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Using Location Quotients to Determine Public–Natural Space Spatial Patterns: A Zurich Model

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Abstract: The layout relationship between the public space system and the natural system of cities determines the trend of urban spatial forms. From the perspective of the integration of landscape architecture and urban design discipline, this paper generalizes three restriction/dependence relationship modes between urban public space and natural landscape layout: (1) overlapping mode, (2) separation mode, and (3) the mode of edge combination. Using Zurich, Switzerland, as a case study, this paper quantitatively explores the layout relationship between public space and natural landscape using the location quotient method. The research findings reveal an obvious layer distribution trend of Zurich urban public space and natural factors: the public space and mountain layout have a clear separation relationship. The regressive equation is $PQ = -0.188 \ln MQ + 0.660$, forming the mutually supplementary mechanism of the advantageous resources of public activities. The Zurich model shows that when a proper relationship is established among the natural system and the urban public space, human activities, and the public activity centers of the city, the new system provides significant ecological and social benefits. This finding provides an exemplary reference for urban construction in other countries.

Keywords: spatial pattern; urban public space; location quotient; natural landscape; urban design

1. Introduction

Landscape architecture plays an inestimable role in the urban process. Artificial environments and natural environments should not be regarded as two mutually separate systems. On the contrary, cities should attach importance to the existence of nature [1], and urban forms and processes should be incorporated with landscape architecture [2]. Indeed, multidisciplinary integration is an inevitable trend for future landscape architecture. As this discipline develops, an important concern is how to more thoroughly participate in the research and practice of integrated urban design [3]. Urban design is an arrangement of various spatial relationships, with the object of research being the urban public space. The key problem is how landscape architecture interposes the urban public space.

In urban design, the mutual relationship between the space and surrounding factors is one of the most fundamental and decisive components. Therein, the urban public space system and natural open space system concerning landscape architecture constitute a "double framework" layout pattern. The layout pattern largely determines trends in the structural forms of cities and dictates the formal structure and evolution rules of the material space. This layout pattern takes the recognized principle of "design with nature" [4] as its chief basis. The evolution of this principal has morphed through various theories—from Olmsted [5] to McHarg [4] to Simmonds [6]—and practices, from garden city and landscape urbanism to ecological urbanism. Despite progress, the following questions remain relatively vague: (a) how to more specifically combine the urban system and the natural system, (b) how to carry out this combination on the spatial form, and (c) which spatial order should come into being. Therefore, from the perspective of landscape ecology, it becomes difficult to maintain refined control over the inside of cities.

This paper quantitatively explores the modes of different layout relationships between urban public space (the major occurrence site of public life in cities) and natural factors (natural factors broadly include landform, climate, animals, plants, and so on. This paper emphasizes the discussion about the structural forms of urban space. Therefore, this paper is limited to natural factors that occur frequently in cities and visually occupy a certain physical space, namely mountains and water bodies, park greenbelts, and other artificial natural landscapes) using the location quotient method. More specifically, the paper explores how to extract and organize these systems to show how they can jointly constitute the underlying dynamic of sustainable urban spatial forms. A case study taken in Zurich, Switzerland, was used to solidify the findings. Finally, this paper aims to provide effective suggestions on the spatial organization structure for urban sustainable development.

Both urban public space and natural space are integral components of the built environment of cities. Urban public space refers to an open space that is accessible to the public where people can engage in collective and individual activities. (Different countries have different definitions of public space. In the United States (USA), public space is almost equivalent to urban open space [7]. North Europe regards all natural areas as public space [8]. However, in the United Kingdom (UK), public space is almost equivalent to civic space, merely referring to hard and non-green space while excluding large parks and other green spaces. Public space and green space together constitute open space [9]. This paper adopts the UK concept). The urban public space in this paper specially refers to the open space that is open to the public, closely related to the walking and non-motor vehicle traffic, and dominated by artificial factors. This includes town squares, streets, and waterfront public spaces, among others. Public space bears the social lives and cultural images of local residents. Natural space is also an important factor of urban forms and images, dictating the environmental condition and natural process in urban space. Together, urban public space and natural landscape systems constitute the urban open place, affecting people's perceptual experience [10]. With the stresses of modern cities—such as traffic jams, environmental pollution, and social pressures—urban public space and natural space are regarded as a "good remedy" that brings opportunities for urban environmental upgrading, ecological health, social justice, and economic development [11–13].

2. The Restrictive/Dependent Relationship between the Layout of Urban Public Space and Natural Factors

A dialectical relationship of mutual restriction and dependence exists between the layout of urban public space and natural factors. The pattern of urban space and the generation of public space systems are directly dependent on the natural and geographic conditions in the area. Natural factors are prerequisites in urban construction, such that the existing ecological patterns of the Earth dictate development capabilities. However, the self-evidence of nature is relative. Nature depends on the coordinated mutual construction of cities, while cities bestow humanistic values upon nature. The precondition for natural factors in cities to have a greater role is their adaptability with the public space system.

According to spatial logic, the layout relationship between urban public space and natural factors can be classified as three modes. (1) The overlapping mode of "union" refers to the overlap in terms of spatial distribution. Typical cases include the "emerald necklace" park system of Boston designed by Olmsted. In this paper, space of this type is referred to as "natural public space". (2) The separation mode of "emptiness" refers to the relative independent distribution of urban public space and natural factors. European traditional cities usually apply this layout mode. (3) The edge-binding mode of "intersection" refers namely to the layout of urban public space in connection with the edges of natural factors, characterized by public space leaning against mountains and water, which is particularly represented by "waterfront public space". Each mode contains a more restrictive or dependent synergy. For example, the overlapping mode is dominated by the dependent relationship between public space and natural factors. The separation mode is dominated by a restrictive relationship. The edge-binding mode manifests as a mutual balance between the two (Figure 1).

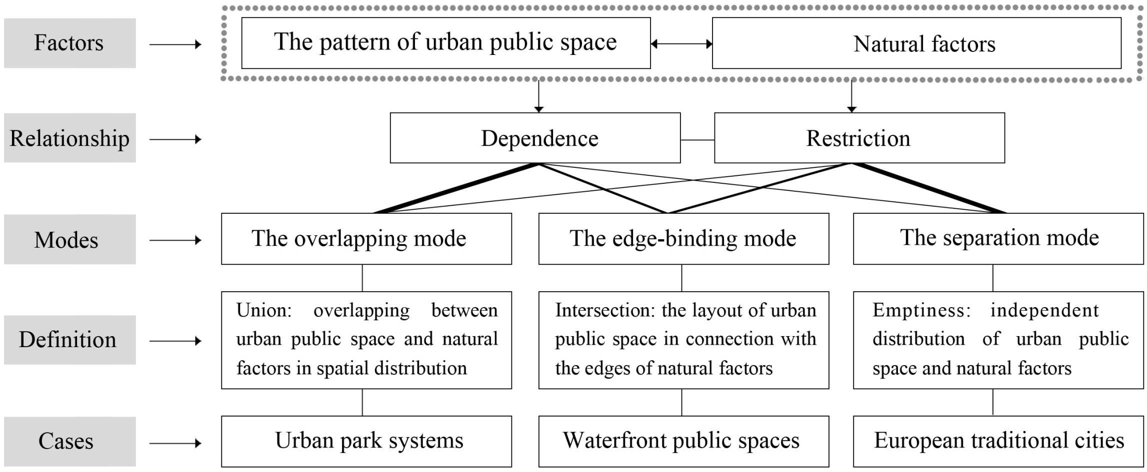

Figure 1. The layout relationship modes between urban public space and natural factors.

