land

MDPI

Article

A Syntactical Spatio-Functional Analysis of Four Typical Historic Chinese Towns from a Heritage Tourism Perspective

Pan Liao [1], Rongrong Yu [2], Ning Gu [2] and Sahar Soltani [2,3,*]

[1] School of Architecture and Design, China University of Mining and Technology, Xuzhou 221116, China
[2] UniSA Creative, IVE: Australian Research Centre for Interactive and Virtual Environments, University of South Australia, Adelaide, SA 5000, Australia
[3] Future Building Initiative, Caulfield Campus, Monash University, Melbourne, VIC 3145, Australia
* Correspondence: sahar.soltani@monash.edu; Tel.: +61-399034183

Abstract: This study presents a quantitative approach to exploring the spatio-functional characteristics of historic Chinese towns (HCTs) from a heritage tourism perspective. In recent years, HCTs have evolved from being resident-oriented to being more tourist-oriented, in part due to their heritage significance for attracting tourists. Spatio-functional qualities of a historic town are essential elements of the town's urban morphology and of great concern for preservation. Previous studies that discussed this issue often used qualitative descriptions, and only limited studies have systematically explored the spatio-functional qualities of HCTs. Thus, there is presently a lack of understanding around this issue, especially based on rigorous quantitative approaches. This study examines the spatio-functional qualities of HCTs using space syntax, a commonly used method in urban studies that enables measurement of spatial characteristics through mathematical means. Four HCTs with heritage significance, Pingyao, Lijiang, Kulangsu, and Wuzhen, were selected as case studies. The study has examined the role of heritage tourism and the results show that tourist-focused functions tend to distribute and aggregate in the urban core of HCTs. By contrast, cultural relics are freely distributed and not expanded over time. Spatio-functional patterns of the four HCTs were theorised, and the paper concludes with suggestions regarding future land-use optimisation for the four HCTs concerning heritage tourism.

Keywords: historic Chinese towns (HCTs); spatio-functional analysis; space syntax; star model; heritage tourism

check for updates

Citation: Liao, P.; Yu, R.; Gu, N.; Soltani, S. A Syntactical Spatio-Functional Analysis of Four Typical Historic Chinese Towns from a Heritage Tourism Perspective. *Land* **2022**, *11*, 2181. https://doi.org/10.3390/land11122181

Academic Editor: Hannes Palang

Received: 11 November 2022
Accepted: 25 November 2022
Published: 1 December 2022

Publisher's Note: MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Copyright: © 2022 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

1. Introduction

With a history of over 3000 years, China encompasses more than 2000 historic towns and cities [1]. With Quanzhou: Emporium of the World in Song-Yuan China added to the World Heritage (WH) list in 2021, China so far has 56 recognised heritage properties including 38 cultural properties [2]. A growing concern on protecting these valuable towns has been raised and emphasised in the current literature.

As a fundamental part of urban morphology and the main area of concern for heritage conservation, spatio-functional qualities of historic Chinese towns (HCTs) need to be properly understood, including their physical spatial structures and land-use patterns [3]. However, there is an identifiable lack of quantitative approaches to the spatio-functional analysis of HCTs. The majority of studies were either focused on broader urban areas in major Chinese cities [4–6] or individual towns without a systematic approach [7,8][1]. Spatial characteristics of HCTs have been analysed using quantitative measures in our prior study [9]. With a compound analysis of both spatial configuration and land use, this study extends our previous spatial analysis and presents a syntactical spatio-functional analysis of HCTs. This analysis can quantitatively reveal the spatial distributions of different types of land use, which can be utilised by designers, planners, policymakers, and conservationists, for directing heritage planning in terms of land-use optimisation and tourism management.

Recently, heritage tourism has become a key strategy for the conservation and development of historic towns across the world. However, some negative impacts have emerged, including increased traffic pressures, unregulated land-use changes, spatial segregation, and the loss of spatial and cultural authenticity [10–12]. With the rapid development of the tourism industry in China, many HCTs have experienced the above-mentioned issues to various extents. Understanding the relationship between the spatio-structure and land use in HCTs is crucial for future HCT development. Thus, there is an urgent need to critically examine how heritage tourism may affect the spatio-functional qualities of HCTs.

In this study, four towns that exemplify typical core characteristics of HCTs were selected as case studies to perform the spatio-functional analysis. They are Pingyao, Lijiang, Kulangsu, and Wuzhen. The four chosen HCTs characterise geographical (northern China and southern China), cultural (the dominant ethnic, ethnic minority, and a blend of Western cultures), and spatial (orthogonal and organic) diversities of HCTs. Three research steps were conducted to carry out the analysis. Firstly, points of interest (POIs) retrieved from Baidu Maps (a major online Chinese map provider) were used to identify land use in each HCT and represent the function of a building. POIs were further categorised according to whether they were used by tourists and/or residents. Secondly, spatial measure values calculated by space syntax [13] were assigned to POIs, so that the spatial characteristics of each categorised type of POIs can be directly compared to each other. Finally, a correlational analysis was undertaken to examine the impact of spatial configurations on function aggregation within a given radius in the four selected HCTs.

This paper aims to present a robust methodology to quantitively analyse the spatio-functional qualities of HCTs. The methodology is formal, compatible, and expandable, and can therefore be rescaled and applied to other cultural contexts in the world. Moreover, the analysis results enable a generation of strategies regarding land-use optimisation for HCTs to mitigate the negative impacts of heritage tourism.

2. Background

2.1. Spatio-Functional Qualities of HCTs

Historic town conservation is an important topic in China and has been studied from various perspectives, such as from a broader overview of historic Chinese towns [14] to narrower focuses on individual towns [15]. Traditionally, more attention has been paid to the conservation of cultural relics within historic sites. Later, the single conservation system for cultural relics was expanded to a dual-level system in which historic town conservation was considered a complement to protecting cultural relics in China [1]. A three-tier hierarchy in heritage conservation then followed, comprising individual sites and buildings, historic-cultural conservation areas, and entire cities, all categorised based on scale [16]. Hence, there has been a shift in the focus of strategies being applied to heritage conservation, shifting from individual buildings to broader urban settings. Such a shift is in line with international charters that acknowledge the significance of the conservation of historic towns and urban areas [17].

The expansion of the conservation system for historic towns leads to more comprehensive conservation strategies. Distinguished from static cultural relics, historic towns are a living heritage with dynamic and complex urban systems involving multiple dimensions, such as physical, social, cultural, economic, and spatial aspects. Accordingly, approaches to historic town conservation focus on these different contexts [18]. Furthermore, the spatial and spatio-functional properties of historic towns that have evolved from their inception to today, as identified in *Hoi An Protocols for Best Conservation Practice in Asia* [3] are important dimensions of authenticity. Spatial structures of historic towns encompass both natural elements (e.g., a river flowing through the street network) and built elements (e.g., urban land uses). This paper focuses on investigating the key spatio-functional qualities of HCTs to gain a comprehensive understanding of the essential spatial and functional patterns and their relationships.

Ruan et al. [1] summarised four main aspects that need to be preserved for historic Chinese towns and cities: cultural relics, historic streets, specific characteristics, and traditional cultures. 'Specific characteristics' of a historic town may include a plan graph of the town, an axis of the town, associated streets, as well as a river system [1]. These characteristics can be used to differentiate historic towns in China. For example, in general, more rigid planning of historic towns is evident in northern China and more organic planning of historic towns is evident in southern China. The spatial characteristics of HCTs and associated land use reflect the relationship between the town's geographic environment and the social, cultural, and historical assets of the town at that time. Therefore, understanding the spatio-functional qualities of HCTs is a significant component of heritage conservation in China.

In the current literature, studies of HCTs often focus on regeneration [19], restoration [20], and revitalisation [21]. However, limited studies to date have directly examined the spatio-functional qualities of historic towns using systematic quantitative methods. Considering this gap, the present study conducts a spatio-functional analysis of HCTs using a syntactical approach based on space syntax theories.

2.2. Impacts of Heritage Tourism on HCTs

Heritage tourism can have significant impacts on HCTs from different dimensions, including social [22], political [23], and economic [24]. Once historic towns are nominated as World Heritage (WH) sites, they are publicly acknowledged worldwide and have strong attractions for tourists. Heritage tourism development in a WH site may contribute to increasing local job opportunities and improving residents' living conditions. In China, most historic towns can utilise the WH title to encourage heritage tourism, promoting further economic growth [25].

Effective tourism management is beneficial for heritage conservation by engaging with communities and influencing relevant policies [26]. However, conflicts often exist between heritage conservation and tourism development [27,28]. Moreover, the over-development of heritage tourism has accelerated the spatial and functional transformation of historic towns, converting them into 'open-air museums', rather than respecting them as living heritage sites [29]. In this regard, as a conservation strategy for HCTs, heritage tourism should be carefully managed so that it does not negatively impact the authenticity and their spatio-functional qualities. The impacts of heritage tourism on the four selected HCTs are summarised in Table 1 and will be further discussed in the analysis.

Table 1. A comparison of the four case studies.

Cases	Spatial Characteristics	Location	Cultural Form	Scale	Tourism Development Characteristics	2020 Tourist Number	Underling Issues
Pingyao	Walled enclosure, north-south orientation, orthogonal spatial layout, axiality.	Northern China	Typical planning, building and construction characteristics of the traditions of China's main ethnic group—the Han people. Shanxi Business Culture.	Approximate 2.32 km^2	WH site, 1997. Tourists can access the old town area for free with an entrance fee needed for accessing several attractions.	4,880,600	Heritage tourism is prevalent in all four case studies. A large number of traditional buildings have now been transformed into guesthouses due to tourism demands; recreation dominates; cultural relics are not adequately emphasised in planning.
Lijiang	Surrounded by mountains, trees, and rivers, presenting a natural topography, organic spatial layout.	Southern China	Mixed cultural influences from both the Han people and an ethnic minority called Naxi.	Approximate 1.49 km^2	WH site, 1997. Tourists can access the old town area for free with an entrance fee needed for accessing several attractions.	26,251,000	
Kulangsu	Undulating geography, curved streets, organic spatial layout.	Southern China	Primarily influenced by modern architectural design and planning principles. Amoy Deco Style.	Approximate 1.79 km^2	WH site, 2017. The tourism management of Kulangsu is managed effectively with a restricted tourist number (50,000, subject to change) landing per day. An entrance fee is needed to access several attractions on the island.	3,661,500	
Wuzhen	Unique water supply system, organic spatial layout responsive to the geographical features.	Southern China	Waterfront town representing a 'southern style' of the building traditions of the Han people.	Approximate 1.92 km^2	WH tentative list, 2008. Tourists need to pay to access the old town areas of Wuzhen, which is different from the other three towns that only charge fees for specific tourist attractions.	2,660,400	

3. Methodology

Space syntax [13] has been employed in this study due to its recognised syntactic theory and associated mathematical measures that are appropriate for the spatio-functional analysis of HCTs. Space syntax applies topological measures to index spatial configuration and interpret social effects. For example, land use has been found to be positively related to the spatial configuration of urban spaces, with empirical evidence indicating the most accessible streets are more likely to aggregate commercial land uses in a city [30].

Most space syntax techniques commence by abstracting spatial entities (e.g., street networks) and their inter-relationships into a graph utilising graph theory, in which each space is seen as a node, and connections between them as edges [31]. There are two critical measures in space syntax: integration and choice. Integration indexes how close a node is relative to all the other nodes in a graph with a given radius (e.g., radius *n* for global scale and radius 500 m for local scale), while choice indexes how frequently a node can be encountered in a graph with a given radius. Both integration and choice are calculated based on topological distances (e.g., axial integration and axial choice) and geometric distances (e.g., angular integration and angular choice) [32–34]. The angular integration and angular choice values can be normalised for comparison among different street networks that may differ in scale, which are denoted as normalised angular integration (NAIN) and normalised angular choice (NACH), respectively. Moreover, Hillier et al. [35] used a star model that standardises NAIN and NACH, so the differences between different cities can be scaled up as *z* scores ranging from −3 to 3 for comparison. NAIN and NACH are two key spatial syntactic measures (SSMs) in this study as they are essential for configuring street networks associated with land use in urban systems.

Axial segments generated from a street network with the top 10% values of NAIN and NACH measures were considered as the NAIN and NACH cores [35,36]. The two cores can be further combined and referred to as the syntactic core. The syntactic core is a collective concept that aims to combine the configurational role of NAIN and NACH cores and identifies the spatial centre of a historic town. Figure 1 illustrates the research framework of this study.

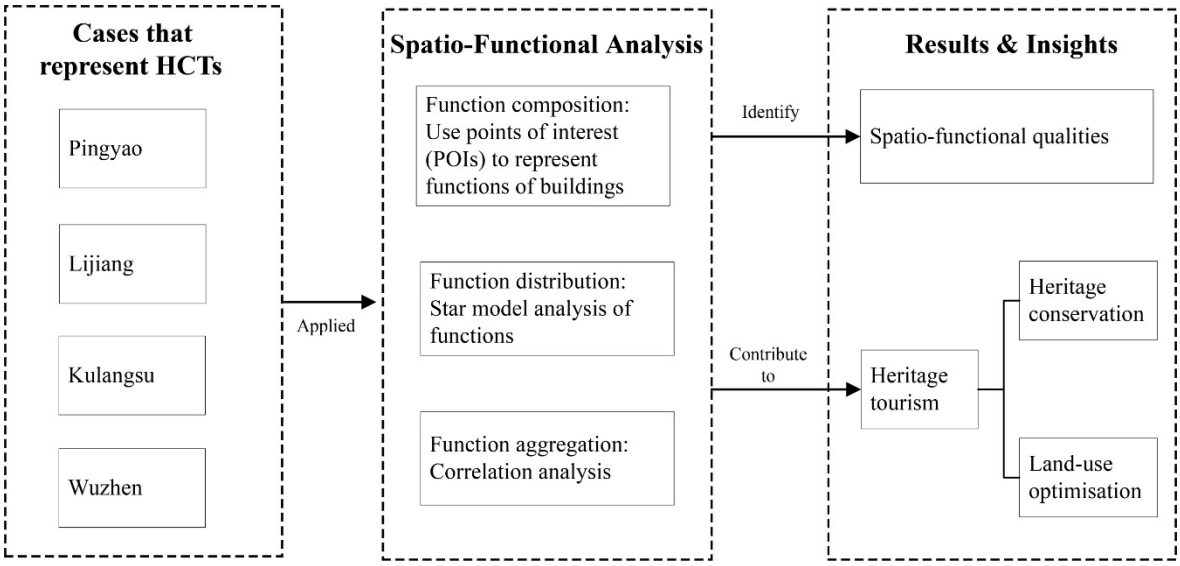


Figure 1. Research framework of this study.

