

Article

Heritage Spatial Association and Influencing Factors for Huizhou Traditional Villages

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Abstract

Integrated conservation has become a mainstream principle for protecting traditional village heritage. However, regional-scale conservation research still has notable deficiencies: the heterogeneous quality of traditional villages' heritage is often overlooked, and systematic exploration of the spatial associations of heritage remains insufficient. Taking Huizhou traditional villages as the research object, this study first identified the spatial agglomeration characteristics of village heritage resources, quantitatively analysed the intensity of heritage spatial association, and revealed the core driving factors of inter-village heritage correlation. The results indicated significant spatial heterogeneity in the heritage value of Huizhou traditional villages. Their heritage distribution exhibited three typical spatial association types—high-high (H-H) clustering, low-high (L-H) clustering, and high-low (H-L) clustering—presenting marked network-based spatial correlation characteristics. This study further clarified the distinct influences of natural, social, and economic factors on heritage spatial association. Among these, social conditions—particularly those reflecting linguistic attributes and accessibility, as measured by the distance to the central city—played a pivotal role in shaping the spatial association of Huizhou's traditional village heritage. Economic factors contributed only to a limited extent. The research findings provide a scientific basis for formulating targeted policies for the concentrated and contiguous conservation of traditional villages. Additionally, the results can support the collaborative and efficient utilisation of regional heritage resources and facilitate the sustainable inheritance and innovative development of traditional village cultural heritage.

Keywords: heritage value; spatial autocorrelation; spatial agglomeration; QAP

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1. Introduction

Traditional villages are living fossils of agricultural civilisation, shaped by the long-term interaction between humans and nature, and are also important carriers of regional culture [1]. They possess extremely high historical, artistic, cultural, and economic value. The protection and utilisation of traditional village cultural heritage have long been international priorities [2,3]. However, amid rapid urbanisation, traditional villages in China are facing a crisis of rapid disappearance [4,5]. From 1990 to 2021, China's urbanisation rate nearly doubled, while the number of villages dropped sharply from 3.773 million to

2.633 million: an average of 101 villages disappeared every day [6]. To address this trend, from 2012 to 2022, the Ministry of Housing and Urban–Rural Development, the Ministry of Culture and Tourism, and the Ministry of Finance jointly released six batches of the List of Traditional Chinese Villages, identifying 8171 traditional villages for rescue protection, and issued a series of supporting policies to protect the precious cultural heritage of traditional villages. However, in practice, this ‘point-based’ protection model has obvious limitations. Isolated point-based protection tends to turn traditional villages into ‘miniature bonsais’, disconnected from their broader environment, making it difficult to maintain their living heritage and ecological integrity [7]. It also leads to resource waste and insufficient protection efficiency [8]. In contrast, cluster-based protection and utilisation are crucial to the sound development of traditional villages [9], as they avoid fragmented and isolated protection. Therefore, in 2020, China began implementing a demonstration program for the concentrated and contiguous protection and utilisation of traditional villages, marking the launch of holistic protection for traditional villages at the practical level. The No. 1 Central Documents of 2022, 2023, and 2024 clearly proposed implementing demonstrations to achieve the concentrated and contiguous protection of traditional villages.

In recent years, traditional villages have attracted considerable research attention, and several multidimensional studies have been conducted. These research perspectives covered the single-village level, including ancient dwellings [10], values [11], public spaces [12], spatial morphology [13], spatial layout [14,15], spatial genes [16], tourism-driven revitalisation of traditional villages [17], and landscapes [18,19]. Studies have also been conducted on the regional level, with proponents arguing for a shift from a ‘point’ perspective, focusing on settlements, to a regional ‘area’ perspective. Studies have explored the distribution characteristics, influencing factors and driving mechanisms of traditional villages [20–23], and types of traditional villages [24], as well as heritage value evaluation [1,25], development level evaluation [26], suitability evaluation [27], and the sustainable development of traditional villages [28]. However, these studies treated traditional villages as isolated points, considering geographical adjacency and focusing on distribution patterns while ignoring the heritage value characteristics and interconnections among traditional village heritage sites.

Traditional villages in China are densely distributed. They form agglomerations due to similar geographic environments, customs, languages, or reliance on regional transport corridors such as ancient roads and canals [29]. Recent studies on traditional village clusters, although the body of literature remains limited, have focused primarily on protection methods [30], protection models [31], settlement unit division [32], and protection strategies [33]. These studies overlooked differences in the quality of heritage value among traditional villages, the inter-supporting, interlinking, and interactive heritage relationships among traditional villages, and the factors that would promote the connection of heritage among traditional villages. Internationally, researchers have adopted a cluster perspective to examine cultural heritage, including fortresses and churches [34–38]. International scholars generally agree that spatial connectivity is critical to the sustainable development of heritage sites [39,40]. Neglecting the spatial connectivity of traditional villages has largely impeded a systematic understanding of their heritage and undermined the integrated protection and utilisation of traditional village heritage, as well as the inheritance and continuity of traditional culture.

As a renowned international tourist destination in China, Huangshan City boasts unique natural landscapes and a profound cultural heritage. It is home to Huangshan Mountain, a world natural and cultural heritage site, as well as the Hongcun and Xidi Ancient Villages, both world cultural heritage sites. Huangshan City is also the cradle and core area of Hui Culture, one of China’s three major regional cultures. Huizhou Studies,

together with Tibetology and Dunhuangology, is one of the three most prominent local schools of advanced cultural studies in China. In ancient times, Huangshan City was called Huizhou. At present, it boasts 310 national-level Huizhou traditional villages, accounting for 3.79% of the national total of 8171 traditional villages and 66.10% of Anhui Province's total of 469, ranking second among all prefecture-level cities in China. Huizhou traditional villages are rural settlements formed in Huizhou that embody rich and distinctive Hui culture. They contain Hui-style buildings characterised by white walls, black tiles, horsehair walls, exquisite carvings and dense, orderly arrangements. Furthermore, the village site selection, spatial layout, alley configuration, and individual architectural design all reflect unique design concepts, distinctive styles, and exceptional ecological adaptation models. Therefore, Huizhou traditional villages possess strong architectural and cultural connotations as well as extremely high heritage value.

Huangshan City is a typical agglomeration area of traditional villages in China, providing representative and practically valuable cases for research on traditional villages. To address research gaps regarding neglected differences in the heritage quality of traditional villages and insufficient studies on their spatial association, this study analysed disparities in heritage value quality, spatial agglomeration characteristics, and the intensity and distribution patterns of heritage spatial association among traditional villages. Given the lack of research on factors influencing the connection and transmission of traditional village heritage, this study further employed the quadratic assignment procedure (QAP) to examine how natural, social, and economic factors affect the spatial association of traditional village heritage. By quantifying the influence of each factor, this study identified the key drivers of the spatial correlation of traditional village heritage. These research findings provide a scientific basis for formulating policies to ensure the contiguous protection and development of traditional villages, improve the efficiency of collaborative protection and utilisation of traditional village heritage resources, and facilitate the cultural inheritance and sustainable development of traditional village heritage.

2. Research Objects and Research Methods

2.1. Research Objects

Huangshan City is in southern Anhui Province, China. It administers three districts (Tunxi District, Huizhou District, and Huangshan District) and four counties (She County, Yi County, Xiuning County, and Qimen County). The city features complex terrain with striking geomorphological variations; its highest elevation is 1826 m, creating a prominent elevation difference. Mountains and hills dominate Huangshan. Within its territory lie Huangshan Mountain, a world cultural and natural heritage site, and Tianmu Mountain, Qiyun Mountain, Baiji Mountain, Wulong Mountain, and other mountain ranges. Numerous mountain basins and valleys are scattered among the high mountains and steep ridges. Encircled by mountains on all sides, the area boasts an intricate, interconnected water system, both internal and external, and abundant water resources.

Unique geographical conditions, together with profound Hui culture, have resulted in a dense scattering of traditional villages across the mountainous terrain. These traditional settlements embody an ancient, elegant style with profound landscape aesthetics, adhering to the ancestral site-selection philosophy of settling in mountain-surrounded areas beside water bodies [1] (Figure 1). Currently, there are 310 national-level traditional villages in Huangshan City. The previous five batches of the List of Traditional Chinese Villages were compiled by expert teams from design institutes in accordance with unified specifications and criteria, based on the Evaluation and Identification Index System for Traditional Villages (Trial) issued by the Ministry of Housing and Urban–Rural Development. The sixth batch, consisting of 39 national traditional villages, was officially designated in March 2023. However, the conservation planning documents for these 39 villages

have not yet been completed under the Ministry, and their heritage quality is markedly inferior to that of the first five batches. Moreover, an examination of their spatial distribution reveals that the sixth-batch villages are relatively evenly dispersed throughout the region (Figure 2). Separate kernel density analyses conducted for the previous five batches and for all six batches indicate that the overall spatial pattern has not undergone any substantial change (Figure 3a,b). Consequently, this study selected the 271 traditional villages from the first five batches as research subjects (Figure 2), as these adequately reflect the overall status of Huizhou traditional village heritage in Huangshan City.



Figure 1. Hongcun, Pingshan, and Xidi. Source: Photographs by the authors.

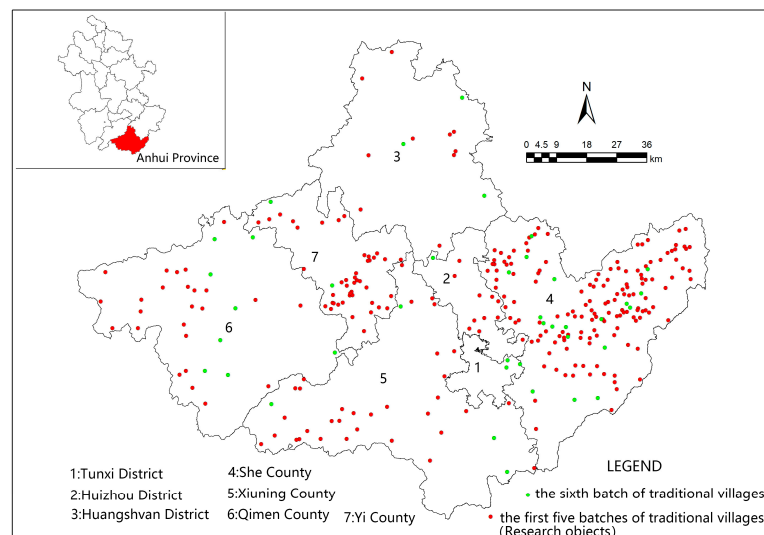
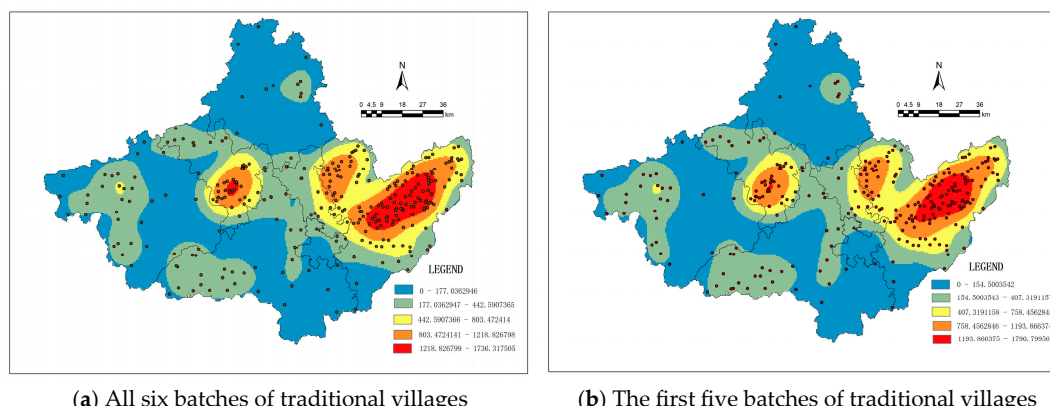


Figure 2. Distribution map of Huizhou traditional villages in Huangshan City.