2.1. The Overlapping Mode

The overlapping mode refers to the overlap of urban public space and natural factors in spatial distribution. This can be represented by large urban park greenbelts, avenue systems for life, and the revival of post-industrial parcels. In the overlapping mode, nature no longer serves as the environmental background of cities; instead, it is brought into cities. While continuously playing the important role of hydrological management and serving as an ecological channel, the natural space can contain rich urban activities, thus incorporating urban texture into the regional and biological background.

The overlapping mode includes a mutually dependent relationship among the public space and natural factors. Exploration into this mode started in England in the middle of the 18th century, culminating with the Olmsted "pictorial gardens" [14]. In contrast, contemporary designs attach more importance to the presentation of landscape practice based on site traits and reinforce the potential blending relationship between cities and nature [15,16].

2.2. The Separation Mode

The separation mode refers to the relatively independent layout in space between urban public space and natural factors. This is where (1) public space serves as a container that bears citizens' diversified activities, and (2) natural factors essentially function as landscape and an ecological corridor. Each performs its own function.

The separation mode is a product of the inherent tradition of the dichotomy of nature among most European cities. As artificial structures, cities are independent of nature, and natural factors symbolize rural landscape contrasted against the city. The zoning of modern urban planning reinforces the natural space in this mode. Natural factors become both the filling belt and the isolating belt among urban function sites. Into the clear-cut large urban plots, public space and public life are squeezed [17]. In the 1970s, the public space of European cities entered a phase of renaissance where the concept of ecology spread extensively. This rebirth allowed for the relationship between public space and natural factors to return to one of mutual restriction.

2.3. The Edge-Binding Mode

In the edge-binding mode, the spatial geometrical relationship between public space and natural factors lies between the "union" of the overlapping mode and the "emptiness" of the separation mode. Edge-binding manifests as the "intersection" of the layout of the public space in connection with the edge zone of the natural space. This mode extensively exists in waterfront regions and around hilly bodies.

"The edge effect" attracts high attention in both landscape ecology and urban design science. Edge zones, as the boundary of two or more textures, have the most active exchange of substance and energy, with a specific value for protecting biodiversity [18] and a stimulating function for human activities [19]. Therefore, in regions near mountains and water, a subtle relationship of restriction and dependence exists between natural protection and urban development.

Due to differing spatial layout features, the three modes of layout relationship between urban public space and natural factors assume different advantages and challenges (Table 1). In the real urban environment, the layout relationship between public space and natural factors is highly complex. With the uniqueness of cities comprising many different environmental conditions, social and cultural traditions, and spatial orders, these relationship modes usually emerge in different "multi-modules".

Table 1. Comparison of the characteristics of the three layout relationship modes between urban public space and natural factors.

The Overlapping Mode	
Layout	**Union:** urban public space and natural factors overlap in spatial distribution
Advantages	**Ecology:** natural factors play the ecological role, and urban textures are incorporated into the regional and biological background **Aesthetics:** large natural factors become the carrier of cognition of urban features, bring landscape benefits, and improve urban quality [20] **Health:** natural factors help regulate citizens' physical and mental health
Challenges	**Society:** enhancement of diversity and inclusiveness characteristics of natural spaces [13] **Density:** density of urban textures declines **Structure:** large natural factors lead to separation of urban space
The Separation Mode	
Layout	**Emptiness:** independent layout between urban public space and natural factors
Advantages	**Purity:** both the priority of the ecosystem and the "urbanity" of the city are guaranteed **Fairness:** fairness in the pattern of public space and distribution of natural factors **Vigor:** suitable for cities with a centralized layout, providing easier social contact [21,22]
Challenges	**Ecology:** decrease of natural space inside the city **Connection:** isolation between public space layout and natural factors **Dispersion:** decline of accessibility to natural factors
The Edge-Binding Mode	
Layout	**Intersection:** combine urban public space with natural factors at the edge zone
Advantages	**High efficiency:** public space uses natural resources to provide activity support, and the natural landscape is reinforced **Structure:** Intervening in the urban structure, playing an active role in urban life **Development:** a strong "edge effect", facilitating the appreciation of neighboring land and boosting regional economic development
Challenges	**Fairness:** public space around natural environment is threatened by privatization **Vigor:** the public space adjacent to the natural resources, on the periphery of the city, has declining accessibility and service objects

3. Methodology

3.1. The Location Quotient Method

Relationship modes can help understand the layout relationship between urban public space and natural factors, but cannot accordingly extract therein an effective structural rule of urban internal spatial organization. Reaching a definitive conclusion relies on a quantitative method.

Currently, most of the relevant quantitative research findings are concentrated in two fields: (1) the quantification of the public spatial forms of cities [23–25] and (2) the quantification of the layout and accessibility of natural open space [26–28]. Exploration into the interconnecting layout relationship between urban public space and natural factors is often sidestepped. The main reason lies in: current public space research is subordinated to the discipline of urban design and urban sociology, while research of natural open space is affiliated with the discipline of landscape ecology planning. Therefore, the boundary of disciplines results in isolation between theory and application. This makes it critical for this relationship be investigated based on clear individual data and a quantitative method that is suitable for expressing the interaction.

This paper applies an indicator to express the ratio of specialization called the "location quotient" to describe the layout relationship. The location quotient (LQ) was first proposed by British humanistic geographer Peter Haggett in 1965 and applied in regional analysis [29]. The quotient is the ratio of a ratio. As a basic index in regional analysis and industrial structure analysis, the LQ can be used to measure the spatial distribution status of a regional factor and evaluate regional advantageous and disadvantageous industries. That is, LQ can be used to measure the comparison between the spatial distribution status of a regional factor and the average level.

The equation to calculate LQ is shown in Equation (1) [30]:

$$\mathrm{LQ} = [\frac{d_i}{\sum_{i=1}^{n} d_i}]/[\frac{D_i}{\sum_{i=1}^{n} D_i}] \tag{1}$$

In Equation (1), LQ denotes the location quotient of factor i in a region in contrast to the high level of the overall region; d_i is the relevant indicator of factor i in a region, which in this paper is the site area indicator of a public space, mountain, or water body; D_i denotes the corresponding indicator of factor i in the high-level region; and n is the category quantity of the factor.

