors are important factors affecting the overall development level of the region; hence, under a high population distribution, the probability of urban hot spots in areas with large crowds is higher, so it is one of the important factors to analyze and extract the causes of hot spots.

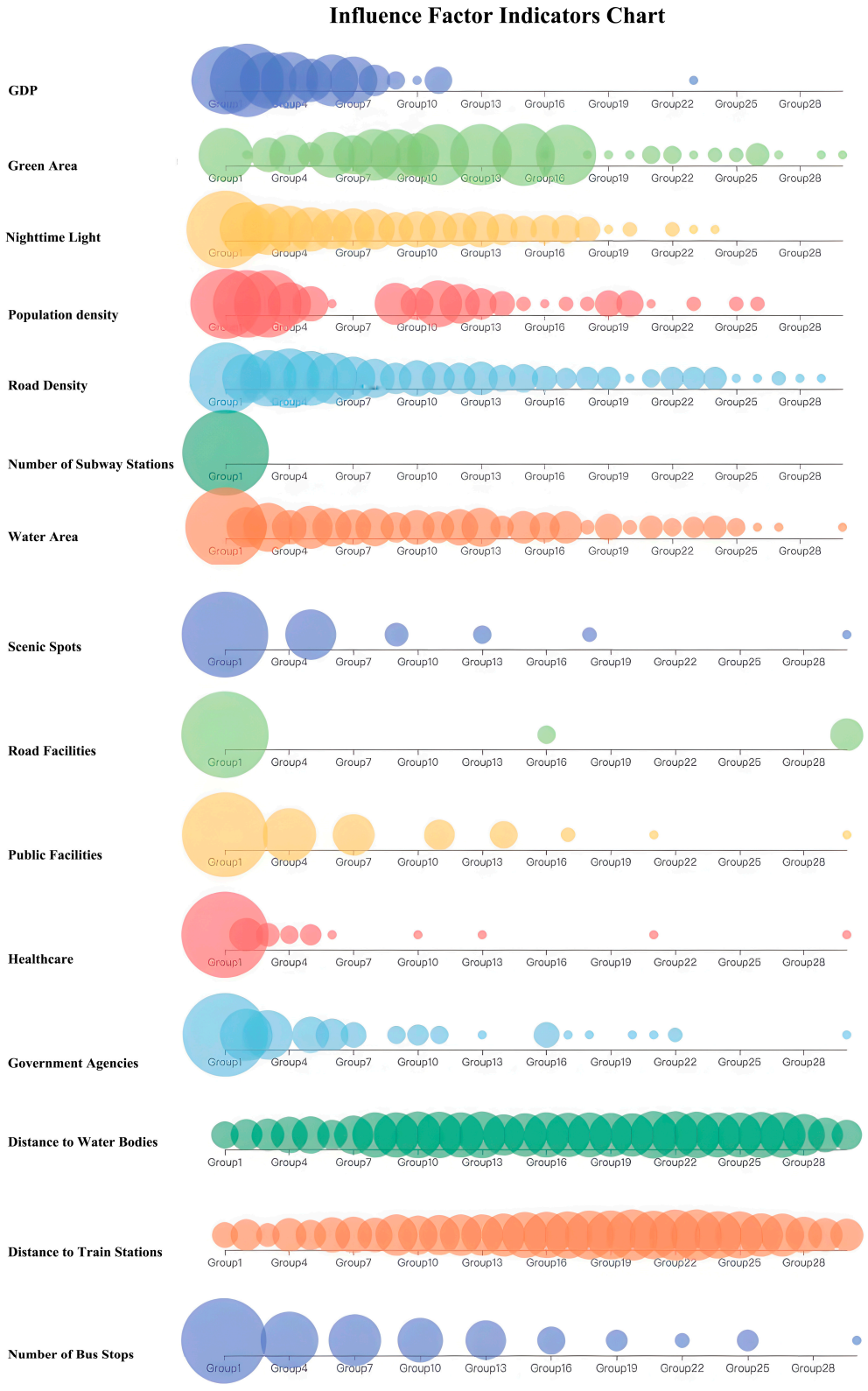


Figure 6. Influence factor indicators chart.

Table 3. Indicators of hot spot influence factors.

Category	Indicator
Basic indicators	Population density
	GDP
Natural environmental factors	Water body area
	Vegetation coverage
Traffic factors	Road density
	Number of subway stations
	Road facilities
	Number of bus stops
Location factors	Distance to water bodies
	Distance to train stations
Infrastructure factors	Healthcare
	Public facilities
	Government agencies
	Scenic spots

(2) Natural Environmental Factors

Green quantity and blue quantity are selected. According to existing research, blue and green quantities have positive effects on urban population aggregation and the development of urban hot spots. Wuhan New City has good ecological conditions, which are important factors in promoting urban vitality and resident aggregation [34]. Therefore, based on the land-use classification data of Wuhan New City, water area and green space coverage area were extracted, and the area of individual grids was calculated as one of the grid's attribute values.

(3) Traffic Factors

For the construction of a new city, traffic is the skeleton of organizational space and linking space, and the indexes of subway, bus lines, and road density are also related to the convenience of residents' lives; the convenience of traffic is also of great significance for promoting urban vitality and urban hot spots [40]. Therefore, this paper selects four traffic facilities factors, road density, number of bus stops, road ancillary facilities, and number of subway stations, as indicators affecting potential hot spots.

(4) Location Factors

As the development of Wuhan New Town and the spatial layout of Wuhan City are linked, infrastructure with a larger service scope is also relatively dependent on the construction of Wuhan City, this paper chooses the nearest ecological resources, such as Liangzi Lake area, and the nearest railway station as the factors for measuring the location of each grid in Wuhan New Town, and it calculates the distance between each single grid and the distance between the site and the grid, thus making a preliminary quantitative analysis of the location of each grid from the two perspectives of traffic and ecological resources. In addition, due to the large collinearity coefficient (VIF) obtained by OLS calculation between the distance to Wuhan Municipal Government and ecological location and transportation location, only transportation location and ecological location were considered in this study.

(5) Infrastructure Factors

Infrastructure construction and service facilities in Wuhan New City will indirectly affect population flow, activities, and hot spot distribution. Different types of facilities will also bring different attractions, providing inspiration and opinions for the direction of future new city construction and the planning of other new city facilities. Therefore, four types of basic service facilities and locations were selected: medical facilities, public service facilities, government organizations, and scenic spots.

A summary and visualization of the distribution of various influencing factors in the grid are presented in Figure 3. Firstly, based on the value of each indicator in individual

grids, the grids are divided into ten groups. Then, the number of grids in each group, where the influencing factor is distributed, is calculated. Scatter points closer to the left side of the *x*-axis indicate smaller values of the factor, while those closer to the right side indicate larger values. The size of the scatter points indicates the number of grids in that group; larger scatter points represent more grids, and vice versa. Based on this analysis, the degree of aggregation of the distribution of individual influencing factors in the grid can be determined.

According to the results, the distribution of factors such as green quantity, blue quantity, luminous remote sensing brightness value, and road network density on the grid shows a balanced situation as a whole, while GDP is relatively more concentrated in the area with a smaller GDP value on the left, the distribution is more concentrated, and the population is discrete on the axis; meanwhile, the indicators represented by the number of subways are extremely concentrated in distribution, not evenly distributed on the grid within the scope of Wuhan New City, and only a few areas have subway stations. The distribution of influencing factors in the grid is illustrated in Figure 7.

