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Spatial analysis and protection of traditional villages based on spatial syntax: A case study of Linlue Village of the Dong ethnic group in Sanjiang, Guangxi

Abstract After a long period of accumulation of agricultural society, traditional villages have bred unique material space and cultural connotations. As a typical representative of traditional villages, Dong villages have unique geographical location and rich material and cultural characteristics, and their spatial protection and cultural inheritance have far-reaching significance and value. Affected by the current urbanization construction, traditional villages have suffered different degrees of destruction. As a representation of the social culture of the village, the protection of the material space greatly affects the development and inheritance of the village.

In this paper, spatial syntax is used to quantitatively analyse the spatial morphology of Linlue Village from the aspects of village integration, connection value, control value, and comprehensibility, and summarize the characteristics of its spatial form and the internal spatial characteristics of village buildings. It is concluded that its spatial development lacks planning and capital intervention is excessive and it is necessary to balance the contradiction between social development and physical space through systematic planning from space to management. Through the analysis of the village space, the article provides a reasonable spatial optimization plan in order to better protect the material space of the village and better inherit the traditional culture.

Keywords Traditional village, Space syntax, Cognition of space form, Cultural landscape, Human settlements.

Introduction

Traditional villages contain profound historical and cultural resources. They are the space carriers for the production and life of farmers, the most basic social unit in the human settlement environment and the spiritual homes for nostalgia. As a rural area with relatively complete functional elements such as natural ecology, material space, human environment and economic development, the protection research of traditional villages has a profound impact on the spatial understanding of the village's living environment and the inheritance of excellent historical culture. The study of spatial morphology and cognition is the premise and foundation of the protection and development of traditional villages. As a quantifiable tool based on numbers, space syntax can abstract the spatial relationship, spatial scale and spatial structure of traditional villages, and then establish an axis model and describe it quantitatively. On the basis of enriching the original qualitative research, it can then find the relationship between spatial structure and human social activities, so as to more accurately and scientifically describe the spatial phenomenon of traditional villages.

The application of space syntax in traditional village spatial morphology theory is relatively short. From the perspective of previous research content, it generally includes concept definition, formal classification, spatial perception, evolution mechanism and structure, etc. The research method has gradually changed from qualitative interpretation with strong subjectivity to quantitative analysis with quantitative analysis. The main research trend in the future will also be based on quantitative research, emphasizing the reflection of spatial organization structure, social nature and image cognition. Based on this, starting from the quantitative research of space syntax, this paper takes Linlue Village, a traditional Chinese village as an example and uses relevant spatial analysis software to quantify its spatial morphological variables to explore the spatial form and development law of traditional villages. In order to reveal the material space and social and cultural characteristics of traditional villages, it can provide a reference for the optimization and sustainable development of traditional village space layout.

Background

Linlue Village is located in Sanjiang County, Liuzhou City, Guangxi Province. In 2018, it was included in the list of traditional Chinese villages within the scope of the central financial support. The residents of the village live in traditional buildings with stilted houses of the Dong nationality. It is a national minority characteristic protected village. The village has a unique geographical environment. It is built on a rich slope in front of the mountain. It is a typical hilly village. There are five drum towers in the whole village. Around the Drum Tower, it has gradually developed into a settlement. The residential buildings in the village are narrow and dense, and have a good living environment. In recent years, with the continuous development of Linlue Village as a traditional village, its rich cultural tourism value has been effectively tapped and attracted a large number of foreign tourists and developers. At the same time, under the background of rapid construction, the contradiction between the protection and development of the internal space of the village has gradually become prominent. Driven by internal and external forces, the spatial settlement of Linlue Village is facing the pressure of transformation and reconstruction. It is urgent to analyse the spatial evolution law of traditional villages from an overall perspective and propose strategies.

In the initial village planning and site selection, the range of village land is mainly selected based on the geographical environment. Generally speaking, mountains, rivers or woods are used as natural boundaries. As the village continues to expand, the boundaries of the village are gradually blurred and multiple settlements gather together, eventually forming a phenomenon in which multiple natural villages are linked into a whole. Through sorting out the documents and documents of Linlue Village, the village originally consisted of two natural villages. The surrounding environment was the cultivated land and natural ecological area on the hillside. The development of the village was affected by many factors such as population migration, social and natural development, geographical environment, natural disasters and so on. From the first few families, the village has gradually developed into the current building scale around the drum tower, newly built houses will also continue the traditional architectural form and follow the laws of topography and landforms to conform to the construction of the mountains. In addition, a fire in the early 2000s destroyed some residential buildings in the village, which affected the original spatial form of the village. With the efforts of many parties, the residential buildings were reconstructed, thus forming the current settlement pattern combining traditional and modern.

