

Article

Study on the Distribution Characteristics and Cultural Landscape Zoning of Traditional Villages in North Henan Province

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Abstract: Traditional villages contain rich natural and humanistic information, and exploring the spatial distribution characteristics and cultural landscape zoning of traditional villages can provide scientific support for their centralized and continuous protection and renewal and sustainable development. In this study, 326 traditional villages in the northern Henan region were taken as the research object, followed by analyzing their spatial distribution characteristics by using geostatistical methods, such as nearest-neighbor index, imbalance index, geographic concentration index, etc., combining the theory of cultural landscape to construct the traditional villages' cultural factor index system, extracting the cultural factors of the traditional villages to form a database, and adopting the K-means clustering method to divide the region. The results show that the spatial distribution of traditional villages in northern Henan tends to be concentrated overall, with an uneven distribution throughout the region. The density is highest in the northwestern part of Hebi City and lower in the central and southern parts of Xinxiang City, Neihuang County, and Puyang City. Based on the cultural factor index system, the K-means algorithm divides the traditional villages in northern Henan into six clusters. Among them, the five cultural factors of topography and geomorphology, building materials, courtyard form, structural system, and altitude and elevation are the most significant, and they are the cultural factors that dominate the landscape of the villages. There is a significant correlation between topography, altitude, and other cultural factors, while the correlation between the street layout and other factors is the lowest. Based on the similarity between the clustering results and the landscape characteristics, the traditional villages in northern Henan can be divided into the stone masonry building culture area along the Taihang Mountains, the brick and stone mixed building culture area in the low hills of the Taihang Mountains, the brick and wood building culture area in the North China Plain, and the raw soil building culture area in the transition zone of the Loess Plateau.

Keywords: traditional villages in northern Henan; spatial distribution characteristics; cultural landscape; K-means clustering; regional division



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1. Introduction

Traditional villages refer to villages that were formed relatively early (before 1912), have a wealth of tangible and intangible cultural heritage, and have certain historical,

cultural, scientific, artistic, social, and economic value, as well as regional cultural characteristics or traditional landscapes. In the process of rapid urbanization and industrialization, traditional villages have suffered severe internal and external environmental impacts and are caught in a dilemma between inheritance and renewal. For the study of traditional villages, international scholars studying traditional villages focus on the protection and reuse of vernacular architecture [1–3], the investigation and maintenance of the landscape of rural settlements [4–6], the spatial distribution and typological characteristics of rural settlements [7–9], the physical environment and climate adaptability of rural settlements [10–13], the cultural landscape genes of rural settlements and the laws of their formation and development [14,15], as well as the sustainability of tourism development in traditional villages [16–18]. Chinese scholars' research on traditional villages is more diverse in content, mainly including the characteristics, evolution, and formation mechanism of the spatial form of traditional villages [19,20], protection strategies and specific measures for traditional villages [21,22], models and methods for tourism development in traditional villages [23,24], the form and function of public space in traditional villages [25,26], the spatial distribution of traditional villages and its influencing factors [27,28], the types and zoning of traditional villages [29,30], the landscape genes of traditional villages [31], and the aesthetic value of the landscape of traditional villages [32].

Cultural landscape is a synthesis of a certain period of time created by the natural and human factors of a certain geographic area, and its distribution, connection, and origin can be understood through the classification of landscape elements [33]. The current research on cultural landscape is mainly carried out from three perspectives: perception, value, and protection of cultural landscape. Cultural landscape perception should be analyzed based on the user's perspective, as over time people's preference for cultural landscapes presents diversification, to identify the perception of cultural landscapes that can provide more in-depth understanding of its regional culture and development rules in order to develop management strategies [34–36]. Cultural landscape value is the attribute of cultural landscape perception, which can be divided into tangible and intangible, and can be accurately captured and quantified through landscape value mapping, and it is beneficial to maintain or enhance the uniqueness of the cultural landscape by conducting surveys and inventories of the value of cultural landscape [37–39]. Cultural landscape value informs the public about the type of land use, lifestyle, historical events, etc. and enhances the benefits of cultural landscapes by increasing the value and promoting the protection of cultural landscapes [40,41].

To summarize, it is the mainstream trend to carry out research on the spatial pattern and protection and renewal of traditional villages based on the theory of cultural landscape, and most of the research adopts quantitative and spatial analysis techniques to perceive and identify the characteristics and distribution patterns of cultural landscape. In Henan Province, the research on the cultural landscape of traditional villages is mostly carried out in the scope of the province, focusing on the macro spatial distribution at the geographic level, but lacking multiscale research at the settlement level (meso), the residential architecture level (micro), and the socio-cultural level, and the identification and classification of the cultural factors are mostly carried out by the method of qualitative description, which is comparatively insufficient in terms of scientificity. K-means clustering is a partitioned cluster analysis algorithm that allows random selection of specified K centers of mass in a dataset by evaluating the distance of each data point from all selected centers of mass and assigning each data point as a member of the cluster of that center of mass to the nearest center of mass. The center of the cluster is re-evaluated when assigning new members to the cluster. With iterative execution of repeated computations until convergence to a local

minimum cluster membership is stabilized, this clustering algorithm has been widely used in the fields of medicine, finance, and urban development [42–45].

Therefore, the first step of this study is to initially grasp the macro geographic distribution of traditional villages in northern Henan through GIS spatial analysis techniques. The second step is to construct the cultural factor index system based on the cultural landscape theory, extract the cultural factors of 326 traditional villages in northern Henan, and quantify the value assigned to each cultural factor index. In the third step, the K-means algorithm is used to cluster the cultural factors, and the correlation analysis of the cultural factors is used to analyze the dominant factors affecting the clustering and the interaction between the cultural factors. Finally, based on the clustering results, the traditional villages in northern Henan are divided into cultural landscape zones, revealing their spatial differentiation patterns. This study has formed a research path of “geospatial distribution–cultural factor identification and extraction–cluster analysis–cultural landscape zoning”, exploring the cultural landscape characteristics of traditional villages in the northern Yu region from multiple spatial scales in a scientific way and type zoning. It is hoped that this will provide a reference for the centralized and continuous protection and renewal of traditional villages in other regions, promote the sustainable development of the cultural landscape of traditional villages, and pass on quality traditional culture.

2. Materials and Methods

2.1. Regional Overview and Data Sources

North Henan refers to the area north of the Yellow River in Henan Province, including the six cities of Anyang, Xinxiang, Jiaozuo, Puyang, Hebi, and Jiyuan. North Henan is located in the transition stage from the second to the third terrace of China’s geomorphology, with the elevation gradually decreasing from west to east and from north to south from the Taihang Mountains to the North China Plain, and mainly contains three types of landscapes: mountainous, hilly, and plains. The climate is hot in summer and cold in winter, with four distinct seasons, an average annual humidity of 68%, an average annual rainfall of 650 mm, being dry with little rain, and the most common wind direction throughout the year is northeast east, with an average annual wind speed of 2.45 m/s [46]. The Haihe River system and the Yellow River system cover the whole area of northern Henan. By the end of 2023, the total land area of northern Henan was 28,500 square kilometers, with a total population of 21.03 million (<https://baike.baidu.com/item/%E8%B1%AB%E5%8C%97/8337823>, accessed on 24 March 2025).

Located at the junction of the provinces of Shanxi, Hebei, and Henan, the northern Henan region has given rise to a regional landscape of diverse cultural fusion and development, which has given rise to a large number of traditional villages with their own unique characteristics. By the end of 2024, a total of 101 villages had been selected for inclusion in the List of Chinese Traditional Villages (Ministry of Housing and Urban-Rural Development of the People’s Republic of China <https://www.mohurd.gov.cn/>), and 263 villages had been selected for inclusion in the Henan Province List of Traditional Villages (Henan Provincial Department of Housing and Urban-Rural Development <https://hnjs.henan.gov.cn/>). After field research, an additional 59 traditional villages with high historical and cultural value that were not on the list were added. After screening, 326 traditional villages were finally selected as samples for research.

Village latitude and longitude coordinates were transformed using MapLocation (<https://map.yanue.net/>), and administrative boundaries of the study area were extracted through the Aliyun data visualization platform (http://datav.aliyun.com/portal/school/atlas/area_selector, accessed on 24 March 2025) and formatted using MapShaper (<https://mapshaper.org/>). Digital elevation model (DEM) data were obtained from the Data

Cloud Platform of the Chinese Academy of Sciences (<https://www.gscloud.cn/>), according to which elevation, slope, slope direction, river network, and other data were extracted, and the spatial distribution of traditional villages in northern Yulin was demonstrated using ArcGIS 10.8 after the processing of the above data (Figure 1). In addition, the information on village morphology, residential architecture, and social culture was obtained through the Digital Museum of Chinese Traditional Villages (<https://www.dmctv.cn/>), local histories, genealogies of ethnic groups, and field surveys.