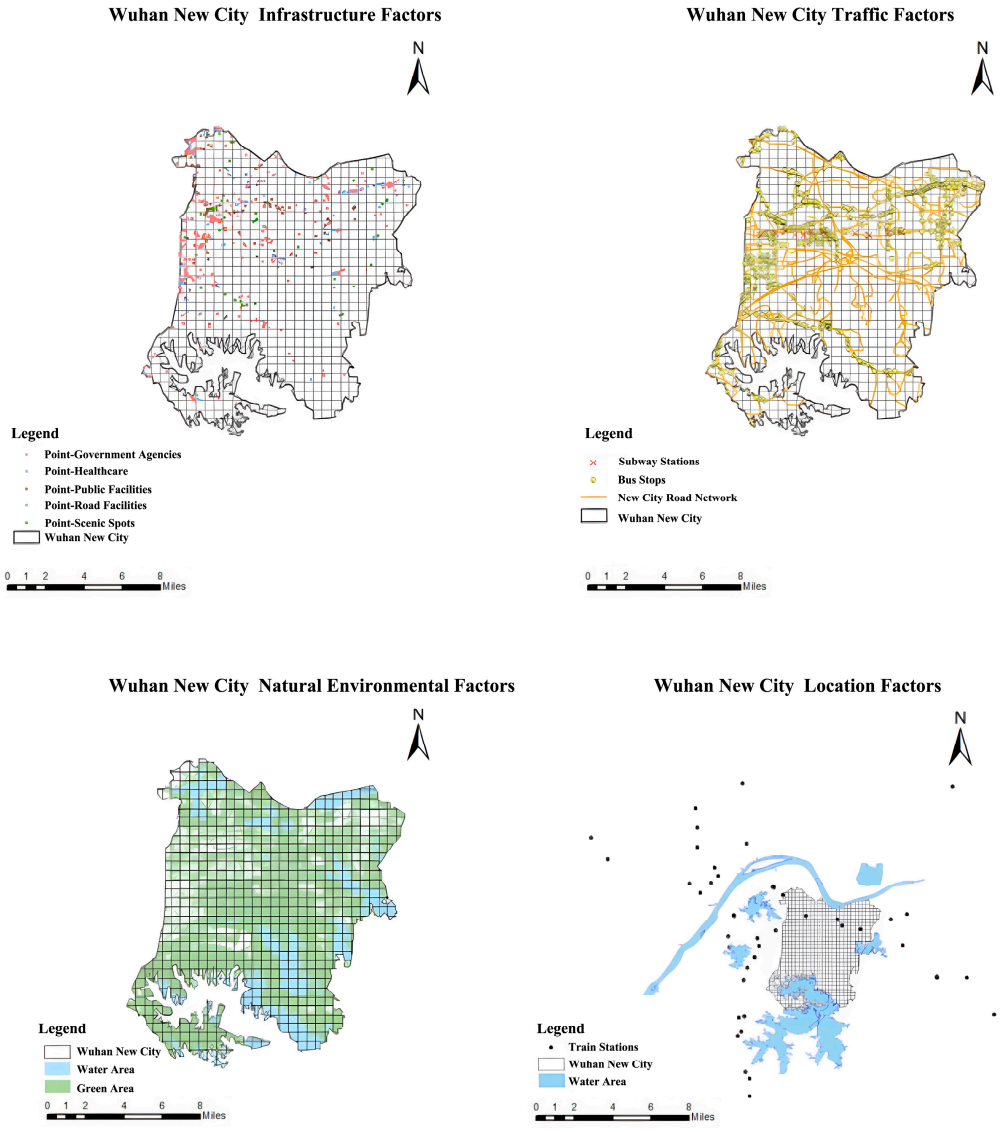


Figure 7. Grid distribution of influencing factors indicators in 2019.

4.3. Technical Route

In order to avoid the occasional results of short-term studies and enhance the reliability and determinacy of the research, this paper quantitatively summarizes the development and change patterns of hot spots from a longer time perspective. Firstly, based on the remote sensing of night-time light emissions for Wuhan New City from 2010 to 2019, this study extracts hot spots in Wuhan New City during the research period using the space-time cube model and analyzes their spatiotemporal patterns. Then, from the internal natural environmental factors (vegetation coverage, water body area), internal traffic factors (road density, number of bus stops, number of subway stations, road facilities), internal service facility factors (healthcare facilities, government agencies, public service facilities, scenic spots), external location factors (distance to water bodies, distance to train stations), and other factors (population, GDP), 14 influencing factors are selected as influencing factor indicators. The influencing factors of hot spots in Wuhan New City are then analyzed using the bivariate Moran index. Secondly, based on the results of the space-time cube, four categories of emerging hot spots in Wuhan New City are extracted, and the influencing factors of the four types of emerging hot spots are analyzed using the unordered multivariate logistic regression model. Finally, a summary of the current development status and optimization strategies for Wuhan New City is provided, aiming to provide a basis and inspiration for the efficient and orderly promotion of new city construction. The specific research framework is shown in Figure 8:

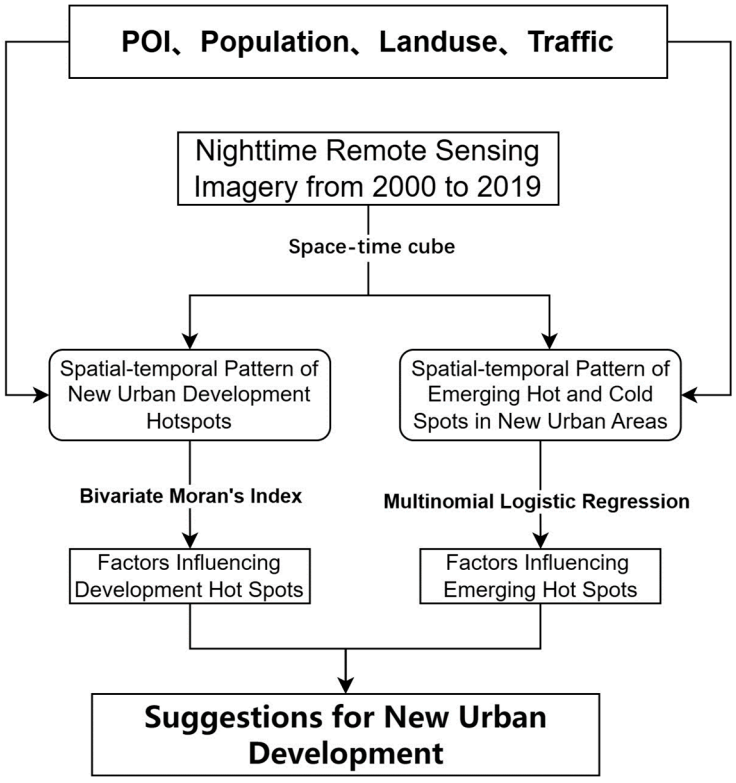


Figure 8. Technical route.

5. Results and Analysis

5.1. Spatio-Temporal Patterns of Hot Spots in Wuhan New City from 2010 to 2019

5.1.1. Spatio-Temporal Patterns of Hot Spots

Based on remote sensing of night-time light emissions, a three-dimensional space-time cube was constructed to analyze statistically significant high values (hot spots) and low values (cold spots), as shown in Figure 9. The analysis categorized the space-time cubes into three main types: those exhibiting an upward trend, a downward trend, and those

without a significant trend. The confidence interval determines the strength of significance, with darker colors indicating stronger significance and lighter colors indicating weaker significance. According to Table 4, there are a total of 550 grids in the image. Among the grids showing an upward trend, 112 grids have a 99% confidence interval, exhibiting a dense and continuous distribution. These grids are concentrated mainly around railway lines in the east-west direction and in the western part of Wuhan New City in the north-south direction. Additionally, there are 141 grids with a 95% confidence interval, which are the most numerous and have a more concentrated distribution, forming the main part of the upward trend grids. Furthermore, 63 grids have a 90% confidence interval, showing a more scattered distribution, mostly located at the edges of Wuhan New City and lacking spatio-temporal clustering. There are 232 grids with no significant trend, exhibiting a relatively dispersed layout.

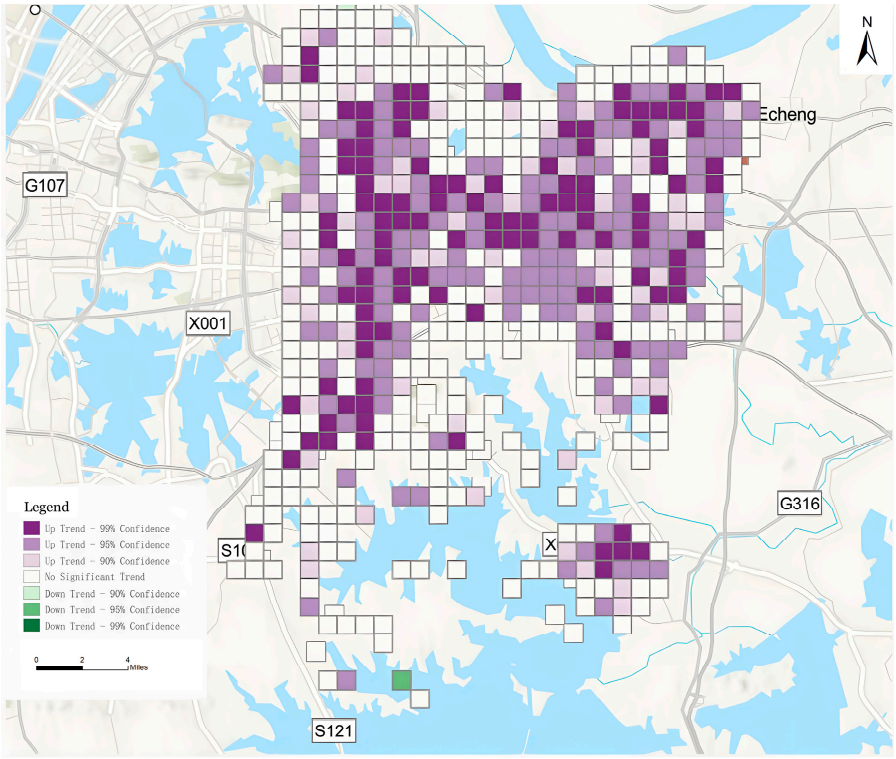


Figure 9. The results of space-time cube.

Table 4. Statistics of grid quantities from the space-time cube results.

Category	Confidence Interval	Quantity
Upward trend	99%	112
	95%	141
	90%	63
Downward trend	99%	0
	95%	1
	90%	1
No significant trend	-	232
Total		550

The grids showing a downward trend are very few, with only two grids identified: one with a 95% confidence interval located in the southwest of Wuhan New City, and another with a 90% confidence interval situated in the northwest of Wuhan New City. In summary, grids showing a significant upward trend are densely distributed and concentrated in

the central part of Wuhan New City, with fewer upward trends observed at the edges. Conversely, grids showing a downward trend are rare and dispersed, indicating that the regional activities and economic development of Wuhan New City are predominantly trending upwards.