For example, if d_i is the site area of urban public space in a certain region, then n is the quantity of site types, $\sum_{i=1}^{n} d_i$ is the sum of the sizes of all of the site types in the region (i.e., the total site area of this region), and $d_i/\sum_{i=1}^{n} d_i$ is the site area percentage of urban public space in this region. Similarly, D_i is the site area of urban public space of the overall region, $\sum_{i=1}^{n} D_i$ is the sum of the sizes of all of the site types in the overall region (i.e., the total site area of the overall region), and $D_i/\sum_{i=1}^{n} D_i$ is the site area percentage of urban public space in the overall region. Through division, $\mathrm{LQ} = [\frac{d_i}{\sum_{i=1}^{n} d_i}]/[\frac{D_i}{\sum_{i=1}^{n} D_i}]$ represents the spatial distribution of the area share of urban public space in a region in contrast with the overall region.

As can be easily inferred, LQ is a non-negative value. If LQ > 1, then the position or function of factor i in a region exceeds the average level. If $\mathrm{LQ} \leq 1$, it indicates that the position or function of factor i in a region is equal to or below the average level. The bigger the LQ, the bigger the proportion of the position or function of the factor in the entirety would be, indicating a higher degree of clustering in the corresponding region.

The advantage of the LQ method lies in its effectiveness and simple and distinct calculation. Therefore, it is extensively applied in regional analysis and industrial structure analysis, making it convenient to rapidly grasp the scale advantage or disadvantage of the industry in a region. However, due to it originating from Haggett as a geographer, the LQ was previously only applied in the sectors of geography and economics, emphasizing abstract expression at the macro level. Since similar quantifying indexes are prevalent in the geography sector, LQ has not aroused enough attention, and its data potential has not been fully tapped yet. This paper first applies LQ to the sector of urban design, trying to build a method to map/understand public–natural space spatial patterns, and then expresses the outcome in a visualized way.

3.2. The Framework of Quantitative Calculation

The basic process of this study is shown in Figure 2. The framework of quantitative calculation was applied to Zurich, Switzerland, as a case study [31]. Zurich represents a typical case of the compact development that is common in European cities. Since 2000, Zurich has been frequently ranked as the most livable city in the world. Its world-famous life quality is largely attributed to how its superior natural environment and systemized public space system combine to build a network of public activities, creating a sense of identity and affiliation among its citizens (N.X. had stayed in Zurich for one year when engaged at the Institute for the History and Theory of Architecture of ETH Zurich with Professor Dr. Vittorio Magnago Lampugnani from October 2010 to October 2011). The Zurich experience provides an exemplary reference for urban construction in other countries.

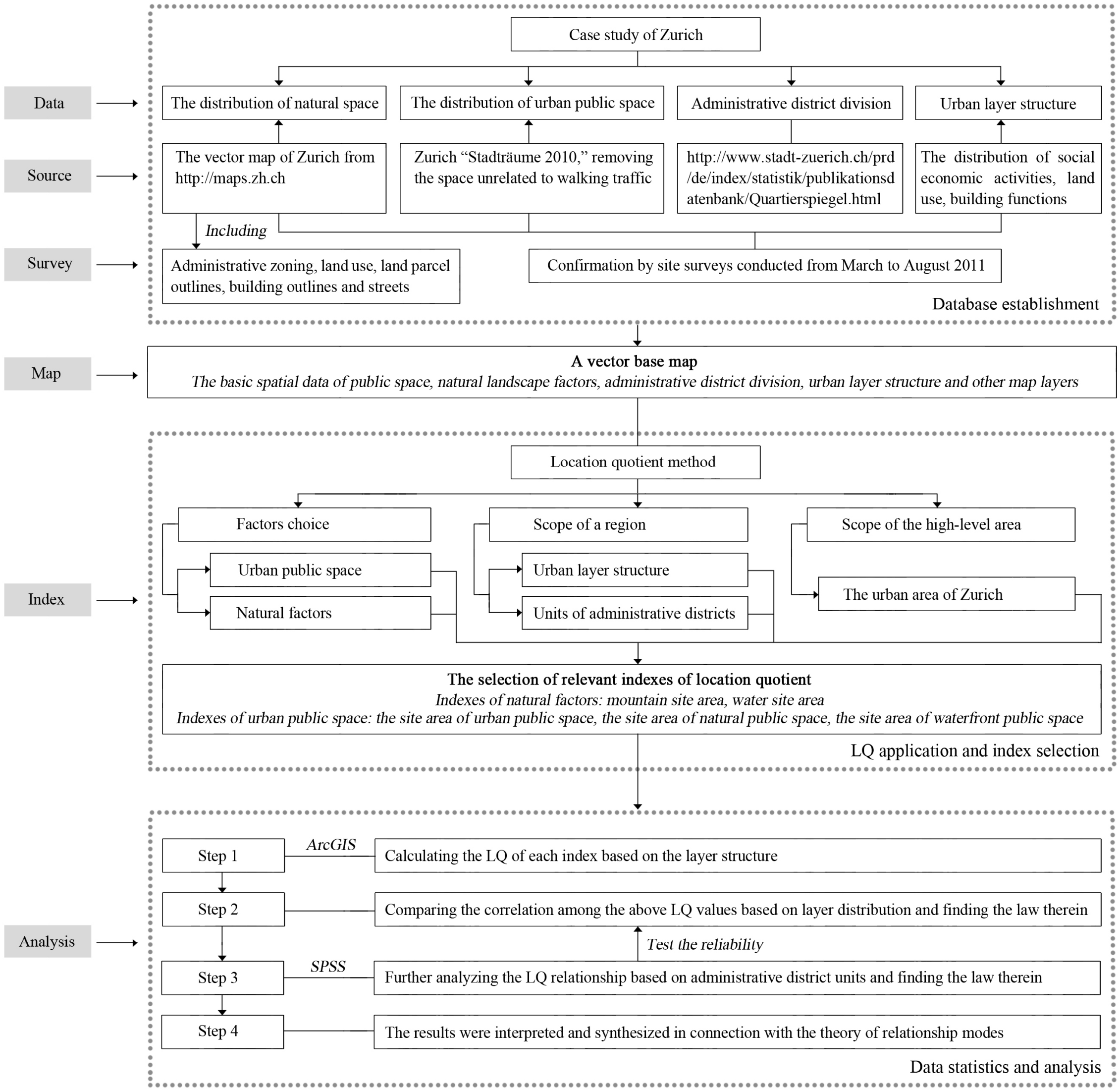

Figure 2. The technical route applied by the location quotient method.