3.1. Case Selection

To analyse the spatio-functional qualities, the following four HCTs (Figure 2) were selected as case studies based on the below two selection criteria. Firstly, the heritage significance of historic towns was considered based on UNESCO's nomination of the WH site as having 'outstanding universal value'. The historical period of the towns was also

taken into account to include both ancient and modern times. Secondly, since China has a vast territory with a variety of ethnic groups, the cases were selected to capture diverse geographical and cultural settings.



Figure 2. The four HCT case studies, from left to right: Pingyao, Lijiang, Kulangsu, and Wuzhen [photos were taken by the lead author].

As demonstrated in Table 1, the four HCTs show a diverse range of spatial characteristics, geographic locations (Figure 3), cultural forms, and tourism development characteristics, suitable for a comprehensive investigation and analysis of their spatio-functional qualities. Figure 4 illustrates the planned land uses of the four HCTs, adapted from the available resources published by the local government of each town. It should be noted that officially, Kulangsu is not a 'town', but a historic international settlement inscribed on the WH list in 2017. There are two reasons for considering Kulangsu as a town for this study: firstly, the scale of Kulangsu is similar to the other three towns; secondly, located on an island, Kulangsu is isolated from the urban centre, Xiamen; therefore, its spatial layout is well-preserved with some degrees of integration.



Figure 3. The locations of the four selected HCTs.

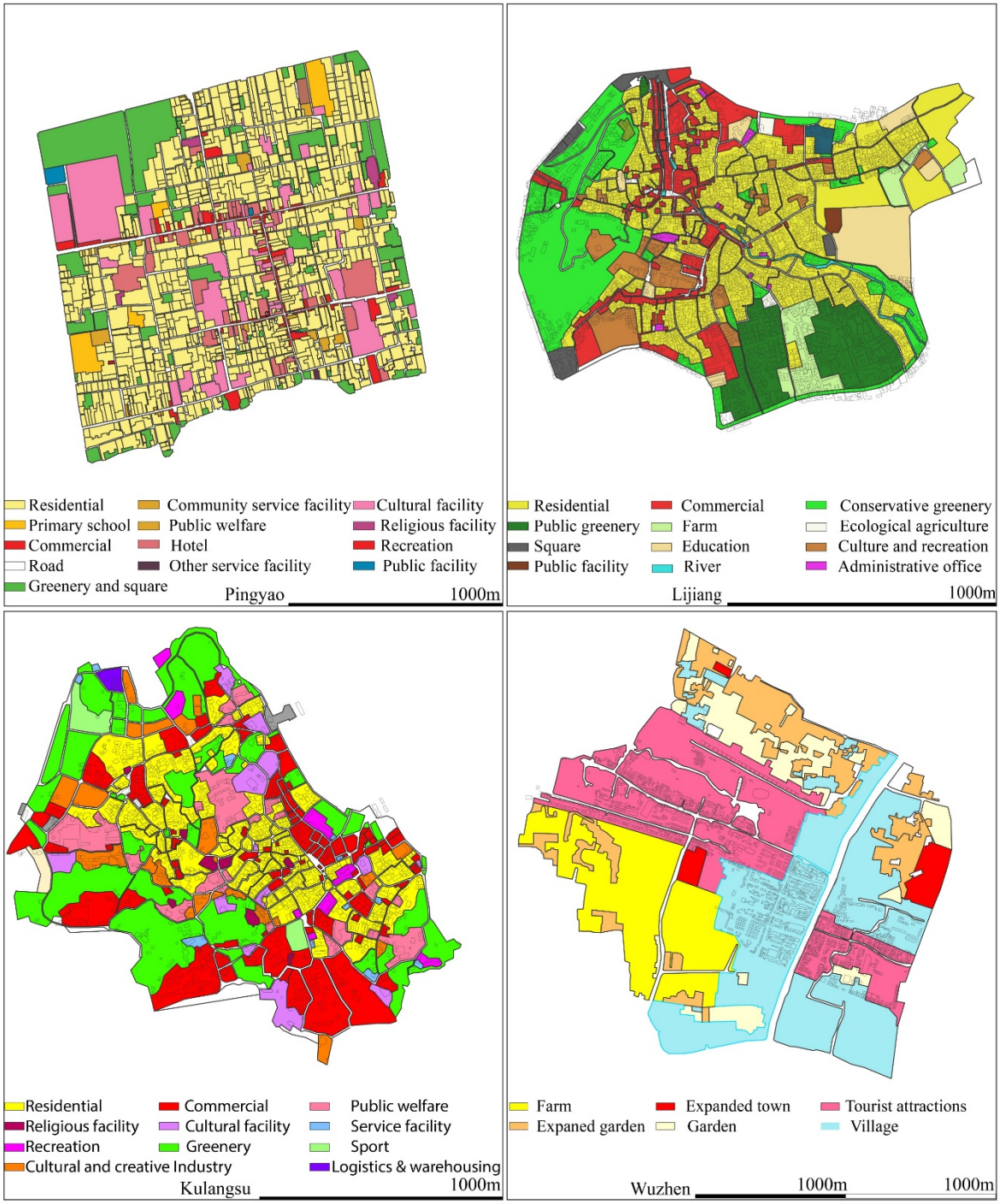


Figure 4. The planned land uses of the four HCTs.

This comparative research enables a systematic analysis and investigation of the spatio-functional qualities of the four HCTs. The analysis result can show the heterogeneity of land-use distribution amongst the towns since the spatial layouts of the towns are different from each other. In addition, the adoption of the method will allow us to propose future land-use optimisation strategies.

3.2. Research Steps

Step 1: Using points of interest (POIs) to represent land use

This study explores the relationship between spatial configurations and functional patterns of HCTs regarding heritage planning and tourism management. In the first step,

the land-use composition in each selected HCT was examined. More specifically, we can assess whether tourist-focused functions occupy a large portion of overall functions. Points of interest (POIs) were used to represent land use. POIs were retrieved via the Baidu Maps application programming interface (API) and mapped onto the street network in each[2]. Land-use classification in the four HCTs is based on tourists' and/or residents' needs. When tourists visit a specific historic town, they undertake various activities related to leisure, accommodation, shopping, etc. For residents, activities are largely centred on residential, local logistics, and community services.

Based on the above activities, five categories of land use have been defined in this study including accommodation, recreation, culture, public facilities, and exclusive supply. 'Accommodation' is mainly for tourists, which is used to demonstrate how heritage tourism developments influence commercial rental activities since many original residential houses have been transformed into guesthouses. 'Recreation' is for both tourists and local residents but primarily delivered to tourists. The term 'recreation' is used to index all possible commercial activities targeting tourists that occur in HCTs. 'Culture' is usually created/hosted by local residents and delivered to tourists. The reason for including the culture category is that cultural relics are an important component of a historical town [37]. 'Public facilities' are for both local residents and tourists, which support the everyday life in HCTs. Finally, the category 'exclusive supply' is mainly for supporting local residents' activities. The mapping of POI categories is shown in Table 2.

Table 2. The mapping of POI categories in the study.

Land-Use Categories	POI Categories	Intended Users	Examples
Accommodation	Hotel	For tourists only	Hotels, guesthouses
Recreation	Catering, shopping, beauty service, recreation, sport, cultural facility, daily service	For tourists and local residents, but mainly for tourists	Catering, commercial, recreational facilities
Culture	Tourist attraction, cultural facility	Created and hosted by local residents and delivered to tourists	Museums, heritage sites, relics
Public facilities	Daily service, hospital, commerce (e.g., ATM)	For both local residents and tourists	Municipal utilities
Exclusive supply	Daily service, commerce, cultural facility, education, car service, real estate, company, government	Mainly for local residents	Residential, administration and public services industrial, manufacturing

After the land-use categorisation was defined, the POI land-use composition was then calculated as the number of POIs with a certain function divided by the total number of POIs in each town. This produced a percentage value for each function, to allow the POI land-use composition to be compared amongst the four HCTs.

Step 2: Calculating spatial syntactic measure (SSM) values associated with land use

In this step, the normalised measures NACH and NAIN were calculated in *depthmapX*, which is a stand-alone application to perform space syntax analysis using the following formulas:

$$\text{NACH} = \log(\text{value}(\text{“T1024 Choice”}) + 1)/\log(\text{value}(\text{“T1024 Total Depth”}) + 3) \quad (1)$$

$$\text{NAIN} = \text{value}(\text{“T1024 Node Count”})\text{^}1.2/(\text{value}(\text{“T1024 Total Depth”}) + 2)$$

This step aims to calculate spatial syntactic measure (SSM) values associated with land use (i.e., assigning NACH and NAIN values to land use). To achieve this, firstly, each POI was assigned a specific function and colour-coded (Figure 5a). Secondly, edges were created between axial segments and POIs, which were determined by the centre point of each axial segment and the POI that was closest to that segment (Figure 5b). Finally, a highly abstracted graph was generated, containing edges, axial segment nodes (centre points of axial segments), and POIs (Figure 5c). The SSM value of each POI was then determined

by the nearest axial segment. The distance was calculated from the centre point of the axial segment to the POI. In other words, each POI inherits the NAIN/NACH value of its closest axial segment. This approach is similar to Yang et al. [38] which focused on the spatio-functional patterns of Beijing. Figure 6 shows the *Grasshopper* algorithm components for computing the process.

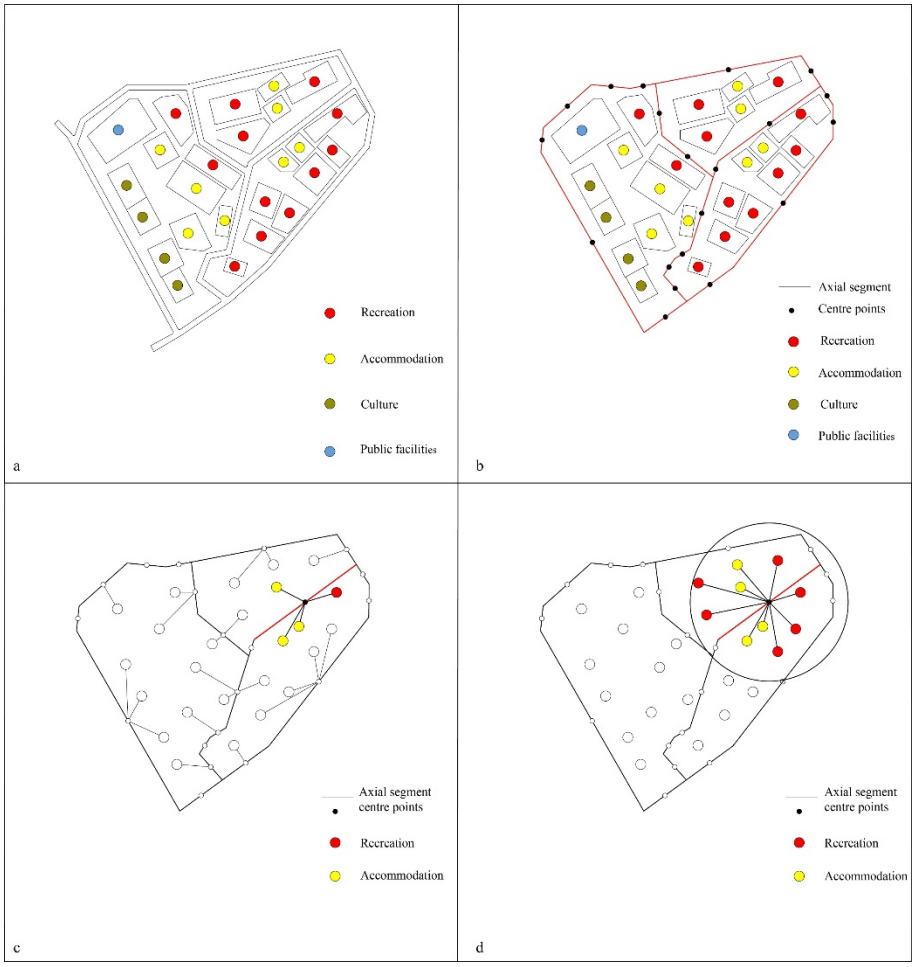


Figure 5. (**a**) Colour coding POIs; (**b**) generating axial segments; (**c**) creating the edges between axial segments and POIs; (**d**) illustrating the attractiveness of an axial segment to POIs within a given radius.

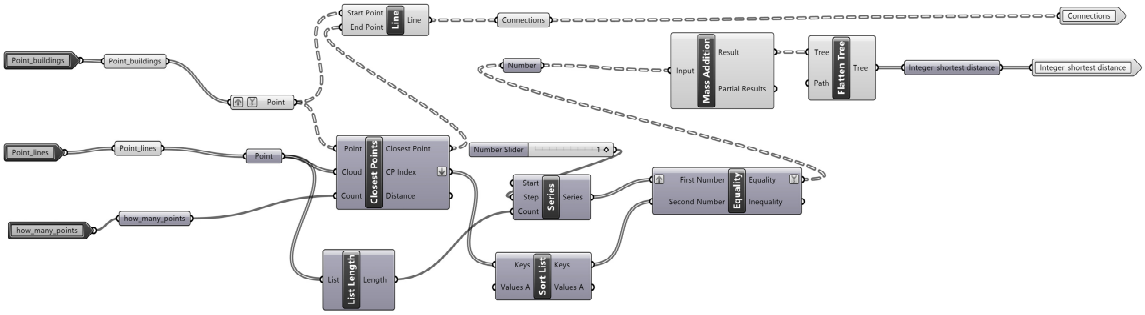


Figure 6. Grasshopper components used to determine the spatial syntactic measure (SSM) value of each POI land use.

The mean NACH and NAIN values of street networks in the four HCTs are shown in Table 3, while the detailed NACH and NAIN values at the axial-segment scale in each town can be retrieved from the Supplementary Materials.

Table 3. The NACH and NAIN values of street networks in the four HCTs.