Visualizing the 10-year remote sensing data of night-time light emissions as a heatmap, the results are shown in Figure 10. The horizontal axis represents the brightness value of the remote sensing of night-time light emissions, while the vertical axis represents the year. The color intensity indicates the quantity of grids, with lighter colors indicating fewer grids and darker colors indicating more grids. From the graph, it is observed that the number of grids with higher brightness values gradually increases over the years, but the change is not uniform over time. Significant breakthroughs are observed in 2011 and 2018, while decreases in brightness compared to the previous year are observed in 2012 and 2014. This suggests that the brightness of the remote sensing of night-time light emissions data in Wuhan New City is generally increasing. Additionally, the number of grids with lower brightness values is rapidly increasing, indicating a spatial expansion of the remote sensing of night-time light emissions data in Wuhan New City. Therefore, the intensity and extent of regional activities and economic development in Wuhan New City are continuously strengthening, consistent with the analysis results obtained through the space-time cube.

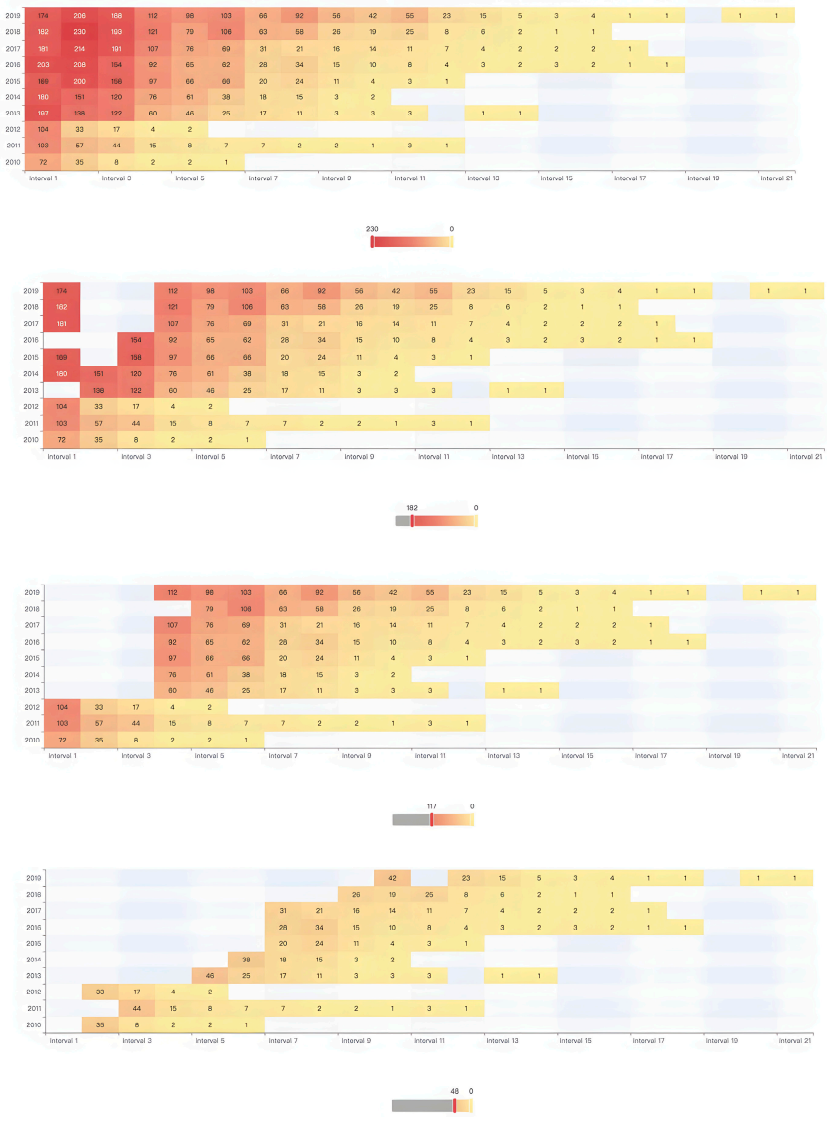


Figure 10. Statistical chart of 10-year remote sensing data of night-time light emissions.

5.1.2. Spatial-Temporal Pattern of Emerging Hot Spots

Analyzing the z-score values at each location, the results of emerging hot and cold spots in Wuhan New City are obtained, as shown in Figure 11. Grids with warmer tones indicate the presence of a spatio-temporal hot spot pattern, while those with cooler tones indicate a spatio-temporal cold spot pattern. Overall, the emerging hot and cold spots in Wuhan New City exhibit a spatio-temporal distribution where hot spots are concentrated in the center, while cold spots are dispersed towards the edges, as depicted in three dimensions in Figure 12.

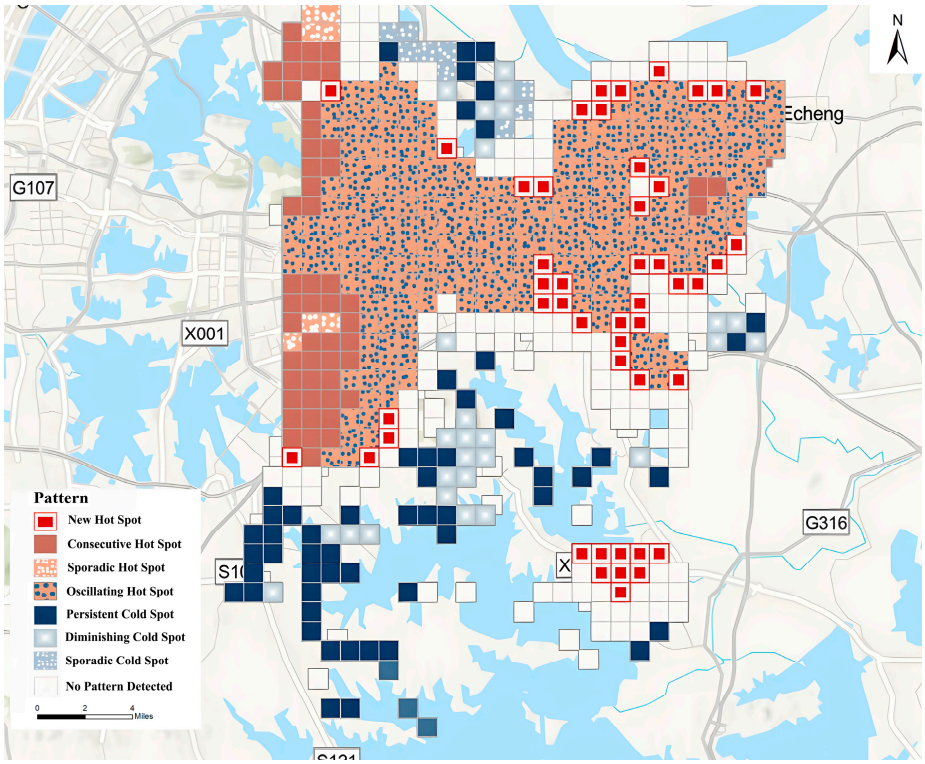


Figure 11. Plane distribution map of emerging hot and cold spots.

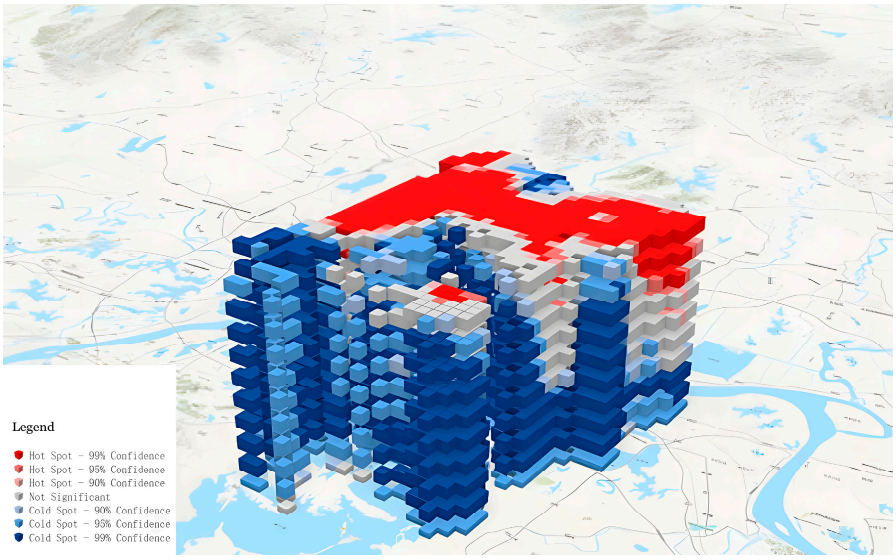


Figure 12. Cubic distribution map of emerging hot and cold spots.