(a) All six batches of traditional villages

(b) The first five batches of traditional villages

Figure 3. Kernel density map of traditional villages.

2.2. Methods

2.2.1. Heritage Quality Analysis

A theoretical framework for the heritage value of traditional Huizhou villages was established from a cultural ecology perspective (Figure 4), and a three-level evaluation index system was developed based on three dimensions: integrity, diversity, and continuity (Table 1). Based on this index system, the comprehensive evaluation method was employed to calculate the heritage quality of traditional villages.

Table 1. Indicator system of Huizhou traditional village heritage value [1].

Criteria Layer	Sub-Criteria	Index Layer	Evaluation Criteria	W_{ij}
Diversity Value (A1)	Functional richness (B1)	Traditional building (C1)	Number of traditional building types	0.0941
		Historical environmental element (C2)	Number of historical environmental element types	0.0272
		Intangible cultural heritage (C3)	Number of intangible cultural heritage types	0.0505
	Chronological richness (B2)	Landscape (C4)	Number of landscape types	0.0505
		Traditional building (C5)	Number of traditional building chronological types	0.0833
		Historical environmental elements (C6)	Number of historical environmental element chronological types	0.0278
Integrity Value (A2)	Heritage ontology (B3)	Degree of preservation of traditional village patterns (C7)	Complete (9 points); More complete (7 points); Fair (5 points); Less complete (3 points); Very incomplete (1 point).	0.0947
		Preservation of details of traditional buildings (groups) (C8)	Complete (9 points); More complete (7 points); Fair (5 points); Less complete (3 points); Very incomplete (1 point).	0.0350
		The scale of traditional buildings (C9)	Number of traditional buildings/total number of buildings	0.0947
		Scale of historical environmental elements (C10)	Number of historical environmental elements/population	0.0129
		Scale of intangible heritage (C11)	Number of intangible heritage/population	0.0129
	Relationship between the heritage ontology and the surrounding environment (B4)	Village site selection and surrounding natural landscape environment (C12)	Maintained well (9 points); Maintained relatively well (7 points); Somewhat altered (5 points); Suffered relatively severe damage (3 points); Suffered severe damage (1 point).	0.0357
		Village and surrounding natural landscape environment (C13)	Very unique (9 points); more unique (6 points); average (3 points); very average (1 point)	0.0357
		Intangible heritage and village environment (C14)	Intangible heritage is closely related to the specific physical environment of the village and cannot be separated (9 points); It is somewhat dependent on the village space, and its organisation activities is closely linked to the village's (7 points); It is relatively close to the village (5 points); It is generally linked to the craft heritage and the village (3 points); Intangible heritage can maintain independent inheritance (1 point).	0.0119
	Continuity Value (A3)	Continuing quality (B5)	Traditional construction techniques (C15)	Traditional materials, tools, and techniques are widely used in daily life architecture construction, which is in harmony with traditional style (9 points); More application, in harmony with the traditional landscape (7

		points); Average application, in harmony with the traditional landscape to some extent (5 points); Rarely used, less coordinated with the traditional style (3 points); No application, inconsistent with the traditional style (1 point);	
	Clan system (C16)	Very good (9 points); Better (7 points); Average (5 points); Poor (3 points); Very poor (1 point)	0.0078
	Agricultural landscape scenery (C17)	Very good (9 points); Better (7 points); Average (5 points); Poor (3 points); Very poor (1 point)	0.0475
	Production methods and production techniques (C18)	Very good (9 points); Better (7 points); Average (5 points); Poor (3 points); Very poor (1 point)	0.0489
	Traditional architecture (C19)	Traditional building level×quantity; National level (9 points); Provincial level (6 points); Municipal level (3 points); County level (1 point); No Level (0 points)	0.0475
	Intangible cultural heritage (C20)	Intangible cultural heritage level×quantity; National level (9 points); Provincial level (6 points); Municipal level (3 points); County level (1 point); No Level (0 points)	0.0247
	Inheritor (C21)	Inheritor level×quantity; National level (9 points); Provincial level (7 points); Municipal level (5 points); County level (3 points); No level with inheritors (1 point); No inheritors (0 points)	0.0057
	Historical events and celebrities of the village (C22)	National scope (9 points); Provincial scope (7 points); Municipal scope (5 points); County scope (3 points); Rural scope (1 point)	0.0143
Longevity (B6)	Village site (C23)	Tang Dynasty and before (9 points); Song Dynasty (7 points); Yuan Dynasty (5 points); Ming Dynasty (3 points); Qing Dynasty (1 point)	0.0082
	The earliest traditional buildings (C24)	Yuan Dynasty and before (9 points); Ming Dynasty (7 points); Qing Dynasty (5 points); Republic of China (3 points); 1949 to 1980 (1 point)	0.0304
	The earliest historical environmental elements (C25)	Yuan Dynasty and before (9 points); Ming Dynasty (7 points); Qing Dynasty (5 points); Republic of China (3 points); 1949 to 1980 (1 point)	0.0447

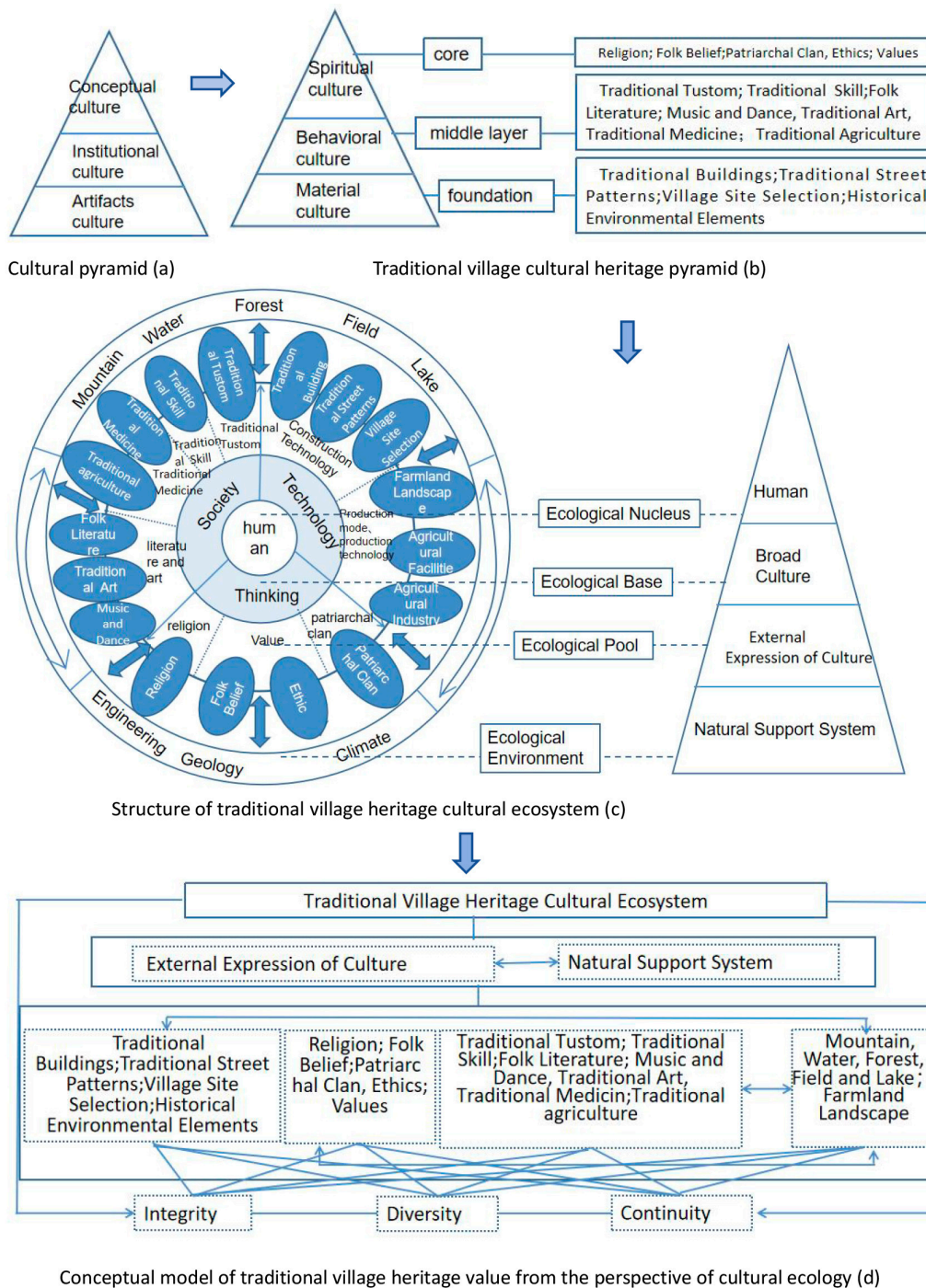


Figure 4. Constructing a conceptual model by theoretical deduction [1].

The diversity values (A1), reflecting the resource endowment and development conditions of traditional village heritage, included the functional richness (B1) and chronological richness (B2) of heritage elements. These specifically comprised the types of traditional building functions (C1), types of historical environmental elements (C2), types of intangible cultural heritage (C3), landscape types (C4), chronological types of traditional building (C5), and chronological types of historical environmental elements (C6). The integrity value (A2), as a core connotation of traditional village heritage, primarily reflected the heritage ontology (B3) and the relationship between the heritage ontology and the surrounding environment (B4), including the degree of preservation of traditional village

patterns (C7), preservation of details of traditional buildings/groups (C8), scale of traditional buildings (C9), scale of historical environmental elements (C10), scale of intangible heritage (C11), village site selection and surrounding natural landscape environment (C12), village and surrounding natural landscape environment (C13), and intangible heritage and village environment (14). The continuity value (A3), which served as a vital indicator of village vitality, reflected the continuity quality of tangible and intangible cultural heritage (B5) and their longevity (B6), encompassing the continuity of traditional construction techniques (C15), continuity of clan systems (C16), continuity of agricultural landscape scenery (C17), continuity of traditional production methods and production techniques (C18), continuity of traditional architecture (C19), continuity of intangible cultural heritage (C20), continuity of inheritors (C21), influence of historical events and celebrities of the village (C22), antiquity of the village site (C23), construction date of the earliest existing traditional building (C24), and antiquity of the earliest existing historical environmental element (C25).

