

Visualization Analysis of Spatial Characteristics of Traditional Villages in Southeast Shanxi Province

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Abstract. Traditional villages are rich in material and intangible culture, which is the key point of rural revitalization. Their spatial distribution has certain laws and typical characteristics, which is of great value to the current spatial research of traditional villages. Therefore, this paper chooses one of the core gathering areas of three traditional villages, that is southeast Shanxi Province as the research object. The related GIS spatial analysis method is used to study. The results show that: Traditional villages in southeastern Shanxi Province are in a condensed state, mainly concentrated in the southern region and the southern source of Zhuozhang River, the spatial distribution of villages is closely related to rivers and landforms. From the type point of view, mountain traditional villages are the main ones, while hilly and plain traditional villages are in a minority state, and different types of villages have their own unique spatial construction characteristics. Relevant research contents can provide some reference for the related research of traditional villages in southeast Shanxi Province.

1 Introduction

Traditional villages, also known as ancient villages, preserve rich material and intangible cultural heritage and are important carriers of traditional culture¹. In recent years, they have received increasing attention from the society. After five batches of selection, the number of selected villages has reached 6,819. Academic circles have also carried out abundant research on the spatial distribution, morphological characteristics, evolution, driving factors, protection and evaluation of traditional villages, and made a lot of supplements to this field. However, as a typical representative of one of the core gathering areas of the three traditional villages², The research content is relatively lacking, It seldom involves the analysis of the spatial distribution characteristics of traditional villages, Therefore, this paper takes southeast Shanxi as the research area, selects 235 national traditional villages as the research object, and makes correlation analysis by using the average nearest neighbor method in spatial analysis, and then obtains the spatial distribution characteristics of traditional villages in this area, expecting to provide relevant reference for the study of traditional villages in southeast Shanxi.

2 Study area and methodology

2.1 Study area

The research area of this paper is the traditional villages in the southeast of Shanxi Province, namely Changzhi City

and Jinzheng City (Figure 1). Traditional villages in this area are one of the three high-density areas of traditional villages in China (the border zone of Shanxi, Henan and Hebei provinces, mainly Jinzheng and Changzhi in Shanxi)³, which is of great value to the spatial research of traditional villages at present.

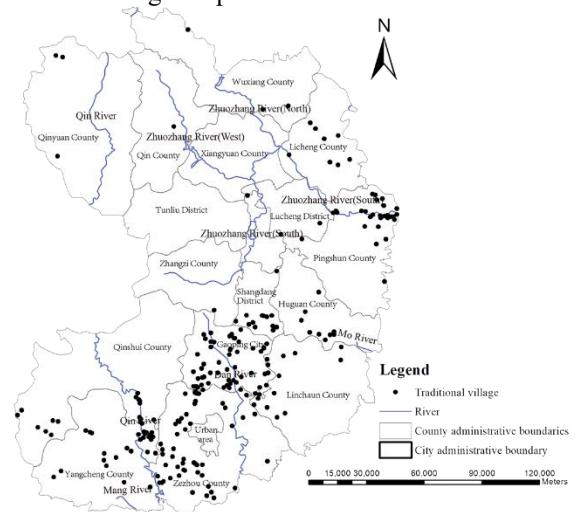


Fig. 1. study area

2.2 Data sources

The data source is the list of traditional villages published by the Ministry of Housing and Urban-Rural Development five times. By 2022, there were 235 national traditional villages in southeastern Shanxi, equivalent to 42.7% of the

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province. WGS-84 geographic coordinate data of traditional villages are extracted in batches with Map location, and basic data such as water system, DEM and administrative boundary are obtained through official website such as geospatial data cloud. Then in ArcGIS 10.8 software, pretreatment of the collected data, analysis of the relevant data needed for this study, the spatial distribution of traditional villages in southeastern Shanxi visualized performance, and based on the relevant data information for analysis and research.