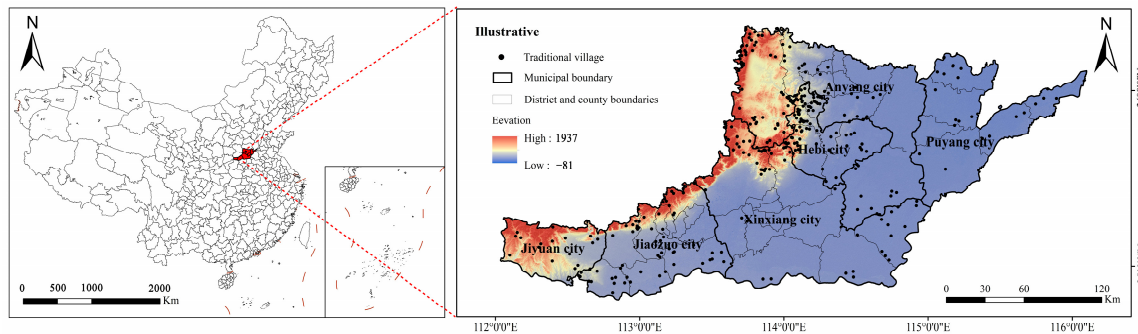


Figure 1. Schematic diagram of the location and distribution of traditional villages in northern Henan Province.

2.2. Research Methodology

2.2.1. Nearest Neighbor Index

Traditional villages can be abstracted as point-like elements with three spatial distribution types, random, uniform, and cohesive, which are usually measured by the nearest neighbor point index (R) [47]. The nearest neighbor point index is calculated as

$$R = \bar{r}_i / r_E \quad (1)$$

$$\bar{r}_E = \frac{1}{2\sqrt{m/A}} = \frac{1}{2\sqrt{D}} \quad (2)$$

where: $\bar{r}_i$ represents the average value of the distance between each point and its nearest neighbor; r_E is the theoretical nearest neighbor distance when point elements are randomly distributed; m represents the number of point elements; A represents the study area; D represents the number of point elements per unit area. When $R = 1$, point elements tend to be randomly distributed; when $R > 1$, point elements tend to be uniformly distributed; and when $R < 1$, point elements tend to be cohesively distributed.

2.2.2. Imbalance Index

The imbalance index (S) can reflect the degree of balanced distribution of traditional villages in the cities of northern Henan, calculated as follows:

$$S = \frac{\sum_{i=1}^n Y_i - 50(n+1)}{100n - 50(n+1)} \quad (3)$$

where: n denotes the number of prefecture-level municipalities in the region, and Y_i denotes the cumulative percentage of the number of traditional villages in each prefecture-level municipality to the i th position in the total number of traditional villages in the whole region in descending order. S takes values from 0–1: when $S = 0$, traditional villages are distributed evenly across municipalities, and when $S = 1$, all traditional villages are concentrated in a single municipal area.

2.2.3. Geographic Concentration Index

The geographical concentration index (G) indicates the degree of concentration of the distribution of research objects, and is calculated as follows:

$$G = 100 \sqrt{\sum_{i=1}^n \left(\frac{X_i}{T} \right)^2} \quad (4)$$

where: X_i denotes the number of traditional villages owned by the i th prefecture-level city; T is the total number of traditional villages; n denotes the number of prefecture-level cities in the region. The larger the value of G , the higher the degree of concentration, assuming that the average distribution of traditional villages is found when $G = G_0$; if $G > G_0$, it means that traditional villages are concentrated, and the opposite is more scattered.

2.2.4. Kernel Density Analysis

Kernel density analysis calculates the density of point elements around each output raster, which can intuitively reflect the degree of centralized discreteness of traditional villages [48], the formula is

$$F(x, y) = \frac{1}{nh^2} \sum_{i=1}^n K\left(\frac{d_i}{h}\right) \quad (5)$$

where: $F(x, y)$ is the kernel density estimate at position (x, y) ; d_i is the distance from position (x, y) to the i th observation position; K is the kernel density function; h is the bandwidth or smoothing parameter; n is the observed value.

2.2.5. K-Means Clustering Algorithm

K-means cluster analysis is a center-based clustering algorithm that iteratively groups samples into K classes such that the sum of the distances between each sample and the center or mean of the class to which it belongs is minimized, and it is capable of automatically classifying a batch of sample data according to their closeness in nature in the absence of a priori knowledge [49]. First, K initial village clustering centers C_i ($1 \leq i \leq K$) are randomly selected from the sample, and the number of village centers is calculated as

$$K = \sqrt{n/2} \quad (6)$$

where n is the total number of sample villages and K is the number of initial clustering centers.

Then calculate the Euclidean distance between the remaining village samples and the clustering center C_i , find out the closest data sample village to the clustering center C_i , and use this as a basis for calculating to get the inter-village similarity, and assign the data sample villages to the clusters corresponding to the clustering center C_i , and the Euclidean distance is calculated by the formula

$$d(x, C_i) = \sqrt{\sum_{j=1}^m (x_j - C_{ij})^2} \quad (7)$$

where x is any random village, C_i is any clustering center, m value is the number of sample classification dimensions, x_j , C_{ij} is the j th attribute value of x and C_i .

Finally, the number of village cluster K values is optimally adjusted, and the sum of squared error (SSE) of all clusters is calculated. The cluster center position is continuously updated based on the similarity between the sample and the cluster center to reduce the

SSE of the cluster, until the cluster center C_i no longer changes or the maximum number of iterations is reached, the formula is

$$SSE = \sum_{i=1}^K \sum_{x \in C_i} |d(x, C_i)|^2 \quad (8)$$

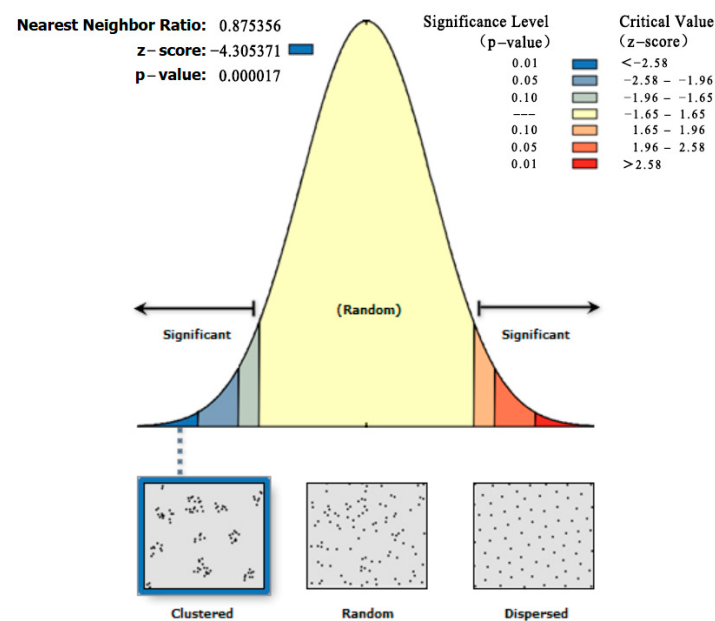
where K is the number of clusters, and then the SSE value is compared by setting different K values for multiple trials, where the smaller the SSE value the better the clustering effect.

3. Results

3.1. Spatial Distribution Characteristics of Traditional Villages in Northern Henan

3.1.1. Types of Spatial Distribution

Spatial distribution type analysis can reflect the spatial distribution correlation and spatial aggregation characteristics of traditional villages. Based on ArcGIS, the average actual closest neighbor distance of traditional villages in the northern Henan region is $\bar{r}_i = 4092.31$ m, which is smaller than the average theoretical closest neighbor distance $\bar{r}_E = 4675.02$ m, and the closest neighbor index $R = 0.875$, i.e., $R < 1$, the Z -value is -4.305 , and the level of significance $p \approx 0$. Then, the probability of randomly generating this aggregation pattern is less than 1% (Figure 2), which indicates that the traditional villages in the northern Henan region are close to each other in the space, and the overall spatial distribution tends to be aggregated.



