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Multi-Source Spatio-Temporal Data-Based Tourism Structure Analysis of Demonstration City for Global Tourism: Case Study of Liyang, China

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Abstract: Tourism can bring economic development and social benefits to cities. At present, global tourism is the leading urban tourism development model in China, and there is a growing tendency to use global tourism demonstration cities as models for urban tourism development; however, existing research has mostly focused on the theoretical level, and it is unclear whether such cities achieve sustainable development on a realistic level. This study selected the first demonstration cities of global tourism in China and conducted a coupling analysis using multi-source big data, clustering algorithm models, regional tourism flow distribution characteristics, etc., to explore whether the model cities meet development requirements. The following findings can be drawn from the analysis results. Firstly, the clustering algorithm coupled model study can provide a more accurate assessment of the current situation of regional tourism compared to the thermal values; secondly, the selected cities did not meet the development requirements of sustainable tourism and are in urgent need of improvement. The overarching contribution of this study is to propose a quantitative and replicable framework for urban tourism evaluation, combining spatial big data, computer algorithmic models and urban economics, etc.; this study also extends the interpretation of global tourism cities, reminds scholars, urban planners and urban tourism managers not to underestimate the possible tourism-related unsustainability of global tourism cities, and provides theoretical support for future tourism construction and urban planning development in China.

Keywords: sustainable tourism development; global tourism; big data; coupling analysis; urban planning

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1. Introduction

In the 20th century, sustainable tourism became a key topic in urban development planning [1,2], as it was one of the most widely recognized ways of promote regional economic development and social creativity [3]. Since the beginning of the 21st century, China has proposed the concept of tourism development with mutual coordination between global tourism and sustainable tourism, and the development of global tourism in China has now evolved following two different trajectories. On the one hand, early research focused on the level of theoretical definitions, defining Global Tourism as a new model of tourism development based on sustainable tourism [4–8], emphasized the four new concepts of tourism image, tourism environment, tourism resources, and tourism time, and extended the scope of tourism market concerns [9–11]. With the transformation of the concept and the development of the theory, global tourism is no longer limited to tourism itself, but spans from tourism to the overall development of the city [12–15], focusing on universal participation, spanning across all of time and covering all destinations, as well as emphasizing the ability of tourism to drive the regional economy, planning and construction development, etc. [16–18]. At present, with the promotion of the demonstration city of global tourism, the concept of global tourism has gradually shifted from a single development to the national development level, and in general, has undergone a qualitative change. On the other hand, a number of scholars have attempted to sublimate the concept of global tourism, putting forward ideas for the future development trend of global tourism and proposing the concept of 'Global Tourism+' [19,20], which defines global tourism as an important means of promoting the economy that encompasses multiple aspects such as the regional economy, flow of people, popularity and landscape environment design, etc., to form a systematic tourism theory that can be promoted around the world [21–24].

Whilst the global tourism research at a theoretical level has been significant, it is evident that research at the practical level has not been adequately discussed. At present, it is still unclear whether the concept of global tourism promotes the development of urban tourism, and it is also still unclear whether the model cities follow the development of urban tourism under the concept of global tourism, the reasons for which can be summarized in the following three points. Firstly, there are gaps in the standards required by cities for tourism development [25,26], and no unified standardized development requirements have been proposed in existing theoretical studies of global tourism. Secondly, there is also no unified quantitative evaluation method among existing studies, and the quantitative evaluation of tourism is currently at the stage of comparing thermal values, a method which lacks accuracy and cannot be used as the sole basis for evaluation. Furthermore, current theoretical research levels ignore the development and availability of geospatial big data [27,28]. Machine learning techniques can complement the limitations of traditional statistics in terms of reduced reliability and slow computation in the processing massive amounts of data, and the emergence of multi-source big data can more accurately describe and visualize the development status of regions of tourism [29]. Therefore, it is worth further discussing how to study a quantitative and replicable framework for evaluating urban tourism, and new data and methods can lay a solid foundation for the healthy development of global tourism.

With the help of multi-source big data, this study proposes a quantitative and replicable urban tourism evaluation framework that creatively couples spatial big data, computer algorithmic models, and urban economics to explore quantifiable methods for evaluating cities for global tourism. The paper is arranged as follows: Section 2 introduces the research methodology and analyzes the research framework throughout the text. Section 3 describes the study area and data sources. Section 4 presents the analysis of the results. Section 5 discusses the empirical results. The conclusion is summarized in the final section.

2. Analytical Framework

A quantitative research approach was adopted to understand the current state of tourism in the region at multiple levels and to explore the value plasticity and sustainability of tourism in the region. The methodology consists of three basic components. First, we used open source geospatial big data to measure the tourism dynamics of the region. Second, the tourism density of the region was defined and measured, and the innovative machine clustering algorithm was used to analyze the regional tourism density in class clusters. Finally, the distribution characteristics of the regional tourism flow traffic were analyzed and discussed from multiple perspectives, including temporal characteristics, spatial characteristics, and effect characteristics (Figure 1).

2.1. Measurement of Dynamic Thermal Status of Tourist Areas

The dynamic thermal status can be defined and quantified [30], as the dynamic thermal status is one of the expressions of the regional density, which is a way of expressing the location of a mobile user interface through spatial expression processing based on the big data of mobile terminals, with the special display form of Highlight, and with different colors distinguishing the different degrees of user density in different areas; this can not only describe the distribution and gathering of the crowd, but also predict the changing trends of the crowd. Table 1 lists several commonly used measurement methods which generally fall into two theoretical types: one considers that heat can refine urban boundaries and evaluate urban public service systems, whilst the other is based on multi-source data, which is processed through quantitative studies and spatial representations to study the state of urban or regional heat, under which Highlight is commonly used as a special display form to express the location of mobile user interfaces [31]. Different colors are used to distinguish the intensity of users in different areas [32], which not only describes the distribution and aggregation of the crowd, but also predicts the trends of change in crowd. In this study, Python was used to collect the regional data to study its dynamic thermal.