2.3 Research method

2.3.1 Average nearest neighbor index

Average nearest neighbor index refers to the average of the nearest distance between two points. By comparing the average distance of the nearest neighbor with the average distance of the nearest neighbor in the random distribution pattern, the spatial distribution pattern can be judged⁴. The formula is:

$$R = \frac{R_0}{R_r} = \frac{R_0}{\frac{1}{2}\sqrt{n/A}} = 2R_0 \sqrt{n/A} \quad (1)$$

In the formula: R is the nearest neighbor index; R₀ is the average observation distance; R_r is the expected average distance, and n is the number of point elements; A is the area where the point element is located. When R < 1, the spatial distribution of traditional villages is in a condensed state; When R=1, the spatial distribution of traditional villages is in a random state; When R > 1, the spatial distribution of traditional villages is in a uniform state⁵.

2.3.2 Kernel density estimation method

Kernel density estimation method is an effective way to measure local density changes and explore space hot spots. The formula is:

$$f(x) = \frac{1}{nh} \sum K\left(\frac{x-x_i}{h}\right) \quad (2)$$

In the formula: f(x) is the kernel density estimate; K($\frac{x-x_i}{h}$) is a kernel function; h is bandwidth; n is the number of point elements; x-x_i is the distance from the estimation point x to the event x_i. Therefore, the greater the nuclear density, the denser the spatial distribution of traditional villages⁶.

2.3.3 Buffer zone analysis

Buffer analysis is an information method to form polygonal entities with a certain range around a group or a class of geographical elements according to the set distance conditions, and then realize the data diffusion in two-dimensional space. In the study, we can take the river as the first element, take it as the center, build a polygon outward, and analyze the superposition between the traditional village point elements and the river buffer zone, so as to study the spatial distribution law of traditional villages. The formula is:

$$B_i = \{x: d(x_i, O_i) \leq R\} \quad (3)$$

In the formula: The buffer with buffer radius R of the spatial target object O_i is the set of all points less than or equal to R from the object.

3 Visualization of Spatial Distribution of Traditional Villages

3.1 Spatial distribution type

By importing the collected data of 235 traditional villages into ArcGIS 10.8 and analyzing the average nearest neighbor index, it is concluded that the average observation distance is 5.010 km, the expected average distance is 9.270 km, and the nearest neighbor index R is about 0.540 < 1. Therefore, the spatial distribution of traditional villages in southeastern Shanxi is in a condensed state. As shown in Figure 2, traditional villages are mainly distributed in the south source of Qinhe River, Danhe River and Zhuozhang River, especially Qinhe River and Danhe River in Jincheng City, occupying most villages. In the basin, the distance between villages is small and the concentration is strong. Moreover, the area has low altitude, gentle and open terrain, which is suitable for the construction and development of villages; Villages in other areas are randomly distributed, and there is no obvious rule to follow.

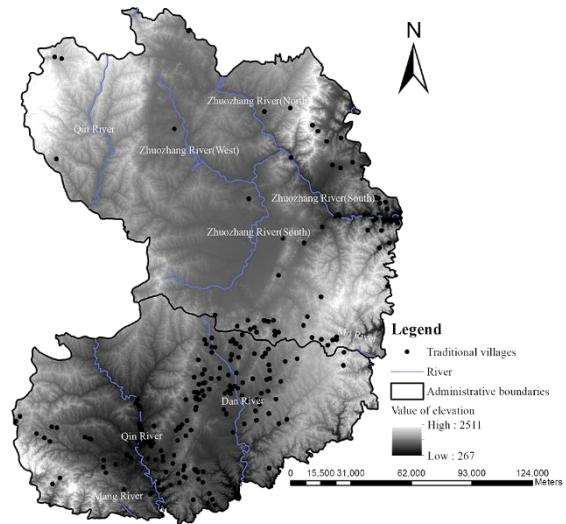


Fig. 2. Spatial distribution of traditional villages

3.2 Spatial distribution density

The application of kernel density estimation method can intuitively reflect the spatial distribution law of traditional villages⁷, That is the spatial geographical location of dense areas and discrete areas. In order to intuitively reflect the distribution patterns of traditional villages in southeastern Shanxi under different radii, the nuclear density analysis was carried out for many times, and finally it was determined to be 20.3 km. In this case, the analysis result was the most significant, and the nuclear density analysis image was shown in Figure 3.