Name	Spatial Syntactic Measure	N (Axial Segments)	Minimum	Maximum	Mean	Std. Deviation
Pingyao	NACH	1085	0.000	1.492	0.875	0.416
	NAIN	1085	0.501	1.356	0.924	0.192
Lijiang	NACH	1666	0.000	1.426	0.842	0.403
	NAIN	1666	0.216	0.721	0.528	0.082
Kulangsu	NACH	1749	0.000	1.380	0.885	0.352
	NAIN	1749	0.278	0.660	0.473	0.085
Wuzhen	NACH	1487	0.000	1.484	0.819	0.405
	NAIN	1487	0.331	0.899	0.609	0.120

To conduct a systematic comparison amongst the towns, a *z*-score transformation strategy was considered. This study compares the mean SSM values between each type of POI land use and the entire street network of the town, which considers the overall POI land use, not a single point of interest. The mean SSM values of the entire street network in each town were standardised based on the 13 cases of historic Chinese towns and cities [9], as shown in Table 4. The expanded 13 cases include Pingyao, Lijiang, Kulangsu, Wuzhen, the historical spatial layout of Pingyao, the historical spatial layout of Lijiang, the historical spatial layout of Kulangsu, the historical spatial layout of Wuzhen, four historic capital cities, and the ideological 'ideal city' that serves as a prototype of the spatial layout of an HCT in Chinese cultural history. They form a local system for representing a typical spatial pattern of historic Chinese towns and cities [9]. In that manner, the standardised SSM values ensure a systematic comparison between different cases within this system. Note that the relative differences between the SSM values for land use are not affected by the standardisation. The standardised SSM values for each type of POI land use were calculated using the following formula:

$$z_SSM_{Land\ use_a} = (SSM_{Land\ use_a} - Mean_SSM)/Std \quad (2)$$

where $Land\ use_a$ refers to the POI land use in type a (a belongs to accommodation, recreation, culture, public facilities, and exclusive supply); $SSM_{Land\ use_a}$ refers to the *SSM* values (*mean_NACH*, *max_NACH*, *mean_NAIN*, and *max_NAIN*) of all the POIs in land-use type a; *Mean_SSM* refers to the mean *SSM* values based on a calculation of the 13 cases of the selected historic Chinese towns and cities; and Std refers to the standard deviation for each *Mean_SSM* (see Table 4). The *z*-scores of the SSMs form a star model of functions, as shown in the results section.

Table 4. Mean/max. NACH and mean/max. NAIN measures of the 13 cases of the selected historic Chinese towns and cities.

SSMs	N	Mean_SSMs	Std. Deviation
Mean_NACH	13	0.868	0.121
Max_NACH	13	1.422	0.070
Mean_NAIN	13	1.030	0.485
Max_NAIN	13	1.298	0.452

Step 3: Correlational analysis between SSMs and function aggregation

For each axial segment that represents a street segment broken by junctions, the number of POIs with a specific function was used to describe the attractiveness of that axial segment, as shown in Figure 5d. By setting a radius of 100 m (with 10% tolerance to 110 m) from the centre of an axial segment, the number of POIs that each axial segment can be accessed was calculated. Figure 7 shows the *Grasshopper* algorithm components for computing the process. The scale of the four cases is relatively small; therefore, unlike

similar studies [39] that set multiple-scale catchments, only a small scale was considered in this paper. The scale is suitable for HCTs since the radius of the entire town is approximate 1.5 km for each selected town. This step adopted the methods of Ozbil et al. [40] and particularly considered the scale of HCTs. Once the above preparations were completed, correlational analysis was then conducted.

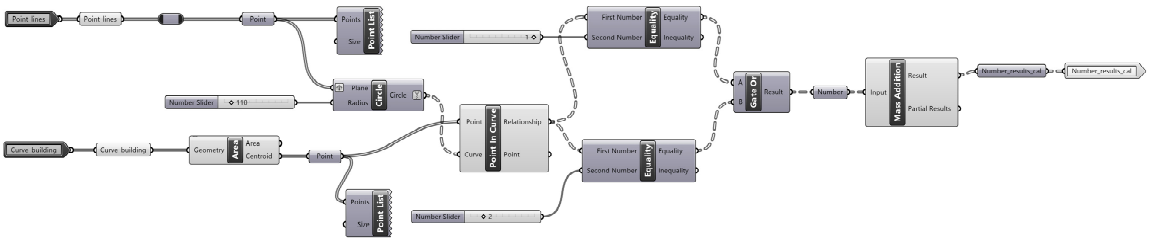


Figure 7. Grasshopper components used to calculate the number of POIs that each axial segment can access within a given radius.

Bivariate correlational analysis was performed in this study. In interpreting the coefficient (*r*) value, a value of 0.1 represents a small effect (slightly correlated), 0.3 a medium effect (moderately correlated), and 0.5 a large effect (well correlated) [41].

4. Results

4.1. Step 1: POI Distribution Results

Figure 8 illustrates the POI distribution in the four HCTs, while Figure 9 shows the ratio of the five types of POI land use amongst the selected towns. In the four HCTs, recreation POIs have the highest ratio (except for Pingyao) among all five types of land use. Moreover, recreation POIs dominate in Lijiang with a ratio of 44.37%. This figure is in line with the tourist number of Lijiang, which is significantly higher compared to the other three towns. This supports the fact that Lijiang is very tourism focused. Accommodation POIs are popular in the four HCTs to serve tourists. Regarding culture POIs, Pingyao has the highest ratio throughout the entire town. The culture POIs ratio in Lijiang is relatively small compared to the other three HCTs, which only occupies 2.8% of all POI land uses.

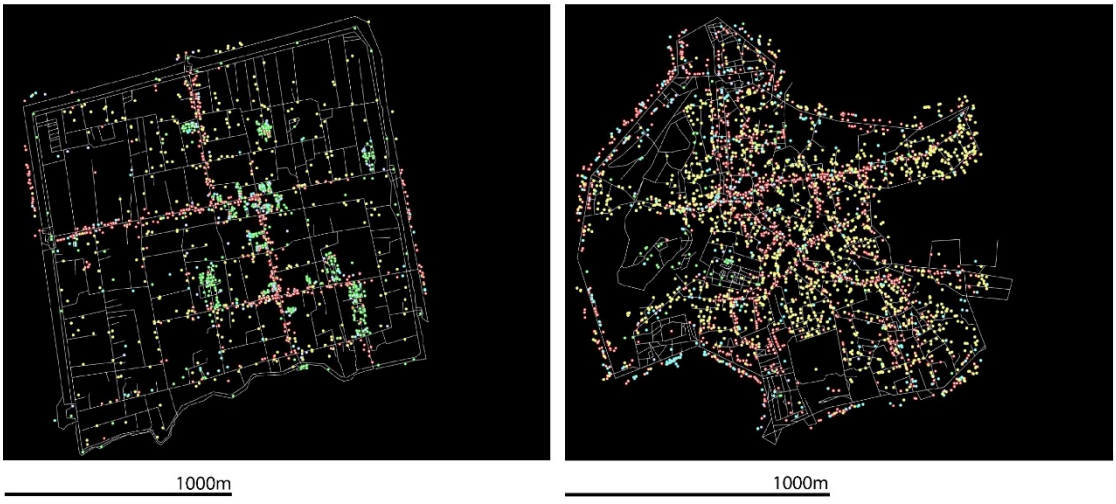


Figure 8. *Cont.*

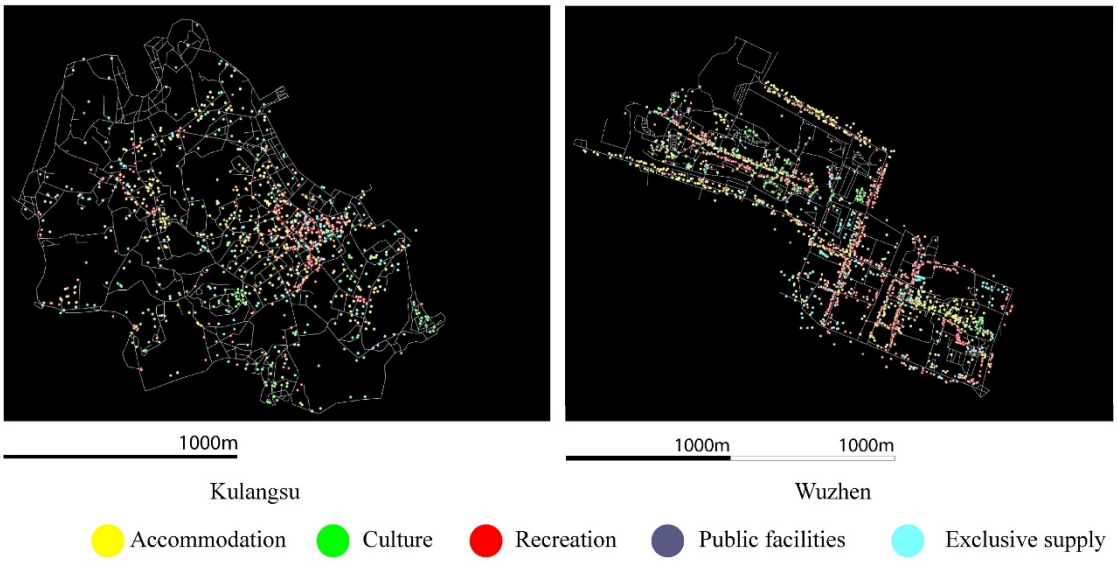


Figure 8. POI distribution in the four HCTs.

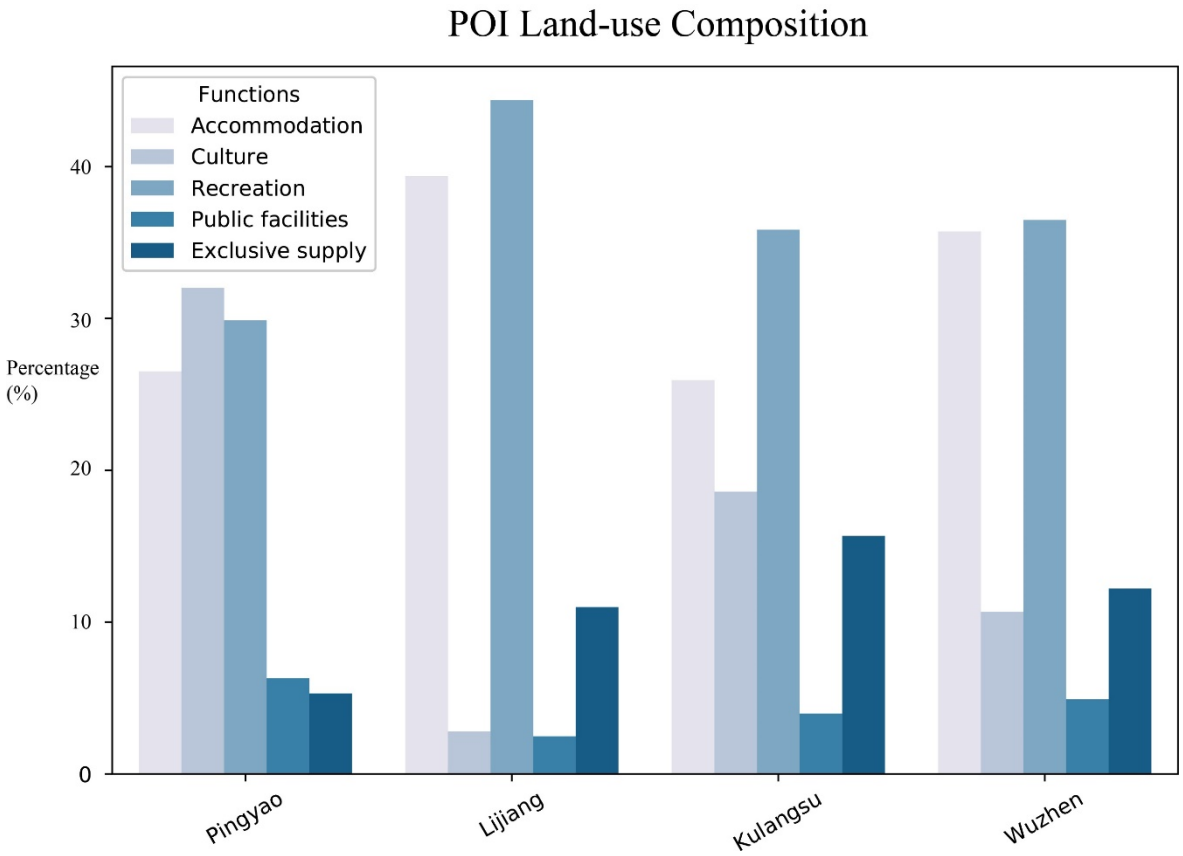


Figure 9. The ratio of the five types of POI land use in the four HCTs.

All four HCTs provide public facilities to serve both tourists and local residents. Lijiang has the lowest ratio of public facilities POIs amongst the four HCTs. Finally, all four HCTs have exclusive supply POIs for local residents. Kulangsu and Wuzhen have a higher exclusive supply POIs ratio compared to Pingyao and Lijiang, while Pingyao has the lowest ratio (5.3%). In summary, the results have shown that heritage tourism is dominant in the four HCTs where accommodation and recreation POIs together represent over 50% of all POI land uses in each town, as illustrated in Figure 9.

4.2. Step 2: SSM Values Associated with the Land-Use Analysis Results

Figure 10 presents a star model demonstrating the comparison of the SSM values (i.e., NACH and NAIN) of the five types of POI land use with the counterpart measures of street networks in each town. In the star model, the mean NACH and NAIN values (vertical axis) represent the background structure, while the max. NACH and NAIN values (horizontal axis) represent the foreground structure. When these four values are applied to land use, a direct visual comparison can be made between each type of POI land use, benchmarking against the entire respective street network in each town.

It can be observed that the POI land use of the four HCTs tends to be distributed in favour of NACH rather than NAIN. This is because the difference between the mean NACH values of POI land use and those of each town's entire street network is often larger than the counterpart difference regarding mean NAIN values. Therefore, we mainly focus on the NACH comparison of land use.

The most noticeable difference between mean NACH values of POI land use and those of the street network was observed in recreation POIs (Figure 10 mid-left). Recreation POIs in the four HCTs generally have much higher mean NACH values than the other land uses, which can be considered as a reflection of prevailing heritage tourism developments in these HCTs. Recreation POIs are structurally formed in places with higher NACH values which can be frequently accessed by tourists.