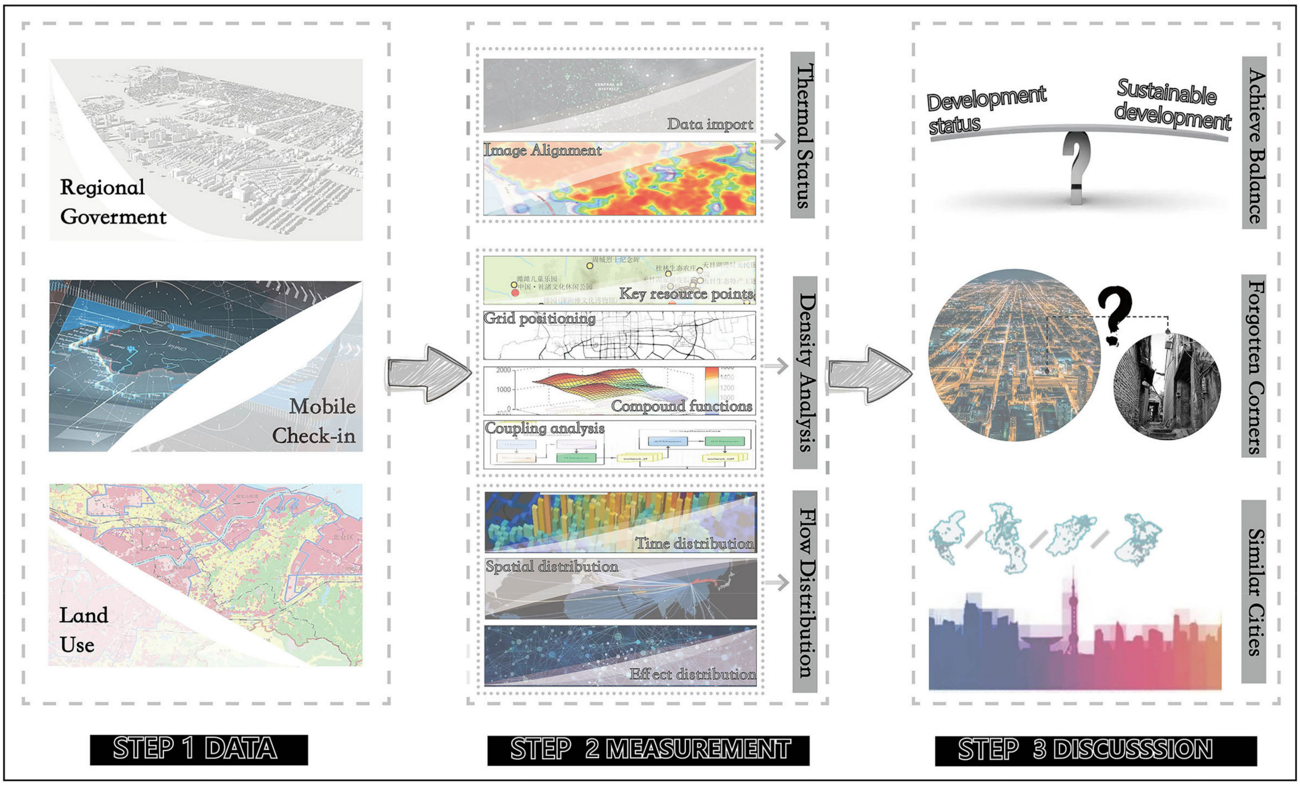

Figure 1. Analysis approach.

Table 1. Commonly used methods of measuring the dynamic thermal status.

Author (Year), Study Area	Data Source and Method	Advantages	Disadvantages
[33] London, UK	Web-based open source multi-genre data	Study using multiple types of data for the first time. Objective and realistic analysis.	The cost of data collection is too high to promote its use.
[34] Six cities, Italy	Mobile Wi-Fi location data	A detailed analysis of the dynamic thermal can be carried out on a macro-scale. 9i	Subjective with a human starting point. Some Wi-Fi access points (e.g., private Wi-Fi) are excluded and some groups (e.g., people who do not use mobile phones) are ignored.
[35] Tehran, Iran	Questionnaire and linear regression analysis methods	The factors influencing dynamic thermal status can be analyzed in terms of traffic.	Traffic represents only one particular aspect of heat. Traffic data are not free from their inherent biases.

Table 1. *Cont.*

Author (Year), Study Area	Data Source and Method	Advantages	Disadvantages
[30,36] U.S. and Singapore	Google Street View Images, Expert scoring and GIS	Data are easy to access and are a powerful way of reflecting the thermal status of the city.	Only the area during the departure and arrival of the Street View camera can be captured and the data are not accurate.
[37]China	Big data	Four dimensions—national, Yangtze River Delta, city, and street space—are used to complete the theoretical framework for urban thermal analysis.	Parts of the data are not disclosed to the public and access to the dataset is difficult.
[38] Shanghai, China	Baidu map Heat map	Helps overcome the ambiguity of spatio-temporal data by moving from a 'time-space' perspective to a point of view.	The intuitiveness of spatial perspective analysis is ignored.
[39] Shanghai, China	Commercial facility building base volumes, cellular signaling data and POI data	The spatial resources are evaluated in different dimensions and the results can be used to facilitate urban planning.	It is difficult to obtain this dataset for the building base of commercial facilities and the dimensional selection is small.
[40] Beijing and Guangzhou, China	POI data obtained by open API services of Dianping	Data are easy to access and are a powerful way of reflecting the urban pattern.	Unable to take into account the contribution of each point to the heat.

2.2. Measurement of Tourism Area Density Analysis

A cluster algorithm model is proposed to carry out an accurate calculation of the density of the tourist area, and it is suggested that the density analysis is a further accurate analysis of the thermal power of the tourist area. Clustering algorithms are an important class of algorithmic approaches that can mine data, dividing objects into sets based on the principle that there is similarity between the data and the objects that produce them, each set being called a 'cluster' [41]. Clustering algorithms, as a branch of statistics, are among the most important tools for data processing; Table 2 lists several common clustering algorithms [42,43].

Table 2. List of clustering algorithm forms.

Types of Clustering Algorithms	Major Clustering Algorithm Models	Advantages and Disadvantages
Delineated clustering algorithm	K-means Algorithm, K-medoids Algorithm, Expectation Maximization Algorithm [44]	Easy to understand and implement.
Hierarchical clustering algorithms	BIRCH Algorithm, CURE algorithm, CHAMELEON Algorithm [45–47]	Less flexible; need to be used in conjunction with other methods.
Density clustering algorithm	DPC Algorithm, DBSCAN Algorithm, OPTICS Algorithm, DENCLUE Algorithm [48–51]	High accuracy; any shape of clustering can be found.
Grid clustering algorithm	STING Algorithm, CLIQUE Algorithm, WAVE-CLUSTER Algorithm [52–54]	Fast processing speed; low volume of data.
Model clustering algorithms	COBWEB Algorithm, Competitive Learning Algorithm [43,55]	Selected results are representative.
Other clustering algorithms	FCM Algorithm, Quantum Algorithm, SVM Algorithm, etc. [43]	Immature; low feasibility.

2.3. Measurement of Regional Tourism Flow Distribution Characteristics

Tourism flow characteristics can be conceptualized as a collective term for cultural, information, industrial and capital flows, and as a predictor of tourist activity in a tourist destination [56]; coupled analysis based on density and tourism flow characteristics can provide a more intuitive picture of the cultural, industrial, and sustainable tourism development of that touristic region. In this study, we examine the temporal, spatial, and tourism effect characteristics in terms of 'time, tourism route preference and tourism income' [57]. The quantitative study of the distribution characteristics of tourism flows can reduce the negative effects due to uneven distribution and play an important role in the sustainable development of regional tourism [58].

2.4. Empirical Strategies

In this study, we chose the density peaks clustering (DPC) algorithm model [59], which was first proposed by Alex et al. in 2014, but the model at this stage has drawbacks including its truncation distance sensitivity and the presence of errors [60]; in 2018, Yang et al. improved the algorithm to address these drawbacks and proposed using Gini Impurity to find error-free dc values to avoid errors and ensure the accuracy of the algorithm model [61]. The main basic idea of the DPC clustering algorithm model is divided into two kinds: one is that the cluster center itself is denser than the surrounding neighboring points; the other is that the distance between the cluster center and the sample points with higher density is relatively large [59].

In this study, the establishment of the DPC clustering algorithm model is divided into three steps: one is to identify the important resource points of the region; the second is to carry out raster location annotation; and the third is to establish the DPC algorithm model compound function to analyze the regional cluster center point distribution map, and the specific compound function formula is:

Create a value set M, $M = \{x_i, x_{ii}, x_{iii} \ldots, x_j\}$, and the relative distances of the sums in the set of values M are:

$$d_{ij} = ||x_i - x_j||_2 \tag{1}$$

where x_i is the value point at each location in the 'Yi-Travel' data collected below, and its local density ρ_i is calculated, as well as the neighbouring density d_{ij} for each point and its surroundings. d_{ij} represents the relative distance between the value points x_i and x_j, which is the density of the index point x_i with the shortest distance to its surroundings distance from the high numerical value point.

The local density of the value set M is calculated as a function of both a truncated kernel and a Gaussian kernel, which can be expressed and distinguished by defining the number of focal raster points. The sum of the number of all numerical points within the cut-off distance is defined as the truncation kernel, and the sum of the Gaussian distances from all numerical points to that numerical point is defined as the Gaussian kernel, both of which are expressed as different functions and graphs [62]; the specific compound function formula is:

$$\rho_i = \sum_{j=1}^{n} x(d_{ij} - d_c) \tag{2}$$

$$\rho_i = \sum_{j=1}^{n} exp(\frac{d_{ij}^2}{d_c^2}) \tag{3}$$

Equation (2) shows the truncated kernel and Equation (3) shows the Gaussian kernel—where d_c is the truncation distance. When $x < 0$, $\chi(x) = 1$; when $x \geq 0$, $\chi(x) = 0$, $d_c > 0$ and $i \neq j$.