This index system covered the types, quantities, scales, functions, and relationships with the surrounding environment of both tangible and intangible cultural heritage in traditional villages, thereby providing a comprehensive reflection of their level of heritage quality. The weights of the indicators were determined by inviting 18 experts in the field of traditional Huizhou village conservation—comprising three government administrators, five senior engineers from design institutes, and ten university professors—to evaluate the importance of each indicator, followed by the analytic hierarchy process (AHP). This methodological component has been previously published; details are available in the cited literature [1].

2.2.2. Analysis of Spatial Distribution of Heritage Quality

Spatial autocorrelation analysis centres on measuring spatial correlation. It explores the spatial agglomeration and spatial outliers of geographical phenomena and reveals the interactive relationships among geographic elements across spatial contexts [41]. In the present study, Global Moran's I and Local Moran's I (LISA) were adopted to examine overall and local spatial patterns, including similarity, dissimilarity, and spatial independence [42–44]. The global autocorrelation model was used to characterise the overall distribution of the heritage values of Huizhou traditional villages and to identify whether significant agglomeration characteristics existed within the study area. Local autocorrelation further assessed whether high- or low-value observations clustered in specific regions.

2.2.3. Analysis of Heritage Spatial Association Strength

On the premise of mutual attraction and agglomeration among traditional village heritage resources, spatial associations were used to characterise the relational connections among traditional villages, forming a spatial association network based on heritage quality. The modified gravity model, which has been widely applied in research on spatial interaction effects [45,46], incorporates two core influencing factors: quality and distance. In this study, individual Huizhou traditional villages were regarded as nodes, and network edges represented the intensity of heritage influence between villages. Specifically, the strength of spatial relationships, co-determined by 'quality' and 'distance', constituted the edge connections of the network, with 'quality' referring to the heritage value of traditional villages. The classic gravity model, which relies solely on a single measure of mass, is insufficient to capture the multifaceted heritage values of traditional villages. To address this limitation, this study developed a multidimensional composite index of traditional village heritage quality based on the evaluation system for Huizhou traditional vil-

lages from the perspective of cultural ecology. An improved gravity model was then formulated to compute and construct a spatial network of heritage value associations among traditional village clusters, enabling the identification of heritage value, as shown below:

$$F_{ij} = k \frac{Q_i Q_j}{D_{ij}^2}$$

Here, F_{ij} denotes the heritage association intensity between traditional village i and village j , and Q_i and Q_j represent the heritage quality of traditional village i and j , respectively. The heritage interactions among traditional villages were assumed to be bidirectional and reciprocally synergistic, rather than merely unidirectional radiation effects; accordingly, parameter k was set to 1 [45].

Additionally, as the study area is mountainous with significant topographic relief, using only road mileage would overstate the spatial fragmentation between adjacent units and neglect the influence of historical mountain paths and foot trails. In contrast, straight-line spatial distances would fail to account for the frictional effects of terrain and road networks. These two types of distance metrics characterise two completely independent dimensions of spatial impedance, which are not mutually substitutable; therefore, it was necessary to construct a composite distance indicator by integrating them [47,48]. Following the approach of Miao and Zhao [49], this study adopted the arithmetic mean of straight-line distance and road distance as the composite distance metric in the gravity model. This composite distance accounted for both the objective geographical proximity and the accessibility of the transport network. Notably, a state-level study in Mexico compared the performance of various distance definitions in gravity models and found that at that geographical scale, the choice of distance definition had no significant effect on the model's explanatory power [50]. This finding implies that when different distance measures do not produce substantial differences in model results, employing a computationally convenient geometric mean as the composite distance metric is a reasonable approach.

This paper defines D_{ij} as the geometric mean value of the shortest highway mileage and the straight-line spatial distance between two village nodes. Since internal traffic in traditional villages in the study area relies predominantly on highway networks, highway mileage was adopted to characterise the shortest traffic distance between villages. The shortest highway distances were measured on the Amap platform, and straight-line distances were extracted via ArcGIS 10.5.

2.2.4. QAP Analysis Method

QAP is specifically designed for the analysis of relational data. Based on permutations of matrix data, it calculates and compares the lattice values of relational networks between two matrices, derives correlation coefficients between the matrices, and conducts non-parametric tests on them; this effectively resolves the problem of multicollinearity [12,51]. By addressing the endogeneity of relational data, QAP yields more robust results than parametric methods [12,51]. The QAP method has been proven to exhibit highly reasonable statistical bias and efficiency properties [52]. Traditional Huizhou villages exhibited mutual attraction and agglomeration, forming a stable spatial heritage network. This study employed the QAP method to investigate the factors influencing the spatial association of heritage among traditional Huizhou villages.

Identification of Influencing Factors

Traditional villages are an extremely important and precious part of China's cultural heritage. According to the theory of cultural ecosystems, developmental factors such as nature, society and the economy underpin the survival and development of traditional

village heritage, forming an indispensable cultural–ecological environment. Under the combined influence of multiple regional factors, including natural, social, and economic conditions, Huizhou traditional villages, characterised by clustered clan settlements and white-washed walls with black tiled roofs, have formed a traditional settlement system with unique spatial forms and patterns [53]. Changes in any single element will affect the inheritance of this heritage. Because nature, society, and the economy jointly construct the cultural ecosystem of traditional village heritage, this study explored the factors influencing the spatial association of traditional village heritage from these three perspectives.

(1) Natural dimension

The natural dimension encompasses topographic conditions such as terrain, geology, climate and natural disasters, as well as the ecological environment formed by natural resources, including mountains, rivers, forests, farmland, and lakes. Elevation is an important factor affecting the distribution of traditional villages [54]. However, the relationship between elevation and the spatial association of traditional village heritage is unclear. Thus, elevation was selected as a measurement indicator to construct a difference matrix. The location of traditional villages is closely associated with river systems, exhibiting a settlement distribution along watercourses or a directional orientation toward rivers [20,55]. Accordingly, river systems were selected as a measurement indicator to construct a difference matrix (Table 2).

Table 2. Influencing factors of the heritage spatial association of Huizhou traditional villages.

Level 1	Level 2	Specific Variable	Indicator Explanation or Calculation Formula
Natural Dimension	Natural Conditions	Elevation	Elevation
		River System	Traditional villages located within 500 m, 500–1000 m, 1000–2000 m, 2000–3000 m, and beyond 3000 m of river buffers are assigned scores of 5, 4, 3, 2, and 1 respectively.
		Shannon's Diversity Index	A higher value indicates more diverse land use and a higher degree of landscape fragmentation. $SHDI = -\sum_{i=1}^m P_i \ln P_i$ where m is the number of landscape patch types [56,57].
	Ecological Environment	Contagion Index	This represents the degree of aggregation or extension of different patch types in the landscape. A higher contagion index indicates that certain dominant patches have formed good connectivity, while a lower value indicates weak connectivity between patches. $CONTAG1 = \frac{\sum_{i=1}^m \sum_{j=1}^n \frac{P_{ij} \ln(P_{ij})}{2 \ln(m)}}{2 \ln(m)}$ where m is the number of landscape patch types, and P_{ij} represents the perimeter of patches [58–60].
Social Dimension	Population	Population Density	Population Density
		Language Customs	Assigned a value of 1 for consistency, 0 for inconsistency.
	Accessibility	Distance to Central City	The straight-line spatial distance spatial distance between traditional villages and central cities.

Economic Dimension	Agriculture	Agriculture	Total area of cultivated land and garden plots within the buffer zone.
	Non-Agriculture	Non-Agriculture	Number of industrial and service POIs within the buffer zone.

Regarding the ecological environment, existing studies have reported both dense distributions of traditional villages in areas with superior ecological conditions and sparse distributions in ecologically favourable regions [29]. Huizhou traditional villages are situated according to the ideal settlement pattern of backing onto mountains, facing water, and enclosed by screening hills, indicating a close relationship between villages and the ecological environment. Hence, this study examined the spatial association between the ecological environment and heritage clusters of traditional villages. In combination with the actual conditions of Huizhou traditional villages and the relevant literature [56–60], two representative landscape pattern indices—diversity and sprawl—were adopted as measurement indicators (Table 2).

(2) Social dimension

Sharing a common language enables closer communication and connections among villagers, making it easier for them to form a shared behavioural culture, including customs and traditions. The degree of linguistic similarity indicates the closeness of interactions between regions, providing an important indicator for researching the architectural styles and lineages of different regions [61]. Additionally, linguistic differences contribute to divergence in the heritage values of traditional villages [62]. Therefore, linguistic differences among traditional villages were selected as a measurement indicator.

Central cities exert a strong radiating influence on traditional villages in their regions, with a close correlation between the two [63]. Accordingly, the distance from traditional villages to the central city was selected as a metric to construct a dissimilarity matrix. In this study, central cities were the seats of government of each county-level administrative division, specifically: Huicheng Town (in Shexian County), Haiyang Town (in Xiuning County), Qishan Town (in Qimen County), Biyang Town (in Yixian County), Yangshu Town (in Tunxi District), YanSi Town (in Huizhou District), and Gantang Town (in Huangshan District). Additionally, population serves as the foundation for the emergence of settlements and the development of villages, and larger population sizes promote village development [54,64]. Thus, a difference matrix was constructed using population data (Table 2).

(3) Economic dimension

Studies have shown that economically developed regions place greater emphasis on disseminating and protecting cultural heritage concepts, and that most traditional villages in China are concentrated in such regions [21]. However, existing research on the relationship between the spatial distribution of traditional villages and economic development has neglected the heritage-value attributes of traditional villages and the correlation between economic development and heritage quality. Therefore, this study explored the impact of economic development on the spatial heritage associations of traditional villages. The economic development of traditional villages is characterised by agriculture, industry, and service industries. In this study, the agricultural economy of traditional villages was represented by the total area of cultivated land and garden plots, while the development of industry and service industries in traditional villages was indicated by the number of industrial and service POIs (Table 2).

QAP Analysis

This study employed QAP correlation and regression analyses to determine the factors influencing the spatial association of Huizhou traditional village heritage. The elevation (EL), river systems (RS), Shannon's diversity index (SHDI), contagion index (CONTAG), population density (POP), language customs (LANG), distance to central city (CC-DIS), agriculture (AG), and non-agriculture (NAG) were calculated as differences between traditional villages, processed by range standardisation and transformed into relational matrices for each variable to construct their respective difference matrices. The dependent variable was the heritage spatial association matrix of Huizhou traditional villages.

2.3. Data Sources

Two hundred and seventy-one state-level traditional villages from five batches in Huangshan City were obtained from the official website of China's Traditional Villages. Spatial coordinates were extracted by integrating Google Earth imagery and Baidu Maps, with the spatial location of each state-level Huizhou traditional village georeferenced at its geometric centre to establish a spatial distribution database and generate a spatial distribution map (Figure 2).

