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Analysis of the Spatial Form Characteristics of Traditional Villages in the Qingjian River Basin and Their Relevance to the Geographical Environment

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ABSTRACT: The basic characteristics of spatial forms of traditional villages in the Qingjian River Basin, Northern Shaanxi Province in the Loess Plateau were analyzed through field investigations. The results revealed eight characteristics that were closely related to the spatial form of villages. Correlations among these eight characteristics were analyzed using SPSS19.0, and the results suggest that characteristics of spatial forms of traditional villages are most closely related to landforms. Based on these data, the spatial forms of traditional villages in the Qingjian River Basin were divided into river valley, slope platform, and ridge-top slope areas. In addition, five components of spatial forms were analyzed, spatial morphological features were summarized, and correlations between environmental features and spatial forms of villages in the Qingjianhe River Basin were discussed.

KEY WORDS: traditional village; spatial form; characteristic factor; topographic characteristics; Qingyjian River Basin

Introduction

Northern Shaanxi is located in the Loess Plateau region ofChina, where soil erosion is severe and the ecological environment is fragile. The region is crisscrossed with gullies, and undulating ridges and hillocks. The complex hillock-and-ridge landforms and harsh living environment have made river valleys the primary habitats for human settlements in northern Shaanxi. In the Stone Age, the valleys of the primary tributaries of the Yellow River were the preferred places for primitive humans to settle. From south to north in northern Shaanxi, there are 12 primary tributaries of the Yellow River, including Luo River, Yan River, Qingjian River, and Wuding River. Different river basins have formed multiple independent human settlement environment units with their own characteristics and overall unity due to differences in geographical locations, climatic conditions, soil characteristics, river length and width, cultural history, etc. The population density generally exhibits a decreasing trend from south to north, which aligns with the rising elevation of the Loess Plateau in northern Shanxi from south to north and is also consistent with the distribution pattern of the river basins [1, 2].

The Qingjian River Basin is located at the junction of Yulin City and Yan'an City on the west side of theShanxi-Shaanxi Grand Canyon. The basin mainly includes Yanchuan County, Zichang County, and Qingjian County. The main river channel runs northwest-southeast [3]. Among the 12 primary tributaries of the Yellow River, the

[The format of citation in this article]
JIN Yibing, HOU Lishuang, WANG Jiayun, et al. Analysis of Spatial Form Characteristics of Traditional Villages in the Qingjian River Basin and Their Relevance to the Geographical Environment[J].Journal of South Architecture, 2025(2): 25-40.

• **Fund Projects**: National Key R&D Program (2019YED1100700); National Natural Science Foundation of China Youth Fund (51208419)
Document Identification Code A **DOI** 10.33142/jsa.v2i2.16526 **Article number** 1000-0232(2025)02-003-16

Qingjian River Basin has a relatively dense population, sufficient research samples, typical landform features, moderate main river length and basin range, and low village diversity. Therefore, traditional villages in this area were selected as the research object to explore their spatial form characteristics and their relevance to the geographical environment (Figure 1).

Traditional villages were formed in agricultural society, reflecting the simple concept of symbiosis between people and the material environment, and manifesting themselves as active or passive relationships between people and the land [4]. The purpose of studying village morphology is to find the differences between villages, the relationship between villages and their environment, and to analyze the rational layout within the villages [5].The geographical environment characteristics of northern Shaanxi are typical, and the formation and development of traditional villages are closely related to the geographical environment. This article employs field investigation, mapping interviews, literature review, comparative analysis, and other methods to extract the spatial form characteristic factors of traditional villages in the Qingjian River Basin. Combined with the typical topographic and geomorphological characteristics of the Loess Plateau, it analyzes the spatial form characteristics of villages, extracts the main influencing factors, analyzes the relationship between influencing factors and spatial forms, and clarifies the mechanism of the main influencing factors.

1 Basic characteristics and characteristic factor extraction of traditional village spatial forms

1.1 Investigation of basic characteristics of traditional village spatial forms

In the Qingjian River basin, there are a total of 739 administrative villages. Based on the results of national and provincial evaluations of traditional villages and on-site surveys, combined with the typicality of the village's layout, style, historical relics, and other characteristics, it was determined that there were about 160 villages in the basin that met the definition criteria, accounting for 21.6% of the total number of villages in the basin. The distribution of traditional villages in the upper, middle, and most areas of the lower reaches of the basin has obvious characteristics of dense distribution along the river, but there are fewer distributions around the county towns of Zichang County, Yanchuan County, and Qingjian County, and the relationship between the distribution of villages in the ridge-and-hillock hills in the lower reaches and the river is unclear. Based on the characteristics and quantity of the spatial distribution of 160 traditional villages along the terrain and along the water system, 34 traditional villages were selected as the main survey objects (Figure 2). The main survey contents include the characteristics of the village's material basis, social basis, and spatial form.

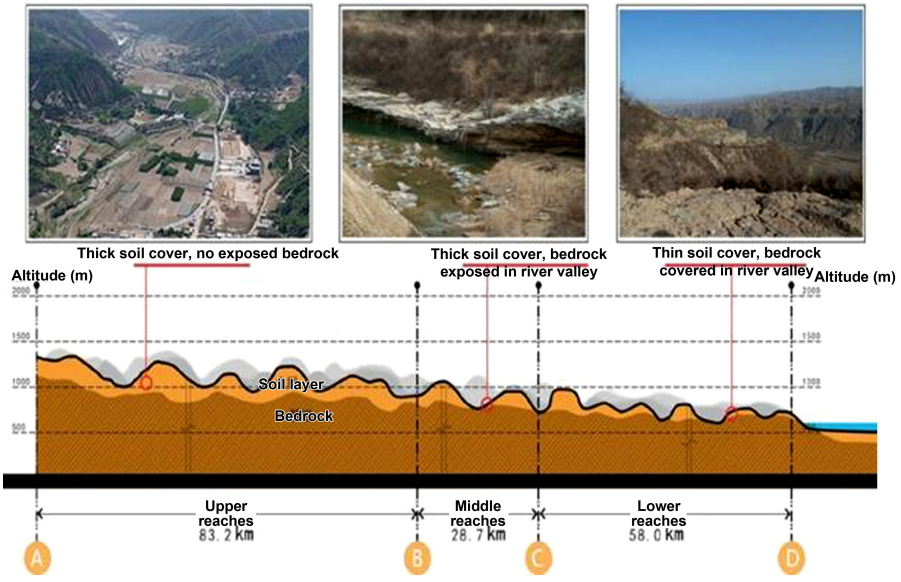


Figure 1 Schematic diagram of thealtitudes and landforms of the main channel of the Qingjian River