When both the relative distance δ_i and the local density ρ_i exceed the surrounding neighbouring data points, the corresponding numerical point x_i is defined as the peak density, also known as the cluster center point. A decision diagram can be drawn to determine the clustering centroid of a region, with the decision value γ_i shown in Equation (4) below.

$$\gamma_i = \rho_i \times \delta_i \tag{4}$$

Substituting the data into Equations (1)–(4) and coupling ArcGIS, TF-IDF, etc., for layer overlay analysis, the points with relatively large local densities and larger distances can be clearly distinguished, resulting in error-free regional density cluster center point distribution results.

Through the above method, combined with the regional tourism thermal state, regional tourism flow distribution characteristics can clearly and accurately analyze whether regional tourism is in healthy and sustainable development; analyze the current development of the more lagging areas; and consider the joint development with the surrounding areas to promote the synergistic development of the regional economy, industry, etc., to achieve the sustainable development of regional tourism.

3. Case Study

3.1. Study Area

This study was conducted in the Liyang (31°09′–31°41′ N, 19°08′–119°36′ E), Jiangsu (Figure 2). Liyang belongs to Changzhou City, Jiangsu Province, which is in the Yangtze River Delta region and is an important part of Nanjing metropolitan area cities, as well as an important sub-center city and demonstration area on the Ning–Hang ecological economic belt, and one of the first demonstration cities of global tourism in China. Liyang covers a total area of 1535.87 square kilometers, and the terrain of the whole area is gradually flat from west to east, with abundant water resources rich and numerous lakes, most notably Tianmu Lake and Daxi Reservoir. It has a subtropical monsoon climate with an annual average temperature of 15.5 °C, a monthly average temperature of 2.7 °C in January and 28.1 °C in July, and an annual frost-free period of 250 days; its precipitation is abundant with an annual precipitation of 1152.1 mm [(Liyang City Bureau of Statistics, 2021)].

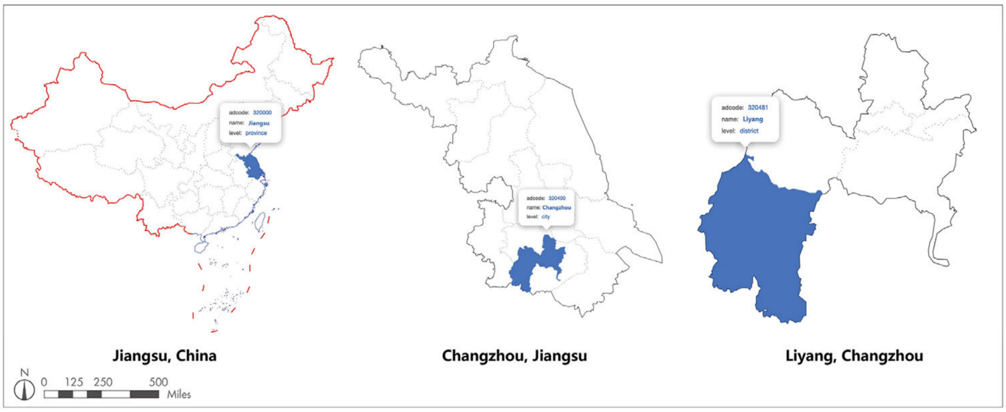

Figure 2. Location map of Liyang.

As one of the first demonstration cities of global tourism in China, Liyang has a very important position among touristic Chinese cities. Liyang, based on its resource characteristics and spatial distribution features, is connected to six landscape areas in the whole area (North Area, South Area, West Area, East Area, Central Area and Tianmu Lake Area) (Table 3) by means of the 'Liyang Highway No.1 Tourism Loop', forming a tourism network of 'big ring and small ring with internal and external connections' (Figure 3). Moreover, with the help of industrial planning and layout, it has integrated the development of the primary, secondary, and tertiary industries, expanded the municipal pattern, promoted the development process of "three mountains and two lakes", and aims to strengthen the construction of tourism facilities, rationalize and optimize the layout, realize the balanced and sustainable development of tourism in each region, and build an area-wide tourism pattern.

3.2. Data Sources

Big data have played a multi-faceted role in the research field of landscape architecture with the rapid development of electronic information technology [63–65], and in this study, we adopted data from a total of three sources.

Table 3. List of tourism development plans of each area in Liyang.

Area Names	Positioning	Development Ideas
North Area	Meditation Eco Resort	Waya Mountain as the core, Jizo culture and meditation culture as the characteristics, leisure sports system construction as the focus
South Area	Bamboo Forest Tea Village Wellness Resort	Relying on the mountains, water, bamboo, forest, hot springs, tea country, etc., in the Nanshan area tourism elements, implanting Deshou culture
West Area	Longevity Slow City Resort	Create an international slow city with local characteristics that integrates ecology, culture, and recuperation
East Area	Water leisure experience Resort	Relying on the Changdang Lake National Wetland Park and the Chinese Ape Geopark, forming a three-dimensional tour space of water, land and air
Tianmu Lake Area	Liyang City Card	Using Tianmu Lake tourism resort resources as a basis to create a city tourism brand Using Tianmu Lake tourism resort resources as a basis to create a city tourism brand
Central Area	Tourism Auxiliary Service Center	Providing tourism services such as catering, accommodation, transportation, entertainment and shopping, and undertaking functions such as tourism information consultation in Liyang.

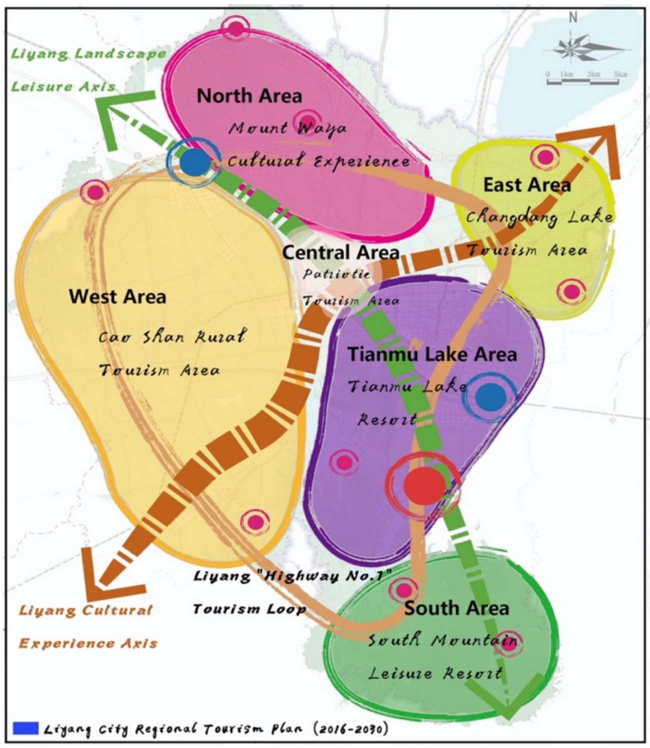

Figure 3. Liyang City Regional Tourism Plan.

3.2.1. Regional Government Planning Data

In addition to the searchable information, finding some of the government's confidential planning documents is difficult. Liyang has been named as a 'model city for global tourism', and the government has issued relevant tourism plans, which are confidential documents and thus difficult to access. Finally, these documents were obtained as the data sources became more diversified with the assistance of the supervisor, many communications from the subject group, relevant official websites, academic journals, and some personal contacts. These planning documents are the main sources of government planning data for this paper (Table 4).

Table 4. List of the planning documents.

Year	Planning Policy	Policy Content
2016–2030	Liyang Municipal Comprehensive Transportation Planning	Developing diversified urban transportation system and building a global tourism leisure corridor.
2016–2030	Liyang Municipal Tourism Traffic Planning	Planning landscape paths and tourist public transport to establish internal and external tourist transport organization and promote the development of global tourism in a comprehensive manner.
2016–2030	Liyang Tourism Planning	Use road networks to connect tourism resources across the region, linking the various tourism sub-regions, with 'global tourism' as the core, realizing the scenery across the city and strengthening the global pattern.
2016–2030	Liyang Municipal Industry Layout Planning	Accelerating industrial transformation, focusing on creating leisure and vacation tourism, and emphasizing the integration of development among the three industries. The emphasis is on creating leisure and holiday tourism and promoting the development of supporting services for global tourism.