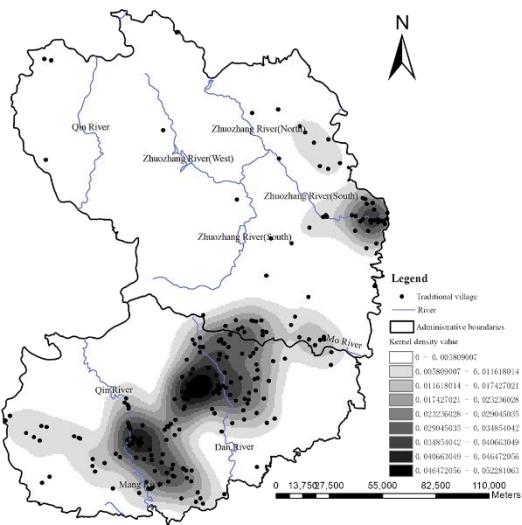


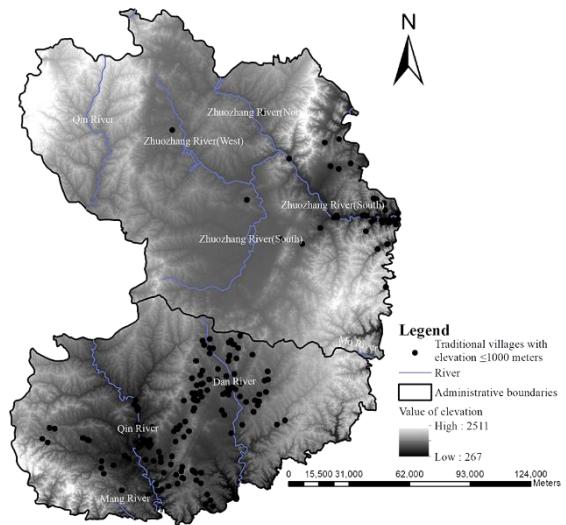
Fig. 3. Nuclear density analysis

Traditional villages in southeastern Shanxi are mainly manifested in three gathering areas. Jincheng Basin is formed by Qinhe River and Danhe River Basin, so there are a large number of traditional villages in this area. Changzhi Basin is mainly used for urban construction, so the number of traditional villages in the basin is small. Among the three gathering areas, there are many gathering areas and villages in Danhe River Basin, and the gathering areas and villages in Qinhe River Basin are mostly distributed along river valleys and river radiation areas, which are closely related to rivers; In the original gathering area of Zuo Zhangnan, the number of villages is relatively small, which is mainly distributed along the banks of rivers. Affected by topography, most of them are built in mountainous areas.

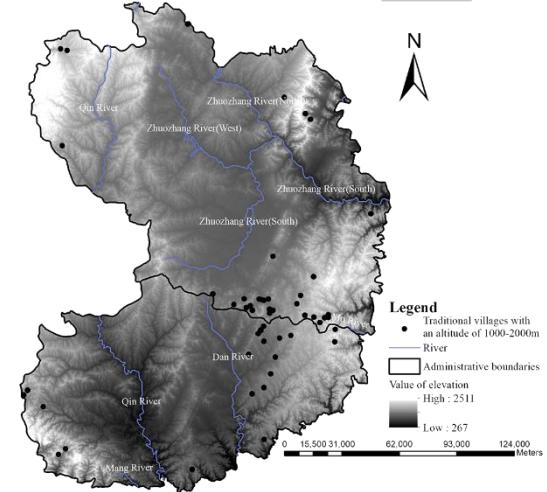
3.3 Spatial distribution law

3.3.1 Spatial distribution law under the influence of elevation

Taiyue Mountain in the west, Wuyun Mountain and Bafuyin Mountain in the north and Wangwu Mountain in the south. The lowest elevation in this area is 267 meters, and the highest elevation is 2511 meters. In addition, due to the influence of topography, the elevation difference changes greatly, which has a strong impact on the spatial layout of traditional villages. Mountains can be divided into three categories according to altitude: low mountains (≤ 11000 meters), middle mountains (1000-2000 meters) and high mountains (> 2000 meters)⁸. In this study, with the help of DEM data with 30 meters accuracy, the elevation value of traditional villages was extracted, and the number of traditional villages in different altitude areas was obtained, as shown in Figure 4 and Table 1.