Usually, the space-time cube can yield 16 types of patterns, including new hot spot, consecutive hot spot, enhanced hot spot, persistent hot spot, diminishing hot spot, sporadic hot spot, oscillating hot spot, historical hot spot, as well as their cold spot counterparts. However, in Wuhan New City from 2010 to 2019, there were four types of hot spot grids (new hot spot, consecutive hot spot, sporadic hot spot, and oscillating hot spot) and four types of cold spot grids (consecutive cold spot, persistent cold spot, diminishing cold spot, and sporadic cold spot). Some grids show no significant patterns and do not fall into any of these categories.

From Table 5, it can be observed that among the hot spots, oscillating hot spot is the most common (with 232 grids), followed by consecutive hot spot and new hot spot (with 53 and 47 grids, respectively). Sporadic hot spot is the least common, with only seven grids. Among the cold spots, persistent cold spot is the most common (with 56 grids), followed by diminishing cold spot and sporadic cold spot (with 27 and 9 grids, respectively). Consecutive cold spot is the least common, with only three grids. Due to the small number of cold spots, they are not considered in this study.

Table 5. Statistics of emerging cold spot quantity.

Category	Quantity
New hot spot	47
Consecutive hot spot	53
Sporadic hot spot	7
Oscillating hot spot	232
Consecutive cold spot	3
Persistent cold spot	56
Diminishing cold spot	27
Sporadic cold spot	9
No pattern detected	116
Total	550

According to the chart, from 2010 to 2019, there were 232 grids in Wuhan New Town, which were interpreted as statistically significant hot spots in the last time step interval; this interval had a history of cold spots that were also statistically significant in the previous time step, and at most 90% of the time step intervals were already statistically significant hot spots. According to the spatial distribution characteristics, most areas in the study area are significant hot spots at present, but they have been cold spots in the past 10 years. This discovery shows that the development of Wuhan New Town is on the upward trend, and the overall development trend is from relatively cold to gradually hot. Additionally, there are seven grids in Wuhan New City that exhibit a sporadic hot spot pattern, indicating intermittent hot spots in history, which suggests the potential for these areas to become hot spots. In the western part of the study area, there are areas with consecutive hot spot patterns, indicating continuous development that needs to be further connected with other oscillating hot spot and sporadic hot spot areas, showing generally good urban construction speed in these areas.

5.2. Analysis of the Factors Influencing Hot Spot Development in Wuhan New City from 2010 to 2019

Based on Figure 13, it can be observed that most areas of Wuhan New City experienced an upward trend in development from 2010 to 2019, while some areas showed no significant trend, and only one grid exhibited a downward trend. Therefore, this section focuses on the areas with an upward development trend, namely hot spots in Wuhan New City. A qualitative and quantitative analysis of the factors influencing the development of hot spots in Wuhan New City was conducted using the bivariate Moran index. Firstly, a grid of 1 km $\times$ 1 km was constructed, with each grid having urban hot spots and 14 categories of influencing factors as attribute values. The bivariate Moran index was employed to analyze the overall correlation between urban hot spots and variables. Factors with Moran's I less

than 0.1 (indicating insignificant correlation) were excluded, and both positive and negative factors affecting hot spot development were identified, as shown in Figures 13 and 14.

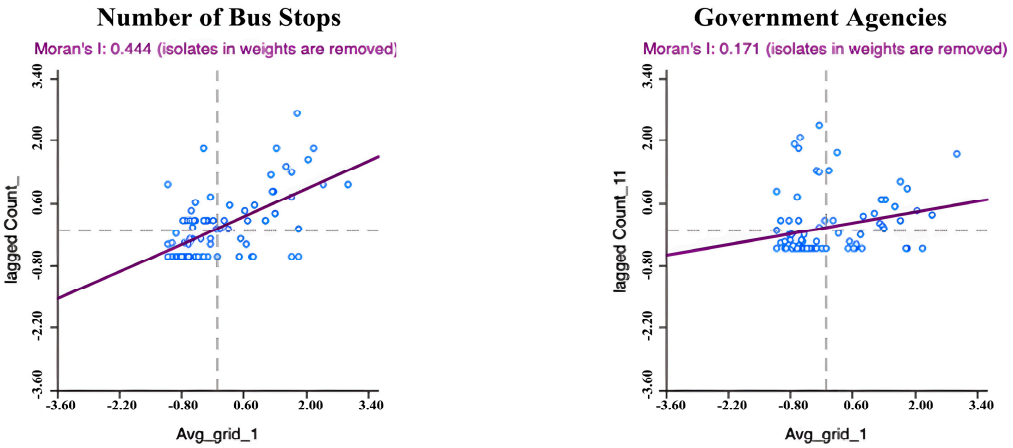


Figure 13. Scatter plot of positive factors' Moran's I.

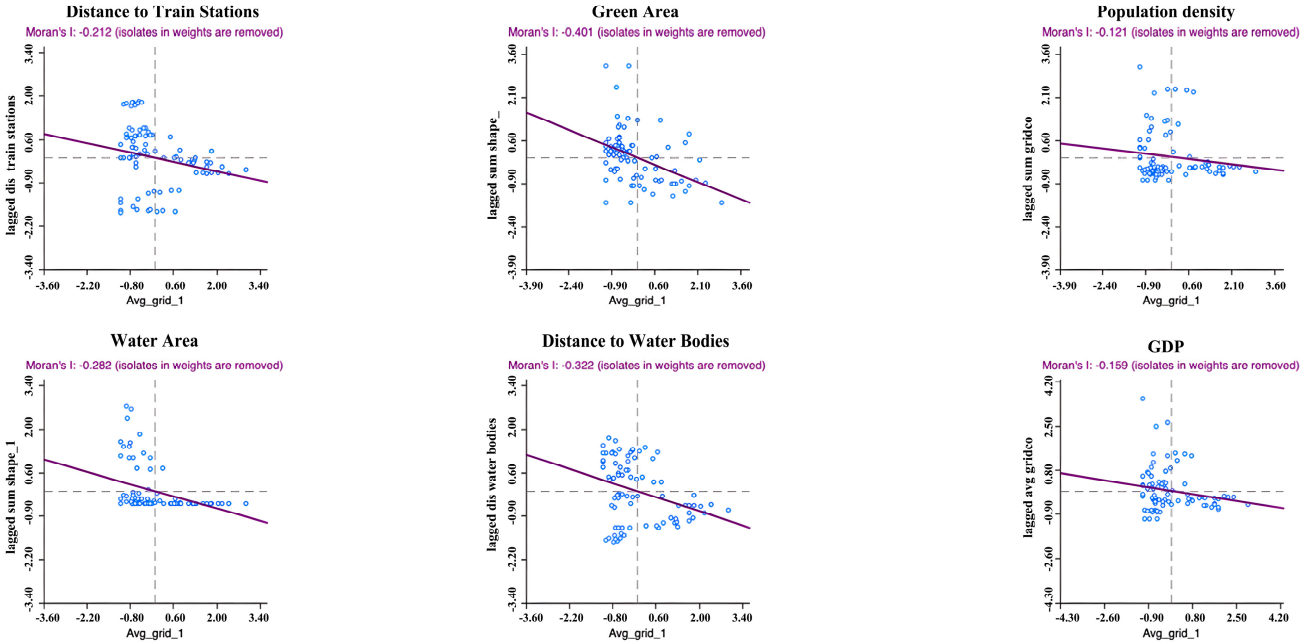


Figure 14. Scatter plot of negative factors' Moran's I.

According to the analysis results of the Moran index, the Moran's I of eight factors, including number of bus stops, government agencies, distance to train stations, vegetation coverage rate, population density, water body area, distance to water bodies, and GDP, is greater than 0.1, indicating significant correlation. Among these factors, number of bus stops and government agencies are positive factors, with Moran's I values of 0.444 and 0.171, respectively, indicating a positive correlation with the development of hot spots in Wuhan New City. These factors exhibit significant spatial autocorrelation with the distribution of hot spots, especially the number of bus stops, which is highly correlated with residents' daily lives. Distance to train stations, vegetation coverage rate, population density, water body area, distance to water bodies, and GDP are negative factors, with absolute values of Moran's I ranging from 0.121 to 0.401, indicating a negative correlation with the development of hot spots. Among these, the vegetation coverage rate has the largest absolute Moran's I value, indicating a significant impact on hot spots. Therefore, it is necessary to appropriately control the vegetation coverage rate in hot spot areas to

maintain a balance between creating a comfortable ecological environment and avoiding adverse effects on urban vitality and the development and aggregation of hot spots.

To sum up, the hot spots in Wuhan New Town show an upward trend on the whole, and the green coverage rate has the most significant inhibitory effect on the development of hot spots in Wuhan New Town, while the number of buses has the most obvious positive effect on hot spots. It is necessary to control the green area while carrying out high-quality urbanization, as well as to simultaneously grasp the configuration of infrastructure and the creation of a good living environment, improve the convenience of public transportation (represented by bus stops), and inject vitality into the lives of residents and the driving force for the sustainable development of hot spots.