3.2.1. Establishing a Vectorized Digital Base Map

First, we should establish a vectorized digital base map covering all of the necessary information. The vector map of Zurich can be downloaded from http://maps.zh.ch. The map includes complete data for administrative zoning, land-use function, land parcel outlines, building outlines, and streets.

According to land-use function, the distribution scope of natural space is distinct, namely mountains and water bodies, park greenbelts, and other artificial natural landscapes. However, the definition of the scope of urban public space is relatively difficult. Based on the public space status quo determined in the urban space strategy of Zurich "Stadträume 2010", this paper obtains the scope of urban public space by removing the spaces that are unrelated to walking traffic, including traffic nodes, expressways, main roads, tunnels, and parking sites. The accuracy of data for all of the natural and public spaces in Zurich was verified via site surveys conducted by Ning Xu from March to August 2011. The urban layer structure is divided into the core, central, and peripheral layers according to the distribution of social economic activities, land-use features, and building functions; the space scope is determined through repeated site surveys.

Thereupon, a vector base map was established through the collection, correction, and data fusion process. The basic spatial data of public spaces, natural landscape factors, administrative district divisions, urban layer structures, and other map layers were included.

3.2.2. LQ Application and Index Selection

LQ is used to measure the role and function of the spatial distribution of a regional factor in the high-level area. Three data items need to be determined to apply the LQ equation: the spatial distribution of what factor is measured, the scope determination of a region, and the scope determination of the high-level area.

First, because this paper seeks to quantify the pattern model of urban public space and natural elements, the factors selected are, respectively, urban public space and natural factors. This paper uses their site area indexes to reflect their spatial distribution statuses.

Next, it is easy to determine the scope of the high-level area. Since this paper studies Zurich, the scope of the high-level area is the spatial scope of the urban area of Zurich, which is numerically equal to the site area of Zurich.

Finally, the key is how to determine the spatial scope of a certain region, which directly affects the creditability of the conclusion. This paper defines the spatial scope of a region in two ways: as an urban layer structure and as administrative district units. On the one hand, similar to most cities, the concentration and expansion of Zurich also assume a concentric zone development pattern [32]. The layer structure not only reflects the law of urban land utilization, but also embodies the regular polarization of social and economic activities. Moreover, measuring the status of the public space and natural space distribution of Zurich conforms to the logic of urban development. On the other hand, administrative districts are also common units of urban analysis that tend to match various indexes of urban analysis. By comparing them, the layer structure can be divided into three layers: core, center, and periphery. Therefore, the correlation comparison is made to three data items, and the assumed results are relatively macroscopic and general, similar to the conventional application mode of LQ. The data quantity of administratively distributed units is large. Zurich has 34 administrative district units, which more accurately represent the relevant data law. In fact, the two sub-regional space scope selections correspond to the two basic understandings of urban space division. In contrast with a single operation, the advantage of calculating two results lies in that they can test and verify each other, which better ensures the reliability of the conclusion.

The LQ-related indexes determined by this paper are shown in Table 2.

Table 2. The selection of relevant indexes of location quotient (LQ).

Index	d_i/D_i	$\sum_{i=1}^{n} d_i$	$\sum_{i=1}^{n} D_i$
Indexes of natural factors	Mountain site area Water site area	The site area of different layers/the site area of different administrative districts	The site area of Zurich
The indexes of urban public space	The site area of urban public space The site area of natural public space The site area of waterfront public space		

3.2.3. Data Statistics and Analysis

To further data processing capabilities, the ArcGIS software was used for data visualization and analysis.

Step 1. We applied the attribute statistics and overlay analysis of ArcGIS according to the layers counting the d_i and D_i values of each index in Table 2. This allowed for calculating, respectively, the LQ of mountains, water, urban public space, natural public space, and waterfront public space based on the layer structure.

Step 2. By comparing the correlation among the above LQ values based on layer distribution, we could identify the law therein. For example, the relationship between the urban public space LQ and natural factors LQ based on layers reflects whether the spatial distribution structural features of urban public space and natural factors are concentrated in dependence or in restriction. The LQs of natural public space and waterfront public space respectively represent the overlap degree and edge-binding degree of urban public space and natural factors. The comparison between their LQs and the LQ of natural factors reflects the relationship between the public space layout and nature under the overlap and the edge-binding models. In actual application, in order to eliminate the impact of the high or low values among variable arrays at different levels, and make different arrays comparable, we used the variable coefficient. The variable coefficient is a unitless value that can be calculated using the standard deviation divided by the average. A larger variable coefficient results in a larger degree of dispersion in the data.

Step 3. By using the same method, we further analyzed the LQ relationship based on administrative district units. This is a vital step. On the one hand, by applying completely different overall region division modes, it can test the reliability of the preliminary conclusion obtained by step 2. On the other hand, a big data quantity allows for the scientific analysis of new data by applying analytic software, for example, by applying correlation analysis, regression analysis, and other operations to data sets using SPSS software in order to (1) obtain the interaction strength among various factors and (2) generate the regressive function. Although no strict function relationship exists between independent variables and dependent variables, through regression analysis, we identified the numerical expression form that best represents their relationship to further identify public–natural space spatial patterns.

Step 4. The regularity cognition of the spatial relationship and spatial mode was obtained, and the results were interpreted and synthesized in connection with the theory of relationship modes.

4. Case Study

4.1. An Overview of the Natural Factor Distribution and Public Space Pattern of Zurich

The urban space pattern of Zurich manifests as the organic blending of mountains, water, and city, as shown in Figure 3. The interaction between the mountains and the water ecology system forms the overall ecological connection network for the city. Restrictions due to land formation result in the finger-shaped development of the urban hinterlands. The trend of urban public space system largely coincides with the major landscape pattern, with good integrity and continuity, embodying a clear logic of internal structure, as shown in Figure 4. The renaissance of the urban public space of Zurich started in the 1980s. It was proposed in "Stadträume 2010" [33], which was enacted in 2003, and stipulated that facility quality, function, sensuality, and aesthetics be skillfully combined to meet citizen demands and benefit the sustainable development of the city.

Figure 3. Bird's eye view of Zurich. Picture source: Photo by Xing Jin.