In terms of the mean NACH values of accommodation POIs, Pingyao and Wuzhen have a higher mean NACH value of accommodation POIs compared to their respective town's entire street network. The distribution of accommodation POIs shows the trend of transitioning from local residences to tourist guesthouses in HCTs. When this trend becomes more dominant, the mean NACH value of the accommodation POIs may then become much lower than that of the town's entire street network. This is evident in Lijiang where the majority local residences have been transformed into tourist guesthouses [23].

The star model analysis cannot fully reflect the overall spatial characteristics of culture POIs in the four HCTs. For example, the mean NACH value of culture POIs of Pingyao is lower than that of the town's entire street network. In fact, the culture POIs in Pingyao are formed as several clusters representing different tourist attractions in which a number of culture POIs are internally segregated and accessed through the same main entrance. Therefore, culture POIs were grouped as tourist attractions for further examination (see Figures A1–A4 in Appendix A).

Since the public facilities in the four HCTs are distributed based on a number of unpredictable factors, including the changing needs of residents/tourists and varying planning strategies, their spatial characteristics cannot be fully reflected by the analysis results. However, it should be noted that POI land uses can normally inherit the max. NACH and max. NAIN values of the town's entire street network, which suggests that each type of POI land use is aligned with the syntactic core of the HCT. There is one exception in Kulangsu. The mean NACH value of public facilities POIs in Kulangsu is lower than that of the town's entire street network, while the difference in terms of the max. NACH values is even greater. This means that public facilities POIs in Kulangsu have not occupied the locations with the highest NACH value. A lower mean NACH value suggests that these public facilities may not be frequently accessed.

Finally, the mean NACH and mean NAIN values of exclusive supply POIs in each town are similar to those of their respective town's entire street network, which suggests that the overall spatial characteristics of exclusive supply POIs cannot be revealed through the comparison of mean SSM values.

4.3. Step 3: Correlational Analysis Results

In this step, correlational analysis was conducted to examine the impact of spatial configurations of street networks on land use aggregation, as shown in Figure 11. The correlation matrix indicates that POI land use overall correlates better with angular integration

than angular choice. This means that the aggregation of these functions is influenced more by integration rather than choice.

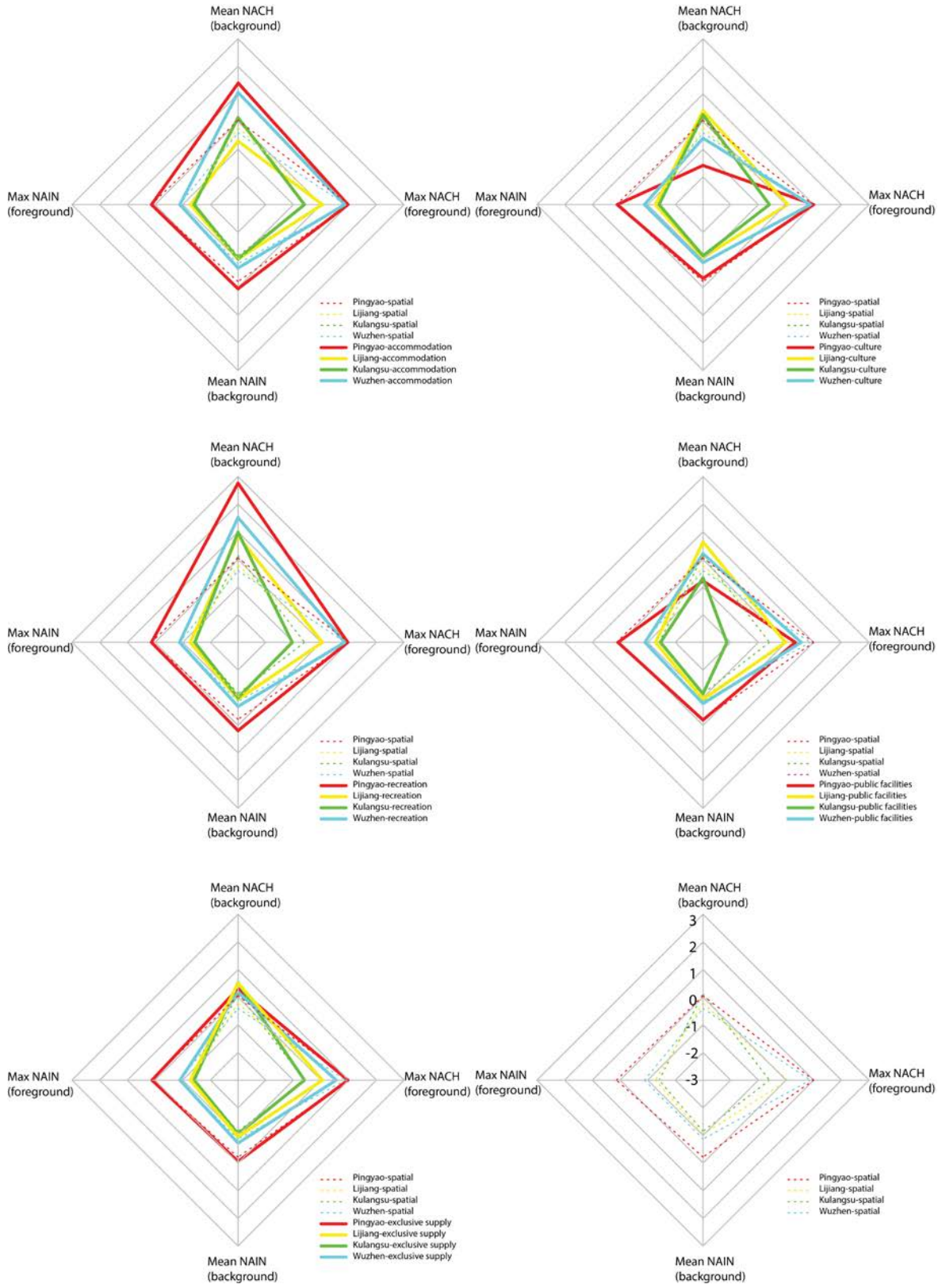


Figure 10. The star model of each type of POI land use, benchmarking against the SSMs of the entire street network at the global scale.

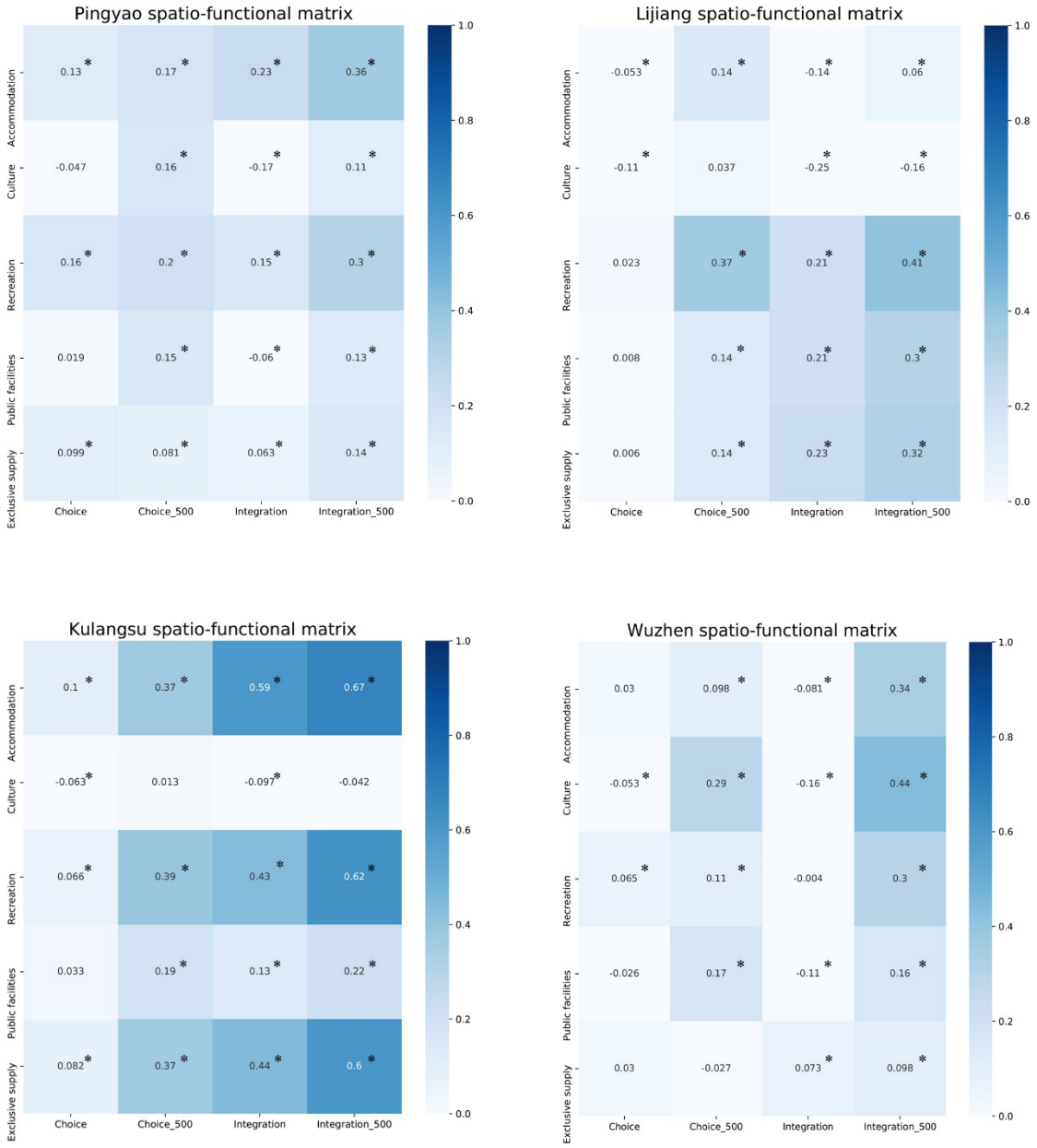


Figure 11. The spatio-functional correlation matrix of the four HCTs where a darker blue colour represents a higher Pearson coefficient value (* correlation is significant at the 0.05 level for 2-tailed).

Commercial functions of the four HCTs (i.e., accommodation and recreation POIs) correlate well with integration. Moreover, they correlate better with integration_500 (integration at the radius of 500 m) than integration at the global scale. This suggests that spatial configurations of the street network positively affect the aggregation of commercial functions. Yet Lijiang is a notable exception; the accommodation POIs of Lijiang do not correlate with integration and choice measures, reflected by the fact that these POIs spread across the street network of Lijiang, most of which are spatially segregated (see Figure 8). This implies that if heritage tourism overdevelops, the centrality of accommodation is likely to be diffused due to the impacts of residents who often spontaneously adapt their private residences into guesthouses to accommodate tourists, and sometimes without proper approval or influence of regulatory controls.

Culture POIs were often formed as an 'anchor' for an HCT, which do not seem to align with the spatial configurations of the street network in the case studies (except for Wuzhen), and the distribution of culture POIs seems to be random. These culture POIs

were built in ancient times but were not significantly developed and expanded over time. Therefore, the correlational analysis cannot address the impact of spatial configurations on the aggregation of culture POIs. In Wuzhen, the culture POIs are moderately correlated with integration_500. This is perhaps due to the two designated tourist quarters (within the old town area) encompassing most of the culture POIs, which also have a higher integration value (see Figure 8). In the other three HCTs, culture POIs are more freely distributed along the entire street network.

Public facilities were planned to serve both tourists and local residents of an HCT. Public facilities POIs do not correlate with integration and choice measures in the case studies, except for Lijiang where the public facilities are moderately correlated with integration_500.

The exclusive supply POIs of Lijiang are moderately correlated with integration_500, while the exclusive supply POIs of Kulangsu are well correlated with integration_500. However, exclusive supply POIs of Pingyao and Wuzhen do not exhibit higher Pearson coefficient values. Part of the reason is that some exclusive supply POIs cannot be clearly identified (e.g., the courtyard houses in Pingyao). Another reason may be the categorisation of exclusive supply POIs overlapping with other types of POIs utilised by local residents, resulting in a weak correlation.

In summary, the correlational analysis results can overall assist in examining the impact of spatial configurations of the street network on the aggregation of commercial land uses. As revealed by the analysis results, the positive relationship between spatial configuration and commercial function aggregation is consistent with the natural movement theory (Hillier et al., 1993), suggesting that street configurations act as multipliers and a key generator for functions to be aggregated.

5. Discussion

5.1. Theorising the Analysis Results

This study has analysed the spatial distribution of land use in the selected HCTs using a quantitative approach, as summarised in Table 5. Figure 12 illustrates and summarises the spatio-functional qualities of HCTs. Despite the underlying differences in the four HCTs, the spatio-functional distribution has nevertheless shown some degrees of homogenisation. It is evident that commercial functions distribute and aggregate along with the syntactic core in the four HCTs. As such, we propose three spatio-functional patterns with respect to the four HCTs: (1) high-ratio commercial functions; (2) concentric commercial activities; and (3) function aggregation with integration. Pattern 1 focuses on function composition, particularly the ratio of commercial use, which reveals the popular heritage tourism status in the four HCTs; pattern 2 elaborates how different types of POI land use are spatially distributed along each corresponding street network; and pattern 3 further reveals how land uses are aggregated in response to spatial configurations. Arguably, the development of these spatio-functional patterns relies on the quantitative analysis and cannot be obtained through qualitative analysis alone.

Table 5. The overall characteristics of the five types of POI land use.