Given the z-score of -4.30537089402, there is a less than 1% likelihood that this clustered pattern could be the result of random chance.

Figure 2. Summary map of average nearest neighbors for traditional villages in northern Henan.

3.1.2. Uniformity of Spatial Distribution

The imbalance index can show the degree of equilibrium in the distribution of point elements in different regions. According to Equations (3) and (4), the imbalance index of traditional villages in northern Henan $S = 0.340$, the geographic concentration index $G = 45.805$, $G_0 = 40.825$, $G > G_0$, and the two indexes indicate that the traditional villages in northern Henan are centrally distributed at the municipal scale and have a high degree of concentration, while the distribution is more unbalanced in the whole region. According

to the statistical data to generate traditional village Lorenz curve (Figure 3), the Lorenz curve is relatively far away from the uniform distribution line, and the curve protrusions in Hebi, Anyang, Jiaozuo, and Xinxiang are relatively large, while they tend to flatten out in Puyang and Jiyuan, indicating that traditional villages are unevenly distributed within each region. Puyang and Jiyuan have relatively few traditional villages, accounting for only 11.96%.

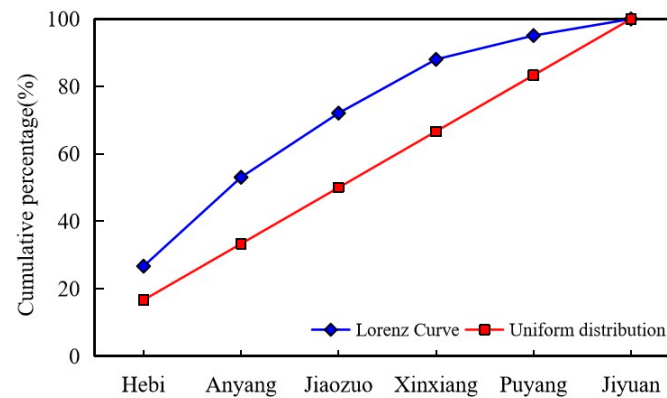


Figure 3. Lorenz curve of traditional village distribution in northern Henan.

3.1.3. Spatial Distribution Pattern

The spatial distribution pattern of traditional villages in northern Henan was revealed by kernel density analysis, which was used to analyze 326 traditional villages in northern Henan in ArcGIS 10.8 (Figure 4). A high-density agglomeration with the largest scale was formed in the northwestern part of Hebi City, and the second high-density agglomeration was mainly distributed in the hinterland of the Taihang Mountains in Linzhou City, Anyang City. In addition, the Taihang Mountains in the north of Jiaozuo City, the plains near the Yellow River in the south, the area along the main stream of the Wei River at the border between Xun County in Hebi City and Tangyin County in Anyang City, the area along the border between the southern part of Hua County in Anyang City and Changyuan City in Xinxiang City, as well as part of the areas with dense river networks, all formed sub-density agglomerations of different sizes of traditional villages, while the traditional villages in the other regions were more dispersed in their distribution.

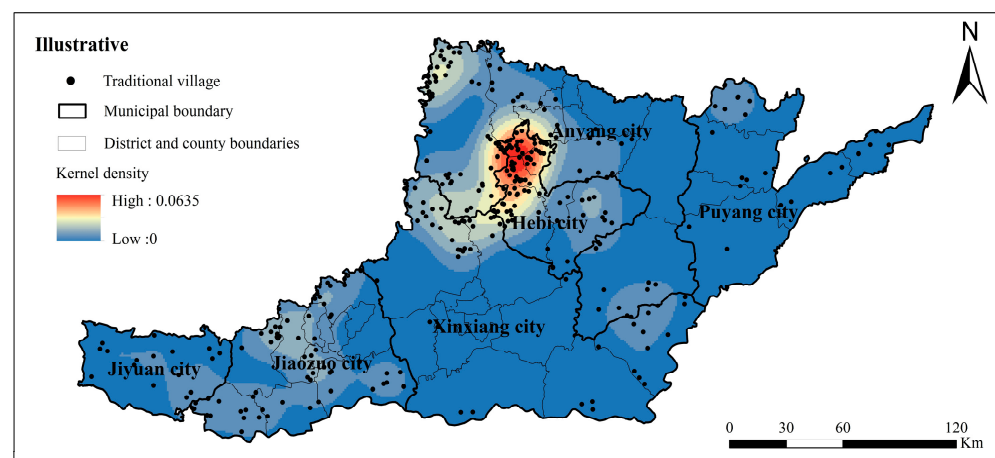


Figure 4. Kernel density estimation map of traditional villages in northern Henan.

3.2. *Traditional Villages in Northern Henan Clustering Zoning*

3.2.1. Extraction of Cultural Factors and Indicator System

The World Heritage Organization considers cultural landscapes to be a synthesis of nature and culture, combining both the materiality of nature and the immateriality of culture, and the components of cultural landscapes include material entities such as natural environments, settlements, buildings, etc., as well as intangible elements such as history, culture, etc. [50]. The selection of indicators for the classification of traditional village cultural landscapes is based on the main purpose of distinguishing the differences in the characteristics of traditional village landscapes, following the principles of consensus, representativeness, and territoriality. The factors with “impressionability” and “recognizability” are used as the key to analyze and interpret the cultural landscape of traditional villages, so as to achieve the purpose of traditional village clustering and zoning. Studies have shown that, among the factors affecting the formation of traditional village landscape, the role of geographical environment is the most important, and the factors of village form and residential architecture level can show the cultural landscape characteristics more intuitively and recognizably [51]. In summary, the cultural factors are extracted from four levels: natural environment, village form, residential architecture, and social culture.

The natural environment is the most critical factor in shaping the traditional village landscape. The complex and steep topography of the Taihang Mountain region in northern Henan Province creates a vertically variable three-dimensional climate, and the distance between the village site and the water source is generally the primary consideration, and the village landscapes within the same watershed are more similar due to population migration and cultural exchanges, so the natural environment level selects the four indicators of topography and geomorphology, altitude and elevation, river class, and river relationship. The morphological layout of traditional villages is the spatial macroscopic presentation of the village landscape, which is mainly reflected by four parts: village scale, morphological layout, village orientation, and street layout. Residential architecture is the spatial microconstruction entity of the village landscape, which is affected by topography, culture, resources, and other factors in different regions, resulting in intuitive differences in the courtyard form, building materials, roof shape, and structural system. The influence of social and cultural environment on traditional village landscape is subtle and profound. In many countries, the two dominant indicators of cultural zoning are language and religion, but in China, the concept of religion is not developed, and this indicator is not as significant as customs [52]. After in-depth field research and a literature review, it is found that the customs and habits of the northern region of Yu are closely related to the dialectal language family, and the similarities of values, festivals, customs, and living habits are higher in the same language family, and as a cultural factor, it is easier to identify. In addition, considering that the Central Plains region has a long history, a homogeneous folk system, and a fast-changing social environment, and that many villages assumed diverse industrial functions during the historical period, three indicator factors, namely, foundation date, dialectal family, and traditional industrial function, were selected. Finally, 15 cultural factors were identified for the landscape classification of traditional villages in northern Henan (Table 1). Based on geospatial visualization, field surveys, and literature review, morphological and typological methods were used to determine and extract the content classification of each cultural factor, and a spatial geographic information database was established (Table 2).

Table 1. Indicator system of cultural factors.