3.2.2. Mobile Terminal Background Check-in Data

The mobile check-in data come from WeChat, and the main data come from the background check-in data of WeChat's 'Yi-Travel' public number. With the rapid development of the Global Position System (GPS) and the mobile Internet, location-based social networks (LBSNs) have changed people's lives in many ways, and everyone's communication is gradually changing to location-based social networks. Unlike traditional social networks, LBSN has added the dimension of geographical location (lng–min–max, lat–min–max) and can extract data such as the number of travelers, time, location, and access paths from the past access history; it also strengthens the connection between the virtual world and the real world in traditional social networks, and provides a more scientific way of thinking for mining the travel density distribution of users. As the largest social media in China, WeChat can generate a large amount of data based on check-in services. 'Yi travel' is a social service platform for sharing and exchanging information that has emerged in the Internet era. Based on the 'Yi travel' backend, it is possible to scientifically and accurately capture the real-time data on the number of people travelling.

3.2.3. Land Use Data

We obtained official land data, both those provided by the Natural Resources Bureau of Jiangsu Province and those by Liyang City, and compared the two to ensure that the land data were up to date. Most of the data were obtained from the official data uploaded by the latest National Land Survey on the official website of the Natural Resources Bureau of Jiangsu Province, which conducted a detailed survey of each city and region, mainly including remote sensing images from the Landsat8 OLI database of Liyang and the digital elevation data of GDEMDEM 12M resolution of Liyang, etc. The boundaries and land properties of each city and region were reconfirmed. These land data need to be confirmed. These land data are subject to the cross-processing of big data.

4. Results

Considering COVID-19, tourist venues have been mostly closed in recent years. To ensure the scientific nature of the research data, the period 2018–2019 was selected for this study.

4.1. Dynamic Thermal Status Results of Tourist Areas

A total of 107,398 real-time all-day people data were extracted for this study. Excluding the presence of off-hour openings and visits by residents in each tourist area, a double filtering of time and travel trajectory was carried out. After excluding local resident visits and off-hour openings, a total of 86,735 valid data were extracted.

Figure 4 shows the dynamic thermals of the different slices, and the dynamic thermals values of the different slices are clearly different. In terms of peak and trough values, Liyang has a peak thermal value of 463.67 for the Tianmu Lake Area and a trough value of 8.1 for the Central Area with a multiplicative difference. In terms of Liyang, the dynamic thermal values are higher in the Tianmu Lake and South Areas and lower in the East Area and Central Area. In terms of the ranking of the thermal values, the dynamic thermal values are significantly different for each area in the following order: Tianmu Lake Area, South Area, North Area, West Area, East Area, and Central Area. The difference in dynamic thermal values indicates that there is a non-negligible dynamic thermal gap between the areas.

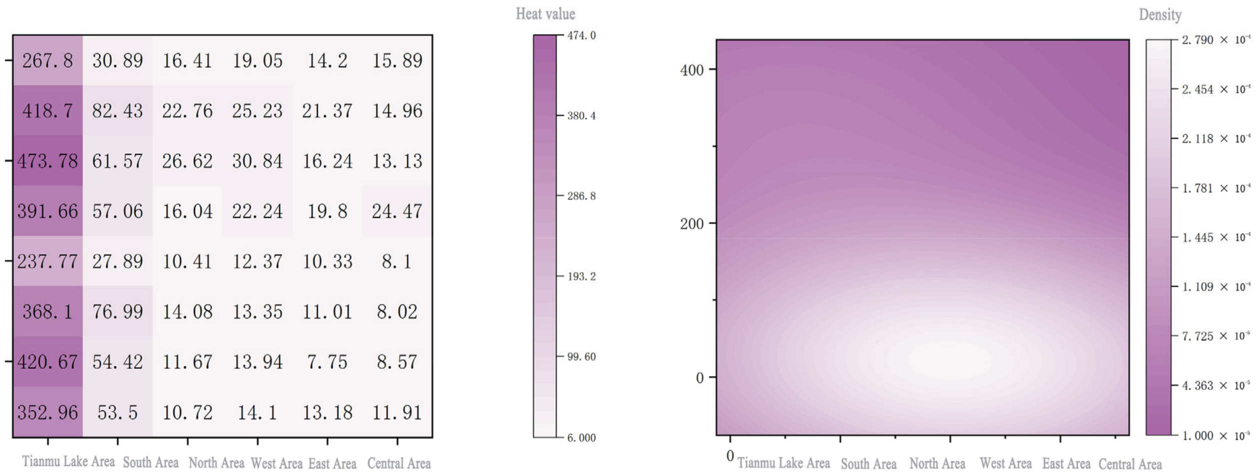

Figure 4. Dynamic thermal measurements in tourist areas.

4.2. Density Results of Tourist Areas

Figure 5 identifies the resource points in Liyang, combining the <Liyang Municipal [Comprehensive (2016–2030)]> and <Liyang Municipal Tourism Traffic [Planning (2016–2030)]>, etc., to collate the existing resource points in Liyang. A total of 132 existing tourism resource points were collated, including Level 1 resource points 19, Level II 25, and Level III 88. Based on the statistics of the number of resource point grids in each area, six important resource points were extracted. Table 4 shows the latitude and longitude of key resource points, specific location names, and the number of raster points (Table 5).

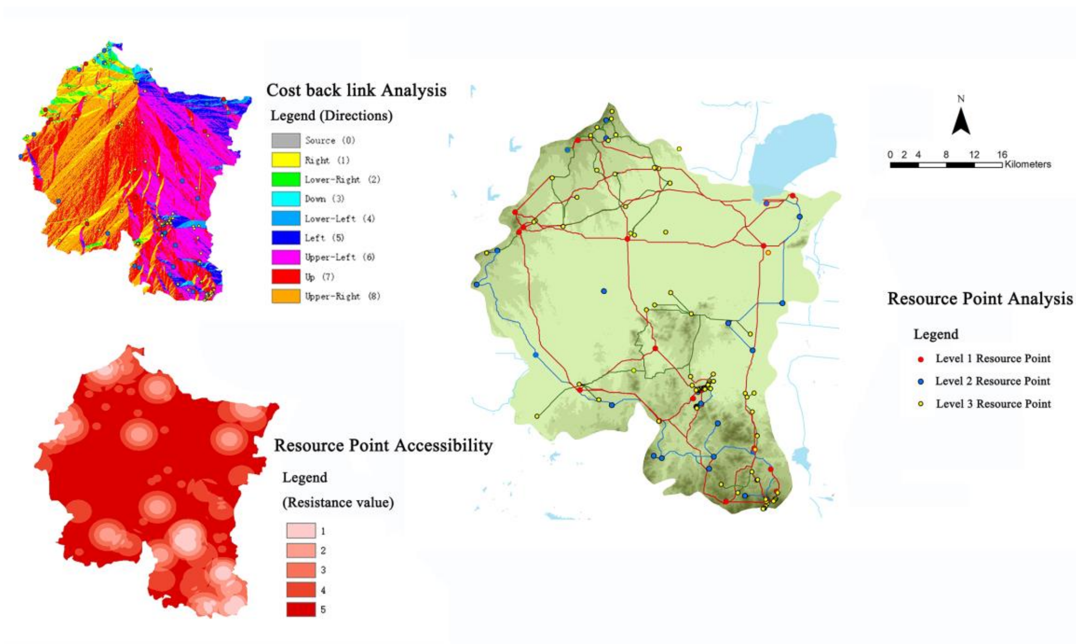

Figure 5. Regional Important Resource Point Analysis Map.

Table 5. Coordinate identification of key resource points.

Number	Coordinate	location Names	Number of Raster Points
1	119°25′48″ E, 31°17′24″ N	Tianmu Lake	26,757
2	119°31′12″ E, 31°10′48″ N	Nanshan Zhuhai	15,783
3	119°18′0″ E, 31°39′0″ N	Wawu Shan	9856
4	119°12′0″ E, 31°31′48″ N	Qicai Caoshan	10,674
5	119°31′12″ E, 31°29′24″ N	Shihou Temple	7325
6	119°30′0″ E, 31°25′12″ N	Gao Jing Yuan	5639

Figure 6 shows the results of the coupled analysis of the raster location and the DPC model. The DPC model results show that a total of 10 regional clustering centroids can be filtered out after the preliminary algorithm model analysis, and the distribution of the current six regional density points and clustering center points can be roughly derived. The order of the regional density points is as follows: Tianmu Lake, Nanshan Zhuhai, Qicai Caoshan, Wawu Shan, Shihou Temple, and Gao Jing Yuan.