POI Land Use	Overall Spatial Characteristics
Recreation	Highest mean NACH values among the five types of POI land use in all four selected HCTs; aggregated along the syntactic core; the most accessible function
Accommodation	High mean NACH value; higher than the counterpart measure of each representative street network, except for Lijiang
Culture	Most culture POIs are close to the syntactic core, except for some that are spatially segregated; freely distributed and not expanded over time
Public facilities	Cannot be revealed through the comparison of mean values of SSMs; Kulangsu exhibits a much lower mean NACH value with respect to that of its street network
Exclusive supply	Cannot be revealed through the comparison of mean values of SSMs; future research is required

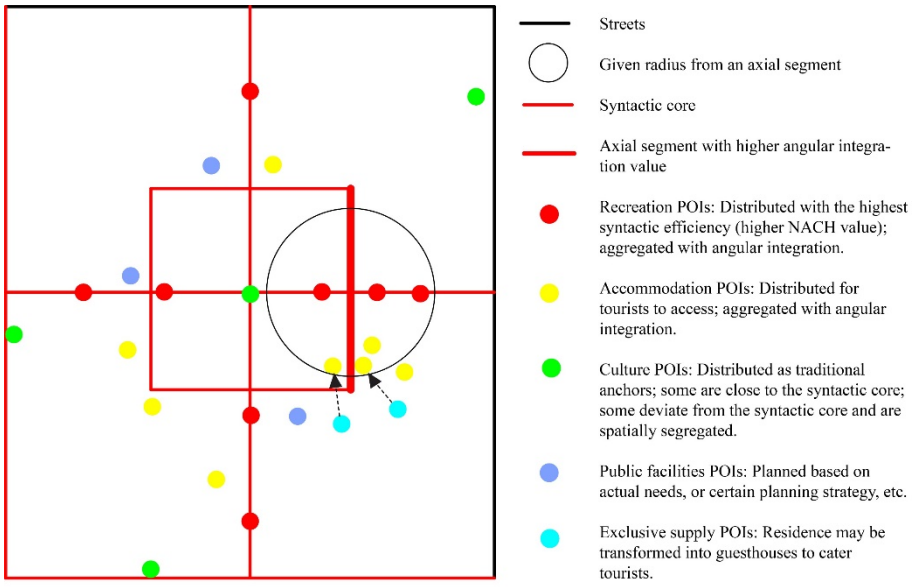


Figure 12. Illustration of the spatio-functional patterns of the five types of POI land use (in a simplified plan of a general HCT).

5.2. Comparison with Similar Studies

The present findings are consistent with similar studies that focus on a spatio-functional analysis of urban spaces [38,39,42]. For example, Ling and Wang [42] analysed the characteristics of commercial activities in which POIs were used in their work to represent functions in an urban village of Guangzhou, China, using angular segment analysis (ASA). Their analysis results show that the distribution of commercial activities, as a whole, is related to the NACH and NAIN values of the street network, while the correlation with NAIN is relatively higher than that of NACH [42].

Based on a correlational analysis, Omer and Goldblatt [39] found that the (axial) choice value correlates better with aggregation of retail shops than (axial) integration, which is different from the current research, in which angular integration correlates better with aggregation of recreation POIs than angular choice. Their studies concluded that it is more appropriate to use axial line analysis (ALA) measures than ASA measures (adopted in the current research) to represent the interactions between spatial configurations of the street network and retail shops, because the correlational analysis using ALA measures is more significant than with ASA measures. They suggested that this is because longer visual lines are more appropriate for aggregating retail shops. To examine if ALA exhibits better correlations than ASA with function aggregation, we applied ALA measures to conduct the correlational analysis, again using the given algorithm in Figure 7.

Figure 13 illustrates the correlation matrix between the five types of POI land use (accommodation, culture, recreation, public facilities, and exclusive supply) and ALA measures (choice, choice_R3, integration, and integration_R3) instead of ASA measures.

Comparing this figure to Figure 11, it seems that the colours in Figure 13 are generally lighter than Figure 11, while a darker blue colour represents a stronger correlation. In other words, function aggregation tends to be shaped by ASA measures rather than ALA measures in our study. Moreover, both figures seem to have a similar correlation pattern, while function aggregation is more likely to be shaped by the integration measure rather than choice, and more insignificant coefficients are presented in Figure 13 than Figure 11. Again, such a finding is contradictory to the results of Omer and Goldblatt [39].

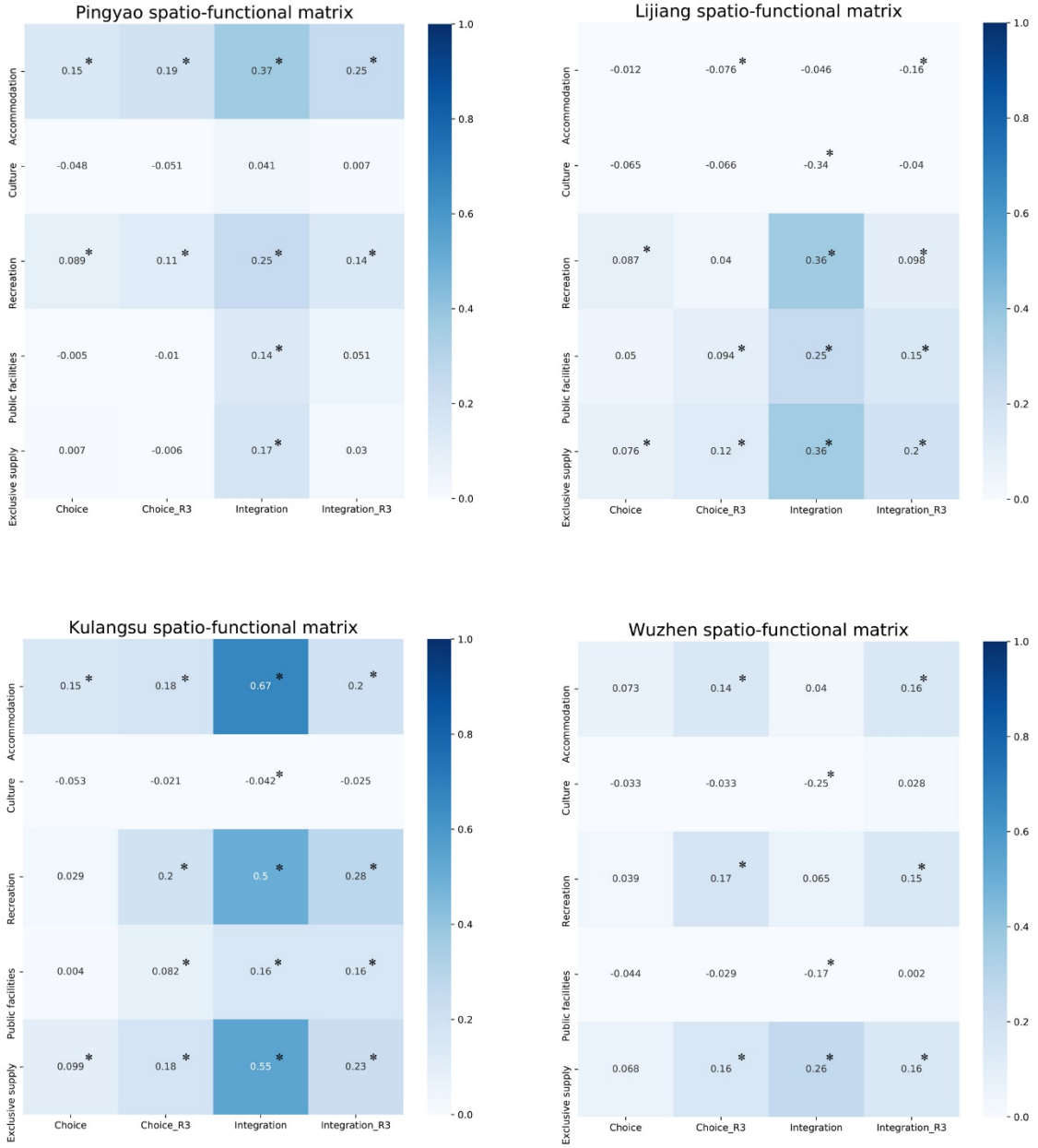


Figure 13. The correlation matrix between the five types of land use and axial line analysis measures: choice, choice_R3, integration, and integration_R3 where a darker blue colour represents a higher Pearson coefficient *r* value (* correlation is significant at the 0.05 level for 2-tailed).

The different analysis results between the study of Omer and Goldblatt [39] and the current research may arise from a different abstraction method for the relationship between spatial configurations and function aggregation. In their study, the association between POI distribution and SSMs is analysed using axial lines, by computing the number of buildings with retail activity that are located within a total buffer of 100 m around each axial line (i.e., 50 m to either side of the line) [39]. Therefore, their function distribution is more linearly defined by a long axial line.

However, the rationale for using ASA measures rather than ALA measures in this research is that an axial segment can be more appropriate for revealing the relations between a street segment broken by junctions (an axial segment can be roughly considered as a street segment) and function aggregation at a finer level. Specifically, this process allows the examination of the extent to which a street segment (rather than an axial line) can attract a specific land use. Hence, this research uses the number of POIs located in a circle with a

radius of 110 m (including a 10 m buffer zone) from the centre point of an axial segment, to define the extent to which the axial segments can shape the aggregation of a specific land use. Despite the differences, all these studies have revealed a correlation between spatial configurations and the aggregation of commercial activities, which is in line with the natural movement theory [30].

Furthermore, results have shown that NACH can be a robust measure to interpret the spatial distribution of land use. As Alalouch et al. [43] argued, although NACH has proven to be a significant measure to predict the distribution of retail land use, it has been scarcely utilised in such studies. This study extends the understanding of NACH further by examining its role in the distribution of land use within HCTs. Another significant finding of this study is that the spatial distribution of culture POIs appears to be random, and the correlational analysis cannot address the impact of spatial configurations on the aggregation of culture POIs. Hence, in the case of tourist/cultural attractors, the movement is not natural but forced between origin and destination [44]. Further evidence is needed to test this in the future.

5.3. Implications, Applications and Future Scenarios

The quantitative and robust methodology applied in this study demonstrates its potential to gain an in-depth insight about the tourist activity patterns, and ultimately, how the built form affects the social patterns. The same methodology may apply to studying broader Chinese heritage environments, and the approach can be further refined and contextualised applicably in other settings. Different radii could be further considered [45,46] and adjusted with the developed algorithm utilised in our proposed methodology. Figures 14 and 15 illustrate examples of suggestions regarding the five types of land use for the four HCTs.

The following subsections will explain in detail how the results can be applicable in better understanding the range of social activities within historic towns as well as recommendations for a more effective management and planning.

(1) Recreational activities in historic towns

It has been found that commercial functions of accommodation and recreation dominate in the four HCTs. Further, they tend to distribute and aggregate along with the syntactic core in each town. This means that recreational activities need to be carefully managed without surpassing the capacity of a historic town when examining their relations with the street network.

Taking Lijiang as an example, the commercial functions of Lijiang were planned in a dense commercial area featuring the 'bar streets', a night-time entertainment district. Recreation POIs correlate well with angular choice and angular integration (at a radius of 500 m), suggesting their multiplier effects on the spatial configuration. The multiplier effects show that, on the one hand, the recreation POIs along the 'bar streets' can be frequently accessed; on the other hand, this is likely to attract even more tourists to the area because of the popular 'bar streets'. The findings support the claim in the reactive monitoring report by UNESCO published in 2008[3] that one issue affecting the cultural values of the Old Town of Lijiang is the development pressure of uncontrolled tourism and related business. Although spatial configurations positively affect the aggregation of recreation POIs, Lijiang should avoid excessive commercial activities to retain its heritage and authenticity. More specifically, heritage tourism needs to be effectively managed to control the pedestrian volume not only along the syntactic core but also on the commercial streets in Lijiang. In fact, all four HCTs should consider avoiding excessive commercial activities.

(2) Tourist guesthouses in historic towns

As per the analysis results, there is a noticeable exception of accommodation POIs distribution in Lijiang where no hierarchy or order can be found concerning their spatial configurations in the street network. Without proper planning, guesthouses are likely to spread across the entire street network, some of which are spatially segregated with poor accessibility. As such, a recommendation with respect to accommodation POIs was given from a syntactic perspective as shown in Figure 14.