Level	Cultural Factor	Indicator Properties
environment	topography and geomorphology (TG)	1 = plains, 2 = low hills, 3 = mountains (mountain basins, river valleys, valley terraces, mountain slope), 4 = Loess Plateau
	altitude and elevation (AE)	1 = $AE \leq 200$ m, 2 = $200 < AE \leq 500$ m, 3 = $500 < AE \leq 800$ m, 4 = $AE > 800$ m
	river class (RC)	1 = class I river, 2 = class II river, 3 = class III river, 4 = class IV river, 5 = class V river, 6 = class VI river
	river relationship (RR)	1 = next to the river: ≤ 1.5 km from class I II river, ≤ 1.0 km from class III IV river; ≤ 0.5 km from class V VI river 2 = near the river: 1.5 km $<$ from class I II river ≤ 3 km, 1.0 km $<$ from class III IV river ≤ 2.5 km; 0.5 km $<$ from class V VI river ≤ 2.0 km 3 = far from river: >3 km from class I II river, >2.5 km from class III IV river; >2 km from class V VI river
village form	village scale (VS)	1 = $VS \leq 10$ ha, 2 = $10 < VS \leq 30$ ha, 3 = $30 < VS \leq 50$ ha, 4 = $50 < VS \leq 70$ ha, 5 = $VS > 70$ ha
	morphological layout (ML)	clustered (1 = row and column of clusters, 2 = compact clusters, 3 = dispersed clusters, 4 = fingerprints), striped (5 = unidirectional strips, 6 = multidirectional strips, 7 = circular strips), scattered (8 = free scattering, 9 = linear scattering)
	village orientation (VO)	1 = sitting north to south (including sitting northeast to southwest and northwest to southeast), 2 = sitting south to north (including sitting southeast to northwest and southwest to northeast), 3 = sitting east to west, 4 = sitting west to east, 5 = multifacing
	street layout (SL)	uniaxial (1 = horizontal extension, 2 = vertical lift), multiaxial (3 = multiaxial parallel, 4 = multiaxial convergence, 5 = cross intersection), regular network (6 = orthogonal network, 7 = radial network), irregular network (8 = freely extending, 9 = organic growth)
folk architecture	courtyard form (CF)	1 = “one”-type, “L”-type, 2 = triple courtyard, 3 = quadruple courtyard, 4 = multiple courtyards, cross courtyards, 5 = kiln house courtyard
	building materials (BM)	1 = earth and wood, 2 = stone and wood, 3 = brick and wood, 4 = mixed brick and stone, 5 = brick and earth, mixed earth and stone
	roof shape (RS)	1 = hanging mountain tile surface, 2 = hard mountain back tile surface, 3 = flat roof house, 4 = hoard roof house, 5 = slate surface, 6 = hard mountain combined tile surface
	structural system (SS)	1 = wood frame, 2 = wall, 3 = wood frame stone wall mix, 4 = wood frame arch coupon mix
social cultural	dialectal family (DF)	1 = shansi dialect hanxin area, 2 = zhongyuan dialect zhengkai area, 3 = zhongyuan dialect luosong area, 4 = zhongyuan dialect yanhe area
	foundation age (FA)	1 = Pre-Tang, 2 = Tang, 3 = Song, 4 = Yuan, 5 = Ming, 6 = Qing
	traditional industry function (IF)	1 = agricultural, 2 = forestry and pastoralism, 3 = military defense, 4 = transportation and trade, 5 = political and cultural, 6 = composite

Table 2. Results of extracting cultural factors from traditional villages in northern Henan (partial excerpt).

Village Name	TG	AE	RC	RR	VS	ML	VO	SL	CF	BM	RS	SS	DF	FA	IF
Yuyang Village	2	1	2	1	4	1	1	7	3	4	2	3	1	1	6
Ren Village	3	2	5	3	5	1	1	6	2	2	2	2	1	4	6
Chaoyang Village	3	4	6	2	1	2	5	8	1	2	5	2	1	5	2
Caomiao Village	3	3	6	1	1	5	4	1	1	2	5	2	1	5	1
Nanjie Village	1	1	2	1	2	1	1	6	4	3	6	1	2	3	4
Dahu Village	2	1	6	1	2	1	1	1	3	4	3	3	1	5	6
Feiquan Village	2	1	6	3	2	4	1	9	3	4	3	3	1	6	6
Wenpo Village	3	2	6	3	1	5	1	1	1	2	2	2	1	6	2
Zhengchang Village	1	1	5	2	4	1	1	6	4	3	6	1	2	5	1
Beizhu Village	1	1	5	2	4	1	1	6	4	3	6	1	1	2	1
Shuangmiao Village	3	4	6	3	2	2	1	8	1	2	4	2	1	2	2
Mogou Village	4	1	6	1	2	4	1	3	5	5	1	4	3	4	1
Duan Village	4	1	5	3	3	1	1	6	3	5	1	1	1	1	1
Liyu Village	3	2	6	1	2	7	5	1	1	2	2	2	1	5	1
Pingdian Village	3	3	4	1	2	2	1	1	2	2	2	2	1	5	4
Dache Village	1	1	2	2	5	2	1	6	4	3	6	1	2	6	1
Danguai Village	1	1	5	3	5	1	1	6	4	3	2	1	2	5	1
Wanglou Village	1	1	2	3	2	2	1	9	3	3	2	1	4	5	1
Shuangfang Village	4	2	6	1	1	5	1	1	1	1	1	1	1	5	2
Zhanghe Village	4	2	5	1	1	2	3	8	1	1	1	1	1	5	1

3.2.2. K-Means Cluster Analysis

The data of cultural factor indicators were imported into IBM SPSS Statistics 27.0 software for K-means cluster analysis, and the algorithm automatically standardized the data by setting the number of iterations (M) = 50 and the convergence criterion (C) = 0. Then, the error sum of squares of the class clusters was reduced by setting different values of K (2–10) for several experiments, and the SSE values of the multiple experiments were compared and an elbow diagram was plotted (Figure 5). When K = 2–5, the SSE value of each clustering scheme shows a sudden decrease, and when K = 6–10, the SSE value of each clustering scheme gradually tends to level off. Therefore, K = 6 is the “inflection point” of the number of clusters, and its corresponding SSE value is 2779.726, which belongs to a small level range, theoretically the best number of clusters, and the clustering results are basically in line with the actual situation of traditional villages in northern Henan, and the final clustering result is determined to be 6. Convergence in the clustering operation with K = 6 was achieved with the number of iterations (M) = 9, when the cluster centers no longer moved or moved only slightly. The maximum absolute coordinate change of any center is 0.000 and the minimum distance between initial centers is 9.327. The number of valid cases clustered was 326 and the number of missing cases was 0.

The German ethnographer Fritz Graebner suggested that “the cultural elements of the place of origin are strongly connected, and the cultural clusters spread and propagate more completely in all directions, combining with a specific place to form a cultural circle” [53]. Therefore, there is a phenomenon of cultural landscape intermingling at the edge of different clustered village clusters, which is characterized by two clusters at the same time. In addition, because K-means clustering is a clustering algorithm based on class centers, the effect of handling some edge points is general, so after the calculation, only the category attribution of the 17 villages is adjusted artificially according to the actual situation, which has less impact on the reproduction of the clustering results. The results of the adjusted cultural landscape type distribution of traditional villages show that: the frequency of Cluster 1 is 99, accounting for a percentage of 30.36%; the frequency of Cluster 2 is 34, accounting for a percentage of 10.43%; the frequency of Cluster 3 is 58, accounting

for a percentage of 17.79%; the frequency of Cluster 4 is 35, accounting for a percentage of 10.74%; the frequency of Cluster 5 is 31, accounting for a percentage of 9.51%; the frequency of Cluster 6 is 69, accounting for a percentage of 21.17%.

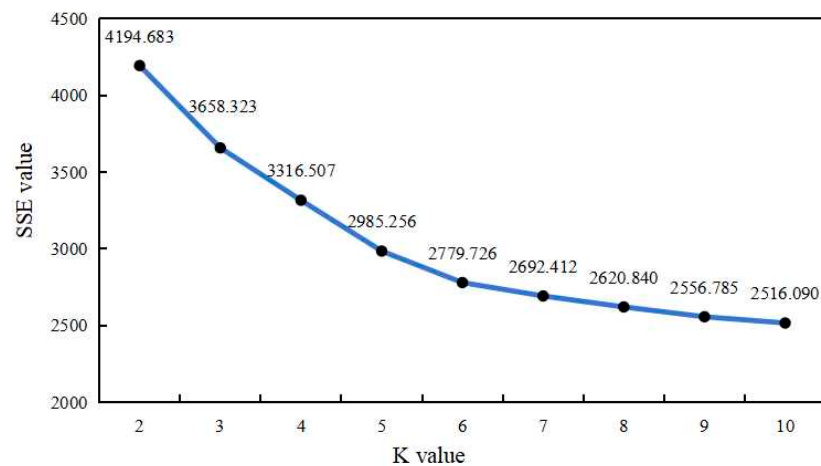


Figure 5. K value vs. SSE value elbow analysis plot.