Figure 1. Location of Linlue Village
Source: authors' own work.

Literature Reviews

Foreign research on space syntax has entered a stage of multi-expansion in application fields, and the research focuses on transportation, housing, urban planning and decision-making (Li et al. 2019). There are many research achievements on space syntax in China. From the perspective of the research scale, it involves different levels such as cities, blocks, campuses, and gardens. From the perspective of application fields, it mainly involves the characteristics of spatial development, the evolution of street space systems, and the analysis of urban traffic (Chen et al. 2018). The domestic research on traditional village space originated in the early 1990s, mainly due to the rapid development of the country's economy and the acceleration of urbanization and the gradual strengthening of the cognition of space.

By 2012, the Chinese government had successively issued documents such as the 'Guiding Opinions on Strengthening the Protection and Development of Traditional Villages' which emphasized the importance and necessity of the protection and development of traditional villages. The theoretical methods and research methods on the study of traditional village spatial morphology are also constantly enriched, and the research scope and application fields are increasingly wide.

> From the perspective of research content, it mainly focuses on concept definition, type structure, influencing factors and evolution mechanism; from the perspective of research scale, it involves top-to-bottom levels such as national, provincial, municipal, county, and village (Wu 2020).

As a quantitative method, space syntax was gradually applied to the space research of traditional villages in the early 20th century. Different scholars have carried out a lot of research on material space, human environment and impact mechanism.

Methodology

Space syntax is a spatial morphological analysis technique proposed by Bill Hillier of the University of London in the late 1970s. It is*:*

> a theory and method to study the relationship between spatial organization and human society through the quantitative description of the human settlement space structure including buildings, settlements, and urban landscapes (Hillier 1996).

On the basis of analysing the characteristics of the internal spatial structure of the village and its development law, it can also analyse its connection with the cultural abstract space. The research results have important reference significance for the inheritance and development of traditional spatial texture and the development and construction of future villages.

As a more commonly used method in space syntax, the axis analysis method uses a series of parameter variables such as the position of the axis and its relationship with each other to reflect the spatial characteristics. It is mainly used in the evolution of spatial pattern, the spatial correlation of streets and lanes and the accessibility of road networks. The streets and alleys in traditional villages serve as the support and framework for the growth of the village space, as well as an important carrier for the daily activities and communication of the villagers. Combined with quantitative indicators such as integration degree, connection value, depth value, and intelligibility in space syntax, we can more intuitively and clearly observe the connection between the various spaces of traditional villages.

Therefore, this paper mainly selects the axis analysis method to analyse the Linlue Village, extracts and abstracts the main road network systems in the village to form an axis diagram, and analyses the main characteristics of the current space. At the same time, based on the analysis of material space, it is linked with social and cultural elements, and the social and economic reasons for the formation of the current situation are more objectively and comprehensively analysed, so as to guide the future transformation, reconstruction and development of Linlue Village. The following four morphological variables are mainly used in this paper (Chen et al. 2018):

Integration: It reflects the degree of agglomeration or dispersion of a space relative to other spaces in the system and the calculation method is as formula (1).

$$I = \frac{2(\mathrm{MD}-1)}{\mathrm{n}-2} \qquad (1)$$

Where n is the number of total axes or nodes in the space system; MD is the average depth. The calculation method of MD is as formula (2)

$$MD_i = \sum_{i-1}^{n} d_{ij}/(n-1)$$
$$D_n = \frac{\{n[log_2(((n+2)/3)-1)+1]\}}{(\mathrm{n}-1)(n-2)} \qquad (2)$$

Comprehensibility: It reflects the ability to perceive the whole space by the connectivity of the local space and the calculation method is as formula (3)

$$R^2 = \frac{[\Sigma(I_{(3)}-I'_{(3)})(I_{(n)}-I'_{(n)})]}{\Sigma(I_{(3)}-I'_{(3)})^2 \Sigma(I_{(n)}-I'_{(n)})^2} \qquad (3)$$

Spatial connection: Examining the number of times a space appears on the shortest topological path indicates the potential of a space to attract crossing traffic.

Space selectivity: Investigate the number of times a space appears on the shortest topological path, indicating the potential of a space to attract crossing traffic.