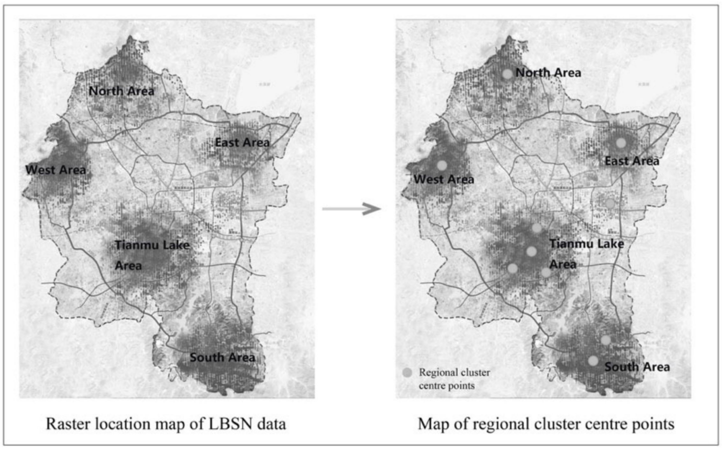

Figure 6. DPC algorithm model analysis diagram.

Figure 7 shows the results of the coupled analysis of slope, slope orientation, water resistance, coverture vegetable, land use, ecological suitability, and traffic accessibility of the Liyang. Figure 8 shows the analysis results of the layer overlay of the DPC algorithm model coupled with ArcGIS, TF-IDF, etc., and the results show that there are four precise regional clustering center points in the region. In terms of cluster center point distribution, consistent with the <Liyang Tourism [Planning (2016–2030)]>, the four cluster center points are located in the Tianmu Lake Area, the South Area, the West Area and the North Area, with no distribution in the East Area and the Central Area; in terms of density, the results of this density analysis are more accurate than the dynamic thermal measurement results, and the order of regional tourism density is as follows: Tianmu Lake Area, South Area, North Area, West Area, East Area, and Central Area.

Comparing the results in Figures 4 and 6, we can see that the research method proposed in this paper allows for a twice as accurate calculation of regional tourism density, and that the distribution of regional clustering center points is an important factor affecting regional tourism density.

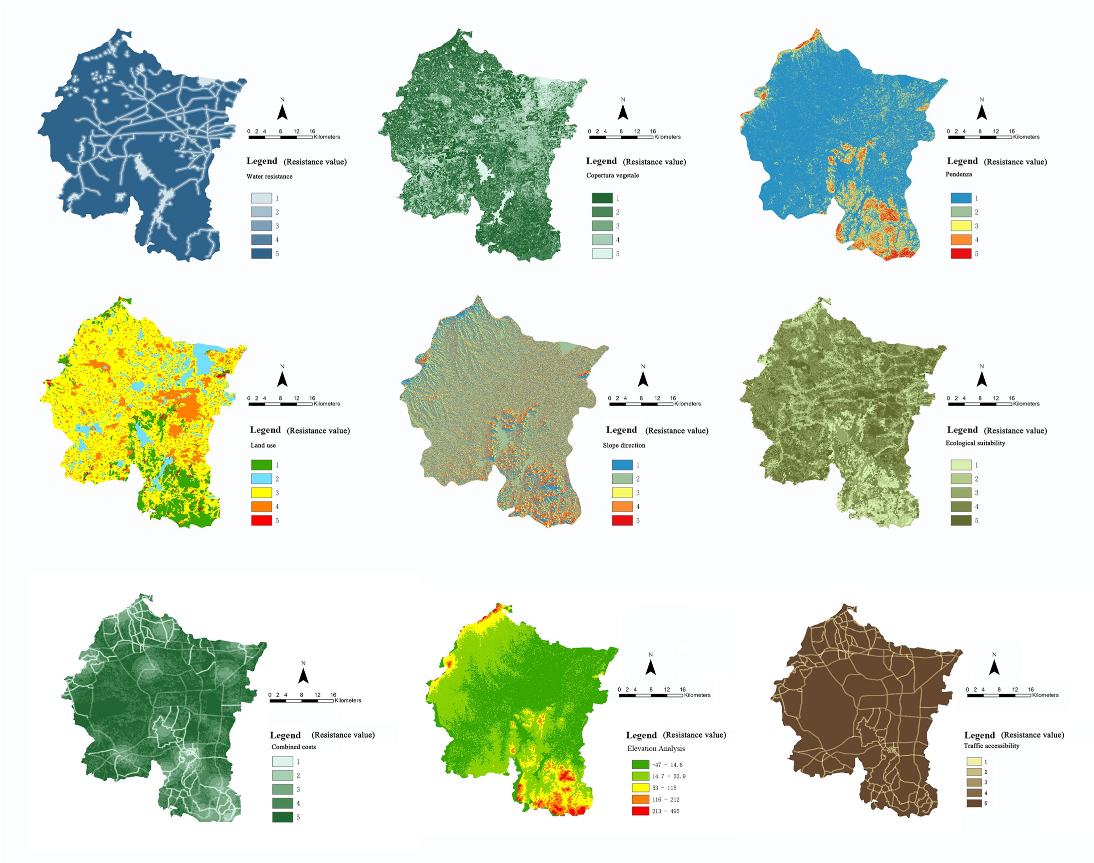

Figure 7. Coupling analysis.

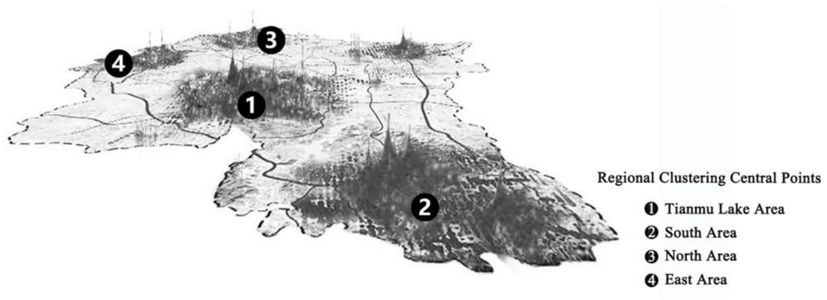

Figure 8. Layer overlay result map.

4.3. Regional Tourism Flow Distribution Characteristics

4.3.1. Regional Tourism Flow Time Distribution Characteristics

Using a time-stratified approach, the regional tourism flows are analyzed at four time scales: annual, seasonal, monthly, and off-peak.

Table 6 illustrates the statistical results of the annual distribution characteristics of regional tourism flows, whilst Figure 9 illustrates the results of the annual distribution characteristics of regional tourism flows, and the results show that there is an upward trend in annual regional tourism flows between 2018 and 2019. From 2018 to 2019, the annual tourism flow in the region showed an upward trend: the overall number of visitors in 2018 was 17,718,100 and the overall number of visitors in 2019 was 21,031,400—an increase of 15.75%. From the viewpoint of the numbers of visitor for each area, all areas also showed an upward trend, however, the tourist flow shows the distribution characteristics of 'single-peak discontinuity'. This is reflected in the fact that there is only one main peak in Liyang, the Tianmu Lake Area, which is continuously at a high level, while the sum of the tourist traffic in the other five areas from 2018 to 2019 is smaller than that of the Tianmu Lake Area, forming a fault structure.

Table 6. List of in-year tourism numbers by region in Liyang, 2018–2019.