GIS kernel density analysis was used to visually identify the spatial distribution characteristics of traditional villages of the six categories (Figure 6). It can be visualized that the traditional villages of the six different cultural landscapes show a clustering pattern in a small area. Cluster 1 traditional villages are mainly distributed in the plains of northern Henan, and are more concentrated in areas with dense river networks such as the Qin River Basin, Wei River Basin, and Jinti River Basin; Cluster 2, Cluster 3, and Cluster 5 traditional villages have a higher degree of overlap in their distribution areas and are concentrated in Boai County, Xiuwu County, Qinyang City, Huixian City, Weihui City, Qixian County, and Linzhou City, which are located along the Taihang Mountains; Cluster 4 traditional villages are mainly located in Jiyuan City, Mengzhou City, and Wenxian County in the overland area of the Loess Plateau in the western part of northern Henan Province; Cluster 6 traditional villages are mainly distributed in the low hills of the Taihang Mountains in Shancheng District, Heshan District, Qibin District, Long'an District, and Yindu District. It can be seen that there are many types of culturally significant villages along the Taihang Mountains in northern Henan, showing a blending of cultural landscapes, which are quite different from the cultural landscapes of traditional villages in the plains.

The results of the difference analysis of each indicator are further derived (Table 3). $p < 0.05$ indicates that the difference of cultural factors is significant, and the smaller the p -value is, the greater the difference between the categories, which means that the corresponding indicator will contribute more to the differentiation of clusters, and vice versa indicates that the data do not show any difference [54]. Based on this principle the p -values of the clustered items are processed into an importance indicator I and output graphically (Figure 7). The formula for calculating the importance indicator for specific clustered items is as follows:

$$I = \frac{-\log_{10}(p)}{\max[-\log_{10}(p)]} \quad (9)$$

where: p is the p -value in the ANOVA table and $\max[-\log_{10}(p)]$ represents the maximum value of $-\log_{10}(p)$.

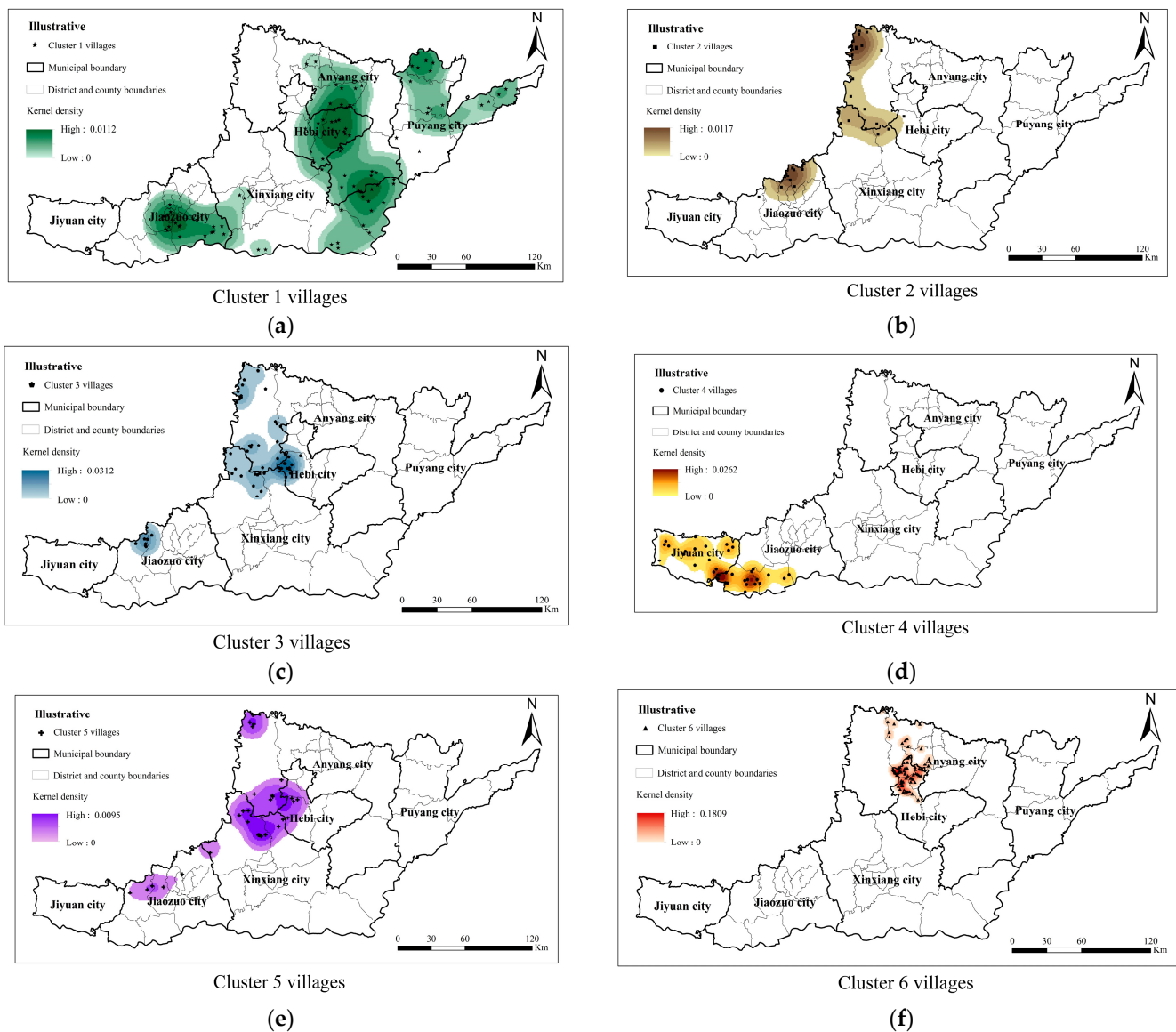
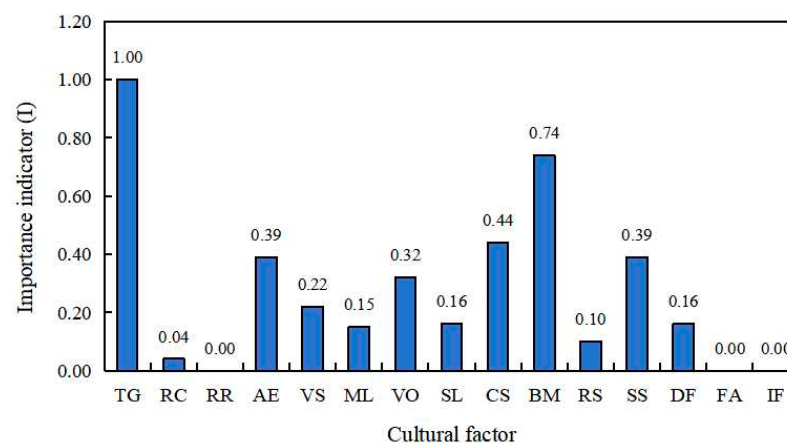


Figure 6. Cluster distribution of traditional villages in northern Henan Province. (a) Cluster 1 Traditional village distribution kernel density; (b) Cluster 2 Traditional village distribution kernel density; (c) Cluster 3 Traditional village distribution kernel density; (d) Cluster 4 Traditional village distribution kernel density; (e) Cluster 5 Traditional village distribution kernel density; (f) Cluster 6 Traditional village distribution kernel density.

According to the results of the analysis, it can be seen that indicators such as river class, river relationship, the foundation age, and traditional industry function are of low importance and are poorly reflected in the classification of clusters and the characteristics of clustered cultural landscapes, and there are significant differences among the categories of clustering in topography and geomorphology, building materials, the courtyard system, structural system, and altitude and elevation. The importance of the indicators is high, which indicates that these five variables have a greater role in the division of clusters and in reflecting the characteristics of clustered cultural landscapes and can be used as the dominant cultural factors in cluster zoning. Three of the indicators belong to the level of folk architecture, and the indicators representing the level of folk architecture have the most significant differences, which can best distinguish the characteristics of cultural landscapes of each cluster.

Table 3. Comparative results of ANOVA differences in clustering categories.