Based on the Google HD satellite map image of Linlue Village in 2019, the spatial axis map of Linlue Village was drawn with the help of AutoCAD. The village has a total of 209 axes, covering the main roads and main branch roads in the village and other traffic flow lines. The building develops outwards with the Drum Tower as the core. The more fringe houses need to turn the more times through the axis. Import the axis map into DepthmapX software to generate the corresponding element data schema, so as to analyse the spatial morphological characteristics of Linlue Village, and obtain more reliable results from multiple perspectives.

Results and Discussions

Analysis of Spatial Integration: The degree of integration indicates the degree of aggregation or dispersion of various parts in the space, which measures the ability of a space to attract traffic as a destination, and reflects the centrality of the space in the entire system. Generally speaking, the higher the degree of integration, the better the connection with the whole space system, the stronger the spatial aggregation, the higher the accessibility, the stronger the centrality and the easier it is to gather people. Relevant research shows that the accessibility of village space is positively correlated with the attraction of the place to villagers. The integration degree can be divided into the global integration degree and the local integration degree according to the different topology steps.

The global integration degree represents the number of topological steps from one axis in the village to all the axes of the village, and it is positively correlated with the spatial accessibility. In the results of software analysis, the darker the colour of the region, the higher the global integration degree. According to the overall integration degree axis diagram of Linlue Village (Figure 2), it can be seen that the main dark axis are the spatial core areas of traditional village development. The axes are distributed around the main roads on both sides of Linlue Village and around the main public spaces. The longest red axis is the main road connecting the whole village. The two sides of the plots are mainly public service facilities and commercial and residential land, including three drum towers in the village: Gaopan Tower, Huagu Tower, and Baiyan Drum Tower.

The space accessibility is relatively high. It reflects the shaping and impact of the village public buildings on the overall space. The street system gradually becomes lighter from the red in the central area to the two sides, indicating that the closer to the outer edge area the global integration is lower, this part of the area is mostly residential houses scattered in the village, the road texture is not clear, mostly muddy paths and villagers' self-built paths, the flow of people is small, and the accessibility of space is low. The average global integration degree of Linlue Village is 0.51, the maximum integration degree is 0.78, and the minimum integration degree is 0.29. On the whole, the spatial accessibility of Linlue Village is poor. This is mainly due to the fact that the settlement is built on the mountain and the internal land is compact, which leads to the intricate streets and lanes and the poor spatial connectivity.

Linlue Village is a hilly Dong village. The village is close to the mountains and faces the river. It is the most typical settlement mode of the Dong people. The main streets and alleys in the village are distributed along the hillside. At the same time, the village is mainly surrounded by five Drum Towers as the centre of residential buildings. As a whole, it is far from the external access roads and has poor external connection, which makes the overall integration degree is not high, and the traffic accessibility is weak.

Compared with the global integration degree, the local integration degree is the closeness of the spatial connection between an axis and a limited topological range. The local integration degree of Linlue Village is between 0.33 and 2.099, and the local integration degree is the highest in the north-south road section connecting the Dong Drum Tower (Fengshui Tower) in the village on the east side (Figure 3). The difference from the overall level of integration is that, in addition to the road crossing the village, the township road connecting the residential houses of the village in the south and the small road connecting the Drum Tower in the north and south are prominent, indicating that these two roads have a high utilization rate and the best accessibility in the village. At the same time, it can also be found that areas with high local integration are formed around the Drum Tower. This is also because several large settlements were formed around the five Drum Towers during the development of Linlue Village, and the axis with high local integration is equivalent to the inner core of each ethnic group, which has good accessibility and publicity.

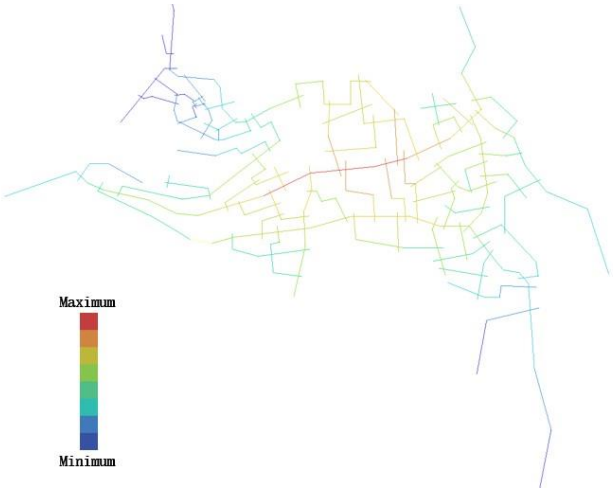

Figure 2. Global integration analysis diagram
Source: authors' own work.