Area Name	2018 (Million People)	2019 (Million People)	Total (Million People)
Tianmu Lake Area	1379.5	1551.94	2931.44
South Area	212.8	231.95	444.75
North Area	46.88	81.83	128.71
West Area	53.76	97.36	151.12
East Area	42.27	71.61	113.88
Central Area	36.6	68.45	105.05

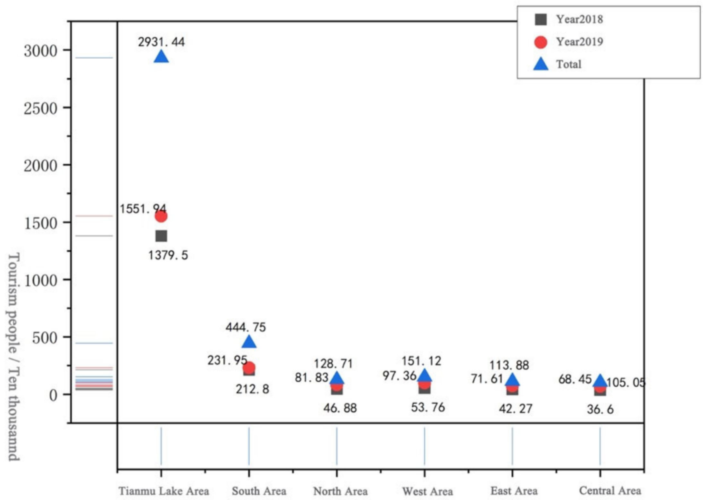

Figure 9. Annual distribution characteristics of regional tourism flows.

According to the China Meteorological Administration, March – May is spring, June–August is summer, September–November is autumn, and December–February is winter [57]. Table 7 illustrates the statistical results of the monthly distribution characteristics of regional tourism flows and Figure 10 shows the results of the seasonal distribution of regional tourism flows. The results show that there is a difference in the seasonal distribution of tourism flows in each area, and the seasonal distribution shows 'variability'. Specifically, tourism flows in Tianmu Lake and the West Area are concentrated in summer, in the South Area and the North Area in autumn, and in the East Area and the central city in spring, with seasonal tourism flows in the order of summer, autumn, spring, and winter.

Table 7. List of tourism numbers by season in each area of Liyang, 2018–2019.

Area Name	2018 Spring	2018 Summer	2018 Autumn	2018 Winter	2019 Spring	2019 Summer	2019 Autumn	2019 Winter
Tianmu Lake Area	352.96	420.67	368.1	237.77	391.66	473.78	418.7	267.8
South Area	53.5	54.42	76.99	27.89	57.06	61.57	82.43	30.89
North Area	10.72	11.67	14.08	10.41	16.04	26.62	22.76	16.41
West Area	14.1	13.94	13.35	12.37	22.24	30.84	25.23	19.05
East Area	13.18	7.75	11.01	10.33	19.8	16.24	21.37	14.2
Central Area	11.91	8.57	8.02	8.1	24.47	13.13	14.96	15.89

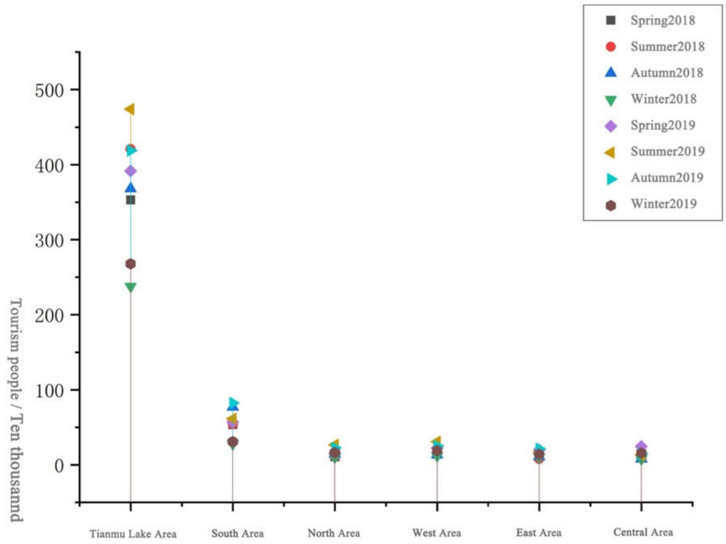

Figure 10. Seasonal distribution characteristics of regional tourism flows.

Table 8 shows the statistical results of the monthly distribution of regional tourism flows in 2018; Table 9 shows the statistical results of the monthly distribution of regional tourism flows in 2019; and Figure 11 shows the results of the monthly distribution characteristics of regional tourism flows. The results show that monthly tourism flows show a 'double peak and multiple valley' distribution, with a 'W' pattern structure between peaks and valleys. The graph shows that there are two peaks, the Golden National Day holiday and the summer holiday, which show a 'spurt' growth trend, but there are significant differences in the growth rate between areas; the multiple valleys are in February, September, November, and December, with a large difference between the peak and valley values in each area and the peak values for Tianmu Lake exceeded the peak values for the North, West, East, and Central City.

Table 8. List of tourism numbers by month in each area in Liyang, 2018.

Area/Month	Tianmu Lake Area	South Area	North Area	West Area	East Area	Central Area
January	100.24	10.22	3.56	3.77	3.79	3.07
February	71.19	8.69	2.98	3.12	2.56	2
March	116.78	10.45	3.46	3.56	4.08	3.78
April	117.56	10.38	3.25	3.55	4.12	3.99
May	118.62	32.67	4.01	6.99	4.98	4.14
June	73.77	9.19	2.68	2.96	1.34	1.99
July	126.34	20.68	4.66	3.44	1.07	2.56
August	220.56	24.55	4.33	7.54	5.34	4.02
September	59.52	8.66	3.54	2.3	2.34	1.77
October	255.87	59.66	6.99	8.65	6.77	4.68
November	52.71	8.67	3.55	2.4	1.9	1.57
December	66.34	8.98	3.87	5.48	3.98	3.03

Note: The unit of the number of tourists is 10,000 people.

Considering various factors such as climate, Golden Week, national holidays, summer and winter holidays, and working days, the off − season, flat season, and peak season are classified. January, July, August, and October were selected as the peak seasons for tourism, with January and July − August being the winter and summer holiday periods and October being the Golden National Day holiday. March, April, May, June, and September were selected as the flat seasons for tourism, with April, May, and June being the national long holidays for the Ching Ming, Labor Day, and Dragon Boat Festival, respectively, and March and September being the early spring and early autumn seasons, respectively, when the weather is more pleasant. February, November, and December were selected as the low seasons, with the three months being the colder months and mostly weekdays. Table 10 illustrates the statistical results of the off-peak season distribution of regional tourism flows and Figure 12 shows the results of the off –flat− peak seasonal distribution characteristics of regional tourism flows. The results show that the off – flat– peak tourism flows show the characteristics of 'similarity' and 'regularity'. In terms of the overall flow, it shows that the peak season > flat season > low season reflects 'regularity'; in terms of the flow of each area, the analysis results are roughly similar to those of the above analysis, showing that the Tianmu Lake Area > South Area > West Area > North Area > East Area > Central Area reflects a 'similarity' feature.

Table 9. List of numbers of tourists by month in each area of Liyang, 2019.

Area/Month	Tianmu Lake Area	South Area	North Area	West Area	East Area	Central Area
January	116.19	12.68	6.13	6.53	5.03	6.43
February	78.06	9.01	3.52	4.25	3.32	4.03
March	126.78	11.12	5.13	5.91	4.95	6.76
April	131.12	10.84	4.32	5.11	5.4	7.98
May	133.76	35.1	6.59	11.22	9.45	9.73
June	86.67	9.42	5.69	6.63	3.35	2.01
July	147.87	23.82	10.01	7.8	4.07	4.35
August	239.24	28.33	10.92	16.41	8.82	6.77
September	65.79	8.76	6.53	4.48	4.39	3.54
October	294.74	64.67	11.72	14.89	14.01	8.36
November	58.17	9	4.51	5.86	2.97	3.06
December	73.55	9.2	6.76	8.27	5.85	5.43

Note: The unit of the number of tourists is 10,000 people.