(a) Spatial Distribution of Traditional Villages at Altitude ≤ 1000 m



(b) Spatial distribution of traditional villages at an altitude of 1000-2000m

Fig. 4. Spatial distribution of traditional villages at different altitudes

Table 1. Number of traditional villages in different altitude areas

Type	Number	Proportion
low mountains (≤ 11000 meters)	183	77.9%
middle mountains (1000-2000 meters)	52	22.1%
high mountains (> 2000 meters)	0	0%

Through spatial analysis, it can be seen that a certain number of traditional villages will be formed in the plain and hilly areas of the basin, especially in the valley areas. This area is relatively flat and rich in cultivated land resources, which is a good location for settlements under farming culture, and it is also easy to improve traffic accessibility. There will be a large number of traditional villages in mountainous areas with high altitude and great terrain changes. The reason is that the topography in southeastern Shanxi is mainly mountainous, and the villages are influenced by geographical environment,

history and culture, and most of them are built in flat areas. Therefore, in the elevation distribution of traditional villages in southeastern Shanxi, the overall distribution is mainly in the area with an altitude of ≤ 1000 m, and there are fewer villages in the area with an altitude of 1000-2000m.

3.3.2 Spatial distribution law under the influence of water system

The spatial distribution of traditional villages in southeastern Shanxi has the characteristics of near water⁹. In this study, the water system map of southeast Shanxi was introduced into ArcGIS, which was superimposed with traditional villages. Using buffer zone analysis tools, the water system buffer zones of 3km and 5km were established, and then the number of traditional villages within different buffer zone radius was counted (Table 2). As shown in Figure 5, it can be known from the image that most villages are built along the banks of rivers, and the characteristics of near water are very obvious. Among the 235 traditional villages, there are 185 villages in the area with a buffer zone radius of 2km, accounting for 78.7% of the total; In the area with a radius of 5km in the buffer zone, there are 229 villages, accounting for 97.4% of the total number.

In addition, traditional villages are mostly distributed in the lower reaches of rivers, The number around tributaries is obviously more than that in the main stream area, and the number of villages on the left bank of the river is higher than that on the right bank¹⁰. The reason is that the lower reaches of the river have abundant water sources and higher soil quality. In addition, due to the influence of geostrophic deflection, the soil on the left bank is relatively fertile and suitable for farming, which is a good location for traditional villages under farming culture.