Cultural Factor	Clustering Category Variance (Mean $\pm$ Standard Deviation)						F	p
	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6		
TG	1.00 $\pm$ 0.00	3.00 $\pm$ 0.00	2.94 $\pm$ 0.41	4.00 $\pm$ 0.00	3.26 $\pm$ 0.49	2.00 $\pm$ 0.00	910.886	0.000 **
RC	4.00 $\pm$ 1.38	5.24 $\pm$ 0.55	4.91 $\pm$ 1.06	4.84 $\pm$ 1.01	4.58 $\pm$ 1.16	4.57 $\pm$ 1.09	8.677	0.000 **
RR	2.03 $\pm$ 0.78	2.38 $\pm$ 0.82	1.99 $\pm$ 0.84	2.26 $\pm$ 0.81	2.07 $\pm$ 0.83	1.98 $\pm$ 0.85	1.539	0.177
AE	1.00 $\pm$ 0.00	3.21 $\pm$ 0.69	2.30 $\pm$ 0.73	1.21 $\pm$ 0.42	1.84 $\pm$ 0.53	1.48 $\pm$ 0.50	123.444	0.000 **
VS	1.00 $\pm$ 0.00	3.21 $\pm$ 1.61	3.86 $\pm$ 1.63	1.42 $\pm$ 1.26	1.33 $\pm$ 0.94	1.77 $\pm$ 1.50	57.044	0.000 **
ML	3.40 $\pm$ 1.22	1.32 $\pm$ 0.53	1.53 $\pm$ 0.65	2.95 $\pm$ 1.31	2.37 $\pm$ 1.29	2.61 $\pm$ 1.08	35.744	0.000 **
VO	1.40 $\pm$ 0.77	3.03 $\pm$ 1.82	6.10 $\pm$ 1.60	2.26 $\pm$ 1.69	2.07 $\pm$ 1.39	2.74 $\pm$ 1.74	95.048	0.000 **
SL	5.88 $\pm$ 1.65	7.68 $\pm$ 1.47	2.64 $\pm$ 2.23	5.11 $\pm$ 1.33	6.51 $\pm$ 2.41	5.70 $\pm$ 2.51	37.928	0.000 **
CS	3.40 $\pm$ 0.49	1.12 $\pm$ 0.33	1.19 $\pm$ 0.39	3.89 $\pm$ 0.99	2.33 $\pm$ 1.13	2.25 $\pm$ 0.54	153.054	0.000 **
BM	3.00 $\pm$ 0.00	2.00 $\pm$ 0.00	2.17 $\pm$ 0.70	5.00 $\pm$ 0.00	1.72 $\pm$ 0.45	4.00 $\pm$ 0.00	424.230	0.000 **
RS	3.62 $\pm$ 1.97	3.88 $\pm$ 1.23	2.79 $\pm$ 1.23	1.00 $\pm$ 0.00	1.95 $\pm$ 0.87	2.75 $\pm$ 0.43	21.324	0.000 **
SS	1.00 $\pm$ 0.00	2.00 $\pm$ 0.00	2.06 $\pm$ 0.41	2.26 $\pm$ 1.52	2.07 $\pm$ 0.80	3.00 $\pm$ 0.00	127.352	0.000 **
DF	1.71 $\pm$ 0.84	1.00 $\pm$ 0.00	1.00 $\pm$ 0.00	2.26 $\pm$ 0.99	1.00 $\pm$ 0.00	1.00 $\pm$ 0.00	39.137	0.000 **
FA	4.35 $\pm$ 1.50	4.88 $\pm$ 1.07	4.31 $\pm$ 1.74	3.84 $\pm$ 1.74	4.00 $\pm$ 1.81	4.13 $\pm$ 1.77	1.608	0.158
IF	2.62 $\pm$ 2.02	2.03 $\pm$ 0.94	2.16 $\pm$ 1.16	2.21 $\pm$ 1.96	2.47 $\pm$ 1.86	2.67 $\pm$ 2.08	1.198	0.310

** $p < 0.01$.**Figure 7.** Graphical representation of indicators of the importance of cultural factors.

3.2.3. Correlation Analysis of Cultural Factors

The three indicators of foundation age, traditional industry function, and river relationship were excluded due to their low impact on the clustering results and weak correlation with other cultural factors. Correlation analyses were conducted for the remaining 12 cultural factors (Table 4) and visualized using heat maps (Figure 8).

It can be seen through the analysis that the two factors of topography and elevation of traditional villages in northern Henan have significant correlation with other factors and only weak correlation with the street layout. There were only 2–3 weak correlations between the three factors of building materials, courtyard form, and structural system and the other factors, with significance second only to topography and elevation. Comparatively speaking, the correlation significance of the four factors river class, roof shape, village scale, and street layout is relatively low and only correlates with a few specific factors, for example, the street layout has a relatively significant negative correlation with the morphological layout and has little or no influence on other cultural factors. When the village is in the form of a group, the street pattern tends to show a more complex network, which is convenient for connecting the various areas of the village. There is also a significant correlation between courtyard form and village scale, morphological layout, and village orientation, with larger-scale regimented villages oriented mostly north to south, and the courtyards are mostly complex multiple courtyards and cross courtyards. The villages with other types of orientation are mostly in the form of a striped and scattered layout that

conforms to the topography, and the villages are smaller in scale with simple and practical “one”- and “L”-type courtyards.

The correlation analysis of cultural factors can not only further quantitatively verify the rationality of topography, elevation, building materials, courtyard form, and structural system as the dominant factors of clustering and zoning but also objectively explore the interactions between cultural factors, reduce the human subjective assumptions, and improve the scientific nature of cultural landscape zoning.

Table 4. Correlation analysis of cultural factors in traditional villages in northern Henan Province.

Cultural Factor		TG	AE	RC	VS	ML	VO	SL	CF	BM	RS	SS	DF
TG	Pearson relevance	1											
	<i>p</i> (salience)	-											
AE	Pearson relevance	0.531 **	1										
	<i>p</i> (salience)	0.000	-										
RC	Pearson relevance	0.276 **	0.312 **	1									
	<i>p</i> (salience)	0.000	0.000	-									
VS	Pearson relevance	−0.422 **	−0.524 **	−0.220 **	1								
	<i>p</i> (salience)	0.000	0.000	0.000	-								
ML	Pearson relevance	0.393 **	0.425 **	0.150 **	−0.452 **	1							
	<i>p</i> (salience)	0.000	0.000	0.007	0.000	-							
VO	Pearson relevance	0.367 **	0.488 **	0.132 *	−0.408 **	0.622 **	1						
	<i>p</i> (salience)	0.000	0.000	0.017	0.000	0.000	-						
SL	Pearson relevance	−0.123 *	−0.051	−0.036	0.223 **	−0.428 **	−0.205 **	1					
	<i>p</i> (salience)	0.026	0.357	0.512	0.000	0.000	0.000	-					
CF	Pearson relevance	−0.410 **	−0.635 **	−0.260 **	0.596 **	−0.503 **	−0.521 **	0.134 *	1				
	<i>p</i> (salience)	0.000	0.000	0.000	0.000	0.000	0.000	0.016	-				
BM	Pearson relevance	−0.292 **	−0.476 **	−0.082	0.296 **	−0.234 **	−0.263 **	0.033	0.413 **	1			
	<i>p</i> (salience)	0.000	0.000	0.140	0.000	0.000	0.000	0.557	0.000	-			
RS	Pearson relevance	−0.378 **	0.053	−0.140 *	0.251 **	−0.085	0.010	0.059	0.102	−0.064	1		
	<i>p</i> (salience)	0.000	0.340	0.011	0.000	0.124	0.858	0.290	0.065	0.246	-		
SS	Pearson relevance	0.404 **	0.269 **	0.194 **	−0.292 **	0.329 **	0.231 **	−0.088	−0.161 **	0.276 **	−0.199 **	1	
	<i>p</i> (salience)	0.000	0.000	0.000	0.000	0.000	0.000	0.111	0.004	0.000	0.000	-	
DF	Pearson relevance	−0.226 **	−0.326 **	−0.165 **	0.168 **	−0.202 **	−0.237 **	0.038	0.468 **	0.291 **	−0.121 *	−0.211 **	1
	<i>p</i> (salience)	0.000	0.000	0.003	0.002	0.000	0.000	0.497	0.000	0.000	0.029	0.000	-

* $p < 0.05$, ** $p < 0.01$.

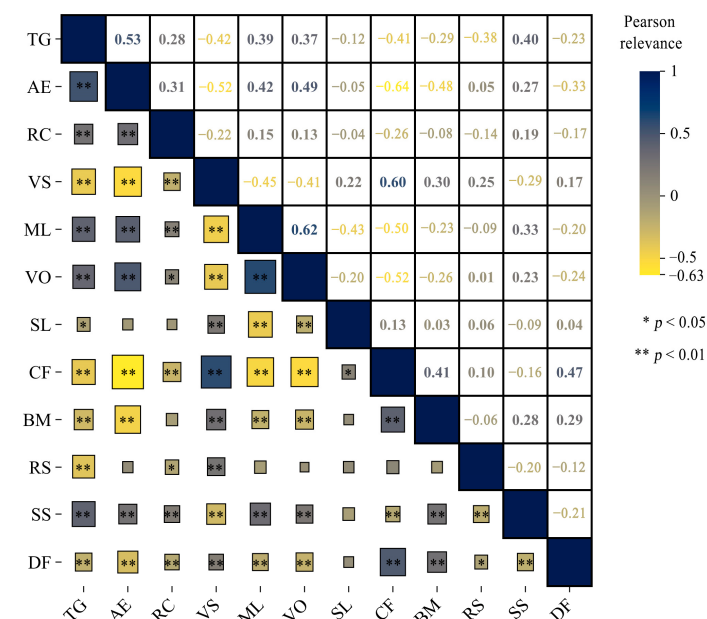


Figure 8. Heat map of cultural factor correlations.