5.3. Analysis of Factors Influencing the Development of Emerging Hot Spots Based on Logistic Regression Model

Using consecutive hot spot, new hot spot, oscillating hot spot, and sporadic hot spot as dependent variables and 14 categories of influencing factors as independent variables, a multiple logistic regression analysis was conducted in SPSS. A *p*-value less than 0.05 indicates a good fit of the model and significant explanatory power, with statistical significance. The specific analysis is as follows:

5.3.1. Consecutive Hot Spot

Consecutive hot spots are predominantly concentrated on the western edge of Wuhan New City, near the Wuhan Optics Valley, exhibiting a linear distribution from north to south. A few consecutive hot spots are also concentrated in the eastern part of the new city, indicating that the western region of Wuhan New City experienced rapid and sustained development from 2010 to 2019. Logistic regression analysis was conducted on the influencing factors of consecutive hot spots, and the results are presented in Table 6. The significance levels of population density, vegetation coverage, distance to water bodies, distance to train stations, and government agencies are 0.053, 0.014, 0.000097, 0.076, and 0.008, respectively, all of which are less than 0.1. This indicates that these five factors have a significant impact on the occurrence probability of consecutive hot spots. Specifically, population density and distance to water bodies are positively correlated with the occurrence probability of consecutive hot spots, while vegetation coverage rate, distance to train stations, and government agencies are negatively correlated with the occurrence probability of consecutive hot spots.

Table 6. Logistic regression results for the development factors of consecutive hot spots.

Indicator	B	Exp(B)	Significance
Population density	0.264	1.302	0.053
GDP	−0.273	0.761	0.117
Water body area	−0.005	0.995	0.771
Vegetation coverage	−0.0003	0.9997	0.014
Road density	−0.017	0.983	0.794
Number of subway stations	-	-	-
Road facilities	10.206	27,053.251	0.998
Number of bus stops	0.583	1.791	0.143
Distance to water bodies	0.209	1.232	0.000097
Distance to train stations	−0.116	0.890	0.076
Healthcare	−0.044	0.957	0.709
Public facilities	−0.168	0.846	0.782
Government agencies	−0.320	0.726	0.008
Scenic spots	0.751	2.120	0.346

There is a positive correlation between population density and the probability of occurrence of continuous hot spots; that is, the greater the population density, the greater the probability of occurrence of continuous hot spots; its exp(B) is 1.302, which indicates

that the probability of occurrence of continuous hot spots will increase by 30.2% with each unit increase in population density. Population density has a significant influence on urban development, which can promote the development of urban economy through the advantages of human resources, innovation ability, and resource utilization efficiency, so that areas with high population density will always be urban hot spots throughout the research period.

Vegetation coverage rate exhibits a negative correlation with the occurrence probability of consecutive hot spots. for every unit increase in vegetation coverage rate, the probability of consecutive hot spots occurring decreases by 0.03%(Exp(B) = 0.9997). As Wuhan New City is characterized by prominent mountainous terrain, areas with higher vegetation coverage rates are subject to controlled development intensity, resulting in a lower probability of consecutive hot spots occurring.

Distance to train stations demonstrates a negative correlation with the occurrence probability of consecutive hot spots. For every unit increase in distance to train stations, the probability of consecutive hot spots occurring decreases by 11%(Exp(B) = 0.890). High-speed rail facilitates the reduction of temporal and spatial distances between regions, fostering the flow of production factors and promoting regional integration. Hence, areas farther from train stations exhibit weaker promoting effects and smaller probabilities of sustained urban hot spot occurrences.

Distance to water bodies shows a positive correlation with the occurrence probability of consecutive hot spots. For every unit increase in distance to water bodies, the probability of consecutive hot spots occurring increases by 23.2% (Exp(B) = 1.232). The ecological pattern of mountains and water bodies forms the foundation of Wuhan New City, with Liangzi Lake as the regional landscape center. Controlled development intensity near water bodies results in lower development intensity, leading to a smaller probability of consecutive hot spots occurring.

Government agencies exhibit a negative correlation with the occurrence probability of consecutive hot spots. For every unit increase in the number of government agencies, the probability of consecutive hot spots occurring decreases by 27.4% (Exp(B) = 0.726).

5.3.2. New Hot Spot

New hot spots are mostly dispersed around the edges of Wuhan New City, indicating that the development of the city's periphery was relatively slow in the early stages from 2010 to 2019, but accelerated in the later stages. Logistic regression analysis was conducted on the influencing factors of the newly added hot spots, and the results are shown in Table 7. As indicated in the table, the significance levels of vegetation coverage rate, road density, and distance to water bodies are 0.077, 0.073, and 0.022, respectively, all of which are less than 0.1, indicating that these three factors have a significant impact on the occurrence probability of new hot spots, with distance to water bodies having a significance level below 0.05, indicating the most significant impact on new hot spots.

Vegetation coverage rate is negatively correlated with the development of new hot spots, meaning that the higher the vegetation coverage rate, the smaller the probability of new hot spot occurrence, with an exp(B) of 0.9999, indicating that for each increase in one unit of vegetation coverage rate, the probability of new hot spot occurrence decreases by 0.01%. The government's efforts in green space protection in the later stages of the research period have shown some effectiveness, controlling development in areas with high vegetation coverage rates, such as around Hua Mountain, effectively preventing the disorderly addition of hot spots in ecological corridors, greenways, urban parks, and other areas.

Table 7. Logistic regression results of factors influencing the development of new hot spots.

Indicator	B	Exp(B)	Significance
Population density	0.199	1.220	0.178
GDP	−0.158	0.853	0.363
Water body area	−0.021	0.979	0.143
Vegetation coverage	−0.0001	0.9999	0.077
Road density	−0.131	0.877	0.073
Number of subway stations	-	-	-
Road facilities	9.820	18,391.593	0.998
Number of bus stops	−0.386	0.680	0.587
Distance to water bodies	0.109	1.115	0.022
Distance to train stations	−0.064	0.938	0.138
Healthcare	−0.015	0.985	0.909
Public facilities	−0.200	0.818	0.739
Government agencies	−0.175	0.840	0.221
Scenic spots	0.255	1.290	0.765

Road density is negatively correlated with the development of new hot spots, meaning that the lower the road density, the greater the probability of new hot spot occurrence, with an exp(B) of 0.877, indicating that for each increase in one unit of road density, the probability of new hot spot occurrence decreases by 13.3%. This suggests that new hot spots tend to appear on the outskirts of cities, as Wuhan New City continues to expand outward.

Distance to water bodies is positively correlated with the development of new hot spots, meaning that the farther the distance to water bodies, the greater the probability of new hot spot occurrence, with an exp(B) of 1.115, indicating that for each increase in one unit of distance to water bodies, the probability of new hot spot occurrence increases by 11.5%.

5.3.3. Oscillating Hot Spot

Oscillating hot spots are the most numerous types of emerging hot spots, which are distributed in the central part of Wuhan New Town, indicating that cold spots and hot spots appear alternately in this area from 2010 to 2019, while they are mainly urban hot spots in the later period of the research period. On the whole, Wuhan New Town has experienced a transition from cold to hot and maintained a stable development stage. Logistic regression analysis was conducted on the influencing factors of oscillating hot spots, and the results are shown in Table 8. The significance of population density, GDP, water body area, vegetation coverage, road density, distance to water bodies, distance to train stations, and healthcare are 0.026, 0.052, 0.001, 0.016, 0.017, 0.000463, 0, and 0.09, respectively; these are all less than 0.1, indicating that these eight factors significantly affect the occurrence probability of oscillating hot spots.

Population density is positively correlated with the occurrence probability of oscillating hot spots. As population density increases, the likelihood of oscillating hot spots increases. The exp(B) value is 1.338, indicating that for every unit increase in population density, the probability of oscillating hot spots increases by 33.8%. Population aggregation is crucial for urban development, enabling the transition of the area from a cold spot to a hot spot and maintaining it as a hot spot for an extended period in the later stages, thus driving economic growth and urban prosperity.

There is a negative correlation between GDP and the probability of occurrence of oscillation hot spots. The greater the GDP, the smaller the probability of occurrence of oscillation hot spots. The exp(B) is 0.745, and the probability of occurrence of oscillation hot spots decreases by 25.5% with each unit of GDP increase. The region with a high level of GDP has long been an urban hot spot, which does not conform to the characteristics that the oscillation hot spot has changed from a cold spot to a hot spot. On the contrary, a region with a relatively low GDP and certain development potential is more likely to be an oscillation hot spot.

Table 8. Logistic regression results of influencing factors on oscillating hot spot development.

Indicator	B	Exp(B)	Significance
Population density	0.291	1.338	0.026
GDP	−0.294	0.745	0.052
Water body area	−0.058	0.944	0.001
Vegetation coverage	−0.0001	0.9999	0.016
Road density	−0.133	0.875	0.017
Number of subway stations	-	-	-
Road facilities	10.114	24,677.782	0.998
Number of bus stops	0.373	1.453	0.328
Distance to water bodies	0.149	1.161	0.000463
Distance to train stations	−0.279	0.757	0
Healthcare	−0.184	0.832	0.09
Public facilities	−0.474	0.622	0.362
Government agencies	−0.119	0.888	0.126
Scenic spots	−0.074	0.929	0.923

Water body area is negatively correlated with the occurrence probability of oscillating hot spots. A larger water body area corresponds to a lower probability of oscillating hot spots. The exp(B) value is 0.944, indicating that for every unit increase in water body area, the probability of oscillating hot spots decreases by 0.6%.