The data on the heritage quality of traditional villages were derived from 271 'One-Village-One-File' dossiers and 271 'Conservation and Development Plans' for traditional villages. These documents were prepared by design institutes under the oversight of the Huangshan Municipal Bureau of Housing and Urban–Rural Development, following the unified standards and protocols established by the Ministry of Housing and Urban–Rural Development, and had all passed expert review. Quantitative data for indicators C1, C2, C3, C4, C5, C6, C9, C10, C11, C19, C20, C21, C22, C23, C24, and C25 were obtained directly from the 271 dossiers and plans. The remaining indicators were scored based on textual analysis, current condition photographs, satellite imagery, village site selection analysis maps, natural environment analysis maps, conservation element analysis maps and survey drawings, as well as floor plans, elevations, sections, detailed architectural construction photographs, and multiple current condition photographs of each historic building in the aforementioned documents. This methodological component has been published previously, with details available in the cited literature [1].

The data sources for factors influencing the heritage spatial association network of Huizhou traditional villages were as follows. Elevation (EL) was sourced from DEM data on the Geospatial Data Cloud (<http://www.gscloud.cn/>) with a spatial resolution of 30 m. River systems (RS) were derived from Third National Land Survey data and calculated using ArcGIS 10.5. Population data were obtained from the Seventh National Population Census. Language customs (LANG) were sourced from the Language Atlas of China. Distance to central city (CC-DIS) was calculated using ArcGIS 10.5. Agriculture (AG) was derived from Third National Land Survey data and calculated using ArcGIS 10.5. Non-agriculture (NAG) was sourced from Amap POI data.

The ecological indicators—Shannon's diversity index (SHDI) and contagion index (CONTAG)—are landscape pattern metrics. From a landscape ecology perspective, land use was classified into seven categories: cultivated land, garden land, forest land, grassland, water area, construction land, and other land (Table 3). Based on data from the third National Land Survey, the landscape patterns of 271 state-level traditional villages in Huizhou were analysed. The selection of buffer zones was based on the following criteria: they should reflect the interdependence between traditional villages and the natural environment, capture the diversity and integrity of the landscape elements surrounding the villages, and maintain the spatial independence of each village sample unit. Based on the 3 km buffer zone adopted in previous studies [65], landscape pattern indices were calcu-

lated at circular buffer radii of 2, 3, 4, and 5 km. Among these, the 3 km buffer zone exhibited the best performance in characterising landscape heterogeneity and spatial representation. SHDI and CONTAG were calculated using geographic information systems and Fragstats 4.2.

Table 3. Land use classification.

Land Type	Specific Content
Cultivated Land	Paddy fields, irrigated land, dry land
Garden Plot	Orchards, tea plantations, other garden plots (for mulberry trees, medicinal herbs, and other perennial crops)
Woodland	Arbor woodland, bamboo woodland, shrub woodland, other woodland (including sparse woodland with canopy closure ≥ 0.1 and < 0.2 , young afforested land, burned-over land, nurseries, etc.)
Grassland	Grassland with canopy closure < 0.1 , having a soil surface and not used for grazing
Water Area	River surface, reservoir surface, pond and pit surface, inland tidal flats, ditches, water conservancy construction land
Construction Land	Commercial and service land, industrial, mining, commercial and storage land, residential land, public administration and public service land, transportation land
Other Land	Idle land, facility agricultural land, bare land, bare rock and gravel land, special land

3. Results

This study constructed a progressive analytical framework comprising ‘spatial differentiation of heritage quality, measurement of heritage association relationships, and identification of multi-dimensional driving factors’, with these three aspects being hierarchically supportive and inseparable. Sections 3.1 and 3.2 of this paper present the heritage spatial distribution and spatial differentiation analysis of traditional villages, respectively. These sections examined spatial agglomeration and differentiation patterns to determine whether associations existed, since heritage association is the key to sustaining the agglomeration of traditional villages. Based on the identified heritage spatial agglomeration and differentiation, Section 3.3 describes the heritage association strength of Huizhou traditional villages, presenting the heritage spatial association strength and network visualisation. These measurements also served as the dependent variable in the subsequent QAP analysis. Section 3.4 then describes the introduction of nine natural and human factors as explanatory variables, and the use of QAP analysis to reveal the influencing factors of heritage spatial association

3.1. Spatial Distribution Analysis of Heritage Quality Levels of Huizhou Traditional Villages

There were substantial differences in the heritage quality of Huizhou traditional villages in Huangshan City, as evidenced by a relatively high standard deviation and coefficient of variation. As a World Heritage site, Hongcun Village had the highest heritage value of 0.8224, while the lowest was 0.1546 (Table 4). Among the diversity, integrity, and continuity values, the integrity value (A2) exhibited the largest standard deviation and coefficient of variation, indicating considerable disparity in the integrity values of Huizhou traditional villages. Among the six dimensions, the integrity of the heritage ontology (B3) had the largest standard deviation and coefficient of variation, followed by the relationship between the heritage ontology and the surrounding environment (B4). Moreover, the mean value of the latter was the lowest among the six dimensions. The natural breaks method was used to classify the heritage values of Huizhou traditional villages into five

levels: high-value, relatively high-value, medium-value, relatively low-value, and low-value. The heritage value quality of traditional villages was found to exhibit spatial agglomeration. Villages with relatively high values and above were mainly concentrated in Yi County, She County, and Huizhou District. In contrast, villages with relatively low values and below were primarily distributed on the periphery of the region or around high-value traditional villages (Figure 5).

Table 4. Statistics on the evaluation results of the heritage value of Huizhou traditional villages.

	Minimum Value	Maximum Value	Average Value	Median	Standard Deviation	Coefficient of Variation	Proportion of Traditional Villages Below the Average Value (%)
A1	0.0395	0.2440	0.1176	0.1143	0.0398	0.3384	52.40
A2	0.0239	0.3137	0.1148	0.1080	0.0517	0.4503	54.61
A3	0.0448	0.2648	0.1205	0.1176	0.0304	0.2523	53.51
B1	0.0030	0.1676	0.0654	0.0621	0.0315	0.4817	52.77
B2	0.0070	0.0972	0.0523	0.0486	0.0144	0.2753	61.25
B3	0.0021	0.2438	0.0833	0.0813	0.0426	0.5114	54.98
B4	0.0040	0.0744	0.0316	0.0271	0.0153	0.4842	57.20
B5	0.0276	0.2135	0.0795	0.0778	0.0210	0.2642	56.83
B6	0.0001	0.0833	0.0410	0.0437	0.0187	0.4561	48.71
Total	0.1546	0.8224	0.3530	0.3411	0.0976	0.2765	53.87

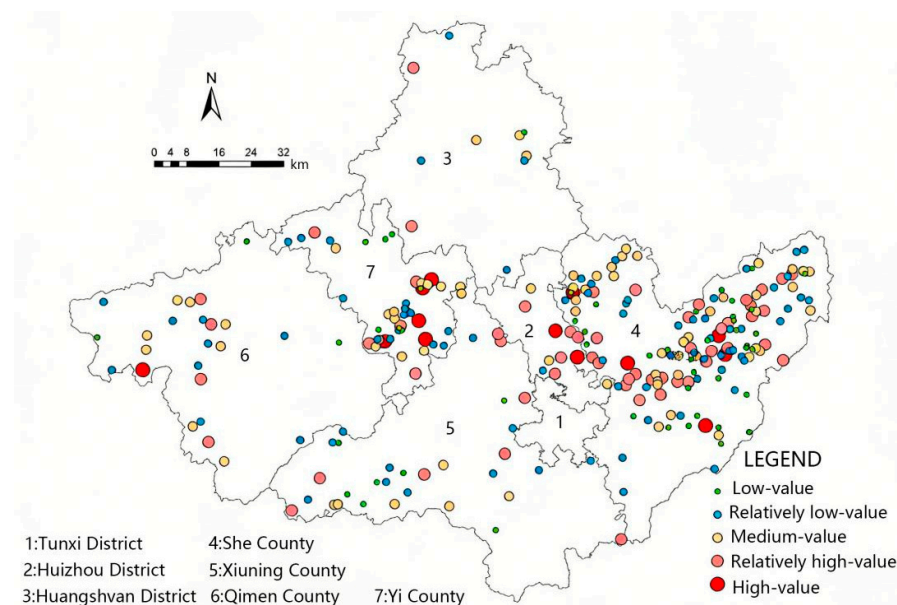


Figure 5. Spatial distribution map of heritage quality in Huizhou traditional villages.

3.2. Spatial Differentiation Analysis of Heritage Quality Levels of Huizhou Traditional Villages

To further investigate the spatial distribution of heritage quality in traditional villages, a grid-based analysis was employed. Based on the grid size selection in previous studies [29], it was found that using a 1–2 km grid resulted in the number of traditional villages being too sparse, with many grids containing no heritage samples, while a 4–5 km grid obscured the spatial differentiation pattern of high versus low heritage values. Through experimentation, a 3 km × 3 km grid was ultimately adopted to examine the spatial distribution and spatial differentiation of the heritage value of Huizhou traditional villages. The global Moran's I results indicated that both Moran's I and the Z-score were

positive, with all p -values less than 0.05 (Table 5). This demonstrated a significant positive spatial correlation in the spatial distribution, as well as pronounced spatial agglomeration and unbalanced spatial distribution. In other words, traditional village heritage interacts and interconnects, exhibiting close spatial correlation characteristics.

Table 5. Results of Moran's I.

	Moran's I	p -Value	Z-Score
Total Value	0.2664	0.0000	14.6088
Diversity	0.2593	0.0000	14.1987
Integrity	0.2560	0.0000	14.1094
Continuity	0.2627	0.0000	14.3850

Local indicators of spatial association (LISA) clustering and outlier analysis were applied to further explore the spatial clustering pattern. With significance tested at the 0.05 level, the heritage spatial distribution of traditional villages presented three types of spatial association patterns: high-high (H-H) clustering, low-high (L-H) clustering, and high-low (H-L) clustering (Figure 6).