Table 2. The number of traditional villages in different buffer radius

Buffer radius	Number	Proportion
2km	185	78.4%
5km	229	97.4%

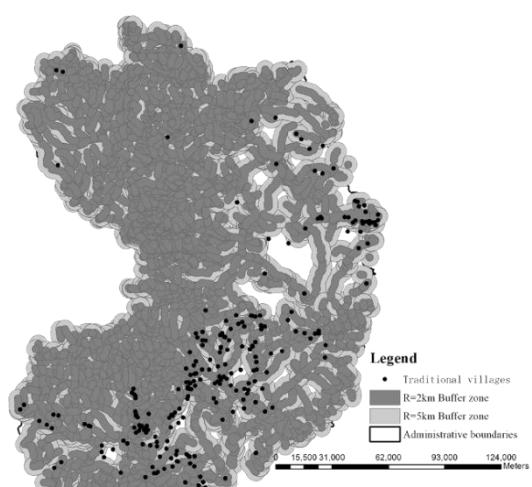


Fig. 5. Analysis of river buffer zone

4 Visualization of Spatial Types of Traditional Villages

4.1 Classification standard

There are many classification standards for rural settlements. As far as traditional villages are concerned, there is no unified classification standard in academic circles at present. Planners divide them into five categories: ancient towns, blocks, traditional ancient villages, ethnic villages and family villages¹¹, while historical and cultural scholars divide them into farming, commerce and military villages¹². Both have different tendencies, but in the process of the formation and development of traditional villages, Topography plays a decisive role¹³, and the previous spatial distribution analysis also confirms this view. Due to its own geographical conditions, historical and cultural particularity, many villages under different landform types have been formed in the development and evolution of southeastern Shanxi for thousands of years, especially the dominant mountain traditional villages.

Therefore, this study classifies the traditional villages in southeastern Shanxi based on topography and geomorphology, and discriminates them with Google image map, DEM data, geomorphology map and other data as auxiliary in the specific classification process.

4.2 Basic type

The basic types of traditional villages in this area can be divided into three types according to topography, which are plain type, hilly type and mountainous type¹⁴. The plain type in southeastern Shanxi refers to the terrain fluctuation in a small range, and the surrounding area is a relatively high terrain area. In southeastern Shanxi, it mainly refers to Changzhi Basin and Jincheng Basin; Hilly area refers to an area with a certain slope and no obvious vein, and the relative altitude is generally less than 200 meters; Mountain type mainly refers to that the altitude is above 500 meters, and the terrain should not only have great ups and downs, but also have obvious venation characteristics. It is a region where many mountains are located, which is obviously compared with hilly terrain, and is the type with the largest proportion of topography in southeastern Shanxi.

The spatial distribution of traditional villages with different landform types is shown in Figure 6 and Table 3. The traditional villages in plain areas are mainly scattered and banded, while a few villages are scattered, and most of them are mainly concentrated around Qinhe River; The traditional villages in hilly areas are mainly loosely reunited, most of which are concentrated in the hilly areas where the Danhe River passes through the largest area, and a few villages are scattered; The spatial distribution of traditional villages in mountainous areas is scattered, but from the local area, they are mostly distributed around hilly areas, which are similar to villages in hilly areas and have obvious hydrophilicity. A certain concentration of traditional villages in mountainous areas will be formed around rivers. Generally speaking, the spatial distribution of traditional villages under different landforms has

certain correlation, especially in the southeast region, where the spatial distribution of traditional villages

unfolds in turn according to the terrain and is closely related.

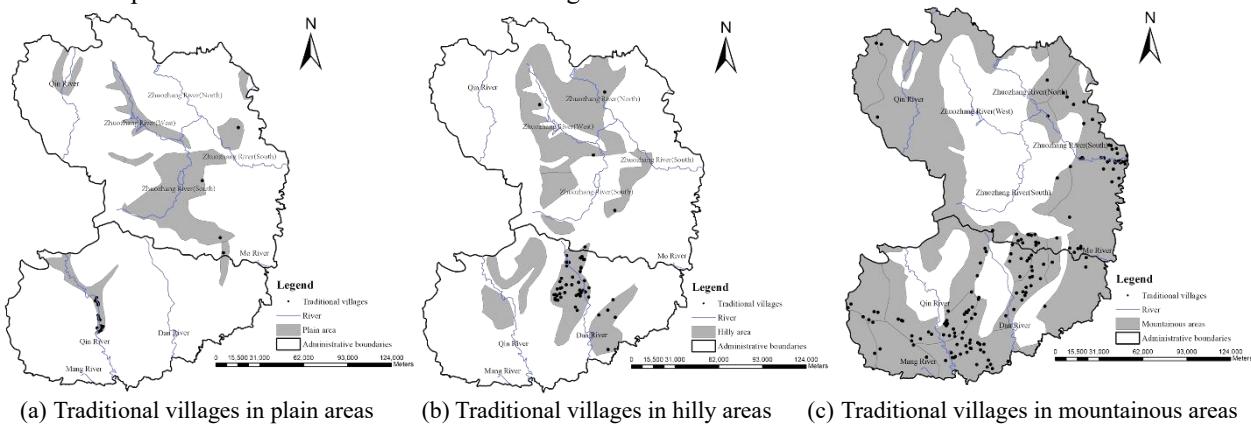


Fig. 6. Spatial distribution of traditional villages with different geomorphic types