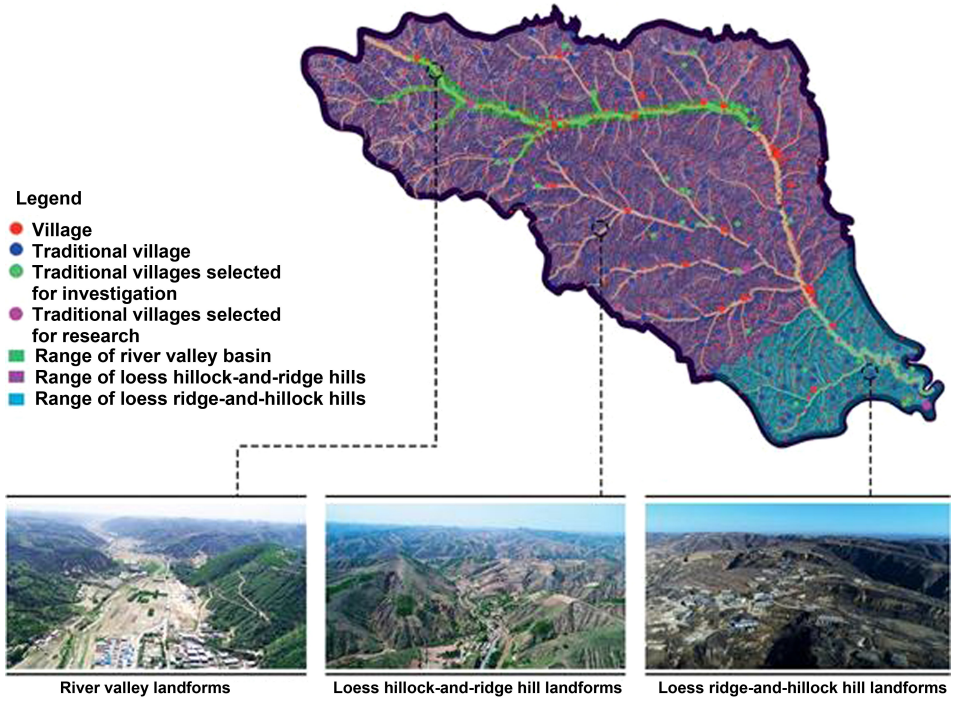


Figure 2 Landform ranges and village distribution in the Qingjian River Basin

1.1.1 Characteristics of the material foundation of traditional villages

The lower reaches of the Qingjian River Basin have the largest area and the largest number of traditional villages. The villages are closely related to rivers. Among the 34 sample villages, 79% are built along rivers, with the distance from the rivers generally not exceeding 100m. Most of them are distributedalong the primary tributaries of the Qingjian River and in their minor gullies. Due to the narrow space in the river valley, 59% of the sample villages are located on the north side of the river. The length-to-width ratio of concentrated residential areas in villages is mostly between 5 and 10, with strip-shaped planes as the main form, and the area is mainly small and medium-sized, ranging from 100 to 200 mu (1 mu, approx. 0.066 7 hectares). The material basis characteristics of traditional villages in the Qingjian River Basin are closely related to the landforms dominated by river valley spaces formed by various river sections and tributaries at all levels (Table 1).

1.1.2 Basic characteristics of village society

The social baseline survey primarily employed questionnaires and interviews, and was distributed in 34 villages.

Table 1 Analysis of traditional village site selection types and topographic and geomorphic characteristics

Site type	River Valley	Slope Platform	Ridge-top Slope
Geomorphic location	The rear edge of the main river valley's low terrace	Gentle slopes and terraces at the foot of river valleys at all levels	Platform ridge top
Geomorphic distribution	Mainly locatedalong the main river channel of the upper reaches of the Qingjian River or in some primary tributary valleys.	Except for the downstreamridge-and-hillock hills and the upper reaches of the main river channel, there is a substantial distribution elsewhere.	Downstream, close to the Yellow River.
Quantity/Proportion	3/9%	24/70%	7/21%

About 200 questionnaires were sent, and 174 valid questionnaires were collected. Most of the current residents in the village are over 50 years old. Young people go out to work. 77% of the villagers are mainly engaged in farming, and the overall income level is relatively low. The survey shows that poor traffic, delayed transportation, and difficulty in using water have prompted villagers to consider riverside or near river as the primary consideration when initially choosing a location to build houses. In addition, favorable fengshui, terrain slope, and proximity to farmland are also important factors. Folk culture, military history, clan beliefs, and commercial activities have wea-

ker relevance to the spatial form of traditional villages.

1.1.3 The relationship between the spatial form characteristics of villages and their geographical environment

The landscape pattern of traditional villages is restricted by landforms and the intervention of human subjective choices, forming a village spatial pattern with mountains, water, forests, fields, and villages as the main components. Through the analysis of 34 sample villages, the spatial pattern of traditional villages in the Qingjian River Basin is divided into three categories: "mountain, forest-water, field, village-mountain, forest", "mountain, forest-village, field-mountains, forest-water" and "mountain, forest-water-village, field". Concentrated residential areas are mainly divided into strips and clusters, and according to the changes in boundary contours, they can be divided into regular and random shapes. According to the layout principles and forms of streets, the 34 surveyed villages can be divided into three categories: regular layout along river valleys, semi-random layout along contour lines, and natural layout along mountain ridges. According to the density of the building combination, it can be divided into cluster type and dispersed type. Under the fundamental principle of facing south as much as possible, building orientations are further categorized into three types: West-facing (literal: sitting west-facing east), South-facing (literal: sitting north-facing south), and East-facing (literal: sitting east-facing west). The formation and classification of the above characteristics are highly correlated with the spatial environmental characteristics of the Qingjian River valley (Table 2).

Table 2 Schematic diagram of the relationship between the spatial form characteristics of typical villages and the geographical environment

Shilipu Village	Taixiangsi Village	Liujiashan Village
		

In summary, the basic characteristics of traditional villages are closely related to the geographical environment, and the spatial form characteristics of different types of villages show obvious differences. It is inevitable to classify the spatial forms of villages according to the geographical environment characteristics of their locations, and then analyze the characteristics of each type of spatial forms.

1.2 Extraction and analysis of spatial form-related characteristic factors

The formation and characteristics of the spatial form of traditional villages are related to multiple factors. Combining field investigation and literature review, taking into account the geographical environment, climate, and hydrology of the Qingjian River Basin, we can extract and analyze spatial form characteristic factors of traditional villages using methods similar to those proposed by scholar Sun Ying [6].Eight characteristic items were selected, including location, landform, river level, distance from the river, village size, street network pattern, building layout, and building materials. The characteristic factors under each characteristic item were extracted and coded (Table 3).