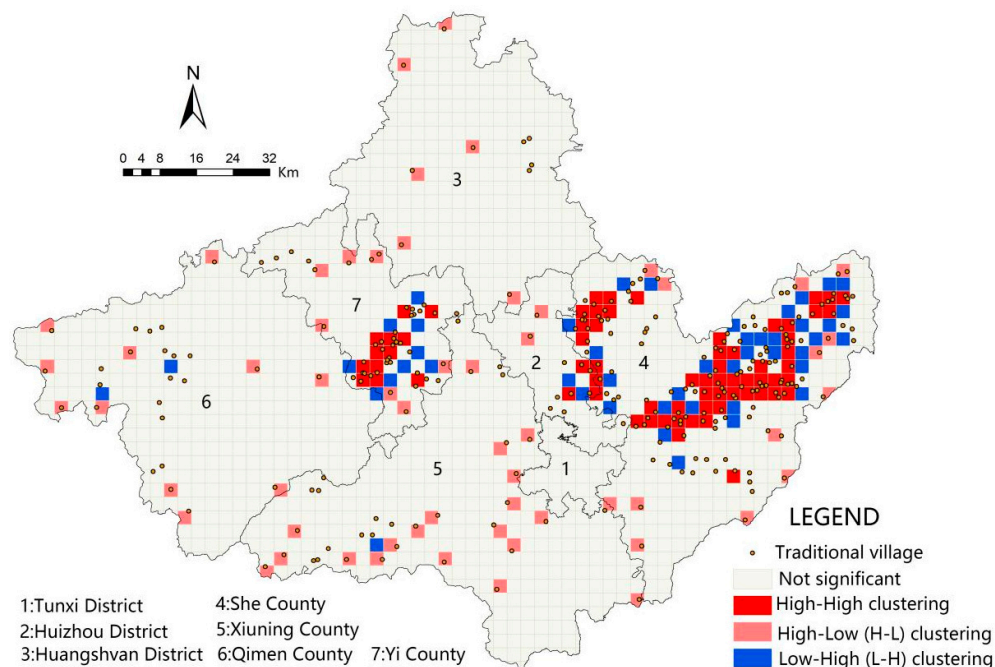


Figure 6. Spatial clustering pattern of heritage quality of Huizhou traditional villages.

High-high cluster zones (H-H) were areas where both the traditional village heritage within the zone and that in its surrounding areas were of high value. These H-H clusters were mainly concentrated in She County, which boasts profound Hui cultural deposits, and Yi County, the coordinated development zone for urban construction around World Cultural Heritage sites. In She County, H-H clusters were primarily distributed in Shendu Town, Bei'an Town, and Qizili Town. This region features dense water networks and abundant forest resources, with some traditional villages nestled among high mountains and steep ridges. It contains distinctive traditional villages with Huizhou architectural complexes of outstanding scientific and artistic value, such as Xucun, the unique Yangchang Tulou buildings, a marvel of Huizhou-style architecture, and Wan'er Village,

which is acclaimed as the Potala Palace of Huizhou. Yi County is home to high-value traditional villages, including the World Cultural Heritage sites of Xidi and Hongcun, as well as Nanping and Pingshan. Another H-H cluster was located in Huizhou District, represented by Tangmo, Shuyuan, and Lingshan, among other villages. Notably, Huizhou District was part of She County before 1987 (Figure 6).

High-low cluster zones (H-L) were areas where the heritage value scores of traditional villages were relatively high, while the scores of the surrounding traditional villages were extremely low. Spatially, H-L clusters exhibited a scattered distribution, mainly located on the periphery of Huangshan City (Figure 6).

Low-high cluster zones (L-H) denoted areas where the heritage value score of traditional villages was significantly lower than that of the surrounding regions. Such zones were primarily distributed around H-H clusters, with a small number scattered on the edge of Huangshan City (Figure 6).

3.3. Analysis of Heritage Spatial Association Intensity of Huizhou Traditional Villages

Huizhou traditional villages exhibited significant spatial agglomeration and strong spatial association. This study adopted a modified gravity model to quantify the intensity of heritage spatial association among Huizhou traditional villages in Huangshan City. A total of 271 nodes were included in the heritage spatial network, forming 36,585 association relationships. The heritage gravity values varied substantially, ranging from a maximum of 9895.8097 to a minimum of 0.0135, with prominent numerical disparities. Taking the average gravity value of 4.2586 as the screening threshold [66,67], 2738 valid spatial association links were retained across all 271 nodes. Additionally, the natural breakpoint method was applied to categorise the pairwise spatial correlation intensity of heritage sites into five levels: high, moderately high, moderate, moderately low, and low (Figure 7).

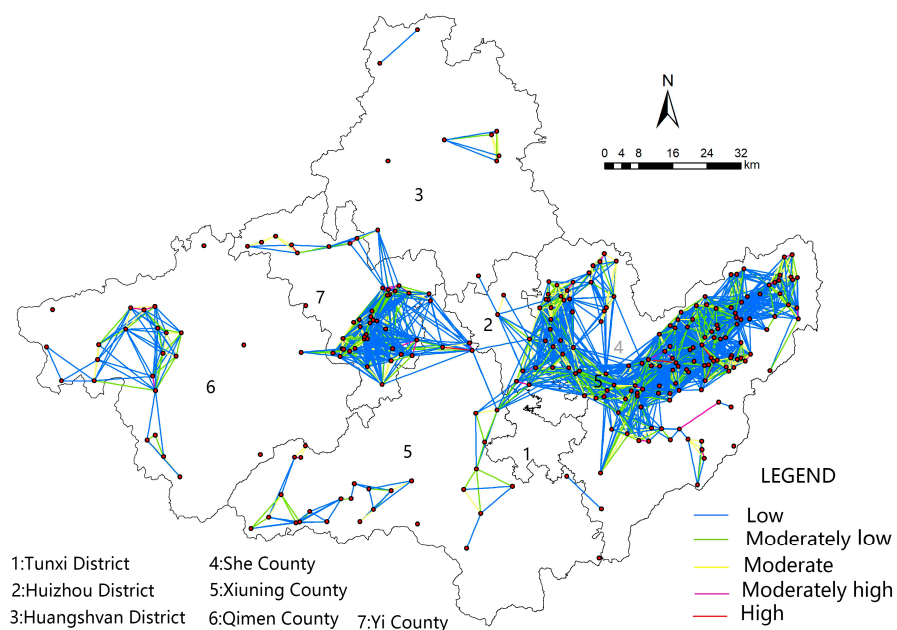


Figure 7. Heritage spatial association intensity of Huizhou traditional villages.

The heritage spatial association of Huizhou traditional villages in Huangshan City exhibited pronounced networked characteristics. However, no distinct growth pole or core node of heritage spatial association existed in the overall network, and the propor-

tions of high- and relatively high-level spatial association were relatively low. The heritage connections between traditional villages in She County and Huizhou District had transcended administrative boundaries, forming a densely interconnected agglomeration. As Huizhou District was under the jurisdiction of She County before 1987, the two regions have high levels of homogeneity in customs, village styles and features, which has been the foundation for their strong heritage association. Another area with close heritage connections was in Yi County. Traditional villages in these two regions share strong similarities in heritage value and village characteristics, which is conducive to the implementation of contiguous protection. In contrast, Qimen County, Xiuning County, and Huangshan District are far from the core area of Hui Culture (She County), and Yi County, where world heritage sites are located, so their traditional village heritage was weakly influenced by the core area. No significant heritage association existed among Qimen, Xiuning, and Huangshan Districts. Traditional villages within each region mainly exhibited relatively low- or low-level heritage spatial connections, with weak overall connections, and most were on the periphery of the city. Additionally, eight traditional villages were located on the periphery of the area. They had no connections with other traditional villages and thus formed isolated traditional villages (Figure 7).

The upper decile of heritage gravity (2.992) was adopted as the threshold, yielding 3659 heritage spatial associations. The results showed that the heritage spatial associations of Huizhou traditional villages included numerous weak connections and exhibited extremely high levels of heritage gravity. When different thresholds were applied, the spatial agglomeration pattern of heritage associations among traditional villages within Huangshan City did not change substantially (Figure 8).

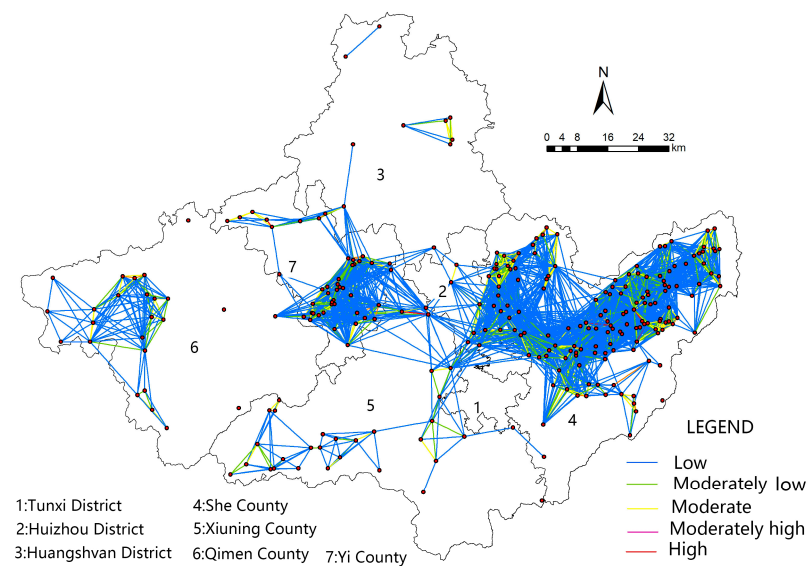


Figure 8. Heritage spatial association intensity of Huizhou traditional villages (the upper decile of heritage gravity).

3.4. Analysis of Factors Influencing Heritage Spatial Association of Huizhou Traditional Villages

3.4.1. Results of QAP Correlation Analysis

Using Ucinet 6.0 software, 5000 random permutations were performed for the QAP correlation analysis. The results indicated that elevation (EL), Shannon diversity index (SHDI), river system (RS), contagion index (CONTAG), population density (POP), linguistic habit (LANG), distance to the central city (CC-DIS), agriculture (AG) and non-agriculture (NAG) are all correlated with the heritage spatial association of Huizhou traditional

villages. Specifically, smaller differences in elevation, distances to the river system, contagion indices, and distances to the central city, and greater similarity in linguistic habit, favoured the diffusion and connectivity of traditional village heritage, and promoted tighter linkages in heritage values. In contrast, larger differences in landscape diversity, population density, and agricultural and non-agricultural economies tended to enhance the connections among traditional village heritage (Table 6).

Table 6. Results of the QAP correlation analysis.

Variable Name	Correlation Coefficient	Significance Level	Standard Deviation
EL (i, j)	−0.150 ***	0.000	0.026
RS (i, j)	−0.067 **	0.012	0.033
SHDI (i, j)	0.315 ***	0.000	0.016
CONTAG (i, j)	−0.296 ***	0.000	0.017
POP (i, j)	0.103 ***	0.000	0.029
LANG (i, j)	−0.627 ***	0.000	0.015
CC-DIS (i, j)	−0.372 ***	0.000	0.012
AG (i, j)	0.252 ***	0.000	0.017
NAG (i, j)	0.082 ***	0.003	0.025

Note: “***” and “**” indicate that the coefficients are significant at the 0.05, and 0.01 levels respectively.

3.4.2. Results of QAP Regression Analysis

Based on the results of the QAP correlation analysis, the QAP regression analysis was conducted. The QAP regression results showed an adjusted R^2 value of 0.5123, indicating that the model explained 51.23% of the heritage spatial association network of traditional villages. The river system variable did not pass the significance test.