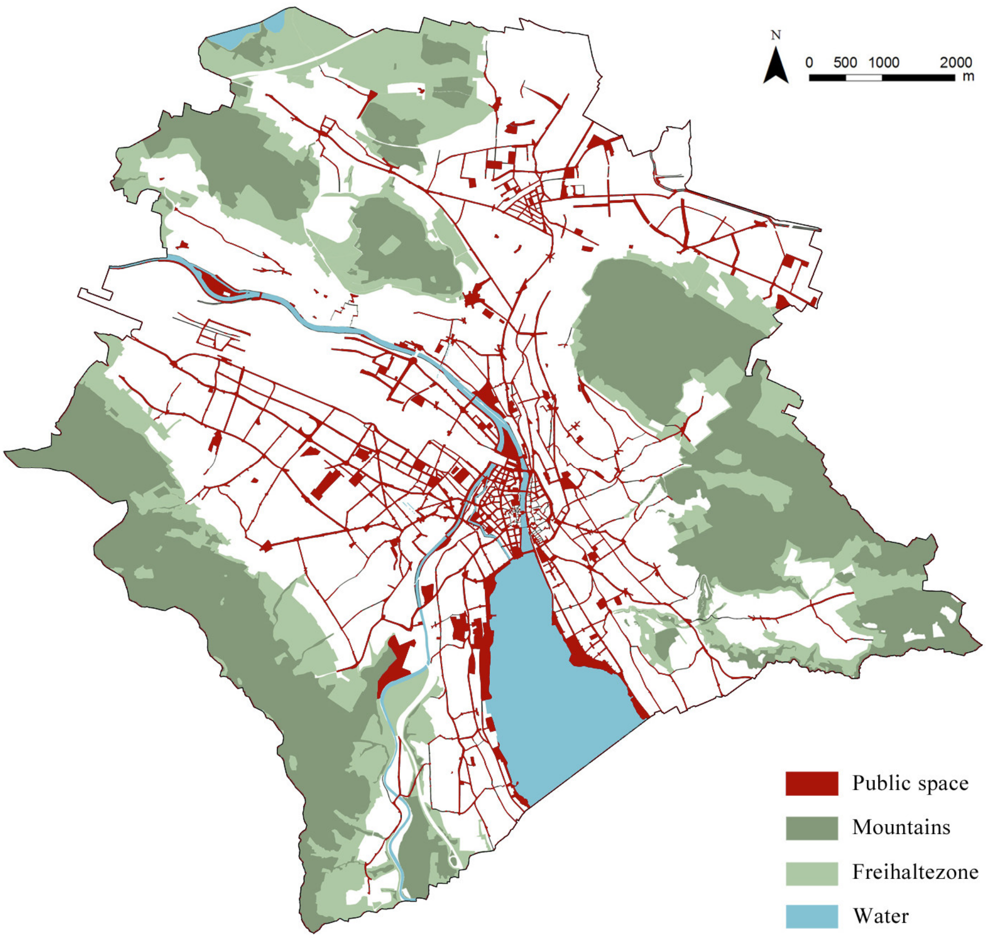

Figure 4. The layout relationship between public space pattern and natural factors of Zurich.

4.2. The Quantification of Relationship Modes

Zurich has 12 districts, each of which includes two to four units, with a total 34 administrative district units [34]. The division of administrative district units and layers of Zurich is shown in Figure 5. According to the social and economic activity distribution, the land-use sites in this city can be classified into three layers: (1) the core layer, (2) the central layer, and (3) the peripheral layer. Table 3 includes the spatial scope, area, and proportion of each layer.

Table 3. The division of layer structure of Zurich.

Layer	Spatial Scope	Area (km^2)	Proportion
Core layer	Old urban area	1.5	1.7%
Central layer	Focused on public areas (the hinterlands of Limmat and railway station yards, and the neighborhoods of Zurich Lake)	11.7	12.7%
Peripheral layer	Focused on residential areas (the district boundary, deducting the core layer and central layer)	78.7	85.6%
Total city	The boundary of administrative districts	91.9	100%

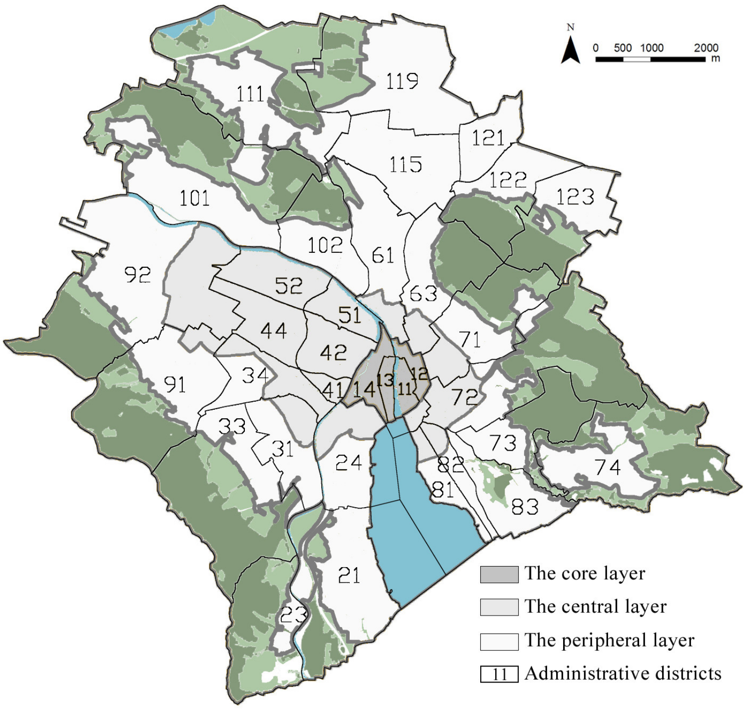

Figure 5. The division of administrative district units and layers of Zurich.

5. Results

5.1. The Layout Relationship between Public Space and Natural Factors Based on the Layer Structure

The location quotient method was applied to respectively count the site areas of public space and natural factors in the three layers of Zurich, as shown in Figure 6, and then substitute them into Equation (1). From this, the data distribution was obtained, as shown in Table 4.

Table 4. The location quotient of public space and natural factors of Zurich based on the layer structure.

Structure	Mountain Bodies	Water Bodies	Natural Public Space	Waterfront Public Space	Urban Public Space
The core layer	0.000	1.555	3.576	6.194	5.796
The central layer	0.005	0.530	1.867	1.556	2.270
The peripheral layer	1.167	1.059	0.820	0.815	0.717
Average	0.391	1.048	2.088	2.855	2.928
Standard deviation	0.549	0.418	1.136	2.381	2.125
Variable coefficient	1.405	0.399	0.544	0.834	0.726