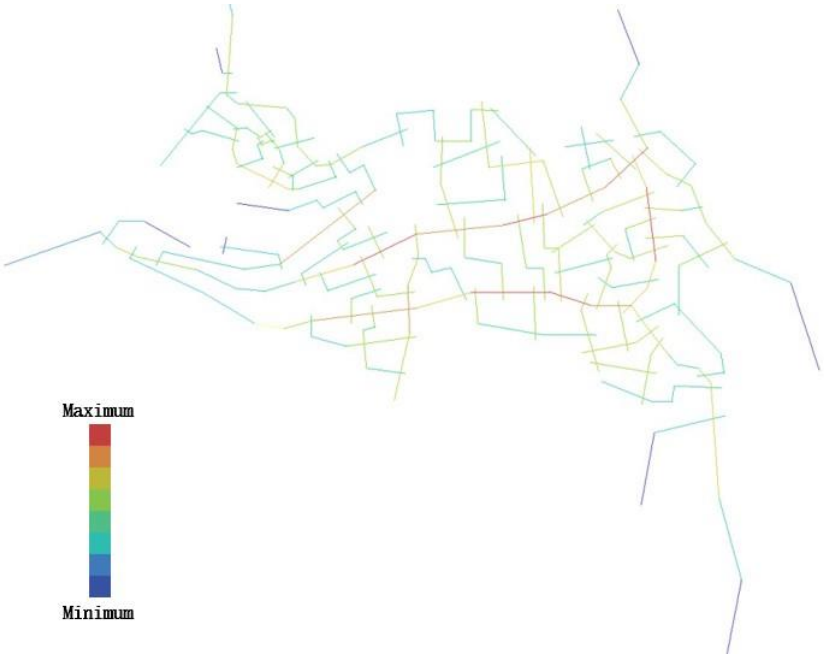

Figure 3. Local integration degree R3 analysis diagram
Source: authors' own work.

Spatial connection analysis: The connection value represents the sum of the number of a certain spatial axis and other connected axes, it represents the visual breadth of a person in a certain space, and the connection value of the space is positively correlated with the permeability of this spatial range. At the village level, the overall connection value of Linlue Village is average and the spaces with higher connection values basically coincide with the axes with higher integration. This also shows once again that these spaces have a great influence on the surrounding spaces and are closely related which further shows the importance of these spaces to Linlue Village (Figure 4).

Figure 4. Connection value
Source: authors' own work.

Spatial selectivity analysis: The degree of selectivity refers to the number of occurrences of a certain element in the space as the shortest topological distance between two nodes, indicating the probability that a space is traversed by other shortest paths in the entire system, and is positively correlated with the potential of the space to attract

traversing traffic. The most selective axis in Linlue Village appears on the main street next to Huagu Tower, Gaopan Tower, Linlue Village Committee, Shanggu Drum Tower and Baiyan Drum Tower, forming an open area with the best accessibility in Linlue Village. There are a large number of space nodes on both sides of the main street. The gathering of the four drum towers also makes this area a public activity centre with the best traffic penetration in the entire village. The closer to the border of the village, the lower the degree of choice and the weaker the accessibility, mainly due to the fact that the inner streets and lanes of Linlue Village are the streets for residents' lives and the spontaneous construction forms a spatial hierarchy with twists and turns. This data provides a more intuitive quantitative basis for the spatial sequence and transportation organization of Linlue Village.