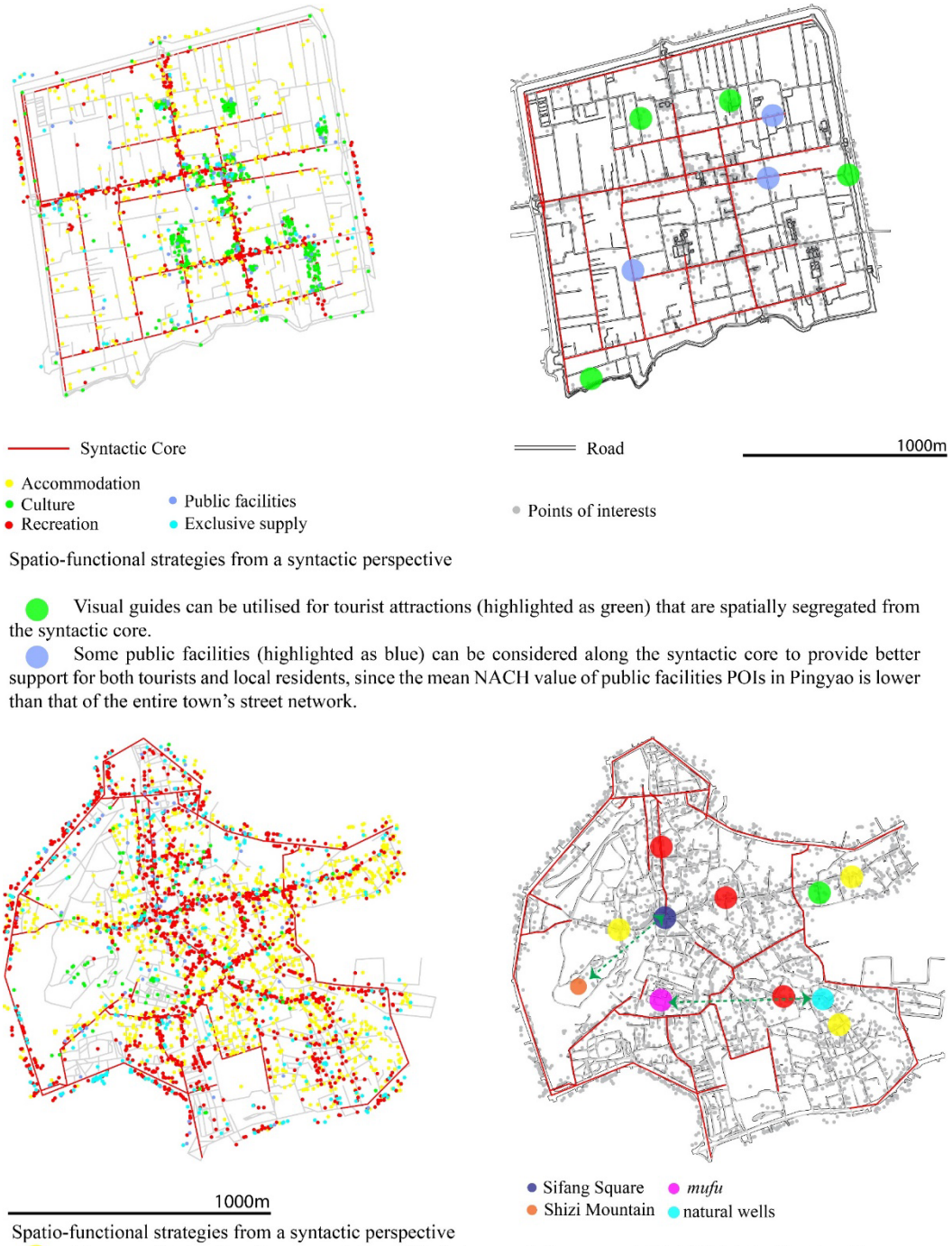
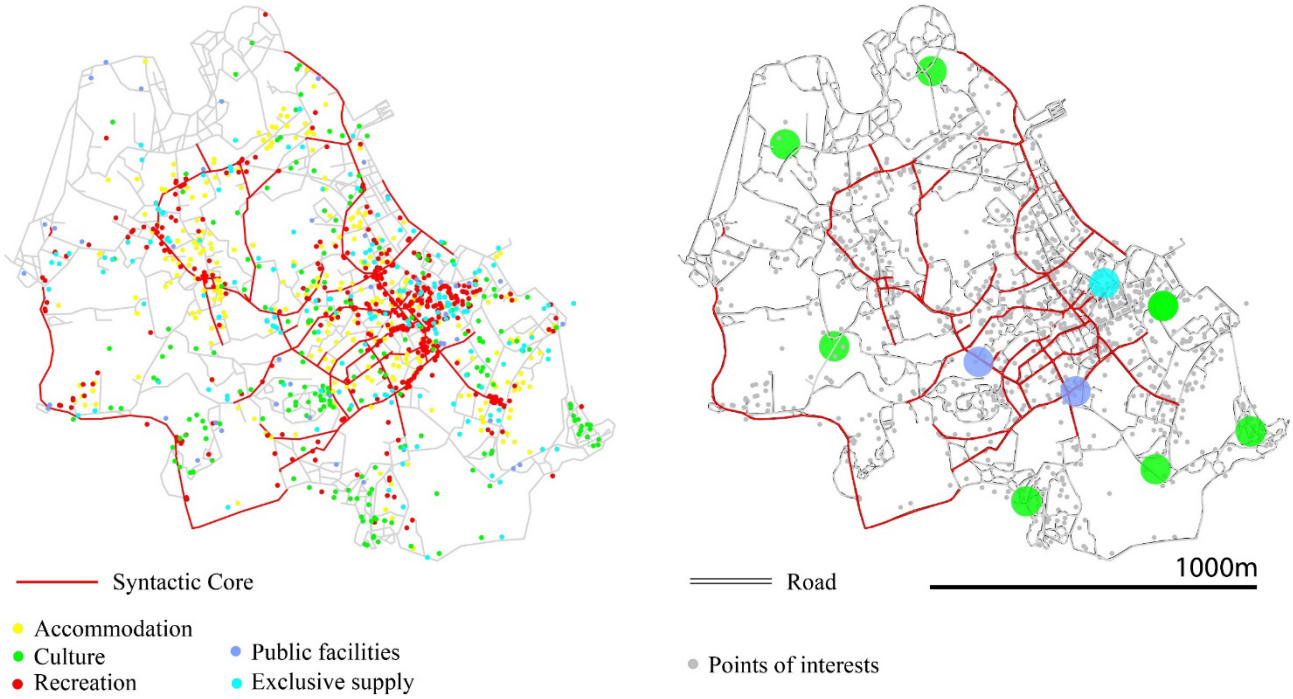


Figure 14. The strategies suggested for Pingyao and Lijiang based on the spatio-functional analysis results.

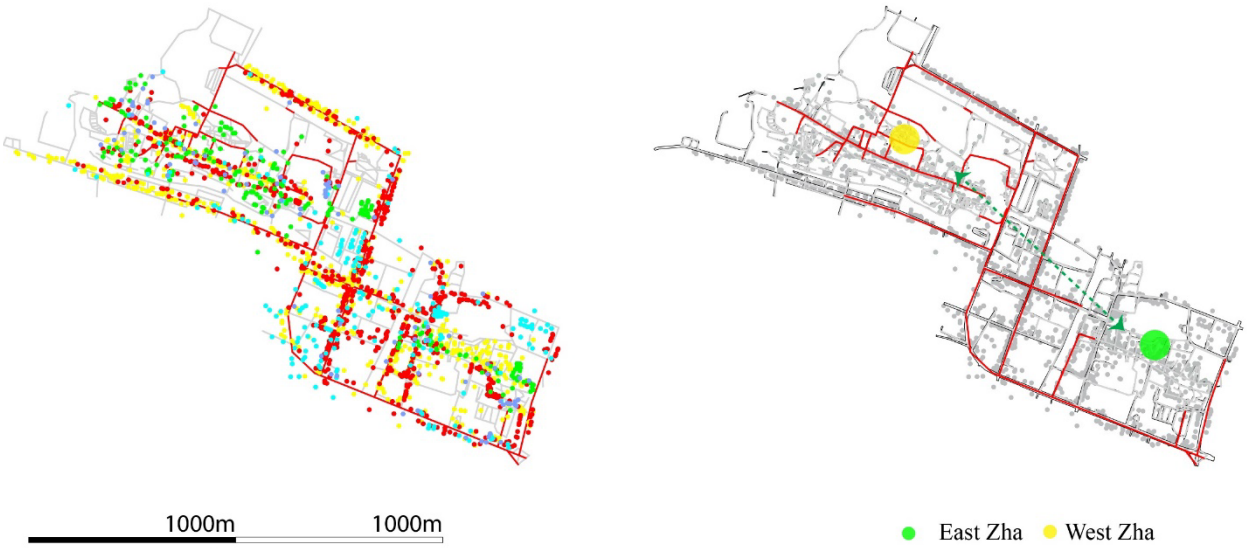


Spatio-functional strategies from a syntactic perspective

Visual aids/guides can be utilised for tourist attractions (highlighted as green) that are spatially segregated from the syntactic core.

Some public facilities (highlighted as blue) can be planned along the syntactic core (currently no nearby public facilities) to provide better support for both tourists and local residents.

When exclusive supply and recreation/accommodation POIs are aggregated together in a popular tourist attraction, the quality of life of local residence needs to be considered.



Spatio-functional strategies from a syntactic perspective

The government may consider enhancing the cultural role of East Zha that deviates from the syntactic core.

The government may wish to consider creating connections between the local residents near the new town and the old town area rather than simply dividing two separate tourist quarters for tourism purposes with a fee charged. It is suggested that locals should be encouraged to keep living in the old town area.

Figure 15. The strategies suggested for Kulangsu and Wuzhen based on the spatio-functional analysis results.

Rather than a bottom-up transformation of tourist guesthouses from the original residence driven by profit, the government needs to regulate guesthouse planning to improve the organisation of the current state in line with the spatial configuration of the town. Therefore, explicit guidelines for guesthouse planning for servicing tourists shall be developed. It should be noted that the aim was to improve the overall accessibility of tourist guesthouses. In fact, this recommendation could be further examined by an on-site survey of the actual usage of tourist guesthouses from the owners.

(3) Cultural relics in historic towns

Showcasing cultural values is important for a historic town. From a heritage tourism perspective, it is necessary to map POI tourist attractions, and the results are shown in Figures A1–A4 from the Appendix A. With the locations of tourist attractions associated with spatial syntactic measures (SSMs), visual aids/guides can then be utilised to make those spatially segregated cultural relics more accessible. Further, the government of each town can design several tour routes starting from the syntactic core of the town and leading to more segregated areas (see Figures A1–A4 in the Appendix A). By doing so, more cultural elements that make the town unique can be experienced, while tourists can be redirected from popular tourist attractions that are often close to the syntactic core, to ensure more even distribution and accessibility. For example, as a financial centre in the 19th century, Pingyao is famous for its Jin Shang (Jin merchants or Shanxi businessmen) culture. Although the exchange shops (e.g., Number 6 in Figure A1) and escort companies (e.g., Number 17 in Figure A1) do not function nowadays, they have become museums to showcase Pingyao's Jin Shang culture. The heritage planning of Pingyao can adopt the above suggestions to better showcase these cultural relics. In the northern part of Pingyao, the Courtyard of Family Ma (Number 7 in Figure A1), another important cultural relic, cannot be often accessed by tourists since the main entrance spatially deviates from the syntactic core. Tourists seem less likely to visit this Courtyard. The 'tour routes' strategy suggested above could be effective in improving this situation.

(4) Public facilities in historic towns

The public facilities in HCTs are utilised by both tourists and residents. Their planning can make use of the analysis results. In Kulangsu, public facilities POIs have a rather low mean NACH value than that of the town's entire street network. Moreover, public facilities POIs do not inherit the max. NACH value of the same street network, and they do not correlate well with spatial syntactic measures. Figure 16 maps the public facilities POIs onto the axial segment map of Kulangsu, showing that the red-coloured segments (NACH value higher than 1.34) cannot be directly accessed by any of the public facilities POIs. Therefore, in future planning, the government may wish to consider setting up some public facilities (e.g., a tourist centre, public toilets, etc.) in the area with a higher NACH value so they can better serve tourists and residents alike.

(5) Needs of residents of historic towns

Exclusive supply POIs should not be overlooked as they are a key to supporting the everyday life of residents. Without local residents, historic towns could not have been deemed living heritage. Taking Wuzhen as an example, as a waterfront town, it can be observed that the entire old town area is planned as two separate tourist quarters on a large scale, East Zha and West Zha, which is different from the other three towns. Entering the two quarters requires an entrance fee, which makes Wuzhen more like a museum in a town scale. As a result, commercial POIs spread out in the two quarters, and functions supporting everyday living are not present in the old town area. In the future, the government may wish to consider creating connections with local residents to rebuild and emphasise the importance of the living heritage of Wuzhen, rather than simply separating specific quarters solely for tourism purposes. Otherwise, the town may lose its spatial authenticity and cultural identity because of the thematisation process of tourism, where real urban life is lost.

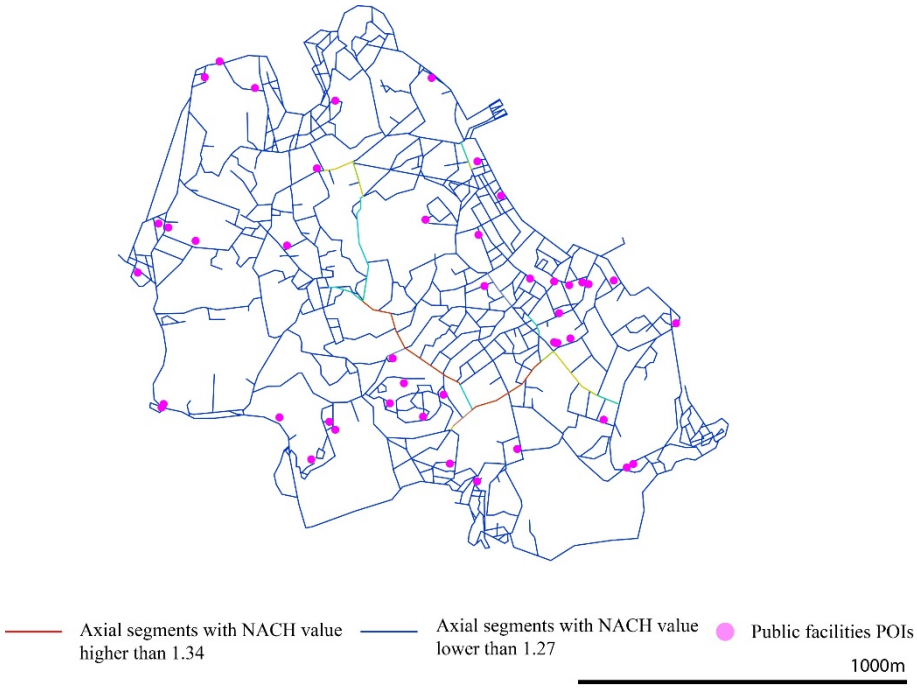


Figure 16. The public facilities POIs in Kulangsu.

In addition, when both resident-focused and tourist-focused functions are aggregated in the same area, it is important to ensure the quality of life of local residents. Kulangsu provides a sound example of achieving this goal (see Figure 15).

In summary, these suggestions—generated from robust syntactic analyses with strong quantitative evidence—can act as guidelines for sustainable tourism in HCTs on a high level. The identified syntactic core enables an in-depth understanding of the urban centre of HCTs at a finer level, which could have not been simply achieved by other approaches. A more refined, systematic, and quantitative approach is possible utilising the methodology proposed in this paper. Moreover, the findings exhibited by this study can effectively be integrated into other studies. For example, Xie et al. [47] applied a typo-morphological approach to analysing the spatial structure of Kulangsu. Their specific measures to address the underlying issues of Kulangsu are quite well aligned with our findings. Future studies can incorporate different types of analyses, methods, and techniques for further refinement and improvement.

6. Conclusions

To conclude, this study has presented and demonstrated a robust quantitative methodology for systematically analysing the spatio-functional qualities of historic Chinese towns (HCTs) from a heritage tourism perspective. This methodology was used for examining the spatio-functional patterns of four typical HCTs: Pingyao, Lijiang, Kulangsu, and Wuzhen. It has been found that heritage tourism plays a dominant role in the development of HCTs. Commercial functions in the four HCTs tend to distribute and aggregate with the syntactic core. The analysis results have illustrated the distribution of cultural POIs and POI tourist attractions and identified mitigation strategies. Moreover, future planning of public facilities POIs and resident-focused functions have been suggested by utilising the analysis results. The suggestions are summarised as below:

Carefully managing recreational activities;
Improving the organisation of tourist guesthouses;
Enhancing the role of cultural relics;
Improving the accessibility of public facilities;
Balancing the needs of residents of historic towns.

These suggestions need to be critically examined by linking to the syntactic core (analysed through space syntax) of street networks where different land uses are distributed and aggregated. With the capabilities of the methodology demonstrated, this quantitative approach can be further enhanced and extended to studying the broader historic built environments in China, further contributing to their heritage conservation, planning and tourism management.