Vegetation coverage rate is negatively correlated with the occurrence probability of oscillating hot spots. A higher vegetation coverage rate corresponds to a lower probability of oscillating hot spots. The exp(B) value is 0.9999, indicating that for every unit increase in vegetation coverage rate, the probability of oscillating hot spots decreases by 0.01%. Due to governmental protection and control of the mountain-water pattern in Wuhan New City, areas with high vegetation coverage rates have lower development intensity, resulting in a lower probability of hot spots.

There is a negative correlation between road density and the probability of occurrence of oscillation hot spots. The greater the road density, the smaller the probability of occurrence of oscillation hot spots. The exp(B) is 0.875, and the probability of occurrence of oscillation hot spots decreases by 12.5% with each increase of road density. Areas with high road density have maintained a high level of development for a long time, usually turning into continuous hot spots instead of oscillating hot spots, and areas with low road density and certain development potential are more likely to have oscillating hot spots.

Distance to water bodies is positively correlated with the occurrence probability of oscillating hot spots. A greater distance to water bodies corresponds to a higher probability of oscillating hot spots. The exp(B) value is 1.161, indicating that for every unit increase in distance to water bodies, the probability of oscillating hot spots increases by 16.1%. In the earlier stages, regions farther from water bodies experienced slow development. However, in later stages, due to governmental protection and control of water resources, urban development shifted to areas farther from water bodies, resulting in the formation of oscillating hot spots.

Distance to train stations is negatively correlated with the occurrence probability of oscillating hot spots. A greater distance to train stations corresponds to a lower probability of oscillating hot spots. The exp(B) value is 0.757, indicating that for every unit increase in distance to train stations, the probability of oscillating hot spots decreases by 24.3%. Train stations bring significant human and logistical flows to an area, promoting further construction and development of the surrounding environment. Since train stations are generally established in areas farther from the city center, the spatial vicinity of train stations has experienced a transition from cold spots to hot spots, exhibiting oscillating hot spots.

The quantity of healthcare facilities is negatively correlated with the occurrence probability of oscillating hot spots. A greater number of healthcare facilities corresponds to a lower probability of oscillating hot spots. The exp(B) is 0.832, and the probability of oscillation hot spots decreases by 16.8% with each unit of medical care.

5.3.4. Sporadic Hot Spot

Sporadic hot spots are relatively few in number, mainly distributed in the western part of Wuhan New City, indicating that hot spots in this area appear intermittently and discontinuously, reflecting fluctuations in development speed. Logistic regression analysis was conducted to identify the influencing factors of sporadic hot spots, and the results are presented in Table 9. From the table, it is evident that the significance of distance to water bodies is 0.001, which is less than 0.1, indicating that this factor significantly affects the probability of sporadic hot spot occurrence. Additionally, distance to water bodies is positively correlated with the occurrence of sporadic hot spots, meaning that a greater distance to water bodies leads to a higher probability of sporadic hot spot occurrence, with an exp(B) value of 1.396. This implies that for every unit increase in distance to water bodies, the probability of a new hot spot occurring increases by 39.6%.

Table 9. Logistic regression results of sporadic hot spot development factors.

Indicator	B	Exp(B)	Significance
Population density	0.038	1.039	0.87
GDP	0.047	1.048	0.874
Water body area	−0.002	0.998	0.962
Vegetation coverage	−0.0006	0.9994	0.472
Road density	0.061	1.063	0.651
Number of subway stations	-	-	-
Road facilities	0.471	1.602	-
Number of bus stops	0.571	1.769	0.224
Distance to water bodies	0.334	1.396	0.001
Distance to train stations	−0.306	0.736	0.114
Healthcare	−0.206	0.814	0.277
Public facilities	0.493	1.636	0.634
Government agencies	−0.116	0.891	0.551
Scenic spots	0.851	2.342	0.399

To sum up, the influencing factors of different types of emerging hot spots are different, and the significant influencing factors of continuous hot spots are population density, vegetation coverage, distance to water body, distance to railway station, and government agencies. The influencing factors of new hot spots are vegetation coverage, road density, and distance to water body. The influencing factors of oscillation hot spots are population density, GDP, water area, vegetation coverage, road density, distance to water body, distance to railway station, and medical care. The influence factor of dispersed hot spots is the distance to the water body. Overall, population density, vegetation coverage, road density, distance to water bodies, and distance to train stations are the most significant factors affecting emerging hot spots. Therefore, it is crucial to focus on these factors, maintain vegetation coverage rate and water environments, enrich ecological environments and tourism resources, create more comfortable green spaces and water areas, and simultaneously plan and layout urban transportation networks rationally to attract more population flow, thereby promoting the orderly and sustainable development of Wuhan New City.

6. Discussion and Conclusion

6.1. Discussion

6.1.1. Overall Development Recommendations

From the analysis of hot spots in Wuhan New Town in 2010–2019, it can be seen that hot spots in Wuhan New Town are positively influenced by transportation factors such as bus stops and infrastructure such as government organizations, and negatively influenced by natural environmental factors such as green space coverage and water bodies. Therefore, in the process of planning and development, Wuhan New Town should give consideration to the relationship between development and protection; control the development intensity of green space and water bodies, while improving infrastructure such as bus stops and

health stations; innovate green and smart transportation networks; and create a unique urban landscape. The development model of Wuhan New City adheres to the principles of "Industry-City Integration, Ecological Priority, Balanced Living and Working, Compact and Intensive". At the same time, it aims to become a "City of Mountains and Waters, City of Homes, and Smart City" [41]. It can be seen that "green", "livable", and "emerging industries" are the three key terms for the development of Wuhan New City. For future planning, it is necessary to combine the emerging technological industries in the Optics Valley, introducing emerging technologies such as intelligent manufacturing, biotechnology, healthcare, and information communication, which are different from traditional industries in terms of lower pollution, greater need for precision instruments and equipment, and different spatial planning patterns. The emphasis on industry-city integration is stronger, combined with the eight major areas of Wuhan New City—including the "New City Center Zone, Optics Valley Zone, Gehua Zone, Huashan Zone, Longquan Mountain Zone, Honglian Lake Zone, Wutong Lake Zone, and Binhu Peninsula Zone"—and forming a spatial pattern with diverse functions. Efforts should also be made to create national laboratories or bases in fields such as optoelectronic science, storage chips, and biological breeding. Finally, Wuhan New City currently possesses high-quality natural resources. Therefore, based on the goal of "green" development, efforts should be made to avoid the destruction of ecological resources during development, adhere to ecological priorities, and integrate green development throughout. The focus should be on long-term benefits and long-term development, avoiding the pollution and resource consumption associated with traditional industries [25,42].

Firstly, as indicated by Section 5.1.1, from 2010 to 2019, a large number of urban hot spots appeared in Wuhan New City, indicating rapid development and effective dispersal of population aggregation from Wuhan Optics Valley. Urban hot spots are concentrated in the Optics Valley area, central area, and Gehua area of Wuhan New City, forming a development pattern with regional centers as the focus of development, gradually expanding outward and maintaining an upward trend overall. This has gradually promoted the integration of Wuhan and Ezhou and played a role in driving the coordinated development of Wuhan New City and its surrounding areas. In addition, most areas of Wuhan New City exhibit oscillating hot spots, indicating a process from cold to hot and from slow to fast urban construction during the study period. Therefore, Wuhan New City, as a remedy for solving the "space constraint problem" in the Optics Valley area of Wuhan, has played a significant role in effectively dispersing population and industrial agglomeration from Wuhan Optics Valley. In the context of the exhaustion of spatial resources in the Optics Valley area, Wuhan New City has expanded the development space and future possibilities. Currently, it is concentrating on developing the Optics Valley area, central area, and Gehua area of Wuhan New City, gradually forming a regional pattern of industry-city integration and high-tech agglomeration. In future development, it should adhere to the concept of "green, low-carbon, people-oriented, and smart governance", creating an ideal spatial model of integration between mountains and waters in Wuhan New City. It should reasonably optimize the allocation of incremental and existing space; highlight the transit-oriented development (TOD) model; guide the aggregation of commercial and service land towards rail transit stations [43,44]; balance the layout of public service land such as medical, health, cultural, sports, and elderly care facilities; optimize research land resources with high-quality resources; and further promote the concentration and scale development of industrial and warehousing land towards industrial parks.

Secondly, as indicated by Section 5.1.2, among the large-scale hot spots in Wuhan New City, the types of hot spots differ, indicating that the spatial development stage of Wuhan New City is relatively unbalanced. The central area of the new city and the Optics Valley area mainly exhibits oscillating hot spots and consecutive hot spots, indicating that the development in these areas is faster and more continuous. The Gehua area mainly exhibits oscillating hot spots, while also having a certain number of new hot spots, indicating that compared to the central area of the new city and the Optics Valley area, the development

speed of the Gehua area is relatively slower, while continuously expanding outward; the development speed at the edge of the area is gradually accelerating. Areas such as Huashan, Longquan Mountain, Honglian Lake, Wutong Lake, and Binhu Peninsula have abundant natural resources, low brightness values in remote sensing night-time light emissions data, relatively fewer economic activities, and fewer areas exhibiting hot spots; they are in a slow development state for a long time.