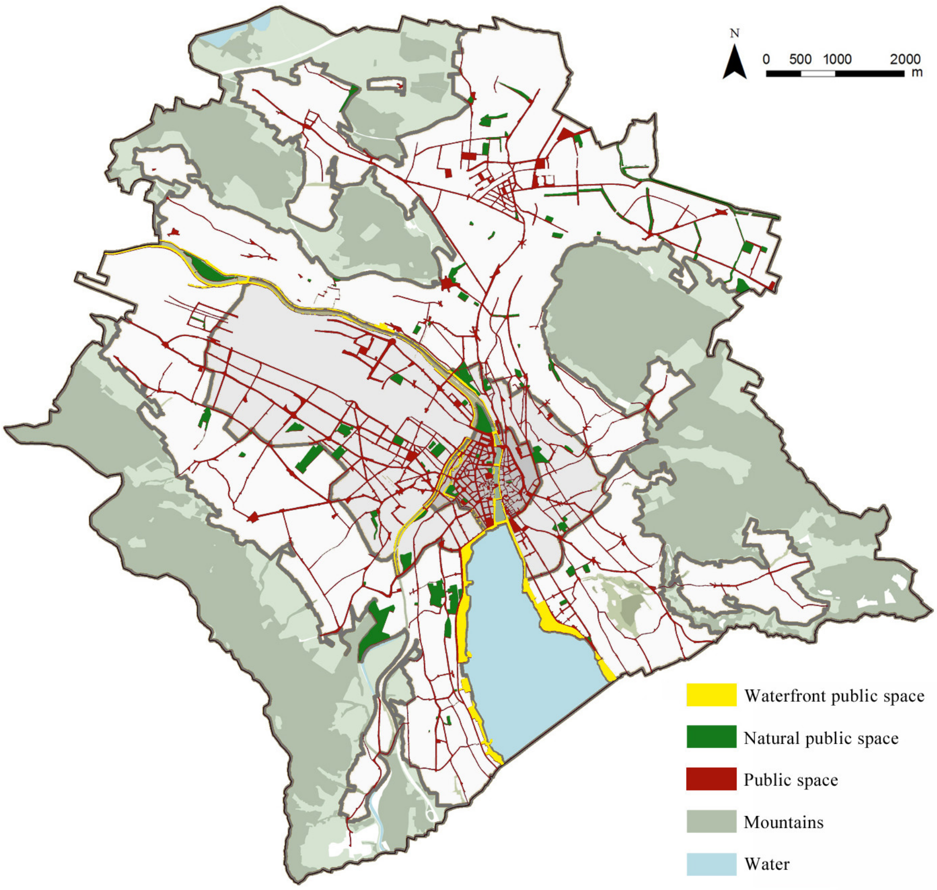

Figure 6. The layout relationship between the public space pattern and natural factors of Zurich based on the layer structure.

5.1.1. The Overlapping Relationship

The overlapping portion between public space and natural factors forms the natural public space in the city. This indicator can be used to judge the overlapping degree between urban public space and natural factors, where the overlapping degree equals the area of natural urban public space divided by the union of the area of urban public space and natural factors.

As indicated by the statistical results, the area of the natural public space of Zurich is about 1.3 km^2, accounting for 2.4% of the total urban construction site and 22.0% of the total public spatial area. The overlapping degree between public space and natural factors is 3.2%. With regard to the old city of Nanjing, with the same statistical specification, the area of the natural public space of Nanjing amounted to about 0.9 km^2, with an overlapping degree of 9.2% [35]. As indicated by the results, the natural public space of Zurich accounts for a low percentage. Therefore, the public space and natural factors tend to be polarizing.

5.1.2. The Separation Relationship

As reflected by the quotient data in Table 4, the distribution of public space and natural mountain bodies in Zurich assumes a clear separation relationship. Most of the mountain bodies are located in the peripheral layer (LQ = 1.167 > 1), increasing progressively from the central layer to the peripheral layer (0.000 < 0.005 < 1.167). Conversely, public space is concentrated in the core layer (LQ = 5.796 > 1), decreasing progressively from the central layer to the peripheral layer (5.796 > 2.270 > 0.717). The public space is more distributed in the area within the urban construction sites, far away from the natural space. This seemingly runs counter to the general rule of "distributing public space in connection with natural factors".

The separation between the artificial and the natural is also embodied inside the urban public space in Zurich. Similarly, the urban public space and natural public space progressively decrease from the center to the periphery. However, the urban public space shows a more obvious progressively decreasing trend (Table 4: 5.796 > 2.270 > 0.717 versus 3.576 > 1.867 > 0.820). Therefore, the percentage of natural public space in the urban public space increases progressively from the core layer to the peripheral layer. In the city center of Zurich, streets, squares, and other social public spaces are important to centralized public life. In contrast, the periphery of the city is gradually softened by the natural public space, thus reinforcing the urbanity.

5.1.3. The Edge-Binding Relationship

The edge-binding relationship of Zurich is mainly embodied in the binding of public space and water bodies. The waterfront public space area of the city is about 0.6 km^2, accounting for 11% of the total public space area. Although the percentage of the waterfront space is minimal, the water bodies pass through the urban center, adding significance.

As indicated by the quotient data, the urban public space distribution and the water area layout of Zurich are not strongly correlated. This is because water areas attract only a portion of the complete system. The layout of other important public spaces—such as streets, squares, and park greenbelts—is jointly determined by other urban structural factors. The decisive factor for the layout of the urban waterfront space is the inherent public attributes that are differentiated among the urban districts.

5.2. The Layout Relationship between Public Space and Natural Factors Based on Administrative District Units

For Zurich, the rules of layout of the overlapping and the edge-binding modes were clear, while the separation mode of public space and mountain body did not conform to the general rule. This leads to the following questions. (a) Why would the relationship rule of separation (not binding) occur? (b) Is the rule accidental or inevitable? (c) To what degree is it tenable? Section 5.2 investigates and discusses these issues using segmented administrative district units as basic units, as shown in Figure 7 and Table 5.

The data of Table 5 were put into SPSS. Since there were two variables: the LQ of mountain bodies and the LQ of public space, the correlation analysis or regression analysis of SPSS can be applied to search for the law of data. However, the correlation analysis can only help to describe the closeness of intervariable association, and cannot clearly reflect the quantitative relation among correlation variables. In contrast, based on correlation analysis, regression analysis can help to make a distinction between independent variables and dependent variables according to the functions of variables, and quantitatively reveal the intensity of the impact of independent variables on dependent variables. The LQ of mountain bodies in this paper depended on the mountain bodies' distribution of Zurich. It was a stable controllable variable and an independent variable. In contrast, the LQ of public space was a changeable random variable and a dependent variable, lying in an interpreted position, so it was applicable to regression analysis.

SPSS was used for curve fitting, of which the fitting effect of the logarithmic curve was the best. Figures 8 and 9 shows the regressive result of the logarithmic curve of public space and the mountain body location quotient of Zurich. The results reflect strong regularity, verifying the negative correlation between the public space and mountain body layout of Zurich. The determination coefficient was $R^2 = 0.613$, and the regressive analysis was $F = 26.511$. With a significance of 0.000, the regressive equation proved effective. The coefficient was substituted into the equation to obtain the regressive equation (Equation (2)) of the public space and mountain body layout of Zurich:

$$PQ = -0.188 \ln MQ + 0.660, \tag{2}$$

where PQ is the location quotient of public space, and MQ is the location quotient of mountain bodies.