The results identified that the heritage spatial association of Huizhou traditional villages is a complex process shaped by multiple factors. Elevation differences, sprawl differences, linguistic habit differences, and distance to the central city all had significant negative effects on heritage spatial association. In contrast, differences in diversity, population, agricultural development, and non-agricultural development showed significant positive effects. Among these, the standardised coefficient of language was the highest, followed by distance to the central city (reflecting accessibility) and population density. This suggests that social conditions play a decisive role in shaping the heritage association of Huizhou traditional villages. The standardised coefficient of elevation ranked fourth among natural conditions, indicating that elevation imposes certain constraints on the spatial association of traditional village heritage. Although the variables representing economic forces—agricultural and non-agricultural development—showed significant positive effects, their coefficients were extremely small. They thus did not dominate the heritage spatial association of Huizhou traditional villages (Table 7).

Table 7. Results of the QAP regression analysis.

Variable Name	Unstandardised Regression Coefficient	Standardised Regression Coefficient	Significance Level
Intercept	4.795	0.000	—
EL (i, j)	−0.001	−0.0936 ***	0.000
RS (i, j)	0.000	−0.039	1.000
SHDI (i, j)	0.231	0.0716 ***	0.000
CONTAG (i, j)	−0.287	−0.0916 ***	0.000
POP (i, j)	0.001	0.0956 ***	0.000
LANG (i, j)	−1.669	−0.5366 ***	0.000

CC-DIS (i, j)	−0.759	−0.2476 ***	0.000
AG (i, j)	0.176	0.0566 ***	0.000
NAG (i, j)	0.002	0.0646 ***	0.000

Note: “***” indicate that the coefficients are significant at the 0.01 levels respectively.

To test the robustness of the findings, the gravitational values of traditional village heritage association were recalculated using both the shortest road distance and the straight-line distance between traditional villages. The QAP regression analysis was then repeated. The QAP regression results demonstrated that given the relatively large-scale spatial association network, different spatial distance measures exhibited robustness. Social conditions, particularly language and the distance to the central city (reflecting accessibility), play a critical role in the heritage spatial association of Huizhou traditional villages, while economic conditions play only a limited role, and natural conditions exert a certain constraining effect (Tables 8 and 9).

Table 8. Results of the QAP regression analysis(the shortest road distance).

Variable Name	Unstandardised Regression	Standardised Regression	Significance Level
	Coefficient	Coefficient	
Intercept	3.499	0	-
EL (i, j)	−0.331	−0.125 ***	0.000
RS (i, j)	0.000	−0.040	1.000
SHDI (i, j)	0.251	0.080 ***	0.000
CONTAG (i, j)	−0.228	−0.075 ***	0.000
POP (i, j)	0.001	0.114 ***	0.000
LANG (i, j)	−1.480	−0.493 ***	0.000
CC-DIS (i, j)	−0.641	−0.216 ***	0.000
AG (i, j)	0.122	0.040 ***	0.001
NAG (i, j)	0.002	0.075 ***	0.000

Note: “***” indicate that the coefficients are significant at the 0.01 levels respectively.

Table 9. Results of the QAP regression analysis(the straight-line distance).

Variable Name	Unstandardised Regression	Standardised Regression	Significance Level
	Coefficient	Coefficient	
Intercept	6.570	0	-
EL (i, j)	−0.249	−0.084 ***	0.000
RS (i, j)	0.000	0.036	1.000
SHDI (i, j)	0.214	0.061 ***	0.000
CONTAG (i, j)	−0.356	−0.104 ***	0.000
POP (i, j)	0.001	0.070 ***	0.000
LANG (i, j)	−1.849	−0.549 ***	0.000
CC-DIS (i, j)	−0.877	−0.263 ***	0.000
AG (i, j)	0.220	0.064 ***	0.000
NAG (i, j)	0.002	0.053 ***	0.000

Note: “***” indicate that the coefficients are significant at the 0.01 levels respectively.

4. Discussion

4.1. Analysis of the Mechanism Influencing the Heritage Spatial Association of Huizhou Traditional Villages

Although most Huizhou traditional villages are situated near mountains and rivers, the river system did not pass the significance test, a finding that was markedly at odds with conventional perceptions. This finding was attributed to the following reasons. The

streams and small rivers within the Huangshan City area are predominantly mountain-torrent channels, and the terrain is highly fragmented. Even when villages share the same water system, the intervening mountains and gorges form natural geographic barriers that impede daily interactions among riverside settlements. Consequently, the water system cannot overcome the mountainous fragmentation to establish a region-wide cultural bond; instead, it exerts cultural connective effects only within localised small-scale valley units, and thus fails to drive the heritage spatial associations of Huizhou traditional villages at the regional scale.

Language is a vital marker of ethnic and sub-ethnic cultures [68]. The smaller the differences in linguistic habits among traditional villages, the easier it is for villagers to communicate, leading to smoother and closer inter-village connections and a greater tendency to live together in clans. The degree of linguistic similarity reflects the closeness of origins and interactions among different regions [69], and strongly favours the dissemination and integration of traditional customs, traditional crafts, production techniques and methods, and village landscapes. Huizhou traditional villages, which evolved and branched out from kinship-based clan organisations, are linguistically rich and have formed a distinctive Hui dialect. This dialect not only differs greatly from Mandarin in pronunciation and vocabulary, but also varies across sub-regions. Traditional villages with more similar linguistic habits and smaller differences are better able to communicate, foster similar customs and cultures, and facilitate the spread and integration of heritage. Thus, linguistic habit is a key factor shaping the spatial association of Huizhou traditional village heritage.

A shorter distance to the central city enhances the latter's attractiveness and influence on traditional villages, owing to its advantages in terms of economy and population, thereby promoting heritage connectivity and diffusion among traditional villages. Population is the foundation for the emergence and development of traditional villages. A higher population density in a traditional village implies a deeper clan foundation, a longer developmental history, and more complete cultural and folk customs, all of which are conducive to the dissemination and interconnection of traditional village heritage.

Elevation was closely linked to the heritage spatial association of Huizhou traditional villages. The terrain of Huangshan City is complex, encompassing Mount Huangshan (a mixed World Cultural and Natural Heritage site) as well as the Baiji, Qiyun, and Tianmu mountain ranges, which traverse the entire region. Numerous intermountain basins and valleys are scattered among the high mountains and ridges, providing natural barriers for Huizhou traditional villages. Elevation determines the agricultural production patterns of villages; similar elevations favour the formation of similar agricultural practices, which in turn influence village size, architectural styles, and traditional customs. A smaller difference in the contagion index indicates that dominant patches among Huizhou traditional villages maintain good connectivity, reducing landscape fragmentation. Lower fragmentation means fewer obstacles to heritage association and dissemination, further facilitating the spread and connection of cultural heritage. The diversity of land use and landscapes in Huizhou traditional villages can enhance their vitality and influence. Traditional villages with rich diversity exert strong attraction and radiation effects on those with low diversity indices, and greater diversity gaps more effectively promote heritage connections among traditional villages.

4.2. Policy Implications

4.2.1. Weakening Administrative Boundaries and Implementing Cluster-Oriented Protection and Utilisation

The heritage quality of Huizhou traditional villages exhibited significant spatial agglomeration, indicating a close association in heritage among them. The constant interaction and connection between different heritages led to the spatial clustering of traditional villages with similar landscapes and patterns, forming traditional village clusters. These clusters presented three spatial correlation patterns: high-high clustering (H-H), low-high clustering (L-H), and high-low clustering (H-L).

An analysis of the heritage association intensity of Huizhou traditional villages revealed that their spatial association has already transcended administrative boundaries. Therefore, it is necessary to systematically comprehend traditional village heritage at the regional level and conduct integrated protection from a cluster perspective. Based on heritage spatial correlation relationships, a conceptual diagram for the conservation and utilisation of Huizhou traditional villages is proposed, in which traditional village clusters are divided into a multi-level spatial structure comprising villages, village groups and cluster domains (Figure 9). This approach transcends administrative boundaries and implements cluster-based conservation and utilisation of traditional village heritage."

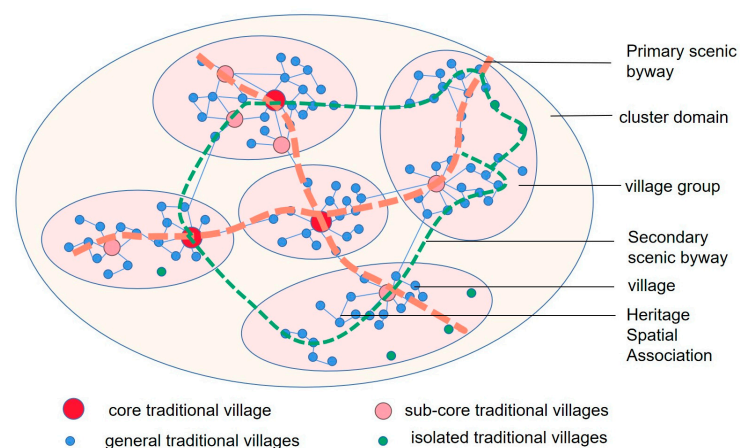


Figure 9. Clustered conservation and utilisation model of Huizhou.

Traditional villages within the same village group shared high similarity and close ties, while different village groups had different, distinct characteristics. Taking village groups as units, efforts should be made to excavate tangible and intangible cultural heritage, exploit the derivative value of heritage, emphasise the characteristic differences among village groups, and create distinctive cultural IPs. Additionally, policies for the zoned, graded and classified protection and utilisation of traditional village heritage should be implemented to improve the efficiency of collaborative protection and utilisation of heritage resources and promote the cultural heritage inheritance and development of traditional villages.

4.2.2. Constructing Heritage Scenic Byways for Traditional Villages to Achieve Regional Collaborative Protection and Utilisation Systems and Practical Heritage Conservation

The QAP analysis indicated that a shorter road distance to the central city significantly promotes the connectivity among traditional village heritage. Relevant literature also suggests that road traffic accessibility can facilitate the holistic conservation and utilisation of traditional villages [70–72]. To enhance the dissemination of traditional village heritage, a scenic byway policy for Huizhou traditional village heritage is proposed, using

scenic byways to strengthen the communication and linkages among village clusters, between individual villages and between villages and the central city (Figure 9). Scenic byways integrate multiple values, including scenery, transportation, recreation, ecology, and culture, thereby promoting the preservation of the heritage and cultural ecology of a specific region [73]. These approaches would enable the coordination of historical and cultural preservation, natural ecosystem balance, and socio-economic development at the regional level [74,75]. Based on the results of heritage quality assessment and QAP regression analysis, criteria for determining the alignment of primary and secondary scenic corridors were proposed. Specifically, these criteria were established based on the existing road network, taking into account contiguous areas of traditional villages with high heritage values, as well as contiguous areas characterised by high linguistic similarity and strong accessibility to the central city. In conjunction with the region's terrain, segmented and differentiated spatial control measures were further proposed for primary and secondary corridors, dividing them into three sections: the core heritage node section, the valley transitional connection section, and the mountain buffer conservation section. In the core heritage node section, high-value traditional villages would serve as the focal points, with strict control over the architectural style of new constructions and the provision of supporting facilities for heritage interpretation and folk custom experiences. In the valley connection section, gentle ancient trails would be utilised to link small and medium-sized villages, preserving the pristine rural landscapes and water-mouth groves while developing slow-traffic pedestrian branch routes. In the mountain buffer conservation section, ecological conservation would be prioritised, with restrictions on large-scale cultural tourism development and the retention of minimal sightseeing trails to minimise human disturbance. Additionally, taking the primary and secondary scenic corridors as axes would establish a multi-tiered, outward-radiating heritage protection system comprising core areas, intermediate areas, and peripheral areas.