Thirdly, as indicated by Section 5.2, traffic factors and infrastructure play a significant promoting role in the formation and development of hot spot areas in Wuhan New City. Therefore, attention should be paid to the development of transportation infrastructure to promote the coordination of internal and external transportation in the new city. In the northern and central regions, areas such as Huashan, the central area of the new city, and the Optics Valley area all need to focus on the improvement of the transportation network, creating a "seven horizontal and seven vertical" skeleton road network system. The "seven horizontal" consists of the Right Bank Avenue, Wuhan–Ezhou Expressway, Forest Avenue, High-tech Avenue, High-tech Third Road, Fenglian Avenue, and Wuyang Expressway, while the "seven vertical" consists of Optics Valley Second Road, Optics Valley Third Road, Optics Valley Sixth Road, Ring Expressway, Future Third Road, Entrepreneurship Avenue, and Exi'an Expressway. In terms of public transportation, a multi-level integrated bus system should be constructed to form a public transportation system with rail transit as the backbone, medium-capacity buses as auxiliary, conventional buses as the foundation, and waterborne buses as the feature. At present, the subway construction in the central area has just started, which needs further sustainable development. The future high-speed rail system will connect Wuhan directly to Beijing-Tianjin-Hebei, Yangtze River Delta, and Greater Bay Area, so it is particularly important to seize the strategic position of the transportation gateway and hub. Internally, roads should be cleared through reasonable traffic organization, public transportation facilities should be rationally allocated to facilitate travel, and—externally—communication and contact with Wuhan should be strengthened through subway and external public transportation, thus laying a foundation for future development and promoting hot development [15,45]. In addition, the protection and control of natural environmental factors such as vegetation coverage and water bodies are also key to the development of Wuhan New City. Transportation construction should be combined with ecological protection to innovate green and smart transportation networks, promote diverse green travel, encourage and support the development of "Internet Plus" transportation modes, and promote the healthy development of new transportation models such as customized buses, shared cars, and autonomous driving [46].

Fourthly, as indicated by 5.3, population factors have a significant impact on the formation of most emerging hot spots in Wuhan New City. Population aggregation can have a positive impact on urban economic development, and urban development and industrial agglomeration can attract more population inflows [1,47]. Currently, the economic development of Wuhan New City is showing an upward trend, requiring a more competitive modern industrial system to enter. Strategic scientific and technological forces should be coordinated and deployed, major scientific and technological infrastructure construction should be strengthened, and digital technology should be deeply integrated with the real economy. New digital industries such as artificial intelligence, big data, blockchain, and the Internet of Things should be nurtured and developed, and the level of industries such as communication equipment, core electronic components, and key software should be enhanced, constructing application scenarios and an industrial ecology based on 5G. In addition, Wuhan New Town should actively support the first-class research universities to cultivate characteristic colleges and infrastructure of science and technology education, and to create original innovation clusters with related disciplines and spatial agglomeration. Focus should be given to key technological breakthroughs and strategic product development in the fields of optoelectronic information, life and health, and intelligent manufacturing.

On the whole, different areas should make appropriate planning arrangements according to their different conditions, such as geographical location, resources, and environment,

so as to achieve the purpose of coordinated development and service to the region. With the rapid economic development in the central area of the new city, we should comprehensively improve the gathering ability of high-end elements, core functions, and large-scale population; focus on the development of modern finance, high-end business, the digital economy, scientific and technological services, and other functions; and promote the construction of the central business district and scientific and technological service center. The Optics Valley area and Gehua area, mainly focused on high-tech industries, should develop into areas for high-end industrial agglomeration, technological innovation sources, emerging industry clusters, and future industrial leading areas, creating comprehensive zones for high-end manufacturing and technological innovation. Areas such as Longquan Mountain, Binhu Peninsula, Honglian Lake, Huashan, and Wutong Lake, which are rich in natural resources and have low development intensity, should maintain their ecological environment, avoid high-intensity development, strengthen the aggregation of characteristic functions, and respectively create scientific-research-bearing areas, cultural tourism and leisure areas, international reception centers and ecological green spaces, digital creative livable areas, healthy and intelligent livable areas, and science, education, and culture livable areas.

6.1.2. Local District Development Recommendations

The development positioning of the central district of Wuhan New City makes it the central business district and technology service center. From 2010 to 2019, the central district mainly exhibited oscillating hot spots and a few new hot spots, with factors such as population density, distance to train stations, and distance to water bodies having a significant impact on the development of this area. The central district is the core area of development in Wuhan New City and should attract populations through economy and transportation while retaining the population through ecology, industry, and infrastructure. Currently, the central district has reached a certain scale of development and should build a high-end business and financial agglomeration area; develop modern finance, a headquarters economy, supply chain management, and other high-end business and financial service industries; promote the deep integration of manufacturing and service industries; and focus on the development of technology finance, green finance, cultural finance, and wealth management to attract more external population and increase population density. At the same time, it should focus on developing international functions such as international exhibitions, cultural exchanges, international consumption and international communities; actively introduce internationally renowned exhibition companies and professional exhibition organizations at home and abroad; layout international exhibition centers, high-end hotels, and specialty commercial districts; and enhance the level of openness. Additionally, traffic factors such as train stations have a certain impact on the overall development of the central district. However, the road density in the central district is relatively sparse, and the distribution and quantity of bus stops, subway stations, and healthcare service facilities do not match the development of the area [48]. In light of this situation, the central district should adopt the Transit-Oriented Development (TOD) model, create a "multi-centered, networked" regional transportation structure, and establish a complete road transportation network. Healthcare service facilities should be hierarchically divided according to the Christaller central place theory, sinking high-quality medical resources, promoting the quality improvement of grassroots service facilities, and meeting the diverse needs of different population groups and future growth-oriented demands [49,50].

The development positioning of the Optics Valley area and Gehua area makes them comprehensive zones for high-end manufacturing and technological innovation, high-end industrial agglomeration areas and technological innovation sources, emerging industry clusters, and future industrial leading areas. As indicated by Section 5.1.2, the Optics Valley area mainly includes two types of emerging hot spots—oscillating hot spots and consecutive hot spots—indicating its significant development driven by the central urban area of Wuhan before 2010. Due to the planning and development of Wuhan New City, previously undeveloped areas have started construction, and now the Optics Valley area

has seen a large amount of development and construction activities. As Section 5.3 indicates, the economic development of the Optics Valley area is affected by factors such as population density, road density, distance to water bodies, and vegetation coverage rate. Therefore, it needs to coordinate industrial development with supporting transportation facilities and green ecological infrastructure. Additionally, compared to the Gehua area, the Optics Valley area is more affected by factors such as transportation and ecology. Thus, it should coordinate road layout, improve road traffic levels, and organize traffic reasonably to reduce the phenomenon of "pendulum-style" traffic. Urban green islands should be planned to promote diverse and green travel, creating a comfortable, convenient, and safe living environment.

As shown in Section 5.1.1, the confidence interval of hot spots in the lakeside area of the Gehua district is larger, indicating a higher significance of development in the lakeside area compared to other areas of the Gehua district. Therefore, water bodies are one of the significant influencing factors in the development of the Gehua district. It should adhere to the principle of "city determined by water, land determined by water, people determined by water, and production determined by water"; strengthen the bottom-line constraints on resources and environment; determine the protection measures of natural river and lake shorelines; optimize production, life, and ecological layouts based on regional resource endowments; balance residents' living, recreation, work, and transportation needs; and promote regional ecological priority and sustainable development [41,42,49,51]. The Gehua district has many new hot spots and enormous existing space, indicating significant development potential. Compared to the Optics Valley area, the Gehua district has better ecological resources. Therefore, in the planning of Wuhan New City, both economic development and natural environment development should be considered for the Gehua district. Under the constraint of resource and environment carrying capacity, it should focus on creating a unique cultural tourism and consumption destination around Sejia Lake and Wusi Lake. At the same time, it should focus on developing cultural creativity, cultural tourism, health and leisure, ecological tourism, commercial consumption, and thematic entertainment functions; organically layout cultural experience, tourism leisure, and other characteristic service spaces; focus on cultivating localized tourism industry chains; and continuously improve tourism service quality.