Table 3. Number of traditional villages with different landform types

Geomorphic type	Number	Proportion
Plain	20	8.5%
Hilly	55	23.3%
Mountain	160	68.2%

4.3 Type characteristics

With the help of ArcGIS 10.8 and Google Image software, this study carried out the spatial visualization of different types of traditional villages in southeastern Shanxi, and selected typical villages for visual analysis of spatial morphological characteristics.

4.3.1 Plain type

Traditional villages in plain areas are beneficial to the formation of large settlements because of their small terrain fluctuation, abundant cultivated land resources, convenient agricultural irrigation and high spatial concentration utilization¹⁵. so they are extremely beneficial to the development of villages and are good places for village planning and site selection. In this study, Guo Bei Village in Jincheng City and Xia Zhuang Village in Changzhi City were selected as analysis samples, which highlighted the spatial layout of traditional villages in the southeast plain of Shanxi Province, and the spatial types were also concentrated. In the specific spatial analysis, the contour lines with a spacing of 10m are analyzed with the help of ArcGIS10.8. It can be seen from Figure 7 that the contour lines in the southeast plain of Shanxi are sparse, and the villages choose the flattest terrain for construction. The spatial layout and development of villages are closely related to the trend of contour lines. The roads outside the villages are mostly designed in straight lines, and there are few rural roads composed of detours, which are in sharp contrast with hilly and mountainous villages. The internal streets and lanes are clear, regular and orderly, and mostly parallel or vertical. In addition, the spatial form of traditional villages in plain areas is closely related to

agricultural production, living areas are bordered by farmland, and buildings show an even outward expansion trend around, maximizing the use of farmland and reducing the distance between living areas and production.

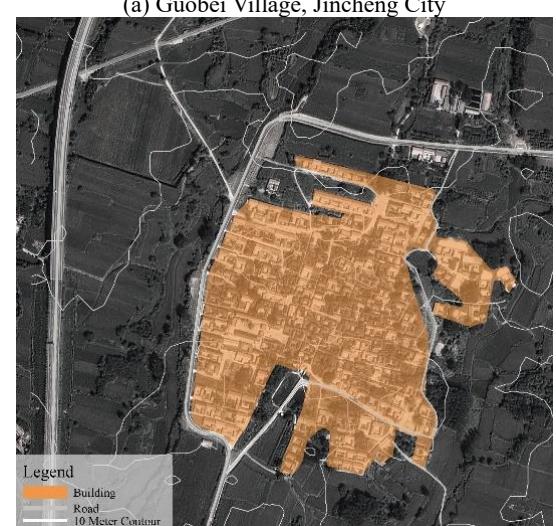
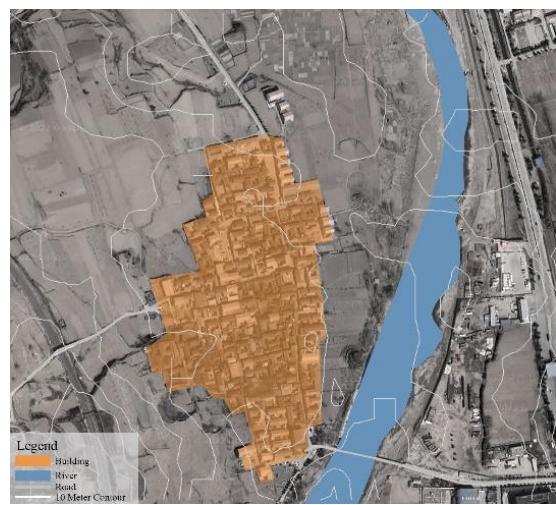
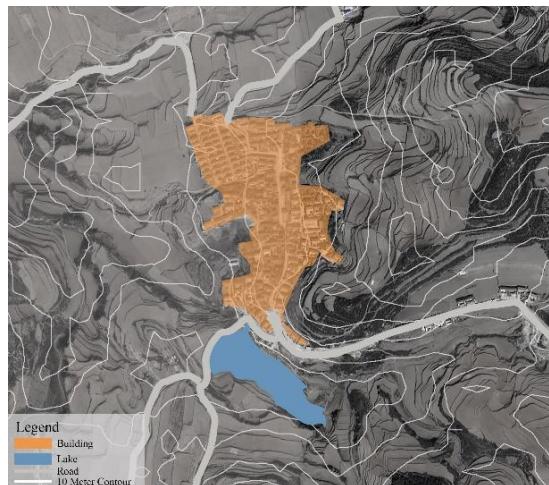