Scenic byways break the traditional isolated 'point-based' protection and utilisation pattern of traditional villages and alleviate the weak connections among village groups. They enable an integrated protection and utilisation model that progresses from 'nodes' (individual traditional villages) to 'routes' (scenic byways) and then to 'areas' (village groups). This model strengthens both the connections and information flows among traditional villages and village clusters, establishes a protection and utilisation framework featuring resource integration and spatial synergy, avoids disorderly competition among traditional village heritage sites, and preserves the integrity and continuity of heritage. Simultaneously, exhibitions, exchanges, and immersive activities are used to promote the deep integration of culture and tourism, providing a concrete pathway for the clustered and integrated protection and utilisation of traditional village heritage.

5. Conclusions

This study employed systematic analysis and empirical research methods to construct a three-tier progressive analytical framework encompassing 'spatial differentiation of heritage quality (attribute layer), construction of the association network (relational layer), and attribution of influencing factors (mechanism layer)'. This framework was designed to address two salient research gaps: the spatial association characteristics of the heritage of Huizhou traditional village systems, and the drivers and influences underpinning spatial heritage connections. The following core conclusions were drawn.

- (1) The heritage values of Huizhou traditional villages vary considerably. Their spatial distribution exhibits significant agglomeration as well as three types of correlation patterns: high-high clustering (H-H), low-high clustering (L-H), and high-low clustering (H-L).

- (2) The spatial association between the heritage of Huizhou traditional villages has broken through the constraints of administrative boundaries, with a prominent networked characteristic and the formation of clustered development.
- (3) The heritage spatial association of Huizhou traditional villages is a complex process shaped by multiple interacting factors. Social conditions—particularly language and the distance to the central city, which reflects accessibility—play a critical role in this spatial association. Natural conditions, including elevation, contagion, and diversity, exert certain constraining effects, whereas economic conditions contribute only to a limited extent.

This study revealed the spatial association patterns and networked characteristics of heritage for Huizhou traditional villages, identified the intensity of various influencing factors on their heritage associations, and clarified the key drivers for the formation and development of these spatial associations of heritage. It provides scientific, reliable theoretical support, and a practical basis for formulating policies for the coordinated protection and development of traditional villages, thereby improving the coordinated protection and efficient utilisation of traditional village heritage resources and promoting the living inheritance and sustainable development of traditional village heritage culture.

However, this study had some limitations. The heritage spatial association of Huizhou traditional villages is complex and has multiple drivers. This study quantitatively examined 10 factors selected from three dimensions—natural, social, and economic—that affect the heritage spatial association of Huizhou traditional villages; other factors were not considered. Additionally, this paper quantitatively analysed the impacts of natural, social, and economic factors on the heritage spatial association without considering their interactive effects; this requires investigation in future research. Heritage corridors can effectively promote the integrated conservation and cultural transmission of traditional village heritage. Therefore, the next step will be to investigate the scientific construction of heritage scenic corridors to strengthen the holistic protection and utilisation of Huizhou traditional villages. To ensure data consistency and maintain the rigour of the study, future research will continue to track updates and incorporate the sixth batch of nationally recognised traditional villages into the research scope, thereby enabling further investigation into this topic.

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References

1. Fang, Q.L.; Li, Z. Cultural Ecology Cognition and Heritage Value of Huizhou Traditional Villages. *Heliyon* **2022**, *8*, 12.
2. Wu, C.; Chen, M.; Zhou, L.; Liang, X.; Wang, W. Identifying the Spatiotemporal Patterns of Traditional Villages in China: A Multiscale Perspective. *Land* **2020**, *9*, 449.
3. Zhao, W.; Xiao, D.; Li, J.; Xu, Z.; Tao, J. Research on Traditional Village Spatial Differentiation from the Perspective of Cultural Routes: A Case Study of 338 Villages in the Miao Frontier Corridor. *Sustainability* **2024**, *16*, 5298.
4. Zhang, Y.; Wu, Z. The Reproduction of Heritage in a Chinese Village: Whose Heritage, Whose Pasts? *Int. J. Herit. Stud.* **2015**, *22*, 1–14.
5. Long, H.L.; Tu, S.S.; Ge, D.Z.; Li, T.T.; Liu, Y.S. The Allocation and Management of Critical Resources in Rural China under Restructuring: Problems and Prospects. *J. Rural Stud.* **2016**, *45*, 392–412.
6. Nie, Z.; Chen, C.; Pan, W.; Dong, T. Exploring the Dynamic Cultural Driving Factors Underlying the Regional Spatial Pattern of Chinese Traditional Villages. *Buildings* **2023**, *13*, 3068.
7. Ruan, Y.S.; Yuan, F. Heading to the New-Water-Town-Era-Conservation and Development of The Historic Water Towns South of the Yangtze River. *Urban Plan. Forum* **2010**, *2*, 35–40.
8. Duan, J.; Yin, M.; Tao, A.J.; Jiang, Y.; Fan, Z.X. Localized Preservation and Transformation of Characteristic Rural Settlements: Perspective Shift, Implementation Path, and Policy Suggestions. *Urban Plan. Forum* **2021**, *2*, 25–32.
9. Fan, J.; Zheng, B.; Yuan, H.; Zhang, B.; Zhang, P. Spatial Connectivity and Development Potential of Traditional Villages in Clustered Areas: A Case Study of Qiandongnan Prefecture. *Land* **2025**, *14*, 1929.
10. Wang, Q.; Yuan, Q.; Li, Z. Spatial Relationships of Traditional Regional Dwellings in Huizhou District. *npj Herit. Sci.* **2025**, *13*, 238.
11. Xu, Q.; Wang, J. Recognition of Values of Traditional Villages in Southwest China for Sustainable Development: A Case Study of Liufang Village. *Sustainability* **2021**, *13*, 7569.
12. Song, J.; Zhu, Y.; Chu, X.; Yang, X. Research on the Vitality of Public Spaces in Tourist Villages Through Social Network Analysis: A Case Study of Mochou Village in Hubei, China. *Land* **2024**, *13*, 359.
13. Huang, X.; Gu, Y. Revisiting the Spatial Form of Traditional Villages in Chaoshan, China. *Open House Int.* **2020**, *45*, 3.
14. Pei, Y.; Gong, K.; Leng, J. Study on the Inter-Village Space of a Traditional Village Group in Huizhou Region: Hongguan Village Group as an Example. *Front. Archit. Res.* **2020**, *9*, 588–605.
15. Li, J.; Chu, J.; Wang, Y.; Ma, M.; Yang, X. Reconstruction of Traditional Village Spatial Texture Based on Parametric Analysis. *Wirel. Commun. Mob. Comput.* **2022**, *2022*, 5151421.
16. Nie, Z.; Li, N.; Pan, W.; Yang, Y.; Chen, W.; Hong, C. Quantitative Research on the Form of Traditional Villages Based on the Space Gene—A Case Study of Shibadong Village in Western Hunan, China. *Sustainability* **2022**, *14*, 8965.
17. Gao, J.; Wu, B. Revitalizing Traditional Villages Through Rural Tourism: A Case Study of Yuanjia Village, Shaanxi Province, China. *Tour. Manag.* **2017**, *63*, 223–233.
18. Li, G.; Chen, B.; Zhu, J.; Sun, L. Traditional Village Research Based on Culture-Landscape Genes: A Case of Tujia Traditional Villages in Shizhu, Chongqing, China. *J. Asian Archit. Build. Eng.* **2024**, *23*, 325–343.
19. Yang, L.G.; Hu, Y.L.; Wu, X.F.; Hu, J. Cultural Landscape Gene Production Process and Mechanism of Dong Traditional Village: A Case Study of Huangdu Village. *J. Nat. Resour.* **2023**, *38*, 1164–1177.
20. Su, H.; Wang, Y.; Zhang, Z.; Dong, W. Characteristics and Influencing Factors of Traditional Village Distribution in China. *Land* **2022**, *11*, 1631.
21. Bian, J.; Chen, W.; Zeng, J. Spatial Distribution Characteristics and Influencing Factors of Traditional Villages in China. *Int. J. Environ. Res. Public Health* **2022**, *19*, 4627.
22. Zhang, H. The Spatial Distribution and Evolution of Traditional Villages Based on Remote Sensing Technology. *Mob. Inf. Syst.* **2022**, *2022*, 8022002.
23. Chen, W.; Yang, L.; Wu, J.; Wu, J.; Wang, G.; Bian, J.; Liu, Z. Spatio-Temporal Characteristics and Influencing Factors of Traditional Villages in the Yangtze River Basin: A Geodetector Model. *Herit. Sci.* **2023**, *11*, 111.
24. Chen, Y.; Li, R. Spatial Distribution and Type Division of Traditional Villages in Zhejiang Province. *Sustainability* **2024**, *16*, 5262.
25. Fu, J.; Zhou, J.; Deng, Y. Heritage Values of Ancient Vernacular Residences in Traditional Villages in Western Hunan, China: Spatial Patterns and Influencing Factors. *Build. Environ.* **2021**, *188*, 107473.
26. Liu, S.; Ge, J.; Bai, M.; Yao, M.; He, L.; Chen, M. Toward Classification-Based Sustainable Revitalization: Assessing the Vitality of Traditional Villages. *Land Use Policy* **2022**, *116*, 106060.