The development positioning of Longquan Mountain, Binhu Peninsula, Honglian Lake, Huashan, and Wutong Lake areas makes them scientific-research-bearing areas and cultural tourism leisure areas; international reception centers and ecological green hearts; digital creative livable areas; healthy and intelligent livable areas; and science, education, and culture livable areas. As shown in Figure 15, these five areas are located on the edge of Wuhan New City and have relatively slow development. Based on the spatial layout of emerging hot spots in Section 5.1.2, it can be inferred that the number of emerging hot spots in this area is relatively small. As indicated by Section 5.3, factors such as population, transportation types, medical facilities, public facilities, and government agencies have a significant impact on emerging hot spots in this area. With the existing high-quality environment and natural resources and the favorable location near Wuhan, future development should focus on constructing and operating efficient urban rail transit systems, planning and building a multi-level rail transit network system with clear levels and high-speed and high-efficiency travel, connecting important cluster centers inside and outside the new city, constructing external bus routes connecting Wuhan and Ezhou, and improving the efficiency of bidirectional flow. Effort should be made in actively embracing industrial creativity and cultural tourism and leisure functions, vigorously constructing suburban parks, improving related service facilities, creating an "ecological business card" for the area, and enhancing the attractiveness of the area. By developing shopping, medical, educational, and public entertainment facilities and ensuring their reasonable distribution; creating better entertainment and leisure spaces; and properly matching living spaces and industrial spaces, the internal synergistic development of Wuhan New City should be achieved.

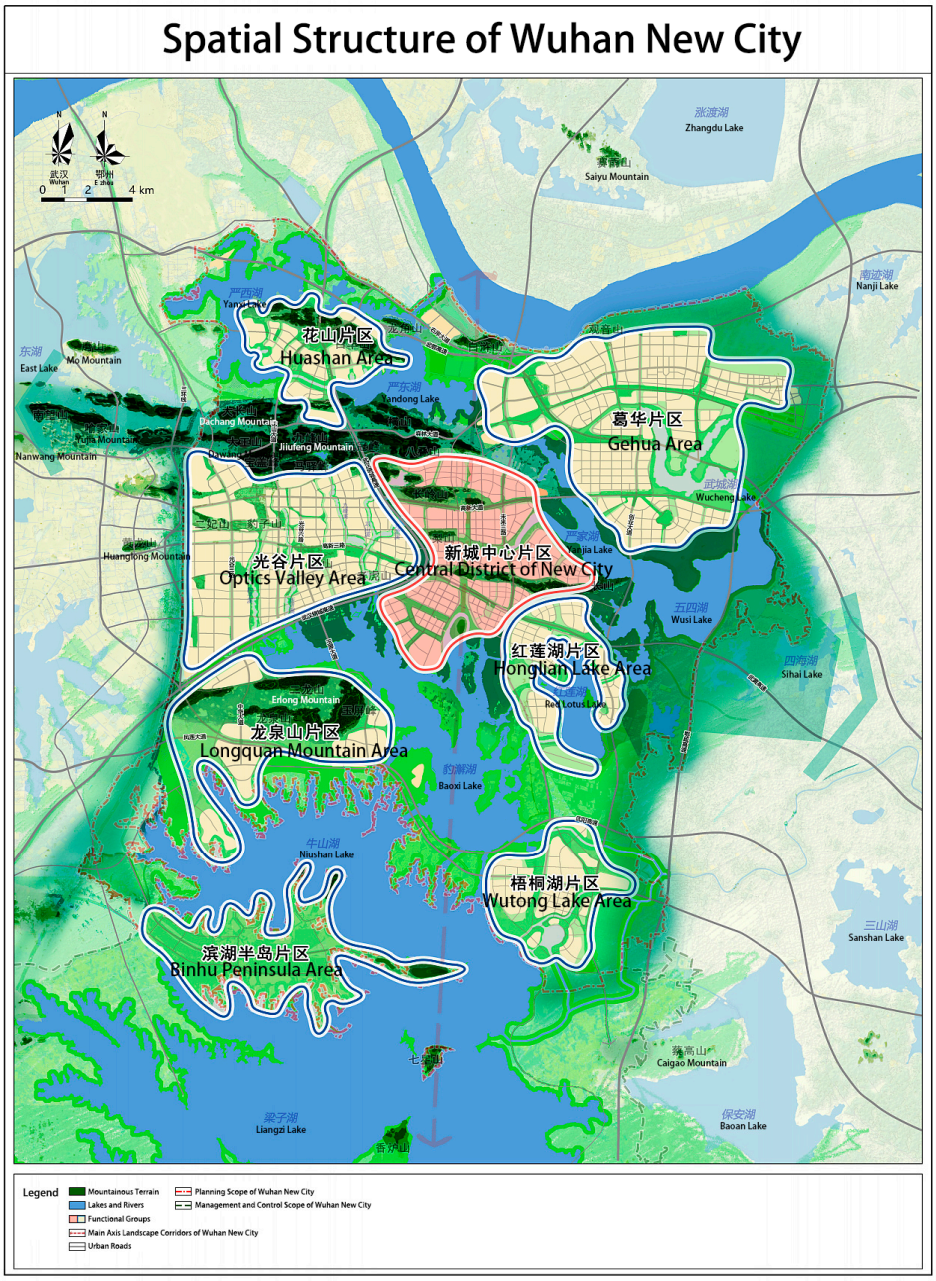


Figure 15. Wuhan New City spatial structure.

6.2. Summary

6.2.1. Summary of Work

Firstly, based on the remote sensing data of night-time light emissions for Wuhan New City from 2010 to 2019, after data preprocessing and kilometer grid construction, the space-time cube model was used to extract hot spots in Wuhan New City during the study period, and their spatiotemporal patterns were analyzed. Secondly, factors including population density, GDP, water body area, vegetation coverage, road density, number of bus stops, number of subway stations, road facilities, distance to water bodies, distance to train stations, healthcare, public facilities, government agencies, and scenic spots were selected as influencing factor indicators from five perspectives: internal natural environmental factors, internal traffic factors, internal service facilities factors, external location factors, and other factors. The bivariate Moran index was used to analyze the influencing factors of hot spots in Wuhan New City. Furthermore, based on the results of the space-time cube, the emerging hot spots in Wuhan New Town are extracted, and the influencing factors of four

kinds of emerging hot spots are analyzed by a disorderly multivariate logistic regression model. Finally, the development status and optimization strategy of Wuhan New Town are discussed and summarized, which provides a basis and reference for promoting the construction of Wuhan New Town efficiently and in an orderly fashion.

6.2.2. Major Conclusions

(1) Through the space-time cube model, it was found that there were 316 hot spots in Wuhan New City from 2010 to 2019, with 232 grids showing no obvious trend. The hot spots in Wuhan New City are mainly concentrated in the central part of the city, with the central and northern parts mainly being oscillating hot spots, showing an overall upward trend.
(2) The two positive influencing factors for the development of hot spots in Wuhan New City are number of bus stops and government agencies. Furthermore, six negative factors are distance to train stations, vegetation coverage rate, population density, water body area, distance to water bodies and GDP. Among them, vegetation coverage rate and distance to bus stops have the strongest significance and greatest impact.
(3) In hot spot areas, it is necessary to strengthen the construction of basic transportation facilities in urban areas, while in non-hot spot areas, emphasis should be placed on the high-quality development of natural resources such as green spaces, with the aim of improving accessibility to external natural resources and enhancing the construction of ecological tourism and smart living environments.
(4) Different categories of emerging hot spots have different influencing factors, with population density, vegetation coverage, road density, distance to water bodies, and distance to train stations being the most significant factors. Focus should be placed on the construction of ecological environments and tourism resources, while also constructing accessibility to Wuhan Station, injecting vitality into the city in excellent environmental and locational conditions, and continuously improving urban accessibility.
(5) Location and traffic are the two aspects that have the greatest influence on Wuhan New Town. Internally, it is necessary to further improve the road density and increase the north–south connectivity. Externally, it is necessary to strengthen the connectivity and accessibility between Wuhan New Town and external stations and natural resources, so as to better promote the population flow into Wuhan New Town, make full use of the existing location advantages, and build influential new town hot spots.

6.3. Issues and Prospects

(1) The study only considers the luminous remote sensing hot spots, which limits the comprehensive analysis of urban hot spots to some extent. Luminous remote sensing mainly represents night data, and its expression during the day is not sufficient and scientific. To solve this problem, future research can use urban surface temperature for analysis, measure the development hot spots of the city through the surface temperature at different times of the day and in different months and years, and compare it with the hot spots at night to more comprehensively understand the spatial distribution and evolution of urban hotspots.
(2) The selection of indicators is not fully considered. The choice of indicators in this paper is limited, and it does not fully measure the accessibility and distance of commercial centers and traffic stations between Wuhan New Town and Wuhan and Ezhou. In order to make up for this deficiency, future research can expand the scope of data collection, integrate more relevant data, and discuss the mechanism of various factors on the formation and aggregation of hot spots in Wuhan New Town more comprehensively.
(3) After selecting indicators, different analytical weights are not accurately defined for different indicators. In the following research, we can further quantify the influence

of different indicators by selecting weights through analytic hierarchy processes and other methods.

Although this paper has made some achievements in the extraction of hot spots and emerging hot spots in Wuhan New Town and the exploration of influencing factors, it still needs to improve the research methods and expand the scope of data collection to improve the scientific and practical research. Further research can provide suggestions for the future development focus, the strategic direction and development path of Wuhan New Town, and provide useful theoretical and practical reference for the construction of new towns in other cities and regions, so as to better promote high-quality urbanization and spatial layout optimization.

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