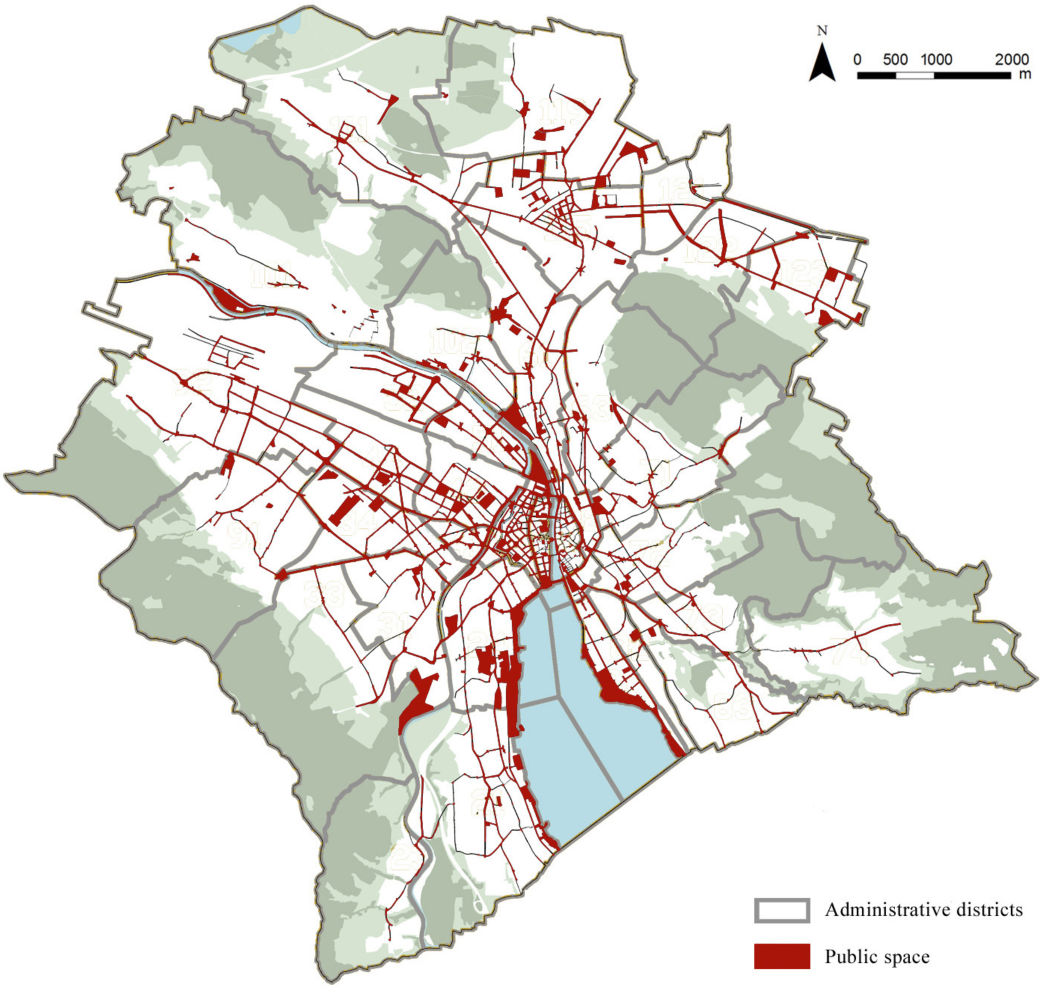

Figure 7. The layout relationship between public space pattern and natural factors of Zurich based on administrative district units.

Table 5. The location quotient of public space and mountain bodies of Zurich based on administrative district units.

Administrative Districts	Mountain Bodies	Public Space	Administrative Districts	Mountain Bodies	Public Space
11	0.000	3.342	73	2.332	0.612
12	0.000	3.983	74	1.391	0.190
13	0.000	4.365	81	0.000	2.655
14	0.000	5.066	82	0.000	0.373
21	0.589	1.097	83	0.380	0.456
23	1.871	0.279	91	1.752	0.637
24	0.000	2.163	92	0.873	0.868
31	0.066	0.531	101	1.331	0.424
33	2.122	0.836	102	1.034	0.684
34	0.000	1.476	111	0.596	0.370
41	0.000	2.723	115	0.038	0.817
42	0.000	2.104	119	0.335	0.625
44	0.000	1.200	121	0.046	0.518
51	0.000	1.995	122	1.577	0.677
52	0.000	0.808	123	1.177	0.892
61	0.000	1.462	Average	0.657	1.383
63	1.564	1.147	Standard deviation	0.779	1.224
71	1.024	0.866	Variable coefficient	1.185	0.885
72	2.217	0.767			

Logarithmic

Model Summary

R	R Square	Adjusted R Square	Std. Error of the Estimate
.783	.613	.436	.933

The independent variable is LQ of mountains.

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Regression	23.069	1	23.069	26.511	.000
Residual	27.845	32	.870		
Total	50.914	33			

The independent variable is LQ of mountains.

Coefficients

	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
ln(LQ of mountains)	-.188	.037	-.673	-5.149	.000
(Constant)	.660	.213		3.104	.004

Figure 8. The regressive result of logarithmic curve of public space and mountain body location quotient of Zurich by SPSS.

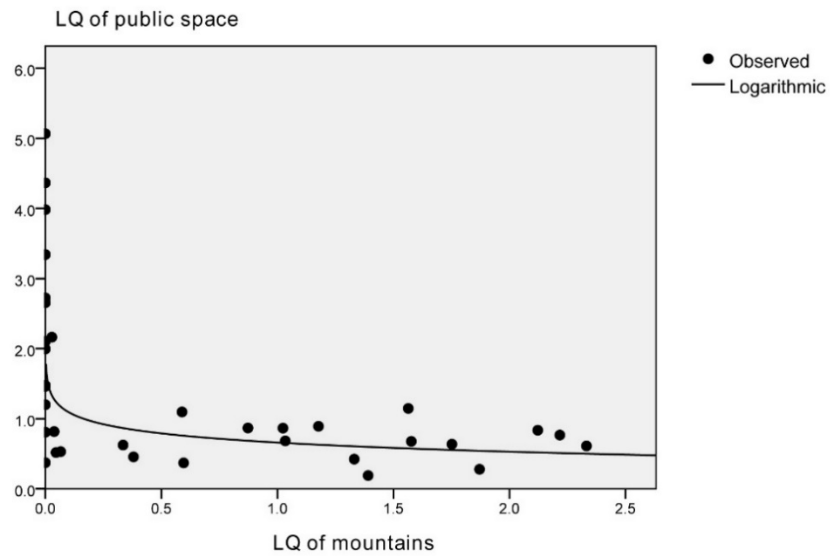

Figure 9. The logarithmic curve of public space and mountain body location quotient of Zurich by SPSS.

The results quantify the distinct separation trend between the public space and mountain body layout of Zurich. Figure 9 shows that the distribution of public space decreases as mountain bodies in the corresponding areas increase. However, at a certain point, this decreasing trend stabilizes, as compliant with a logarithmic curve.