Table 3 Classification and coding of spatial form-related characteristic factors

Serial number	Characteristic Item	Characteristic Factor
1	Location	1 = "upper reaches of the Qingjian River"; 2 = "middle reaches of the Qingjian River"; 3 = "lower reaches of the Qingjian River"
2	Landform	1= "river valley"; 2 = "loess hillock-and-ridge hills"; 3 = "loess ridge-and-hillock hills"

(Continued)

Serial number	Characteristic Item	Characteristic Factor
3	River level	1 = "Level 1: Main channel of the Qingjian River"; 2 = "Level 2: Primary tributary of the Qingjian River"; 3 = "Level 3: Secondary tributaries of the Qingjian River and minor gullies"; 4 = "Level 4: No channel"
4	Distance from the river	1 = "Near: 0~ 40m"; 2 = "Medium: 40~ 100m"; 3 = "Far: more than 100m"
5	Village size	1 = "Small: less than 150 mu"; 2 = "Medium: 151 mu~ 300 mu"; 3 = "Large: more than 300 mu"
6	Street network pattern	1 = "Regular layout along the river"; 2 = "Semi-random layout along the contour line"; 3 = "Random layout along the ridge"
7	Building combination	1 = "compact"; 2 = "dispersed"
8	Main building materials	1 = "blue brick"; 2 = "slate stone"; 3 = "block stone"; 4 = "clay"

There are complex intrinsic relationships between various factors and spatial forms. Based on preliminary investigations, it is proposed that landforms have the strongest relevance to other characteristic items. The characteristic factor coding results were imported into SPSS software to analyze the relevance to spatial form characteristic items and test whether there was a certain degree of association between the variables and the strength of the association. According to the analytical results (Table 4), landform and street network pattern demonstrate stronger relevance to the other six factors, with landform exhibiting a higher Pearson correlation coefficient. Thus, the hypothesis that landform has the strongest correlation with spatial form is validated.

Table 4 Correlation analysis of spatial form characteristics based on SPSS19.0

Characteristic Item		Location	Landform	River level	Distance from the river	Village size	Street network pattern	Building combination	Main building materials
Location	Pearson correlation	1	0.419*	0.181	0.474*	−0.174	0.543**	0.164	0.865* *
	Significance (two-sided)	—	0.037	0.385	0.017	0.405	0.005	0.434	0.000
Landform	Pearson correlation	0.419*	1	0.700**	0.667**	−0.555**	0.929**	−0.044	0.177
	Significance (two-sided)	0.037	—	0.000	0.000	0.004	0.000	0.836	0.397
River level	Pearson correlation	0.181	0.700**	1	0.456*	−0.657**	0.693**	−0.129	−0.052
	Significance (two-sided)	0.385	0.000	—	0.022	0.000	0.000	0.538	0.806
Distance from the river	Pearson correlation	0.474*	0.667**	0.456*	1	−0.559**	0.757**	0.376	0.160
	Significance (two-sided)	0.017	0.000	0.022	—	0.004	0.000	0.064	0.446
Village size	Pearson correlation	−0.174	−0.555**	−0.657**	−0.559**	1	−0.576**	0.016	0.105
	Significance (two-sided)	0.405	0.004	0.000	0.004	—	0.003	0.940	0.617
Street network pattern	Pearson correlation	0.543**	0.929**	0.693**	0.757**	−0.576**	1	0.170	0.294
	Significance (two-sided)	0.005	0.000	0.000	0.000	0.003	—	0.418	0.154
Building combination	Pearson correlation	0.164	0.738**	−0.129	0.376	0.016	0.170	1	0.052
	Significance (two-sided)	0.434	0.836	0.538	0.064	0.940	0.418	—	0.806
Main building materials	Pearson correlation	0.865**	0.177	−0.052	0.160	0.105	0.294	0.052	1
	Significance (two-sided)	0.000	0.397	0.806	0.446	0.617	0.154	0.806	—

Note: * . Significant relevance at the 0.05 level (two-sided); * * . Significant relevance at the.01 level (two-sided).

2 Analysis of spatial form types based on landforms

2.1 Spatial form classification and components

According to the landform features of the villages, the 34 sample villages are divided into river valley type (3 in total, accounting for 9%), slope platform type (24 in total, accounting for 70%), and ridge-top slope type (7 in total, accounting for 21%). The geographical characteristics of the Qingjian River Basin are representative, and the material environment characteristics of traditional villages are prominent. This article focuses on analyzing the spatial form characteristics of villages from the perspective of the material environment components

of the spatial forms of traditional villages. To extend the research content and logic of spatial forms, and with reference to the definitions of spatial morphological components by scholars such as Lu Yuanding, Yang Dinghai, and Duan Yapeng [7-9], the main research contents were determined to be surrounding environment, residential area shape, internal spatial structure, street, and building.

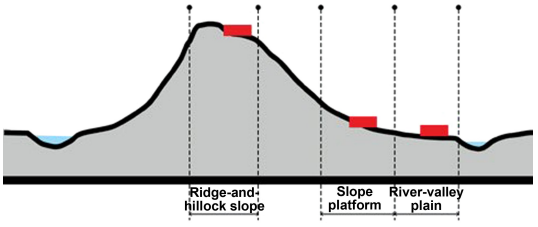
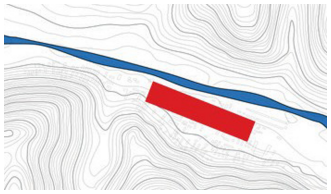
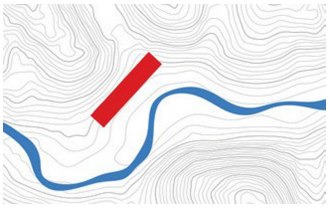
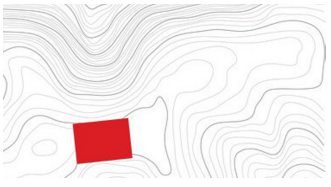
2.2 Comparative analysis of the characteristics of three types of spatial forms

Anding Village in Anding Town, Zichang County, Zhenjiawan Village in Guanzhuang Town, Yanchuan County, and Nianpan Village in Qiankunwan Town, Yanchuan County were selected as research objects, representing river valley type, slope platform type, and ridge-top slope type villages respectively.