27. Long, T.; Işık, C.; Yan, J.; Zhong, Q. Promoting the Sustainable Development of Traditional Villages: Exploring the Comprehensive Assessment, Spatial and Temporal Evolution, and Internal and External Impacts of Traditional Village Human Settlements in Hunan Province. *Heliyon* **2024**, *10*, 11.
28. Lu, Y.; Ahmad, Y. Heritage Protection Perspective of Sustainable Development of Traditional Villages in Guangxi, China. *Sustainability* **2023**, *15*, 3387.
29. Li, J.S.; Wang, X.R.; Li, X.J. Spatial Distribution Characteristics and Influencing Factors of Chinese Traditional Villages. *Econ. Geogr.* **2020**, *40*, 143–153.
30. Huang, J.Y.; Wang, N.N. Method for Constructing a Protection System for Traditional Villages in Concentrated and Connected Areas: Taking the Demonstration Area of Centralized Protection and Utilization of Traditional Villages in Huangnan Tibetan Autonomous Prefecture of Qinghai Province as an Example. *Planners* **2023**, *39*, 123–130.
31. Chang, G.Y.; Hu, Y. Exploring the Protection and Development of Traditional Villages Cluster. *Urban Dev. Stud.* **2020**, *27*, 7–11.
32. Shen, C.Y.; Lu, Q.R.; Chen, Q.X.; Zhang, M.Y. Spatial Identification and Planning Strategy of Traditional Village Cluster Areas: A Case Study of Mountainous and Hilly Regions in Zhejiang Province. *Geogr. Res.* **2024**, *43*, 446–461.
33. Zhang, D.Y.; Zhang, W.J.; Chen, D.L. Analysis and Exploration of the Concept of Traditional Settlement Protection and Development Cluster Mode in the New Period. *Urban Dev. Stud.* **2022**, *29*, 16–21+39.
34. Sahin Körmeçli, P. Understanding the Historic Center by Using Network Analysis with Mental Mapping Method: The Case Study of Amasra, Turkey. *Sustainability* **2024**, *16*, 5387.
35. Zhao, L.; Li, Y.; Zhang, N.; Zhang, Z. Public Policies and Conservation Plans of Historic Urban Landscapes Under the Sustainable Heritage Tourism Milieu: Discussions on the Equilibrium Model on Kulangsu Island, UNESCO World Heritage Site. *Built Herit.* **2023**, *7*, 6.
36. Sladowski, G.; Szewczyk, B.; Barnaś, K.; Kania, O.; Barnaś, J. The Boyen Fortress: Structural Analysis of Selecting Complementary Forms of Use for a Proposed Adaptive Reuse Project. *Herit. Sci.* **2021**, *9*, 76.
37. Wierczynska, K.; Jakubowski, A. Individual Responsibility for Deliberate Destruction of Cultural Heritage: Contextualizing the ICC Judgment in the Al-Mahdi Case. *Chin. J. Int. Law* **2017**, *16*, 695–721.
38. Chang, Q. Evolution of Peak Palace-Fortress in Tibet: The Reappearance of the Sangzhutse Palace-Fortress and Design of the Fortress Museum. *Built Herit.* **2017**, *1*, 36–49.
39. Tavares, D.S.; Alves, F.B.; Vásquez, I.B. The Relationship Between Intangible Cultural Heritage and Urban Resilience: A Systematic Literature Review. *Sustainability* **2021**, *13*, 12921.
40. Ginzarly, M.; Pereira Roders, A.; Teller, J. Mapping Historic Urban Landscape Values Through Social Media. *J. Cult. Herit.* **2019**, *36*, 1–11.
41. Sun, Y.; Ou, Q. Research on the Traditional Zoning, Evolution, and Integrated Conservation of Village Cultural Landscapes Based on “Production-Living-Ecology Spaces”—A Case Study of Villages in Meicheng, Guangdong, China. *Open Geosci.* **2021**, *13*, 1303–1317.
42. Qi, J.; Lu, Y.; Han, F.; Ma, X.; Yang, Z. Spatial Distribution Characteristics of the Rural Tourism Villages in the Qinghai-Tibetan Plateau and Its Influencing Factors. *Int. J. Environ. Res. Public Health* **2022**, *19*, 9330.
43. Sung, C.H.; Liaw, S.C. A GIS Approach to Analyzing the Spatial Pattern of Baseline Resilience Indicators for Community (BRIC). *Water* **2020**, *12*, 1401.
44. Malinowski, M.; Smoluk-Sikorska, J. Spatial Relations Between the Standards of Living and the Financial Capacity of Polish District-Level Local Government. *Sustainability* **2020**, *12*, 5.
45. Wang, J.; Zhang, Y.; Yang, G.; Wang, Y.; Cheng, X.; Xu, B. Spatial Reconstruction of Traditional Villages Towards Synergistic Development in the Fuchun River Basin Based on the Gravity Model. *Land* **2023**, *12*, 1037.
46. Ye, Q.; Li, J.; Kong, X.; Zhang, S. Identification and Optimization of the Spatial Structure of Urban and Rural Settlements from a Hierarchical Network Perspective. *Land* **2021**, *10*, 1177.
47. Guo, Y.L.; Wang, Q. Study on Spatial Patterns of Gravity and Potential of Towns in the Upper Reaches of Min River. *Artif. Intell. Sci. Eng.* **2016**, *41*, 155–161.
48. Miao, J.J.; Zhao, X. Empirical analysis of urban space determined by “urban quality”. *J. Financ. Econ.* **2005**, *31*, 127–135.
49. Duran-Fernandez, R.; Santos, G. Gravity, distance, and traffic flows in Mexico. *Res. Transp. Econ.* **2014**, *46*, 30–35.
50. Buczkowska, S.; Coulombel, N.; de Lapparent, M. A comparison of Euclidean Distance, Travel Times, and Network Distances in Location Choice Mixture Models. *Netw. Spat. Econ.* **2019**, *19*, 1215–1248.
51. Dong, J.; Li, C. Structure Characteristics and Influencing Factors of China’s Carbon Emission Spatial Correlation Network: A Study Based on the Dimension of Urban Agglomerations. *Sci. Total Environ.* **2022**, *853*, 158613.

52. Krackardt, D. QAP Partialling as a Test of Spuriousness. *Soc. Netw.* **1987**, *9*, 171–186.
53. Chen, X.; Xie, W.; Li, H. The Spatial Evolution Process, Characteristics and Driving Factors of Traditional Villages from the Perspective of the Cultural Ecosystem: A Case Study of Chengkan Village. *Habitat Int.* **2020**, *104*, 102250.
54. Zhang, D.; Zhang, X.; Teng, L.; Ma, W.; Tan, L.; Li, H. Distribution Characteristics and Influencing Factors of Traditional Villages in the Lingnan Region of China. *Buildings* **2025**, *15*, 978.
55. Jia, A.; Liang, X.; Wen, X.; Yun, X.; Ren, L.; Yun, Y. GIS-Based Analysis of the Spatial Distribution and Influencing Factors of Traditional Villages in Hebei Province, China. *Sustainability* **2023**, *15*, 9089.
56. Frank, S.; Fürst, C.; Koschke, L.; Witt, A.; Makeschin, F. Assessment of Landscape Aesthetics—Validation of a Landscape Metrics-Based Assessment by Visual Estimation of the Scenic Beauty. *Ecol. Indic.* **2013**, *32*, 222–231.
57. Bosch, M.; Jalignot, R.; Chenal, J. Spatiotemporal Patterns of Urbanization in Three Swiss Urban Agglomerations: Insights from Landscape Metrics, Growth Modes and Fractal Analysis. *Landsc. Ecol.* **2020**, *35*, 879–891.
58. Zou, L.; Wang, J.; Bai, M. Assessing Spatial–Temporal Heterogeneity of China’s Landscape Fragmentation in 1980–2020. *Ecol. Indic.* **2022**, *136*, 108654.
59. Deng, L.; Zhang, Q.; Cheng, Y.; Cao, Q.; Wang, Z.; Wu, Q.; Qiao, J. Underlying the Influencing Factors Behind the Heterogeneous Change of Urban Landscape Patterns Since 1990: A Multiple Dimension Analysis. *Ecol. Indic.* **2022**, *140*, 108967.
60. Yun, J.; Liu, H.; Xu, Z.; Cao, X.; Ma, L.; Wen, L.; Wang, L. Assessing Changes in the Landscape Pattern of Wetlands and Its Impact on the Value of Wetland Ecosystem Services in the Yellow River Basin, Inner Mongolia. *Sustainability* **2022**, *14*, 6328.
61. Chang, Q. Structure and Prospective of Chinese Vernacular Architectural Pedigrees—An Objective Based on a Systematic Study of Sample Preservation and Holistic Regeneration. *Archit. J.* **2016**, *10*, 1–9.
62. Pan, Y.; Cai, M.F.; Shi, Y. The Analysis of the Characteristics of Traditional Settlement Landscape of Hainan Island Ethnic Group Based on Language Zone. *Chin. Landsc. Archit.* **2020**, *12*, 41–46.
63. Fang, Q.L.; Li, Z.; Huang, L. Spatial Distribution of National Traditional Villages in Huizhou Cultural Ecological Reserve and Its Influencing Factor Identification. *Ind. Constr.* **2024**, *54*, 105–113.
64. Yuan, X.; Li, Y.; Song, Y.; Lu, H.; Wang, Y.; Ge, B.; Wang, J. Spatial Distribution Characteristics and Driving Factors of 777 Traditional Villages in Yunnan Province: A Study Based on GWR Model and Geodetector. *Land* **2024**, *13*, 2004.
65. Wang, L.; Wen, C. Traditional Villages in Forest Areas: Exploring the Spatiotemporal Dynamics of Land Use and Landscape Patterns in Enshi Prefecture, China. *Forests* **2021**, *12*, 65.
66. Shao, H.Q.; Wang, Z.F. Spatial Network Structure of Human Settlement Environment and Its Driving Factors of Urban Agglomerations in Middle Reaches of Yangtze River. *Resour. Environ. Yangtze Basin* **2022**, *31*, 983–994.
67. Zhang, M.D.; Xi, S.J. Characteristics of Urban Industrial Spatial Linkage Network in Northeast China. *Areal Res. Dev.* **2022**, *41*, 18–24.
68. Situ, S.J. *Lingnan Historical Human Geography: A Comparative Study of the Guangfu, Hakka, and Hoklo Ethnic Groups*; Sun Yat-sen University Press: Guangzhou, China, 2001; pp. 15–16.
69. Chang, Q. An overview of the pedigree composition and inheritance prospects of vernacular architecture in China: Based on systematic specimen preservation and holistic regeneration goals. *Archit. J.* **2016**, *10*, 1–9.
70. Yin, X.; Hou, S.; Han, X.; Kuang, B. Exploring the Spatial Distribution of Traditional Villages in Yunnan, China: A Geographic-Grid MGWR Approach. *Buildings* **2026**, *16*, 295.
71. Feng, M.; Zhao, W.; Zhang, T. Construction and Optimization Strategy of County Ecological Infrastructure Network Based on MCR and Gravity Model—A Case Study of Langzhong County in Sichuan Province. *Sustainability* **2023**, *15*, 8478.
72. Wang, Q.; Yang, C.; Wang, J.; Tan, L. Tourism in Historic Urban Areas: Construction of Cultural Heritage Corridor Based on Minimum Cumulative Resistance and Gravity Model—A Case Study of Tianjin, China. *Buildings* **2024**, *14*, 2144.
73. Yao, P.; Sun, Y.H.; Xi, Q.H. Research on Ecological Scenic Byways Planning Coupled with Multiple Values-Taking Ulanqab Four Horizontal Traffic Belt as an Example. *Chin. Landsc. Archit.* **2019**, *35*, 101–106.
74. Zhang, B.; Zhou, L.; Yin, Z.; Zhou, A.; Li, J. Study on the Correlation Characteristics Between Scenic Byway Network Accessibility and Self-Driving Tourism Spatial Behavior in Western Sichuan. *Sustainability* **2023**, *15*, 14167.
75. Gao, C.; Wu, Y.; Bian, C.; Gao, X. Spatial Characteristics and Influencing Factors of Chinese Traditional Villages in Eight Provinces the Yellow River Flows Through. *River Res. Appl.* **2023**, *39*, 1255–1269.

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