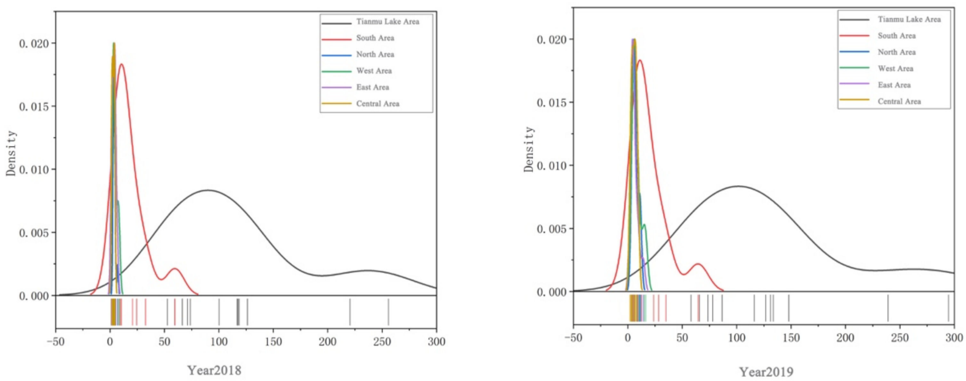

Figure 11. Monthly distribution characteristics of regional tourism flows.

Table 10. List of off-peak and peak seasons tourism numbers by region in Liyang in 2018–2019.

Area/ Off–High–Flat	Tianmu Lake Area	South Area	North Area	West Area	East Area	Central Area
2018 off season	190.24	26.34	10.4	11	8.44	6.6
2018 flat season	486.25	71.35	16.94	19.36	16.86	15.67
2018 high season	703.01	115.11	19.54	23.4	16.97	14.33
2019 low season	209.78	27.21	14.79	18.38	12.14	12.52
2019 flat season	544.12	75.24	28.26	33.35	27.54	30.02
2019 high season	798.04	129.5	38.78	45.63	31.93	25.91

Note: The unit of the number of tourists is 10,000 people.

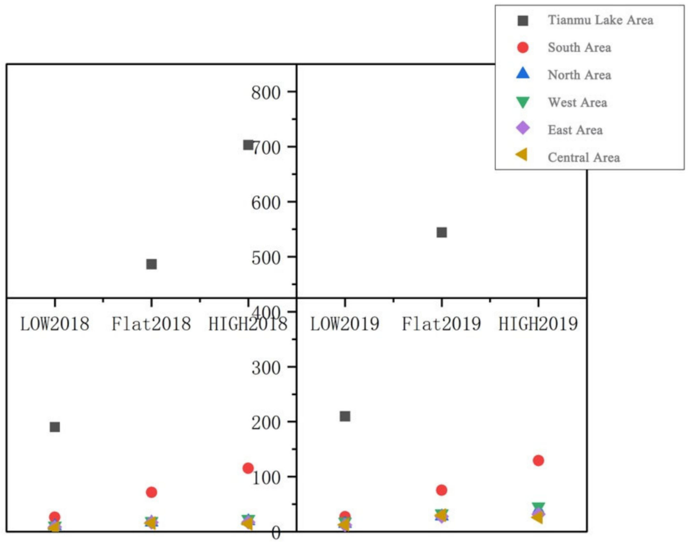

Figure 12. Off–flat–peak season distribution characteristics of regional tourism flows.

4.3.2. Regional Tourism Flow Spatial Distribution Characteristics

Spatial distribution of tourism flows is mainly studied from the perspective of 'tourism route preference', divided into single-destination and multi-destination preference patterns. The single-destination preference model refers to single destination travel, while the dual-destination preference model includes round-trip and regional circuit travel, and travelers tend to choose their travel preference model based on their destination [66].

Figure 13 shows the results of the spatial distribution characteristics of regional tourism flows. The results show that there were 785 tourism routes from 2018 to 2019, mostly in the 'single-destination preference mode', showing 'high aggregation and monocentric' characteristics. The year 2018 was represented by single-destination preference routes in the Tianmu Lake Area, with only two 'double-destination round-trip' routes, namely 'Tianmu Lake to South Area Route' and 'West Area to North Area Route'. There were only two 'double-destination round-trip' routes, namely the 'Tianmu Lake to South Area' route and the 'West to North Area route. There are similarities between 2018 and 2019, reflecting the core dispersion of the Tianmu Lake Area, as well as the addition of several "double-destination round-trip" routes in the South-East Area, while the North-East Area and the Central City remain dominated by single-purpose preferred routes. From 2018 to 2019, there was only one "double-destination circular route", starting from Tianmu Lake Area and passing through the South, West, North and East Areas, thus excluding the Central Area.

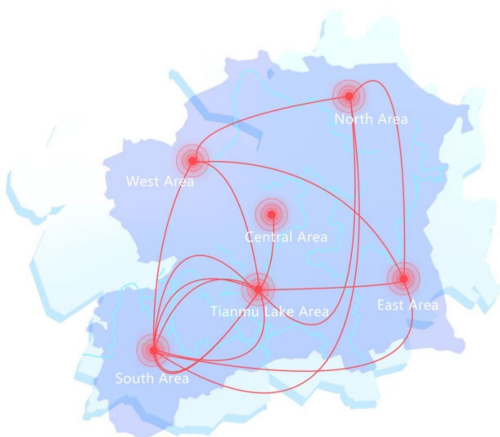

Figure 13. Regional tourism flow spatial distribution characteristics.

4.3.3. Regional Tourism Flow Effect Distribution Characteristics

Tourism systems theory proposes that regional tourism economic revenues can directly reflect tourism in the region [56,57]. Figure 14 shows the results of the effect distribution characteristics of the regional tourism flows. The results show that the total tourism revenue in 2018 was CNY 187,500,000, whilst in 2019, the total tourism revenue was CNY 257,380,000, representing an increase of 27.2%, and the distribution of the effect of tourism flow showed the characteristics of "continuous increase and polarization". In terms of each area, the tourism revenue showed a multiplier gap, the as Tianmu Lake Area accounted for 82.12% of the total tourism revenue, 5.88 times that of the South Area, and 21.03 times that of the sum of the West, North and East Areas and the Central Area.

Figure 14. Regional distribution of tourism flow effects.

Based on the results of the effect of regional tourism flow for an in-depth analysis of the industrial development of each area, Table 11 demonstrates the current industrial development status of each area. From the perspective of an industrial development strategy, the region already achieved the planning goal of developing the tertiary industry in the whole area: as overall industrial development takes Tianmu Lake Area as its platform with the aim of creating a special tourism industry, the industrial development environment is improved by the creation of an innovative culture, whilst the development of the primary and secondary industries is neglected to a certain extent, and only two of the six large areas have a developed primary industry, whilst the development of the secondary industry is also a derivative of the development of tertiary industries. The development of the secondary industry is also a derivative of the development of the tertiary industry; from the perspective of industrial selection and industrial layout, the primary industry develops ecological tourism and leisure agriculture on the basis of existing advantageous industries, actively constructs ecological technology agricultural demonstration areas, and creates ecological agricultural tourism areas; the secondary industry extends the industrial chain to meet the market demand and creates special industrial clusters such as aviation tourism to serve the tertiary industry; the tertiary industry takes the derivative integration, regional coordination, and the integration of the whole area as the guide, and with the implementation of municipal tourism line integration. However, there is evident disparity in terms of the development of the three industries which works against the goal of achieving tourism integration and the sustainable development of the whole area, as the industrial development is similar between the region, where there is a lack of characteristics and the traditional primary and secondary industries are ignored.

Table 11. Current industrial development status of each area.

Area Names	Industry Type	Industry Positioning	Trends
North Area	Secondary industry Tertiary industry	Mountain scenery Air travel	Down
South Area	Tertiary industry Primary industry	Landscape tourism Eco-tourism agriculture	Up
West Area	Secondary industry Tertiary industry	Food processing Metal building materials	Down
East Area	Primary industry Tertiary industry	Efficient aquaculture Wetland tourism area	Down
Tianmu Lake Area	Primary industry Tertiary industry	City card Tourism industry derivation	Up
Central Area	Tertiary industry	Urban modern service industry Tourism distribution center	Down

5. Discussion

5.1. Is There a Healthy Trend towards Sustainable Regional Tourism Development?

Li and Shi et al. [4,18,67] proposed that Global tourism is a new tourism model that needs to be considered from various perspectives such as those of global resources, universal participation, multi-point support, and sustainable development in order to comprehensively increase the participation of tourists and eliminate the disparity between the number of tourists in off-peak seasons, while also proposing to resolutely prevent problems of fragmentation, emptying, marginalization, unevenness, and blank development areas, whilst emphasizing the dispersibility of tourism development [13,20]. Su and ToSun et al. [68,69] proposed that sustainable tourism is based on the theory of sustainable development and is an important strategy for the rational use of natural resources and to ensure regional benefits. Sustainable tourism emphasizes that tourism activities should be developed in harmony with society, the economy, resources, and the environment, and is a concrete application of sustainable thinking in the field of tourism. In comparison with the results of the above analysis, although Liyang is one of the first demonstration cities for global tourism in China, it is not fully in line with the concept of global tourism and sustainable development.