2.2.1 Surrounding environment: Village locations and landscape patterns

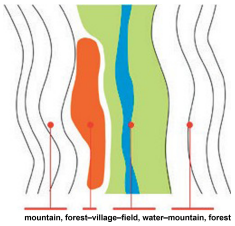
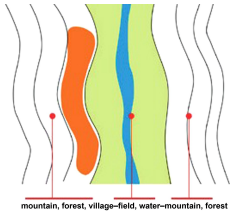
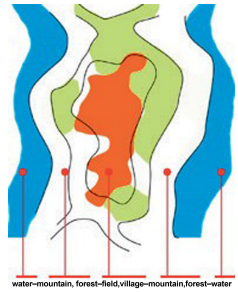
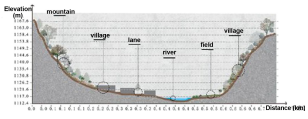
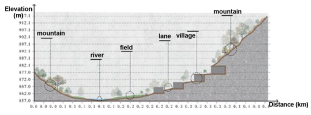
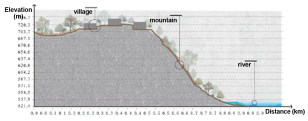
The locations of traditional villages are mainly at the foot of mountainsand on top of ridges. The hillocks have steep slopes, which are not conducive to village construction. River valley-type and slope platform-type villages are mainly restricted by topographic conditions and are mostly located at the foot of mountains. Ridge-top slope-type villages are mainly restricted by geological conditions and are mostly located on platform ridges. The middle and upper reaches of the Qingjian River have a relatively high altitude and a relatively thick soil cover, which is conducive to digging and building cave dwellings. The lower reaches of the river have loess ridges and hills with a low altitude, and only the areas with a small amount of loess covering the top of the ridges can be used to build cave dwellings and cultivate land (Table 5).

Table 5 Villagelocation analysis

Type	River valley type	Slope platform type	Ridge-top slope type
Landform type	River valley	Loesshillock-and-ridge hills	Loessridge-and-hillock hills
Landform characteristics	Thealtitude is high, the soil cover is thick, and the land is wide and flat; the terrain slope is gentle, generally not exceeding 15°.	The valley is narrow, and the riverbed is exposed; the terrain slope is steep, about 15°~45°.	The altitude is low, the soil cover is thin, and the bedrock is exposed in a large area of the valley; the soil covering the top of the ridge forms an irregular strip platform; the terrain slope varies, either flat or steep.
Village location	The foot of the hillock is wide and flat, close to the river.	The terraced land formed at the bend of the terrainon the bottom of the hillock slope, close to the river.	Located on the remnant plateau or gentle slope at the top of the ridge, far from the river.
Schematic cross-section of topography and village site selection			
Plan view			
Village characteristics	The residential area is large and relatively low in elevation. Convenient external transportation, neat and compact building layout.	The residential area is smaller and relatively lower in elevation. The traffic is relatively blocked, and the building layout is compact.	The residential area is small and relatively high in elevation. The traffic is very blocked, and the building layout is scattered.

The traditional villages in the Qingjian River Basin grew up in an area with undulating mountains and dense water systems, eventually forming a landscape pattern composed of mountains, water, forests, fields and villages. The cultivated land area in northern Shaanxi is small, and its unique loess culture and backward social development level have greatly increased the dependence of the people on farmland. All three types of villages show obvious characteristics of the interdependence between villages and fields (Table 6).

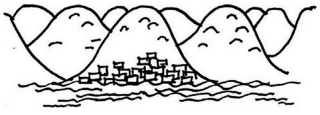
Table 6 Analysis of landscape pattern

Type	River valley type	Slope platform type	Ridge-top slope type
Typical pattern	Mountain, Forest-Village-Water, Field-Mountain, Forest	Mountain, forest, village-Water, field-Mountain, forest	Water-Mountain, Forest-Village, Field-Mountain, Forest-Water
Influencing factors	The valley is flat and open.	The valley is narrow.	The bedrock is exposed in a large area of the valley, making it difficult to build cave dwellings and cultivate land.
Schematic diagram			
Characteristics	The river and fields are adjacent, and the village is on one side.	The river and fields are adjacent, and hills and residential areas are integrated.	Village and fields are adjacent, far from the river
Schematic cross-section of typical villages	 Anding Village	 Zhenjiawan Village	 Nianpan Village

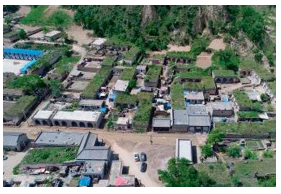
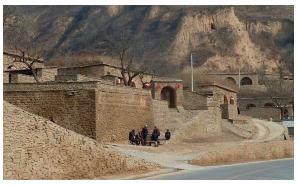
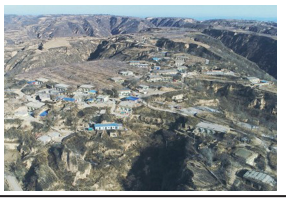
2.2.2 Morphological characteristics of residential areas

The local villages, integrating the varying elevations of the terrain to form cascading cave dwellings, represent the most distinctive and representative vernacular settlement landscape in northern Shaanxi. (Table 7)

Table 7 External landscape analysis

Type	River valley type	Slope platform type	Ridge-top slope type
Main influencing factors	Earlyconstraining factors: landforms Late driving factors – building materials, construction forms	Landforms	Landforms and building materials
Characteristics	The overall height and opening change little, and the external landscape characteristics are not prominent.	It presents a typical landscape of cave dwellings in northern Shaanxi.	External landscape features are not prominent.
Schematic diagram			
Building facade composition relationship	Tight, parallel	Tight, parallel, staggered, stacked	Dispersed, poorly correlated

(Continued)

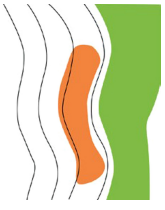
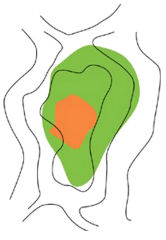
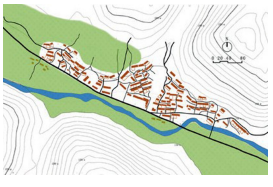
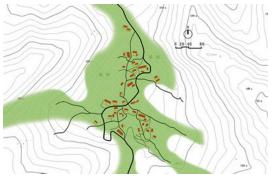
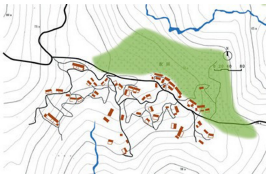
Type	River valley type	Slope platform type	Ridge-top slope type
Typical Examples	Anding Village 	Zhenjiawan Village 	Xiadamu Natural Village 

2.2.3 Spatial structural characteristics

(1) Functional structure: Village functions mainly based on agriculture

When traditional villages first formed, they existed for a certain purpose [10].The Qingjian River Basin is located in the Loess Plateau, which has the living characteristics of "facing the yellow earth with the back to the sky." Agriculture is the basis of survival in the local area, and to this day, it still maintains the survival gene of relying on the weather for food. The relationship between villages and fields is very close, with the field-encircled villages being the most typical (Table 8).