We are cognizant of some of the unavoidable limitations related to the methodology of this study. Firstly, although our methods can explicitly reveal the spatio-functional characteristics of accommodation and recreation POIs, they cannot clearly identify those of resident-focused functions (i.e., exclusive supply POIs). A more refined categorisation could be developed and applied in future work. Secondly, space syntax enables us to analyse spatial configuration and land use in a two-dimensional street network. Other three-dimensional qualities such as building height were not considered. Finally, the axial segment-POI model is a theoretical abstraction of the real-world spatio-functional relationship in an urban space since the edges between axial segments and POIs cannot be treated as actual entrances that link streets to buildings. Despite these identified limitations, the proposed approach has successfully enabled us to illustrate the spatio-functional patterns of the four HCTs systematically, i.e., (1) high-ratio commercial functions; (2) concentric commercial activities; and (3) function aggregation with integration. In future work, the spatio-functional analysis could be extended to other HCTs for a more systematic understanding and to incorporate with other analytical features of HCTs for a more comprehensive investigation.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/land11122181/s1, Table S1: POI_NACH_NAIN; Table S2: POI_zscore; File S1: Axial segments SSM value.

Author Contributions: Conceptualization, P.L., N.G. and R.Y.; methodology, P.L., R.Y. and N.G.; software, P.L.; formal analysis, P.L.; investigation, P.L. and S.S.; writing—original draft preparation, P.L.; writing—review and editing, R.Y., N.G. and S.S.; visualization, P.L.; supervision, N.G. and R.Y. All authors have read and agreed to the published version of the manuscript.

Funding: The APC was funded by the lead author's Scientific Research Foundation [number: 102522349].

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Supplementary data to this article can be found online at.

Acknowledgments: The research is supported by a University President's Scholarship from the University of South Australia. We would like to thank our colleague Victor Calixto for assisting in developing the *Grasshopper* components in this paper. We would also like to thank the anonymous reviewers for their constructive comments.

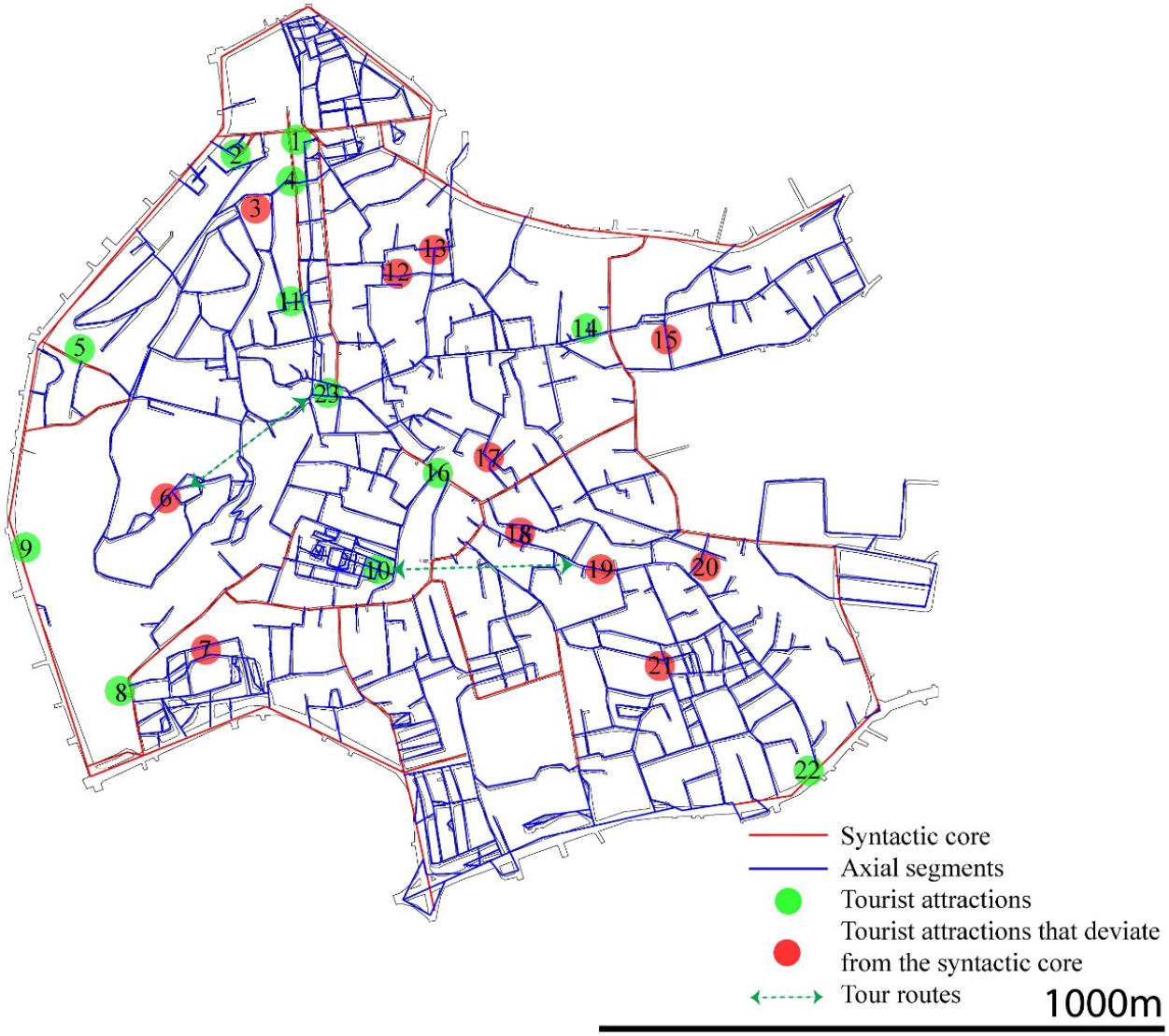
Conflicts of Interest: The authors declare no conflict of interest.

Appendix A



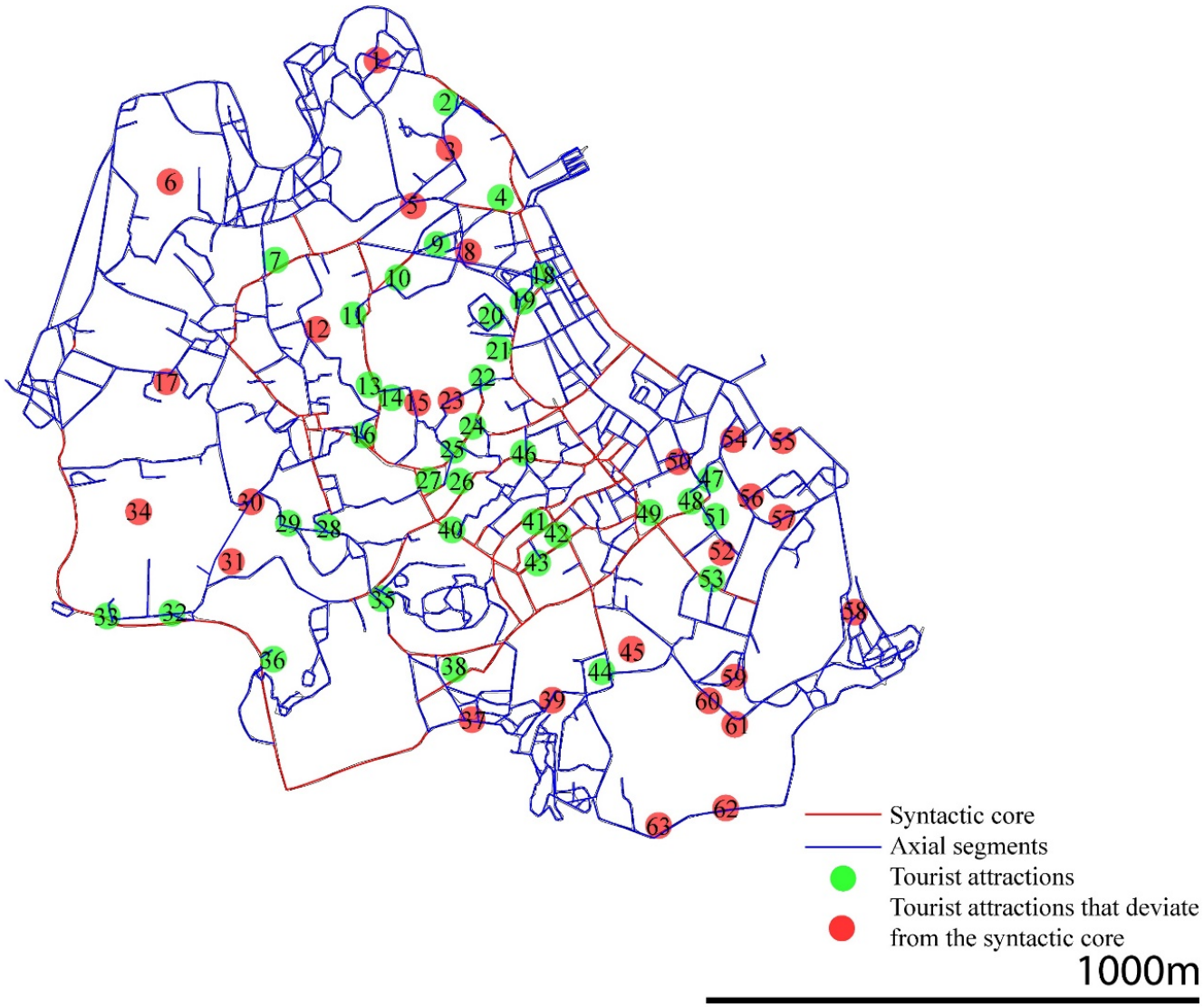
1 Watchtower 2 Corner Tower 3 Town Gate 4 Erlang Temple 5 Former Residence of Wu Xiaxian 6 Wei Taihou Exchange (former site) 7 Courtyard of Family Ma 8 Temple of Fire 9 Taoism Temple 10 Huiyuandang Exchange (former site) 11 Martial Arts Exhibition Gallery 12 Wei Fenghou Exchange (former site) 13 Chamber of Commerce Museum of Pingyao 14 North China First Escort Company Museum 15 Wei Shengchang Exchange (former site) 16 China Private Bank Museum 17 China Escort Company Museum 18 House of Family Wang 19 Former Residence of Ji 20 Christ Church of Pingyao 21 Former Residence of An Kenan 22 Yamen (former government office) 23 Baichuantong (Furniture Museum) 24 Pingyao Han-Tang Room 25 Town's God Temple 26 Rare Newspaper Exhibition Gallery 27 Confucius Temple 28 Wenchang Tower 29 Wu Temple 30 Former Residence of Lei lvtai 32 General Statue

Figure A1. The POI tourist attraction distribution in Pingyao. The red colour indicates that tourist attractions deviate from the syntactic core of the town.



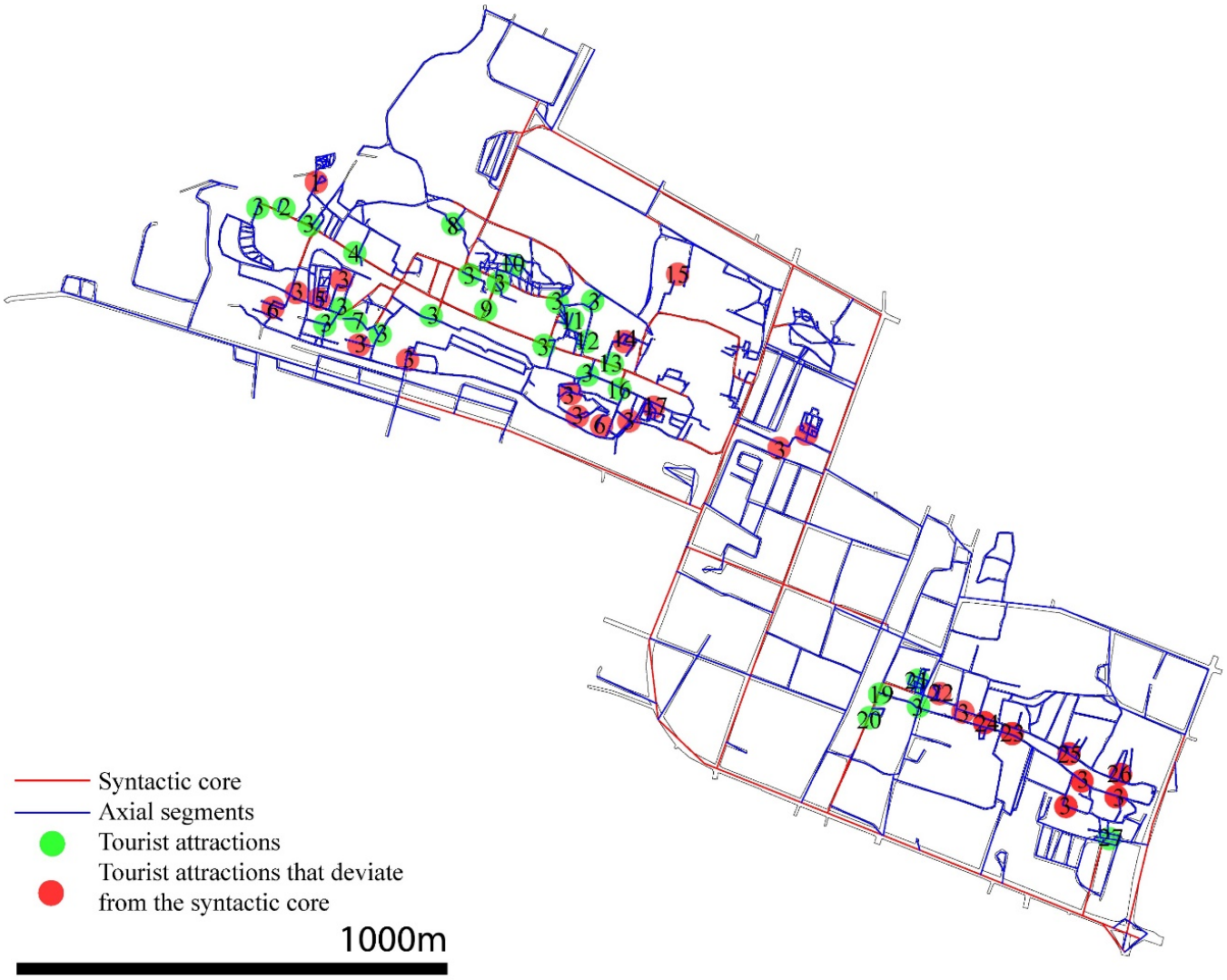
1 Water Wheel 2 Shuangshi Park 3 Huangshan Park 4 Jinglian Temple 5 Former Residence of Gu Bide 6 Shizi Mountain 7 History and Culture Exhibition Gallery 8 Baima Longtan Temple 9 Lijiang Liberation Monument 10 Mufu (former government office) 11 Courtyard of Family Li 12 Dayan Flower Valley 13 Lijiang's Eye Observation Deck 14 Wuyi Street 15 Former Residence of Fang Guoyu 16 Guamen Gate 17 Puxian Temple 18 Sanyan (Three eye) Well 19 Shiliu (Pomegranate) Well 20 Yueji Well 21 Post House of Mufu 22 Yousheng Lane 23 Sifang Square

Figure A2. The POI tourist attraction distribution in Lijiang. The red colour indicates that tourist attractions deviate from the syntactic core of the town.