Exploring the reasons for this disconnect, the dynamic thermal results of the location show that there are great dynamic thermal differences in the area due to the fragmentation of the development in part, the development between the regions not being at the same level—representing an excessive difference in terms of development—and the supportive nature of better developed areas driving the development of less developed areas has not formed. It is thus suggested that relevant tourism managers regularly formulate the development plan of the model tourism areas to promote the good development of regional tourism; the regional density results show that the regional tourism resources are unevenly distributed and hollowed out, with forgotten areas and a lack of coordination among regions: taking the Tianmu Lake Area and the Central Area, for example, there is a significant gap between the findings, but from the distribution of resource points, there are more resource points between Tianmu Lake and the Central Area that have not been exploited. If such resource points can be developed to link the Tianmu Lake Area with the Central Area, the gap mentioned above will be closed. The regional tourism flow time distribution results show that the region failed to eliminate the gap between the off-peak season, as problems of weak participation and marginalization surfaced; currently, all six areas in the region have different seasonal planning priorities, but the tourism flow time distribution characteristics do not reflect current planning; the regional tourism flow spatial distribution results show that the region fails to achieve multi-point support, and the areas present a scattered status without the development trend of route clustering, which is strongly related to the current lack of a well-developed tourism transportation system in the region. The regional tourism flow effect distribution results show that the problem of varying depths of industrial exploitation in each area can directly lead to huge differences in tourism income among the areas, which prevents regional development meeting the healthy trend of sustainable development, and the economic and social situation of each area cannot form a balanced status quo.

Overall, the main reason for which Liyang was selected as one of the first national demonstration cities for global tourism is the existence of a pillar tourism destination; on the contrary, if this destination is threatened, the tourism industry of the whole city will suffer a deep blow, and thus how can there be a tourism demonstration city? Conversely, if the planning can combine the pillar areas with the less developed areas, with a clear regional division, can the region achieve sustainable tourism development? This question needs to be pondered by scholars and urban planners.

At present, global tourism is the most advanced tourism development model in China, but it has not gained worldwide attention and promotion, which shows that there are great problems with global tourism in China. It is suggested that tourism theorists and urban planners should communicate and collaborate with each other to build a new model for the sustainable development of global tourism in China that can be promoted worldwide.

5.2. How Can Truely Global Tourism Be Achieved?

In response to the results of the above analysis, based on the current situation of the development of region-wide tourism in Liyang, the following suggestions are made for its subsequent development. From the perspective of the tourism development trend, Liyang City has formed the awareness of developing the whole area tourism, but the development of tourism is based on the administrative boundary, and the horizontal connection is not enough, so it is suggested that the problem of fragmentation of inter-regional development should be strengthened in the later stage, the development of the point should drive the development of the surface, and the development of the leading industry should drive the joint development of the periphery so as to coordinate and optimize—thus preventing a "polarization" trend. From the viewpoint of spatial structure, in order to alleviate the current fragmentation problem, it is suggested that the tourism land in the region can be sorted out, and the areas with development potential can be planned to form an intermediate effect to link the six large areas to form a tourism effect; from the viewpoint of industrial development, although the region focuses on the development of tourism-based tertiary industries, the development of the primary and secondary industries should not be neglected. The primary industry can promote the modernization process of agriculture on the basis of existing advantageous industries, cultivate the brand of agricultural products, expand the function of agriculture, improve the openness of agricultural development, and actively build an ecological and technological agricultural demonstration area; the secondary industry can be oriented to the agglomeration of enterprises, industrial clusters, and the integration of industry and city, thus enhancing the leading industries, extending the industrial chain, supporting emerging technology industries, and adapting to and leading the market demand; the tertiary industry focuses on creating leisure and vacation tourism, focusing on the integrated development between the three industries, implementing the strengthening of regional tourism cooperation, and promoting the development of tourism support services.

This paper is mainly an analysis of research into the current situation of the area-wide tourism in Liyang City, and thus lacks comparability; a later study can optimize and compare the current situation of the development of the area-wide tourism in Liyang from the above perspectives in order to realize the global area tourism of the study area.

5.3. Can This Study Be Applied to Other Similar Cities?

This study chose to study the demonstration city of global tourism, but the results of the current study are unsatisfactory. Compared to similar cities with better tourism development, the authors suppose that certain cities may have similar problems, taking Hangzhou, Chengdu, and Yangzhou City as examples: the three cities are all extremely rich in tourism resources, but like Liyang, they all present similar problems such as scattered tourism resources, an over-concentration of tourism density in a single area, difficulty in linking tourism spatial routes, and the existence of undeveloped areas. All these problems restrict the sustainable development of regional tourism and need to be studied and improved soon.

Current research in this direction is mostly focused on theoretical discussions and lacks quantitative analysis. The techniques used in this study allow for a more accurate and scientific assessment and analysis of the current tourism situation to improve the sustainable development of regional tourism and realize a truly global tourism.

At the same time, we also hope that in the follow-up, the integration of in-depth domestic and foreign thinking can be carried out, as global tourism is currently China's localized concept and has been not developed and popularized outside China. Nevertheless, the study of foreign tourism cases found that, although there is no similar theory of global tourism abroad, there are cases of inter-regional or national integration development—thus we question whether China's global tourism can be developed from the regional tourism development up to the development of city tourism circle integration? We hope that scholars, urban planners, and urban tourism managers can discuss this issue in depth to promote the further development of global tourism.

6. Conclusions

The main research question of this study was that of whether the current domestic global tourism cities have met the requirements of the theory of global tourism development. Through the empirical study of Liyang, the first demonstration of global tourism cities in China, the following conclusions can be drawn. First of all, the currently studied demonstration cities of global tourism do not meet the requirements of the theory of global tourism development, and there is a disconnect between theory and practice. At present, the theoretical research on global tourism covers too much, but the scholars have neglected the practical aspect of the theory. As a model city, Liyang, as revealed by the coupling analysis of multi-source data combined with clustering algorithm, ArcGIS, TF-IDF, and flow characteristics, suffers from a series of problems such as uneven development within the region, a large variability of tourism flow, prominent spatial development contradiction, and an unsound tourism road facility system. Later, the theory needs to be implemented in practice to plan and update the development of regional tourism. Secondly, taking Liyang as a case study, we call for the analysis and planning of similar cities to implement the development of area-wide tourism cities. At present, global tourism is a new model of tourism in China, and the global tourism demonstration city is also regarded as a benchmark city for the development of tourism, which urgently requires the attention of research scholars, urban planners, and urban tourism managers. Furthermore, through this study, we hope to trigger subsequent thinking among scholars, tourism planners, and urban planners surrounding global tourism, and whether it may be able to go beyond regional boundaries and form a multi-city joint development tourism system in order to facilitate the promotion of this localized concept across the world.

The overarching contribution of this study is to dig deeper into the issue of tourism demonstration cities and to propose a pathway for the more accurate analysis of the current state of urban tourism. By coupling big data with a clustering algorithm model and other quantitative measures on the current state of urban tourism development, we provide an empirical analysis of current global tourism model cities. This path evaluates the current state of urban tourism development, uncovers the development problems of tourism benchmark cities, and provides theoretical support for the sustainable development of global tourism in China.

Since the proposal of global tourism in 2015, China has not yet formed a good environment for the construction of global tourism, and the concept of global tourism has not been extended to the whole world. In the future, this study can serve as evidence to improve the scalability of global tourism and revitalize the tourism planning and construction of cities.

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