Table 8 Functional structure analysis

Type	River valley type	Slope platform type	Ridge-top slope type	
Functional structure	Farming is the main activity, and residential life is secondary. Some large villages have commercial activities, religious activities, etc.	Farming is the main activity, and residential life is secondary. Less religious activities.	Farming is the main activity, and residential life is secondary. Less religious activities.	
Influencing factors	The village society is based on clan blood relationship and the loess culture of "facing the yellow earth with the back to the sky".			
Field location	River valley slope less than 25°			
	Riverside area near the river	Terrace near the river	Ridge-top Terrace	
Village, Field Positional Relationship	Semi-inclusive	Adjacent	All-inclusive	Connect
Schematic diagram				
Typical Villages	Tangjiachuan Village 	Anshang Village 	Xiadamu Village 	Liujiashan Village 

(2) The main axis of the village is constrained by natural environmental elements.

The axis represents a certain consistency, continuity, and extensibility of the village. It is an existing spatial layout logic of the village and a possible route for future development. The formation and development of villages are closely related to the environment in which they are located. Villages constrained by environmental conditions show a growth state that adapts to the geographical environment. The plane form, architectural layout, etc., of traditional villages in the Qingjian River Basin follow a certain order (Tables 9 and 10).

Table 9 Relationship between the village axis and naturalenvironmental elements within the river valley and the slope platform

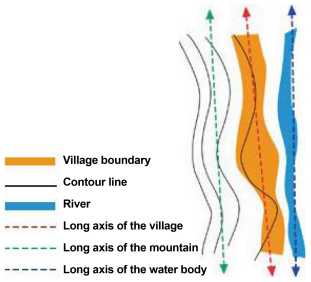
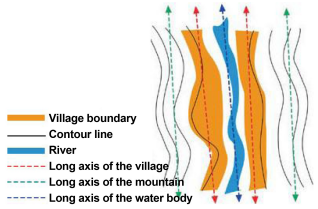
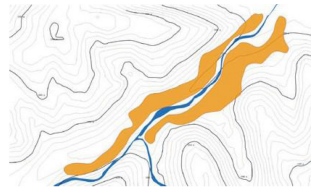
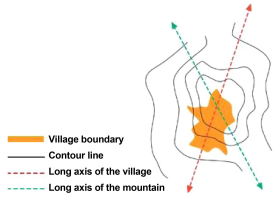
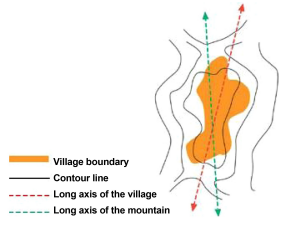
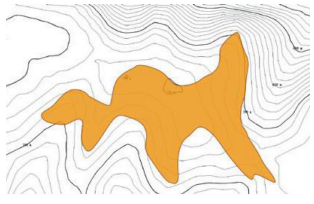
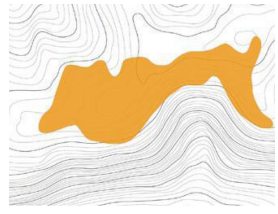
Characteristics	The village growth axis is parallel to the natural environmental elements (river valley type, slope platform type)	
Type	The river passes by one side of the village (Typical type, many river valley and slope platform types)	The river runs through the village (Atypical type, more common in a slope- platform village with narrow valleys)
Schematic diagram		
Characteristics	The natural environment element axis and the village axis are both relatively clear. The natural environment factors impose certain limitations on the growth of villages, and the villages are in the shape of strips.	
Elements imposing limitations	Tangible boundaries: the foot of the mountain, the water boundary	
Typical Villages	Tangjiachuan Village 	Xiyuanjiagou Village 

Table 10 Relationship between the village axis andnatural environmental elements on ridge-top slope

Characteristics	The village growth axis is not parallel to the natural environmental elements (ridge slope type)	
Type	The axis of natural environmental elements and the village axis is not clear (typical type)	The natural environment element axis and the village axis are relatively clear(Atypical type)
Schematic diagram		
Characteristics	Natural environmental elements impose certain limitations on village growth, and villages are mostly irregular in the shape of clusters.	Natural environmental elements impose certain limitations on village growth, and villages are mostly in the shape of irregular strips.
Elements imposing limitations	Invisible boundaries: the boundaries of the top of platform ridges and the top of ruins	
Typical Villages	Shifo Village 	Nianpan Village 

2.2.4 Street characteristics

Streets are the most frequently used places in the village besides houses, and are important places for social interactions. The street form is strongly constrained by the natural environment, and its characteristics reflect the clear interactive relationship between the village and the landforms, reflecting the local people's adaptation and transformation process to the natural environment. Under different terrain and environmental conditions, river valleys and mountains have different impacts on the layout and space of streets (Tables 11 and 12).

Table 11 Analysis of street network patterns

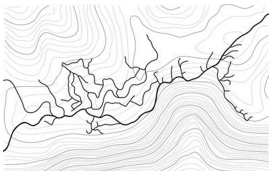
Type		River valley type	Slope platform type	Ridge-top slope type
Influencing factor	Terrain	River-valley flatness	Mountainous variability	Ridge-top fluctuation
	Trend	River flow trend	Contour trend	Ridge-and-hillock top trend
Street network pattern		First-level streets are parallel to the river, second-level streets are perpendicular to the river, and third-level streets are mainly parallel to the river. The layout is relatively regular and well planned.	First-level streets are parallel to the contour lines, second-level streets are perpendicular to the contour lines, and third-level streets are mainly parallel to the contour lines.	The trend of the first-level streets is roughly consistent with the trend of the platform ridge top, and the second and third-level streets are randomly distributed along the ridge top.
Street slope		The slope of the first-level streets is generally negligible, and the slope of the second-level streets is determined according to the slope of the terrain. Generally, it does not exceed 15°, and the slope of the third-level streets is generally negligible.	The slope of the first-level streets is generally negligible, and the slope of the second-level streets is based on the slope of the terrain. Mostly 15°~ 45°, the third-level streets are highly random.	Affected by the topography of the ridge, the slope is not fixed.
Number of streets		There are no more than two first-level streets—often just one—accompanied by four to eight second-level streets. Third-level streets are the most numerous, with their exact count varying according to the village's size.		
Typical village	Villagename	Anding Village	Zhenjiawan Village	Nianpan Village
	Street network pattern			
	Slope	The slope of thesecond-level streets is about 7°	The slope of thesecond-level streets is about 35°	Uncertain slope