1 Yanwei Mountain 2 Foreign Cultural Relic Museum 3 Customs Communication Tower of Xiamen (former site) 4 Consulate of the United States (former site) 5 Former Residence of Lin Zumi 6 Zhaoheshan Park 7 The Site of the Second Fujian Provincial Party Congress 8 Huangjudetang 9 Huifeng Bank Mansion (former site) 10 Huifeng Bank Staff Apartment (former site) 11 Yueguangyan (The Moon Rock) 12 Former Residence of Xu Feiping 13 Chuncaotang 14 Guancailou 15 Yizu Mountain Villa 16 Bishan Park 17 Wu's Ancestral Temple 18 He's Foreign Warehouse (former site) 19 Municipal Council (former site) 20 Eight-Diagram House 21 Organ Museum 22 Pianzaihuang Museum 23 Lin Wenqing Mansion 24 Yinghua Gatehouse 25 Panpo House 26 Clock House 27 Trinity Church 28 Tombstone of Chen Tujing 29 House of Yin Chengzong 30 Anxiantang 31 Gardening 32 Former Residence of Chen Jinfang 33 Kulang Stone 34 Langdang Mountain 35 Sunlight Rock 36 Qin Yuan (Piano Muesum) 37 Beach 38 Guoxing Well 39 Shuzhuang Garden 40 Sanrangyifeng 41 Dafudi 42 Siluo-dacuo 43 Fujian Provincial Committee of CPC (former site) 44 Ma Jordan Memorial Hall 45 Inspector Apartment (former site) 46 Meize House 47 Consulate of Japan (former site) 48 Union Church 49 Century Kulangsu Museum 50 China & South Sea Bank Ltd (former site) 51 Christianity Church 52 Huangrongyauntang Mansion 53 Haitiantang 54 Consulate of United Kingdom (former site) 55 Janpan Humanity Hospital (former site) 56 Meiyuan 57 Octagon House 58 Haoyue Park 59 Yu Garden 60 Residence of Deputy Commissioner of Army Customs (former site) 61 Consular Residence of the United Kingdom (former site) 62 Guanhaiyuan Beach 63 Great North Telegraph Office (former site)

Figure A3. The POI tourist attraction distribution in Kulangsu. The red colour indicates that tourist attractions deviate from the syntactic core of the town.



1 Bailian Tower 2 Temple of Guanyu 3 Bridge 4 Zhu's Hall 5 Temple of General Wu 6 Pavilion 7 Zuiyue Pond 8 Temple of Matchmaker 9 China Foot-Binding Museum 10 Dragon-Style Field 11 Mao Dun Prize Exhibition Gallery 12 Zhaoming Library 13 Marriage Celebration Exhibition 14 Foliage Dyeing Workshop 15 Muxin Gallery 16 Kong Lingjing Memorial Hall 17 Yudetang 18 Jiangzhe Sub Government (former site) 19 Chinese Shadow Puppetry Gallery 20 Huiyuan Exchange (former site) 21 Taoism Temple 22 Former Residence of Mao Dun 23 Qingengyudu 24 Jiangnan Woodcarving Gallery 25 Hongyuantai Dyeing Workshop 26 Folk Custom Exhibition Gallery 27 Statue

Figure A4. The POI tourist attraction distribution in Wuzhen. The red colour indicates that tourist attractions deviate from the syntactic core of the town.

Notes

1 Cities, towns, and villages are defined by their administrative level in China, namely, province-city-town/county/village, which are often determined by geographical size and population. See: http://www.stats.gov.cn/tjsj/pcsj/rkpc/5rp/html/append7.htm (accessed on 29 November 2022).

2 The POIs in this study were primarily retrieved in 2019 and can be roughly cross validated via the online Baidu Maps: https://map.baidu.com (accessed on 29 November 2022).

3 Refer to https://whc.unesco.org/en/list/811/documents (accessed on 29 November 2022).

References

1. Ruan, Y.; Wang, J.; Wang, L. *The Theories of Historical Urban Preservation*; Tongji University Press: Shanghai, China, 1999. (In Chinese)
2. WHC. 2022. Available online: http://whc.unesco.org (accessed on 29 November 2022).
3. Engelhardt, R.A.; Rogers, P.R. *Hoi an Protocols for Best Conservation Practice in Asia: Professional Guidelines for Assuring and Preserving the Authenticity of Heritage Sites in the Context of the Cultures of Asia*; UNESCO Bangkok: Bangkok, Thailand, 2009.
4. Shen, Y.; Karimi, K. Urban function connectivity: Characterisation of functional urban streets with social media check-in data. *Cities* **2016**, *55*, 9–21. [CrossRef]
5. Lin, G.; Chen, X.; Liang, Y. The location of retail stores and street centrality in Guangzhou, China. *Appl. Geogr.* **2018**, *100*, 12–20. [CrossRef]
6. Shen, Y.; Karimi, K. The economic value of streets: Mix-scale spatio-functional interaction and housing price patterns. *Appl. Geogr.* **2017**, *79*, 187–202. [CrossRef]
7. Zhu, H.; Liu, J.; Liu, H.; Wang, X.; Ma, Y. Recreational Business District boundary identifying and spatial structure influence in historic area development: A case study of Qianmen area, China. *Habitat Int.* **2017**, *63*, 11–20. [CrossRef]
8. Chiang, Y.-C.; Deng, Y. City gate as key towards sustainable urban redevelopment: A case study of ancient Gungnae City within the modern city of Ji'an. *Habitat Int.* **2017**, *67*, 1–12. [CrossRef]
9. Liao, P.; Gu, N.; Yu, R.; Brisbin, C. Exploring the spatial pattern of historic Chinese towns and cities: A syntactical approach. *Front. Archit. Res.* **2021**, *10*, 598–613. [CrossRef]
10. Orbaşli, A. Is tourism governing conservation in historic towns? *J. Archit. Conserv.* **2000**, *6*, 7–19. [CrossRef]
11. Xie, F.; Gu, K. Urban morphology and tourism planning: Exploring the city wall in Pingyao, China. *J. China Tour. Res.* **2011**, *7*, 229–242. [CrossRef]
12. Shao, Y. Conservation and Sustainable Development of Human-inhabited World Heritage Site: Case of World Heritage Lijiang Old Town. *Built Herit.* **2017**, *1*, 51–63. [CrossRef]
13. Hillier, B.; Hanson, J. *The Social Logic of Space*; Cambridge University Press: Cambridge, UK, 1984.
14. Wang, S. Modern significance of Chinese urban planning traditions (in Chinese). *City Plan. Rev.* **2019**, *43*, 50–57.
15. Heleni, P. Urban Heritage Conservation of China's Historic Water Towns and the Role of Professor Ruan Yisan: Nanxun, Tongli, and Wuzhen. *Heritage* **2019**, *2*, 2417–2443.
16. Whitehand, J.; Gu, K. Urban conservation in China: Historical development, current practice and morphological approach. *Town Plan. Rev.* **2007**, *78*, 643–670. [CrossRef]
17. ICOMOS. Charter for the Conservation of Historic Towns and Urban Areas (Washington Charter 1987). 1987. Available online: http://www.international.icomos.org/charters/towns_e.pdf (accessed on 22 June 2021).
18. Heath, T.; Oc, T.; Tiesdell, S. *Revitalising Historic Urban Quarters*; Taylor & Francis: Abingdon-on-Thames, UK, 2013.
19. Qun, Q.; Mitchell, C.J.; Wall, G. Creative destruction in China's historic towns: Daxu and Yangshuo, Guangxi. *J. Destin. Mark. Manag.* **2012**, *1*, 56–66. [CrossRef]
20. Cessari, L.; Gigliarelli, E. Heritage-led eco-regeneration: The case of Zhejiang water towns protection, restoration and preservation. In *Euro-Mediterranean Conference*; Springer: Berlin/Heidelberg, Germany, 2012; pp. 369–377.
21. Shen, J.; Chou, R.-J. Cultural Landscape Development Integrated with Rural Revitalization: A Case Study of Songkou Ancient Town. *Land* **2021**, *10*, 406. [CrossRef]
22. Shepherd, R.J.; Yu, L. The social impact of heritage. In *Heritage Management, Tourism, and Governance in China*; Springer: New York, NY, USA, 2013.
23. Su, X.; Teo, P. Tourism Politics in Lijiang, China: An Analysis of State and Local Interactions in Tourism Development. *Tour. Geogr.* **2008**, *10*, 150–168. [CrossRef]
24. Su, X. Urban entrepreneurialism and the commodification of heritage in China. *Urban Stud.* **2015**, *52*, 2874–2889. [CrossRef]
25. Zhu, Y. Cultural effects of authenticity: Contested heritage practices in China. *Int. J. Herit. Stud.* **2015**, *21*, 594–608. [CrossRef]
26. ICOMOS. International Cultural Tourism Charter—Managing Tourism at Places of Heritage Significance. 1999. Available online: http://www.icomos.org/images/DOCUMENTS/Charters/INTERNATIONAL_CULTURAL_TOURISM_CHARTER.pdf (accessed on 22 June 2021).
27. Li, M.; Wu, B.; Cai, L. Tourism development of World Heritage Sites in China: A geographic perspective. *Tour. Manag.* **2008**, *29*, 308–319. [CrossRef]
28. Li, Y.; Lau, C.; Su, P. Heritage tourism stakeholder conflict: A case of a World Heritage Site in China. *J. Tour. Cult. Chang.* **2020**, *18*, 267–287. [CrossRef]
29. Wang, J. Problems and solutions in the protection of historical urban areas. *Front. Archit. Res.* **2012**, *1*, 40–43. [CrossRef]
30. Hillier, B.; Penn, A.; Hanson, J.; Grajewski, T.; Xu, J. Natural movement: Or, configuration and attraction in urban pedestrian movement. *Environ. Plan. B Plan. Des.* **1993**, *20*, 29–66. [CrossRef]
31. Yu, R.; Ostwald, M.J.; Gu, N. Parametrically generating new instances of traditional Chinese private gardens that replicate selected socio-spatial and aesthetic properties. *Nexus Netw. J.* **2015**, *17*, 807–829. [CrossRef]
32. Hillier, B.; Iida, S. Network and psychological effects in urban movement: A theory of urban movement. In *International Symposium on Space Syntax*; TU Delft: Delft, The Netherlands, 2005; pp. 553–564.

33. Serra, M.; Hillier, B. Angular and Metric Distance in Road Network Analysis: A nationwide correlation study. *Comput. Environ. Urban Syst.* **2019**, *74*, 194–207. [CrossRef]
34. Altafini, D.; Musolino, D.; da Costa Braga, A.; Cutini, V. Spatial configuration and the Messina Strait question: A discussion on Reggio-Calabria and Messina road-networks linkage. *Appl. Geogr.* **2022**, *146*, 102750. [CrossRef]
35. Hillier, B.; Yang, T.; Turner, A. Normalising least angle choice in Depthmap and how it opens up new perspectives on the global and local analysis of city space. *J. Space Syntax.* **2012**, *3*, 155–193.
36. Dai, X.; Pu, X.; Dong, Q. Explore the deep spatial structure of traditional villages by space syntax approach (in Chinese). *Chin. Gard.* **2020**, *36*, 52–57.
37. Liu, Z.; Wang, S.; Wang, F. Isolated or integrated? Planning and management of urban renewal for historic areas in Old Beijing city, based on the association network system. *Habitat Int.* **2019**, *93*, 102049. [CrossRef]
38. Yang, T.; Li, M.; Shen, Z. Between morphology and function: How syntactic centers of the Beijing city are defined. *J. Urban Manag.* **2015**, *4*, 125–134. [CrossRef]
39. Omer, I.; Goldblatt, R. Spatial patterns of retail activity and street network structure in new and traditional Israeli cities. *Urban Geogr.* **2016**, *37*, 629–649. [CrossRef]
40. Ozbil, A.; Peponis, J.; Stone, B. Understanding the link between street connectivity, land use and pedestrian flows. *Urban Des. Int.* **2011**, *16*, 125–141. [CrossRef]
41. Field, A. *Discovering Statistics Using SPSS*; SAGE Publications: Los Angeles, CA, USA; London, UK; New Delhi, India; Singapore; Washington, DC, USA, 2009.
42. Ling, M.X.; Wang, Y. Spatial structure of commercial activities in the urban village: A syntactic analysis based on multivariate data. In Proceedings of the 12th Space Syntax Symposium, Beijing, China, 8–13 July 2019; pp. 1–15.
43. Alalouch, C.; Al-Hajri, S.; Naser, A.; Al Hinai, A. The impact of space syntax spatial attributes on urban land use in Muscat: Implications for urban sustainability. *Sustain. Cities Soc.* **2019**, *46*, 101417. [CrossRef]
44. Mansouri, M.; Ujang, N. Space syntax analysis of tourists' movement patterns in the historical district of Kuala Lumpur, Malaysia. *J. Urban. Int. Res. Placemaking Urban Sustain.* **2017**, *10*, 163–180. [CrossRef]
45. Kaplan, N.; Burg, D.; Omer, I. The spatial organization of accessibility and functional hierarchy: The case of Israel. *Comput. Environ. Urban Syst.* **2020**, *80*, 101429. [CrossRef]
46. Omer, I.; Kaplan, N. Using space syntax and agent-based approaches for modeling pedestrian volume at the urban scale. *Comput. Environ. Urban Syst.* **2017**, *64*, 57–67. [CrossRef]
47. Xie, S.; Zhang, X.; Li, Y.; Skitmore, M. Echoes of Italian lessons on the typo-morphological approach: A planning proposal for Gulangyu Island, China. *Habitat Int.* **2017**, *69*, 1–17. [CrossRef]