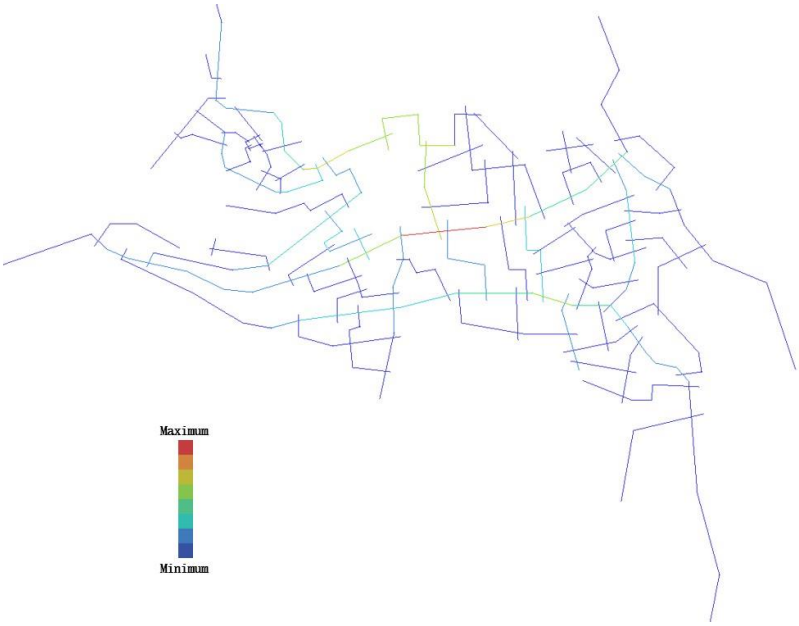

Figure 5. Selectivity degree
Source: authors' own work.

Spatial Comprehensibility Analysis: Comprehensibility describes the correlation between local variables and overall variables, reflects whether the overall space of the village is consistent with the local space and evaluates whether the local vision seen in the space is helpful to establish the cognition of the overall morphological structure of the space. In the space system, if the overall variable value of some spaces increases with the increase of the local variable value, then the intelligibility of these spaces will be high, which is more conducive to the establishment of cognition of the overall space.

In the analysis, the global integration degree is selected as the x-axis, and the local integration degree R3 is selected as the y-axis. Regression linear analysis is performed to obtain the result R2 value (Figure x). Usually, when the R2 value is between 0.5 and 0.7, it is considered that the spatial intelligibility is better and the spatial comprehensibility is the best when the R2 value is above 0.7, the darkest red point in the figure represents the axis with the highest intelligibility in space, and the blue point is the relatively low axis. The fitting coefficients of the global integration degree and the local integration degree of Linlue Village are relatively low and the intelligibility value is only 0.239, indicating that the intelligibility of the street and lane space system in Linlue Village is not high.

One of the reasons for the current status quo is the built environment of the village. Linlue Village has been built for a long time, and its overall shape is S-shaped. Part of the street and lane system in the village is damaged, the spatial structure is not complete, and the non-core space of the village is difficult to identify. From the perspective of local space alone, it is difficult to establish a cognition of the overall space of the village and in terms of the connection with the surrounding natural environment.

It grows spontaneously on the slope, and the land for houses is compact, which leads to the scattered arrangement of streets and lanes, and it is difficult to understand the overall space from the local part; The second is social and humanistic factors. After a long period of natural development, the village lacks planning and the material space is influenced by culture to form different settlements, which makes the public cultural space of the village relatively scattered and it is difficult to form a relatively concentrated core space of the village, which increases the difficulty of space identification.