4. Discussion

Based on the results of the K-means algorithm for the comprehensive clustering of the cultural factors of traditional villages and the significant differences of the cultural factors, it is found that the traditional villages of Cluster 2, Cluster 3, and Cluster 5 have a high degree of overlap in spatial distribution, and the differences of the five significant cultural factors are relatively small, which indicates that the traditional villages of the three clusters have similarities in the main cultural landscapes and customs. The differences in the cultural factors of traditional villages in Cluster 1, Cluster 4, and Cluster 6 are relatively large, and there are more obvious boundaries in the spatial distribution. The delineation of traditional villages' cultural landscape should follow the principles of similarity of landscape features, consistency of cultural background, and geospatial continuity and, through superposition analysis and combining the boundaries of municipal administrative divisions and county administrative divisions for refinement and integration, the traditional villages in northern Yu are culturally partitioned and scoped, and the delineation results are named in the form of "geographic location + cultural landscape features". The result is finally divided into the stone masonry building culture area along the Taihang Mountains, the brick and stone mixed building culture area in the low hills of the Taihang Mountains, the brick and wood building culture area in the North China Plain, and the raw soil building culture area in the transition zone of the Loess Plateau (Figure 9).

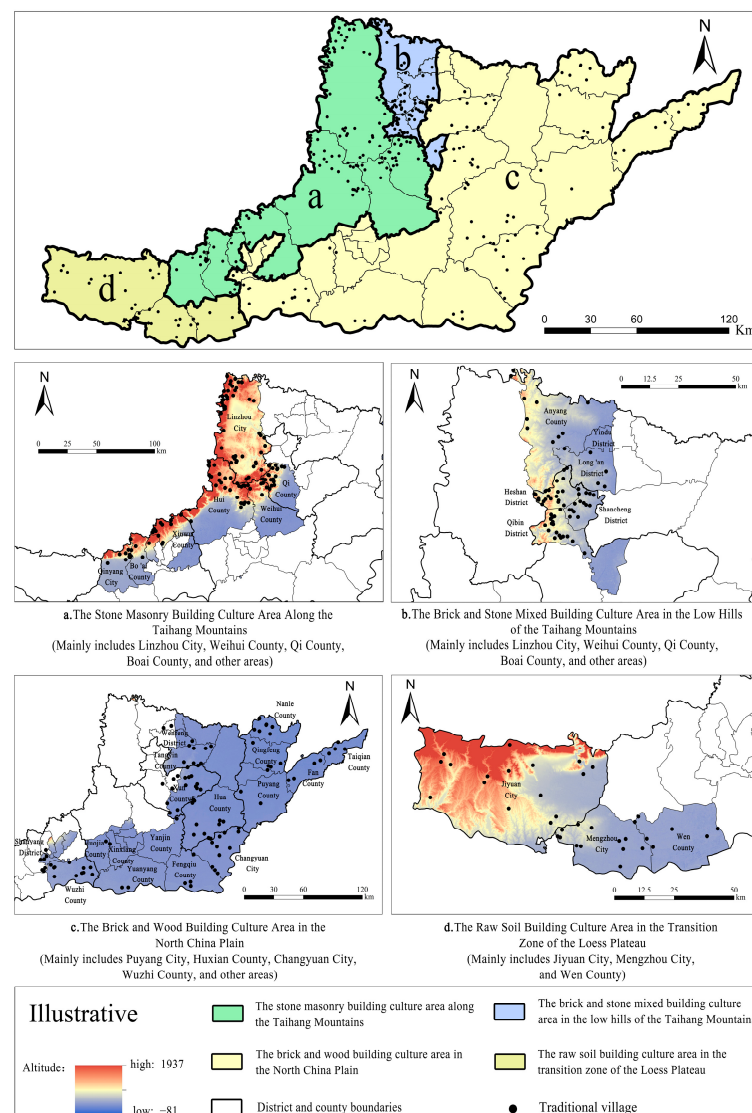


Figure 9. Regional division of cultural sceneries of traditional villages in northern Henan Province.

4.1. The Stone Masonry Building Culture Area Along the Taihang Mountains

The area includes the districts and counties of Jiaozuo, Xinxiang, Hebi, and Anyang along the South Taihang Mountains, and the terrain is dominated by mountains with high altitude, strong cutting, many faults, and rock walls, and the overall difference is large, forming a steep form in the eastern foothills. Therefore, the village sites are mostly located in the mountain basins, hillside terraces, valley terraces, river valleys, and other terrain in a gentle place and subject to topographical constraints. The overall morphological layout of villages is generally presented as spatially compact clusters and strips following the contour alignment of valleys, river valleys, and mountains. In addition, during the Ming and Qing dynasties, Shanxi businessmen and frequent commercial activities along the Taihang Mountains opened up a number of ancient stagecoach routes connecting Shanxi and Henan, and thus leading to the construction and development of many villages along the ancient stagecoach routes, the formation of a larger number of single-axis horizontal extensions of the street layout of the villages, and the formation of the ancient road through the villages or with the neighboring villages. Due to site constraints, most of the courtyards are in the form of affordable “one”-type and “L”-type courtyards. The soil is mixed with gravel, the soil layer is thin, the overall fertility is poor, the annual precipitation is low (about 534 mm), the number of trees is small and of low quality, limiting the use of timber, the building materials are mainly local stone, stone walls are the main load-bearing structure, a small amount of wood is used for roof beams to assist in the load bearing, and the hard mountain back tile roof form is more common and derived a more economical and highly regionally distinctive slate roof and hoard roof (Table 5a).

Table 5. Main cultural landscape features of traditional villages in each district.

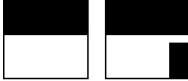
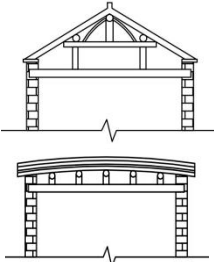
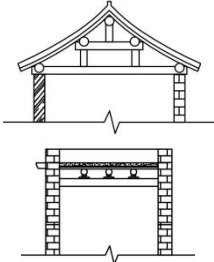
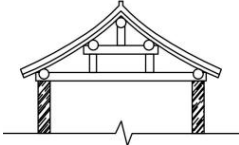
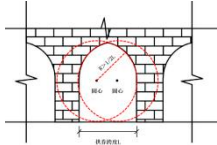
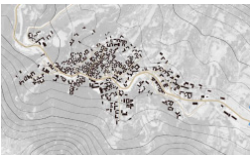
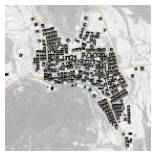
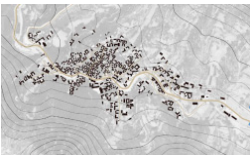
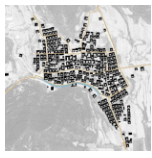
Main Cultural Landscape	(a) The Stone Masonry Building Culture Area Along the Taihang Mountains	(b) The Brick and Stone Mixed Building Culture Area in the Low Hills of the Taihang Mountains	(c) The Brick and Wood Building Culture Area in the North China Plain	(d) The Raw Soil Building Culture Area in the Transition Zone of the Loess Plateau
topography and geomorphology	mountains	low hills	plains	Loess Plateau
building materials	 stone, wood	 mixed brick, stone and wood	 green brick, wood	 raw earth, wood
courtyard system	“one”-type, “L”-type 	triple courtyard, quadruple courtyard  	quadruple courtyard, multiple courtyards, cross courtyards  	triple courtyard, kiln house courtyard 
structural system	 wall	 wood frame stone wall mix	 wood frame	 wood frame (same as above), arch coupon