Next, we investigated whether any specific mountain body in the zone exerted a tremendous influence on the distribution of the public space. All of the high-clustering areas of public space, with a location quotient higher than two, were located in mountainless zones. In general, the percentage of public space in mountainless zones was higher than the average, while the percentage of public space in mountainous zones was unexceptionally lower than the average. The exceptions were Zone 63, which includes large traffic nodes, and Zone 21, which is adjacent to water (Table 5). In zones whose percentage of mountain body site area was lower than the average, when the location quotient of mountain bodies ranged from zero to one, the percentage of public space decreased rapidly, along with an increased mountain body percentage. When the percentage of the mountain body site area was higher than average, with a location quotient of mountain bodies greater than one, the location quotient of mountain bodies increased by the same order of magnitude, and the distribution of the corresponding public space decreased at a slow rate.

The separation layout of public space and mountain bodies in Zurich is not accidental. Protecting the natural environment and landscape is one of the four strategies of the Swiss National Spatial Planning [36]. Natural mountain bodies are highly protected in Zurich and basically encircled by "freihaltezone" [37]. Conservation areas are generally used for pastures, cemeteries, family gardens, sport fields, lawns, and other non-urban construction sites, acting as a buffer zone between mountain bodies and urban construction sites. This type of layout represents how public advantageous resources supplement each other, conforming to the principle of compensatory distribution of public resources. The spatial fairness is ensured at the level of layout. In general, from this example, it can be deduced that during the planning design, we should not distribute a lot of public space without much consideration to the natural landscape. Instead, we should synthetically weigh factors such as the specific urban space pattern and location difference.

6. Discussion and Analysis

For a long time, the urban environment of Zurich has held unique appeal. This paper applies the framework of public–natural space spatial patterns to map/understand Zurich and attempts to, from the perspective of Chinese scholars, unscramble the European city to provide a reference for the study of urban public space.

The layout relationship between urban public space and natural factors in Zurich was determined by the original natural system of the environment and the development process of the city. The Zurich model shows that a balance can be achieved among the maintenance of urban ecological environment, the cultivation of public space, the comfort of sites, and economic feasibility. When the public space system and natural system layout of the city are mutually adapted, the relatively integrated hierarchical composition will manifest landscape cohesion. Further, it will play a commanding role in the mutual construction between ecology and humanism in the overall spatial structure and landscape features of the city. In order to further explore whether the LQ evaluation framework established above applies to other cities, we used Nanjing, a Chinese city with desirable mountain and water natural resources, as a case for analysis and comparison [35]. The vector base map of Nanjing was set up by applying the same method, and the same indexes for data statistics and analysis were selected by applying the LQ method. This is not explained in detail here because of space limitations. The result of Nanjing is quite different from that of Zurich. A certain positive correlation exists between the overall pattern of the urban public space of Nanjing and the distribution of mountains and water in Nanjing. Since these natural resources are mostly concentrated in the periphery of the city, the public space is also mostly distributed in the periphery of the city. In contrast with Zurich, the centrifugal layout trend of public space in Nanjing deviates from the centripetal law of existing urban space structure and public behavior activities. This makes it unbeneficial for daily use and the efficient display of public space. Therefore, although there is not a big gap between the actual percentage of the urban construction site of public space in the old urban area of Nanjing and in Zurich, being 7.7% and 10.8% [35], respectively, the relative scantiness of the public space of Nanjing is tangible. The analysis framework of public–natural space established in this paper aims at quantitatively analyzing and understanding the layout relationship between the public space and natural factors in cities. Therefore, it is inapplicable to cities with scanty natural resources and without mountains, rivers, or lakes. As a result, the correlation between the public space and natural space in these cities cannot be established. Even in cities with little natural space, because of the lack of further empirical studies, it still remains unknown whether this methodology can be replicated efficiently. This is one of the potential limitations of this research. In addition, this research merely attempts to explore cross-sections without considering the progress of time. Other possible evaluation modes, especially the issue of applicability of various relationship models to the cities in different countries, are yet to be further studied. Obtaining the conclusion relies on the accumulation of more horizontal and vertical theoretical and empirical studies.

7. Conclusions

This paper presented a new classification method of the relationship between urban public space and natural landscape by using three spatial distribution patterns: (1) the overlapping mode, (2) the separation mode, and (3) the edge-binding mode. Additionally, the location quotient method was introduced to describe this relationship quantitatively, discovering the rules of its layout. This was the main innovation of this article. However, the conclusions of this study are basically based on a single case study, so other applications could be useful in future developments.

The layout relationship of urban public space and natural factors exerts tremendous influence on the overall spatial structure of a city. This study employed the "double framework" method using two mutually nested and integrated systems: (a) the natural factor and (b) the urban space layout. The natural factor system consisted of ecological functions such as rain-flood management and biodiversity protection. The public space system comprised the functions of citizens' public lives and social integration. This established a general development framework that gathered two structuralized public systems (the natural and the social) into the urban spatial layout domain. To further integrate, "multi-modules," which are referred to as synthetic weights of existing conditions, allowed for a modularized combination layout. By consciously using multiple distribution relationships—including the overlapping, separation, and edge-binding between public space and natural factors—the efficiency of the urban spatial layout could be quantified. With the "double framework" system of natural factors and public space, we can fully consider the significant connection between ecology and landscape, and synthetically weigh the demand and impacts of human behavior on the space. This allows for a greater understanding of future sustainable development guidance considering urban traffic, land-use sites, buildings, and other systems. The overall aim is to have an ecologically sustainable city and, by means of urban design, have the opportunity to achieve high synergy between the city and landscape.

From the case study, it became apparent that natural factors with different urban locations, landforms, and configurations adapt to different patterns of public space—and should therefore guide appropriate development modes according to actual conditions. The general principle is that the percentage and diversity of the afforested area of landscapes should be ensured. With regard to the ecological security pattern of urban landscape, we can bring the space–time process of landscape into the design by developing a framework of urban design for strict protection, constructing a regionally sized system of landscape architecture.

Contemporary landscape is regarded as a framework for the city to exist desirably and an important means for constructing the public sphere. In particular, contemporary landscape continuously plays a role in understanding and intervening in the complex natural environment [2]. Biological habitats and biodiversity are the basis of the service of the natural system, while the welfare of human beings is the goal of the service of the natural system [38]. Urban public space is where citizens interact socially, forming the concrete presentation of society. The strain emerging between the layout of urban public space and natural factors plays a crucial role in upgrading the environmental quality of cities, maintaining urban vigor, and fostering citizens' sense of identity. When landscape architecture and urban design thoughts are integrated gradually—and when a proper relationship is established between the natural system and the urban public space, human activities, and the public activity centers of the city—the new system will have an opportunity to realize significant ecological and social benefits.

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