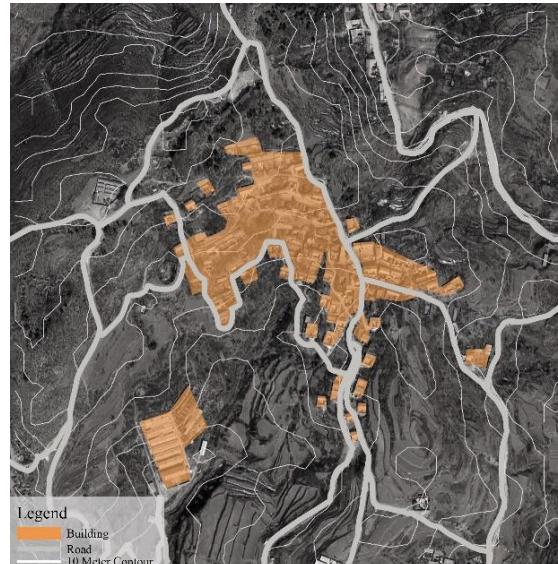
Fig. 7. Plain traditional village

4.3.2 Hilly type

Like Mumford's view of nature, the construction of traditional villages is the scientific cognition of the ancients adapting to the natural environment. The landform of hilly areas is constantly fluctuating and rugged, which is composed of continuous low hills, which has a great influence on the spatial layout and development of villages. The overall layout of villages is mostly concentrated and scattered according to the terrain. This study selected Xiabi Village in Jincheng City and Xiling Village in Changzhi City as analysis samples. In the process of analysis, Downloaded satellite images of villages from Google earth, The contour lines with a spacing of 10m are analyzed in ArcGIS 10.8, As you can see in Figure 8, Compared with plain areas, Contour lines in hilly areas change greatly, The topography is relatively complex, Villages are built centrally in gentle areas with sparse contour lines, Local construction is carried out in available point areas, The overall form and road direction of the village are closely related to the density and direction of contour lines, and the twists and turns are complicated. In the village, the roads are mainly curves, and there are few straight streets and lanes. The natural environment characteristics are integrated with the overall style of the village, which reflects the ancient people's construction wisdom and adaptive planning for the terrain under this landform.