Table 5. *Cont.*

Main Cultural Landscape	(a) The Stone Masonry Building Culture Area Along the Taihang Mountains	(b) The Brick and Stone Mixed Building Culture Area in the Low Hills of the Taihang Mountains	(c) The Brick and Wood Building Culture Area in the North China Plain	(d) The Raw Soil Building Culture Area in the Transition Zone of the Loess Plateau
roof shape				
		hard mountain back tile surface (coexistence type)		hanging mountain tile surface
	 slate surface	 hoard roof house	 flat roof house	 hard mountain combined tile surface
morphological layout	 compact clusters, striped	 compact clusters, striped	 row and column of clusters, fingerprints	 row and column of clusters, striped
	 compact clusters	 striped of clusters	 row and column	 fingerprints
typical village	Huanghou Village, Pingdingyao Village	Feiquan Village, Dahu Village	Danguai Village, Yuyang Village	Shuangfang Village, Mogou Village

4.2. The Brick and Stone Mixed Building Culture Area in the Low Hills of the Taihang Mountains

The region is located in the low hills of the eastern foothills of the South Taihang Mountains to the North China Plain, mainly including the northwestern part of Hebi City and the central and western parts of Anyang City, with an elevation of 200–800 m. The slopes are generally steep in the west and low in the east, consisting of greywacke, shale, dolomite, and other rocks, and the hilly landforms are rounded mounds, with gentle undulation and a bead-shaped north–south distribution, with parallel gullies and valleys, and the terrain gradually decreases from west to east. The site selection of villages in the area is similar to that of villages along the Taihang Mountains, with most of them located in open and gentle places such as valleys and river valleys, and the overall form of the villages is also mostly compact and block-like and strip-like, with the difference that the spatial layout of the villages is relatively spacious and large in scale, and generally triple and quadruple courtyards are adopted. The river slows down here, and the alluvial deposits carried by the mountains sink, forming good soil. The use of wood as a building material increases, and timber is generally used for front walls. The walls no longer bear weight, and the window area can be increased to get more light and ventilation. The region is the last natural barrier left by the Taihang Mountains to the Central Plains. Since ancient times it has been a place of war, but there is also the history of rampant banditry in the region, so the village security and defense features are more obvious, with the construction of fortified gates, fortified walls, artillery towers, and other obvious artificial boundaries to ward off calamities. In the residential architecture this is manifested in the form of roofs in addition to the hard mountain back tile surface. The form of the flat roof is also more prevalent, and the city wall stomp similar to the low daughter wall can be used for security and defense for observation and shooting but also can be used to dry crops on the roof (Table 5b).

4.3. The Brick and Wood Building Culture Area in the North China Plain

The area belongs to the Haihe River Plain part of the Huanghuaihai Plain. It is located on top of the huge alluvial fan formed by the Yellow River and Haihe River basins. It is mainly composed of alluvial sediments from the Yellow River, Haihe River, and their tributaries. It is vast and fertile, with a low-lying topography. Most of it is below 200 m above sea level, gently sloping from west to east. According to the cluster distribution map of traditional villages in northern Henan, there are four relatively concentrated clusters of traditional villages in the region: the Qin River Basin, Wei River Basin, Jindi River Basin, and Majia River Basin. Therefore, the villages in this area are mostly located near water to meet the needs of agricultural irrigation, commerce, and transportation. Due to the immigration policy implemented during the Ming Dynasty, a large number of people from Shanxi moved to the northern plains of Henan Province, which also brought more advanced architectural forms and construction techniques at that time, plus a long period of time as the political center of the radiation area, subject to the cultural constraints of the Central Plains rites. The form of residential buildings generally had clear hierarchical divisions. The prototype of the siheyuan developed gradually into the advanced forms of the multientry courtyard and the courtyard house. The plain areas had good soil quality, sufficient vegetation, and superior economic conditions, which were suitable for firing bricks and tiles as the main building materials. The wooden frame was the main load-bearing structure, and the internal space of the building could be divided more flexibly, and it could still remain standing even if the walls collapsed. In addition to the laying method of the hard mountain back tile, the hard mountain combined tile, which is more waterproof and more aesthetically pleasing, is also more common (Table 5c).

4.4. The Raw Soil Building Culture Area in the Transition Zone of the Loess Plateau

The region is located in the transition zone between the Loess Plateau and the plains. The southern foot of the Taihang Mountains is in the northwest, and the central and southeastern parts are plains in the middle and lower reaches of the Yellow River Basin. The numerous tributaries of the Yellow River Basin have been eroded and washed away, carrying sediment from the Loess Plateau, which has deposited here to form numerous river valleys and gullies, with a thick surface layer of loess. This region is windy and has little rainfall, with precipitation concentrated in the summer. It is prone to flooding and drought. Villages are often located in the open, far from rivers. The form of villages in the plains is mostly large rows and columns of clusters, while villages in the mountains are mostly strip-shaped to adapt to the terrain. In addition to the three-sided courtyard, there is also the kiln house courtyard, which was influenced by the regional architectural culture of Shaanxi and Shanxi. The main building is a brick and stone cave house, and the east and west wings are characteristic courtyards with wooden structures. The main building materials were loess and wood. Loess rammed earth was used as the wall, and the wooden frame carried the load. As rammed earth walls are susceptible to rain erosion, the hanging mountain tile surface was often used for waterproofing (Table 5d).

5. Conclusions

In this study, the research path of “geospatial distribution–cultural factor identification and extraction–cluster analysis–cultural landscape zoning” was formed for the study of traditional villages’ cultural landscapes. Firstly, the GIS geostatistical method was used to analyze the macro geographic distribution of the traditional villages in northern Henan in the region, and then on the basis of this to construct the cultural factor index system, and to identify and extract the cultural factors of each village one by one to quantify them. Then the K-means clustering algorithm was introduced to analyze the clustering and cultural

factor correlation of the 326 villages. Finally, based on the clustering results, the cultural landscape of traditional villages in northern Henan was zoned, and the cultural landscape characteristics of traditional villages in each region were summarized. This method to a certain extent makes up for the shortcomings of the traditional village cultural landscape research, which is mostly categorized in a qualitative way, and the results of the zoning are basically consistent with the characteristics of the cultural landscape of each region in reality, which is highly scientific and innovative. It can provide a methodological reference for the centralized and continuous protection and renewal of traditional villages in different regions and promote the sustainable development of traditional villages as well as the inheritance of traditional culture.

The results of the study are as follows: the nearest neighbor index of the traditional villages in the northern Henan region is $R = 0.875 < 1$, and their spatial distribution as a whole tends to be clustered. The imbalance index $S = 0.340$, and the geographical concentration index $G = 45.805$, $G > G_0$, indicating that the overall distribution is relatively uneven, with Anyang and Hebi accounting for 53.07% and Puyang and Jiyuan only 11.96%. The spatial pattern shows that the largest agglomeration is in the northwestern part of Hebi City; Under the index system constructed by 15 cultural factors in four dimensions: environment, village form, folk architecture, and sociocultural, the K-means algorithm divided the 326 villages into six clusters. Among them, the importance of indicators such as river class, river relationship, the age of the foundation, and the functions of the traditional industry is relatively low, and they have a relatively poor reflective effect on the classification of cultural landscape characteristics. There are significant differences between the categories of cluster classification in terms of topography and geomorphology, building materials, the courtyard system, structural system, and altitude and elevation, and these can best distinguish the characteristics of the cultural landscapes in each cluster. The remaining indicators have varying degrees of influence on the clustering results. There are significant correlations between topography, elevation, and other cultural factors, while the street layout has the lowest correlation with other factors and only has a strong correlation with the morphological layout of the village. In addition to the significant correlation with the cultural factors of the natural environment category, the courtyard form also has significant correlation with the three cultural factors of village scale, morphological layout, and village orientation at the village form level. Based on the clustering results and the principle of landscape feature similarity, combined with administrative divisions, the traditional villages in northern Henan are divided into the stone masonry building culture area along the Taihang Mountains, the brick and stone mixed building culture area in the low hills of the Taihang Mountains, the brick and wood building culture area in the North China Plain, and the raw soil building culture area in the transition zone of the Loess Plateau. They respectively show the characteristics of affordable stone craftsmanship, cultural integration with the right amount of simplicity and complexity, the dignified and orderly characteristics of ritual culture, and the characteristics of cultural transmission adapted to the local area.

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Institutional Review Board Statement: Not applicable.

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Data Availability Statement: The basic data used in the study have been labeled with the sources in the text, and the results of extracting the cultural factors of the traditional villages under study are only partially shown in the manuscript (Table 2) due to the large amount of content; further inquiries can be directed to the corresponding author.

Conflicts of Interest: Author Yalong Mao was employed by the company Architectural Design and Research Institute Co., Ltd. The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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