Table 12 Street space analysis

Type		River valley type	Slope platform type	Ridge-top slope type
Boundary Definition		Courtyard Wallsand Cave Facades as boundaries		A few streets are defined by courtyard walls and cave facades. Most streets have unclear spatial boundaries.
Street scale	Level 1	D/H ≈ 1.0~ 1.5	D/H ≈ 1.1~ 2.1	D/H ≈ 1.5~ 2.5
	Level 2	D/H ≈ 0.7~ 1.0	D/H ≈ 0.8~ 1.5	D/H ≈ 1.1~ 2.0
	Level 3	D/H ≈ 0.3~ 0.7	D/H ≈ 0.3~ 1.0	—
	Remark	Due to the variable terrain of ridge-top slope villages, the dimensions ofthe first and second-level streets were extracted only for the main roads. Some second-level streets and all third-level streets fail to form complete and fixed enclosed spaces.		
Street Space		The first-level streets are open, the second andthird-level streets have a sense of enclosure, the second-level streets are of a pleasant scale, and the third-level streets have a clear inward orientation.	The first andsecond-level streets are open, while the third-level streets have a strong sense of enclosure.	The streets at all levels are extremely open and have a weak sense of enclosure.

(Continued)

Type	River valley type	Slope platform type	Ridge-top slope type
Usage	Thefirst-level streets are suitable for long stays, while the second-level streets are suitable for passing slowly, and the third-level streets for short-time talking.	Pass through thefirst-level streets quickly, stay for a long time in the second-level streets, and stop and talk for a short time in the third-level streets.	Pass through the first and second-level streets quickly, and stop and talk for a short time in the third-level streets.

2.2.5 Building Characteristics

(1) Building combination, orientation and layout

The traditional villages in the Qingjian River Basin are mainly cave dwellings, which are effectively combined with the terrain to form a variety of architectural combination characteristics. Since the layout of cave dwellings in the basin is relatively homogeneous, the geometric center of the village is unclear, and the sense of territory is not strong, the architectural combination forms are divided into three types according to the density of the buildings: compact, semi-compact, and dispersed.

The typical cave dwellings in northern Shaanxi make it necessary to choose a south-facing building with better lighting and more heat during construction. Regardless of the terrain conditions, facing south as much as possible is the main principle for building traditional villages in the Qingjian River Basin [11]. On this basis, different orientation characteristics are formed according to the different geographical environment where the buildings are located (Table 13).

Table 13 Analysis of building orientation and layout

Type		River valley type		Slope platform type	Ridge-top slope type	
Building Orientation		Facing south as much as possible				
Building Location		Strip-shaped planes in gullied valleys		South side of the mountain, sunny side	Ridge-and-hillock slope top	
Influencing factors		The relationship between locations and natural environmental elements				
Orientation characteristics		The buildings on the north side of the river are primarily oriented perpendicular to the river's flow.	The buildings on the south side of the river areprimarily oriented parallel to the river's flow.	Perpendicular to contour lines	The single units located on the slope are primarily oriented perpendicular to contour lines.	Thesingle units located on the platform are primarily oriented randomly, facing south.
Building layout	The single unit of cave dwellings	The single-unit layout of the cave dwellings on the north side of the river is parallel to the river.	The single-unit layout of the cave dwellings on the south side of the river is perpendicular to the river.	The single-unit layout is parallel to contour lines.	The single-unit layout on a slope is parallel to contour lines.	The single-unit layout on the platform is random.
	cave dwellings group	The overall layout is parallel to the river and has a regular shape.		The overall layout is parallel to the contour lines, and the shape is semi-regular, mostly forming a certain arc.	The relationship between the overall layout and the contour lines is unclear, and the layout is random along the top of the ridge.	

(2) Courtyard space

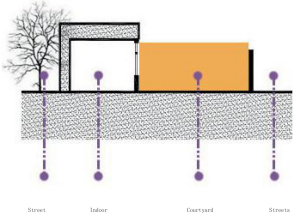
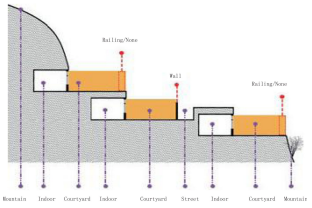
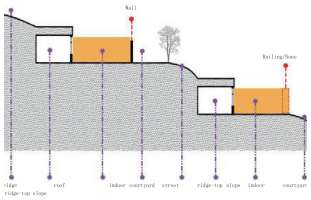
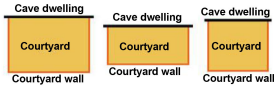
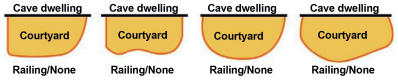
In the Loess Gully area of northern Shaanxi, a courtyard may be surrounded by cave dwellings on only one or two sides, with no physical enclosure on the other three or two sides. The formation of this state is related to the slope characteristics of the mountain itself. An enclosure interface is formed on the side close to the mountain, and there are no objects blocking the other two to three sides. However, there are steep cliffs that isolate the paths, forming an open space that is isolated from the outside world (Table 14).

2.3 Overall characteristics of spatial form

The location of villages is closely related to natural environmental factors. Villages are backed by mountains and face water, and there is a high demand for water sources, loess, and arable land. With the emergence of new water extraction methods, new construction materials, and new production methods, dependence on loess has decreased. Villages with slightly better

economies have slightly reduced their dependence on water sources, but their dependence on agricultural land is still strong. The overall layout presents a typical pattern of tightly interdependent mountain-water-field-dwelling symbiosis. The axis of the residential area is relatively clear and has a close relationship with the natural environmental elements; the long axis is parallel to the natural environmental elements, and the short axis is perpendicular to the natural environmental elements. The first-level streets are parallel to the natural environmental elements, the second-level streets are perpendicular to the natural environmental elements, and the third-level streets are relatively random. The building combination is mainly compact, and the internal transportation efficiency of the village is high. The building orientation is mainly south-facing, and the building orientation, layout, and natural environmental elements are closely related. The courtyards are mainly small and medium-sized, and the spaces are mainly inward.