(a) Xiabi Village, Jincheng City



(b) Xiling Village, Changzhi City

Fig. 8. Hilly traditional village

4.3.3 Mountainous type

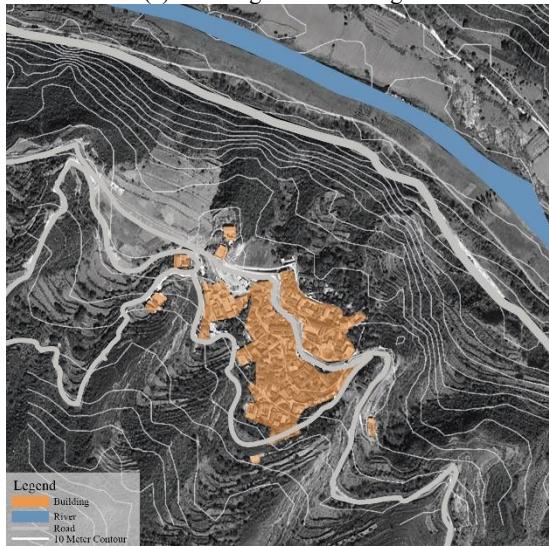
The mountain landform fluctuates greatly and the slope is steep. Compared with the hills, the terrain is steep; The surface morphology is also complex and diverse, and the parallel, overlapping and staggered forms are complicated, which poses a great challenge to the construction and development of villages. It is difficult and costly to build the mountain traditional villages in southeastern Shanxi, so they must be constructed along the terrain and laid out layer by layer based on contour lines. The spatial morphology of villages is varied. In this study, we selected Lanche Village in Jincheng City and Qingcaao Village in Changzhi City as samples, downloaded satellite images from Google earth, and analyzed contour lines with a distance of 10m in ArcGIS. As can be seen from Figure 9, compared with plain and hilly areas, mountainous areas have dense contour lines and steep terrain, and there is very little land for villagers to use intensively. Village sites are located in areas with high altitude and relatively sparse and gentle contour lines.

During the terrain change of Lanche Village, a belt-shaped area with gentle terrain appeared in the middle zone, which correspondingly became the planned site selection of the village, and determined the spatial form and development trend of the village in the future. The road connecting the village with the outside world also showed a north-south trend. The surrounding terrain of Qingcaao Village is steep and rivers pass by, which determines the spatial layout of the village. Especially in Southwest China, the altitude of mountains increases rapidly in a short distance, The contour trend determines the basic spatial form and available land area of the village. Most of the villages are concentrated in relatively flat areas, and are distributed in points in the surrounding flat areas. The changes of village roads and contour lines are basically consistent, and the layout of the whole village is integrated with the changes of mountain potential. Therefore, it can be seen that in traditional villages in

mountainous areas, the spatial site selection and layout are most closely related to topographic changes, which are greatly influenced by topography and geomorphology, and also reflect the construction wisdom of the ancients from the side.



(a) Jincheng Lanche Village



(b) Qingcaao Village, Changzhi City

Fig. 9. Qingcaao Village, Changzhi City

5 Conclusion

This study takes the traditional villages in southeast Shanxi as the research object. With the help of ArcGIS spatial analysis method, the spatial distribution characteristics, morphological characteristics and influencing factors of traditional villages are visually analyzed. The conclusion shows that, the spatial distribution of traditional villages in southeastern Shanxi is generally concentrated, it is mainly concentrated in the southern region and the southern source of Zhuozhang River in the north. In the nuclear density analysis, it is concluded that the traditional villages are mainly concentrated in Gaoping City, Zezhou County and

Yangcheng County of Jincheng City, and the northern part of Pingshun County of Changzhi City (the southern source of Zhuozhang River). The water-near characteristics of villages are very significant, which shows the production and living needs of villages under the traditional farming society.

There are three types of traditional villages in southeastern Shanxi: plain type, hilly type and mountainous type. Influenced by their special geographical environment, there are many mountainous villages, far exceeding the number of plain and hilly traditional villages. In addition, these three types of traditional villages have a high correlation, and they are gathered or scattered in turn according to the terrain, and different types of villages are closely related. In addition, the spatial form, structure and planning of traditional villages under different types are different, which shows the simple thought of the ancients adapting to local conditions and coordinating man with nature, and has certain value significance for the protection and development of traditional villages.

In addition, as a material carrier that has experienced hundreds of years or even thousands of years, the research value of traditional villages is extremely high. This study only analyzes the spatial characteristics, explains the spatial distribution and spatial types of traditional villages in southeastern Shanxi, and focuses on exploring the influence of natural environment on village space. The historical culture, spatial evolution, driving factors and other contents behind it also have great research value, which needs further study, in order to provide reference for the protection and development of traditional villages in southeastern Shanxi.

Acknowledgement

I am very grateful to my teachers and friends for their help in writing my thesis, which enabled me to solve problems easily, and also enabled me to have more expectations and knowledge reserves for academic research, which benefited me a lot.

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