Table 14 Analysis of courtyard space

Type	River valley type		Slope platform type			Ridge-top slope type		
Courtyard Type	street-courtyard-street		mountain-courtyard-courtyard; mountain-courtyard-street; mountain-courtyard-mountain			mountain-courtyard-street; mountain-courtyard-mountain		
Courtyard characteristics	With a complete interface enclosure, the courtyard space is inward and private.		Semi-open	Open and outward	inward and private	Semi-open	Open and outward	inward and private
Schematic diagram	 Type 1: River Valley		 Type 2: Slope platform			 Type 3: ridge-top slope		
Courtyard space size	Length (m)	15~ 28	Length (m)	14~ 30		Length (m)	10~ 40	
	Width (m)	12~ 30	Width (m)	8~ 16		Width (m)	8~ 15	
	Area (m^2)	180~ 840	Area (m^2)	112~ 480		Area (m^2)	80~ 600	
	The length and width are similar, and the area is larger		The short side is smaller, the long side is longer, and the area is smaller			The short side is smaller, the long side is longer, and the area is moderate		
Courtyard Plan (The long side is the cave)	 Regular rectangle (the courtyards of "cave dwelling + courtyard wall" are all regular rectangles)							
	 Irregular shapes (mainly "cave dwelling + railings", "cave dwelling" courtyards)							
Representative courtyard photo 1 (Courtyard type)	 Street-Courtyard-Street		 Mountain-Courtyard-Courtyard			 Mountain-Courtyard-Street		 Mountain-Courtyard-Mountain

The spatial form characteristics of traditional villages in the Qingjian River Basin clearly reflect the village construction concept of being close to water, facing the sun, and saving land when the villageswere built in northern Shaanxi.

3 Analysis of the correlation between spatial forms and influencing factors of traditional villages in the Qingjian River Basin

The formation of the spatial form of traditional villages is affected by the combined action of multiple factors.

During this process, the relationships among various influencing factors, among the five elements of spatial forms, and between the influencing factors and spatial forms, are complex. This article takes the dominant elements of each content as the starting point to analyze the correlation between the dominant influencing factors of the Qingjian River Basin and the dominant elements of spatial morphology. Combined with the previous text, it is concluded that the natural environment, social economy, customs and culture, and relevant policies have an impact on the formation of spatial form (Figure 3).

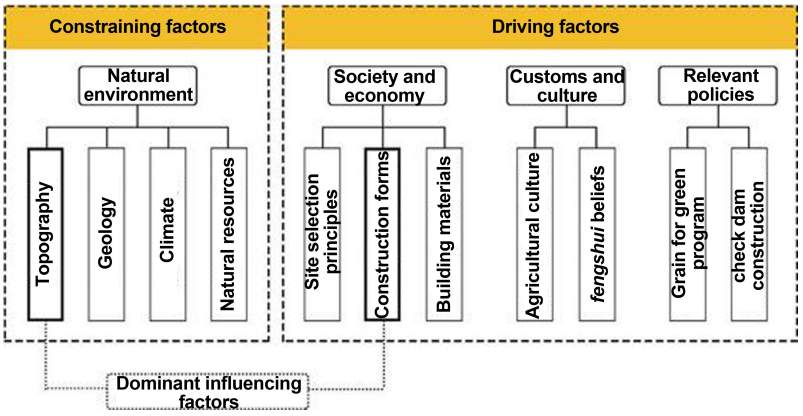


Figure 3 Factors affecting the spatial form of traditional villages and their subsystems

3.1 The correlation between spatial forms and influencing factors

Surrounding environment has a great influence on the other four elements and plays a dominant role in the formation of the spatial form characteristics of the village. Building occupies a core position among the five elements. Surrounding environment and streets have an impact on buildings, which affects the shape of residential areas and internal space structure through the combination of buildings. At the same time, buildings and streets complement and influence each other. The formation of the shape and internal spatial structure of residential areas depends on the layout of buildings and streets, and is indirectly affected by the surrounding environment.

While the natural environment has an impact on the villages, it also has a subtle influence on the social economy, customs and culture, and related policies. Among them, the main influence is the landform characteristics, which have a strong influence on site selection principles, construction forms, construction materials, etc.

The typical natural environment of the Qingjian River Basin is the basis for the formation of traditional villages. The natural environment is the premise that affects the formation and evolution of the spatial forms of traditional villages and is a restrictive factor in the formation of the spatial forms of villages. On the basis of specific natural environmental conditions, the modification of village spatial form by social economy, customs and culture, and relevant policies is the driving factor for the generation of village spatial form characteristics. The influence of the four factors varies when applied to different types of villages. For river valley villages, the society and economy factor has the greatest influence on spatial forms and are the dominant driving force, followed by the natural environment factor and the customs and culture factor, and the relevant policy factor plays a certain role. For slope platform villages and ridge-top slope villages, the natural environmental factor has the greatest influence on spatial forms and is the dominant restrictive force, followed by the society and economy factor and the customs and cultural factors, while the relevant policy factor has less influence (Figure 4).

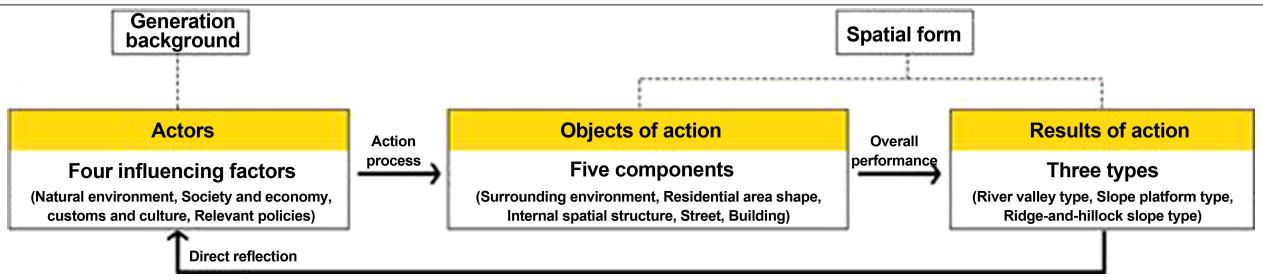


Figure 4 Relationship between spatial forms and influencing factors

3.2 Mechanism of action

(1) The constraints of landforms on village site selection

The concept of boundary is introduced here. The boundary of a settlement is composed of material elements at the edge of the settlement, including natural boundaries, artificial boundaries, mixed boundaries, etc [12]. The unique geographical environment of the Qingjian River Basin is an important factor influencing the formation of villages. The spatial form of traditional villages is closely related to natural boundaries (mountains and rivers), and village development is limited by the natural environmental factor. There are two forms of constraints of natural environmental elements. One is tangible constraints, including the constraint of mountains on village development space and the constraint of rivers on village development path. This form is mainly due to the fact that the village is located in the valley. During the growth of the village, the mountain has physically limited the village's growth space in the vertical direction, and the water has physically limited the village's growth path in the horizontal direction. They all have strong control over village development, and the boundaries between villages and natural environmental elements are clear. The second is invisible boundaries, which is mainly due to the fact that the village is located at a higher place. Although there is no clear object blocking the village in the vertical direction during its growth, the terrain slope increases sharply, making it impossible for the village to continue to expand outward in the horizontal direction. The boundary of the platform ridge top becomes an invisible boundary for the outward expansion of the village. The boundary of the ridge top is fuzzy and has many twists and turns, and the boundary between villages and mountains is unclear (Table 15).

Table 15 Constraints of landforms on village location

Type	River valley type		Slope platform type		Ridge-top slope type
Boundary characteristics	No continuous solid boundaries				
	Clear boundaries		Clear boundaries		Blurred Boundaries
Elements imposing limitations	Mountains	Rivers	Mountains	Rivers	Mountains
Boundary shape	Tangible physical boundaries		Tangible physical boundaries		Invisible non-physical boundaries
Constraint Type	Constrained Space	Constrained Path	Constrained Space	Constrained Path	Constrained Path
Constraint characteristics	1) The landscape environmental elements impose normalconstraints; 2)Constraining force: mountains > rivers; 3) The boundaries between the landscape elements and the village are clear		1) The landscape environmental elements impose strongconstraints; 2) Constraining force: mountain= river; 3) The boundaries between the landscape elements and the village are clear		1) Mountains impose strongconstraints; 2) Blurred boundaries between landscape elements and the village

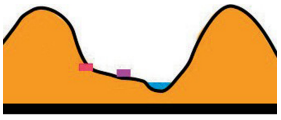
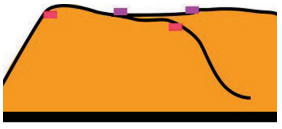
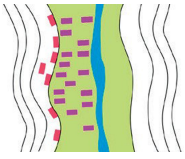
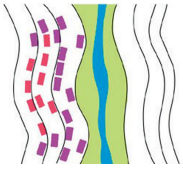
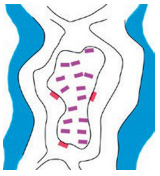
(2) The driving mechanism of construction form on village location

Before the Ming and Qing Dynasties, the three types of villages were mainly mountain-backed cave dwellings. With the emergence of new materials, interfaced and independent cave dwellings appeared, and the combination of cave dwellings became diversified. The location of cave dwellings was no longer limited to those close to the mountain, which greatly reduced the constraints of terrain conditions on house construction, and the spatial forms of

the villages changed accordingly (Table 16).

After the Ming and Qing Dynasties, the river valley villages were mainly built with independent cave dwellings. The emergence of independent cave dwellings greatly reduced the constraints imposed by the mountainous terrain. Villages began to develop from the gentle slopes at the foot of the mountain to the river valley areas, and the constraints imposed by the river increased. The vast land and flat terrain have led to a significant increase in the size of villages, which are gradually moving closer to rivers. The spatial form is mainly reflected in the significant increase in the degree of spatial planning, the proximity of residential areas to farming areas, a more regular layout of streets and buildings, and an increase in the introversion of streets and courtyard spaces.

Table 16 Driving mechanism of construction forms on village locations

Type		River valley type	Slope platform type	Ridge-top slope type
Construction forms	Before the Ming and Qing Dynasties	Mountain-backed Style		
	After the Ming and Qing Dynasties	Independent type	Interfaced type	Interfaced type, independent type
Schematic diagram	Cross-section			
	Plane			
	Legends	Cave dwellings before the Ming and Qing Dynasties Cave dwellings after the Ming and Qing Dynasties		

After the Ming and Qing Dynasties, the slope platform villages were mainly built with interfaced cave dwellings. Most villages were built against the mountains. The river valley space in the area was narrow, and there was less construction land. The constraining power of mountains and water was still very strong. However, since the interfaced cave dwellings had a wider choice of sites than the mountain-backed cave dwellings, they had a stronger adaptability to the mountains. The village develops from the foot of the slope along the contour lines to both sides, and the scale of the village increases relatively. A small number of cave dwellings develop toward the river on the steeper slopes, and a large number of cave dwellings develop toward the river on the gentler slopes. The trend of the village extending towards the river is not as obvious as that of the river valley villages. The trend of extending to both sides parallel to the river makes the plane shape of the village present a more obvious strip-like form.

After the Ming and Qing Dynasties, the ridge-top slope villages were mainly built with interfaced and independent cave dwellings, and houses were built on the flat areas of the ridge-top slope. Although the construction range of the ridge-top slope had an obvious constraining effect on the boundaries of the village, the village's adaptability to the mountain was enhanced. In areas where the ridge-top platform is spacious, the village is planned to a certain extent, the layout of streets and buildings tends to be regular, and the plane shape changes from scattered to irregular clusters. In areas where the ridge-top platform is narrow and long, the layout of streets and buildings is more closely related to the trend of the ridge top, and the plane shape changes from scattered to irregular strips.

Conclusion

This study summarizes the basic characteristics of traditional villages in the Qingjian River Basin, supplements andimproves the relevant research on the spatial forms of traditional villages in the Qingjian River Basin, clarifies the impact of the geographical environment of the Qingjian River Basin on the spatial forms of local tradi-

tional villages, and provides reference value for subsequent research on the protection and development of traditional villages in the Qingjian River Basin. The research in this article is mainly reflected in the following two aspects: (1) trying to use SPSS data analysis software to analyze the interrelationship of the eight characteristics of spatial forms; (2) the integrity of the research subject and the comprehensiveness of data collection. Taking the overall human settlement unit of traditional villages in the Qingjian River Basin as the research object, a comprehensive investigation and analysis of the traditional villages in the Qingjian River Basin was carried out, and data related to spatial forms were collected and sorted out, avoiding the one-sidedness of the study of a certain geographical environment or a traditional village.

The unique natural and social environment of the Loess Plateau is an important influencing factor in the formation of traditional villages. Qingjian River is an important primary tributary of the Yellow River in northern Shaanxi. The abundant water source in the river valley space is the basis for the occurrence of human living environment. The hilly and gully landforms not only restrict the development of villages, but also promote the emergence of various cave construction forms to adapt to this unique terrain and climatic environment. Different types of village spatial forms are spawned under different terrain and landform conditions. The diverse and distinctive spatial forms of traditional villages in the Qingjian River Basin not only convey the village-building wisdom of northern Shaanxi, but also reflect the distinctive landscape features of cave-dwelling villages in northern Shaanxi. In the face of current changes in the natural environment and social changes, traditional villages in the Qingjian River Basin should be protected and developed while retaining their own traditional characteristics.

Sources of Figures and tables

Figure 1, Figure 2, Table 7, Table 14: The bird's-eye views were taken by Shi Jiapeng and Zhang Shaojun, members of the research team.

Figure 2: The base map is from Google Satelliteimagery; All other figures and tables are photographed or created by the authors.

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