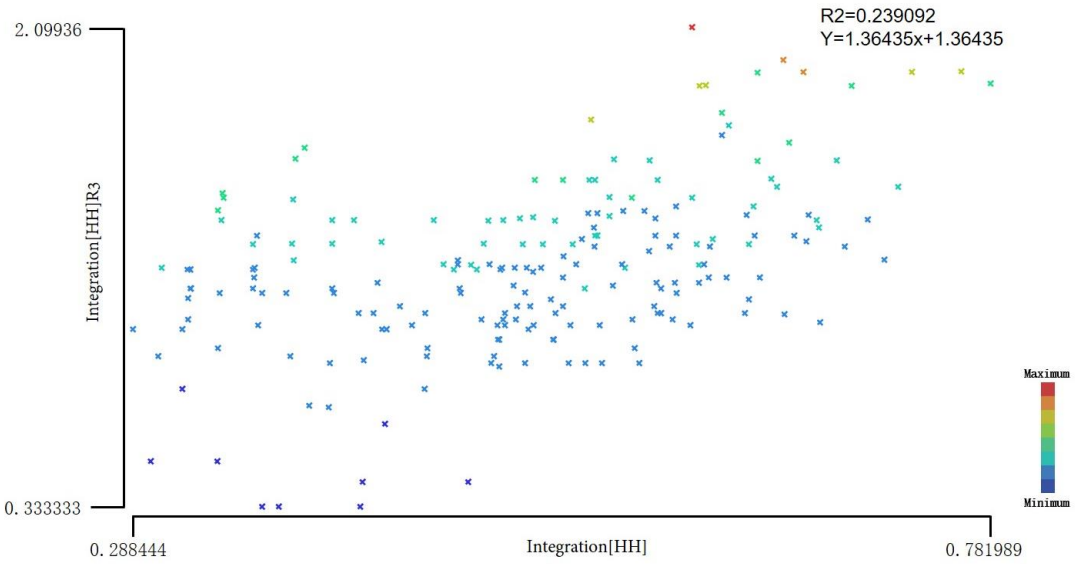

Figure 6. Comprehensibility analysis
Source: authors' own work

Problem summary

The incompatibility between village environment and residents' life: Linlue Village is a traditional village formed by long-term historical accumulation. However, with the development of economy, the relatively closed regional environment, difficult terrain structure, inconvenient traffic conditions and relatively backward social development in the traditional village pattern are no longer suitable for contemporary life. Conflict between the original environment and residents' needs. Like most villages, in the process of rapid urbanization, a large number of villages have lost their population and the young and middle-aged labourers in the villages have gone out to work, leaving a large number of elderly people behind in the countryside, resulting in a hollowing out of the countryside. In the process of modernization development, the old buildings of traditional villages cannot be effectively protected and many historical buildings have problems such as wall rupture and house collapse.

In the process of village development, villagers ignore the traditional village spatial pattern, build houses with modern materials, or demolish and rebuild traditional buildings, causing damage to the traditional architectural style. Through the above analysis, Linlue Village mainly relies on the village highway and its two branch roads as the main traffic of the village in terms of traffic and vehicles, and mainly relies on narrow dirt roads and spontaneously constructed stone brick roads for pedestrians; In terms of terrain, the village is located on a hillside, causing difficulties in infrastructure construction. In terms of social and cultural space, the Drum Tower, as the public communication centre of the village, has not yet formed a complete square landscape around it and urgent planning and construction are needed.

Excessive capital intervention: As a traditional village, all kinds of material and intangible cultural heritage in Linlue Village have high protection value. However, in the process of rapid economic development of the village, due to the introduction of capital to the development and construction of the village, to a certain extent, it has caused serious damage and destruction of the original appearance to the village. From the perspective of architectural space, the villagers are accustomed to using economical and convenient modern building materials and facade decoration techniques that do not conform to the traditional village style, resulting in the lack of local characteristics of traditional villages.

From the perspective of traffic space, the rural roads with pleasant scales that formed spontaneously in the villages were replaced by hardened pavements with split scales, which destroyed the hierarchy of space. In general, although over-commercialization can generate certain economic benefits in the short term, in the long run, it is contrary to the development and protection of villages, and will cause problems such as alienation of spatial patterns and lack of spatial connotation. How to form a balance between blind development and protection is an important factor directly affecting the resource utilization and sustainable development of Linlue Village.

Spatial Optimization Strategies

Optimize the texture of the village space and rationally plan the space organization: Based on the previous analysis, combined with the topographic environment of the village, the future development trend and other factors, the spatial structure of the village is divided reasonably, and the village can be better developed on the basis of retaining the original traditional village pattern. From the perspective of planning, the main village space

is divided into layers, with the location of the five drum towers as the centre and their mutual positions are connected in series to form the main development axis of the village, which constitutes the main spatial pattern. Opening up the tourism route around the mountain in Linlue Village enables the landscape nodes in the entire village to be effectively connected, and solves the problem of inconvenient traffic at the village level. The design of the ring road is also based on the mountainous terrain and local conditions, it can also become a landscape avenue with impressive scenery, things to visit, and mountains and scenery. From the point, line and plane detailed planning of the spatial structure, the original and complete protection of the spatial pattern, architectural features and natural environment of the traditional village of Linlue Village.

Regional features and conservation value: Due to the differences in natural and humanistic environments and the development of river basins, the cultural characteristics formed by the Dong villages are also very different. The village patterns, architectural styles and layouts, and farmland planning in each region have their own characteristics. Under the influence of natural and cultural environment and other internal and external factors, the villagers of the Dong nationality have produced a village civilization that represents the spirit of their own nation by using their own intelligence and talent, which reflects the yearning of the villagers of the Dong nationality for a better life and spiritual realm.

Therefore, in the process of planning and repairing the original village, the village government should keep the natural environment as well as the original traditional architectural form and human environment unchanged as much as possible, and abide by the requirements for the delineation of ecological red lines and cultivated land red lines, prevent excessive development of ecological resources in original villages and destructive damage to ecosystems. Establish the development of core blocks, start from blocks with a high degree of integration, renovate the streets and lanes of the village, and enhance the vitality of blocks on the basis of protecting the spatial pattern. In the protection and development of the human environment, the local cultural resources of traditional Dong villages should be fully tapped, and handicraft skills and construction skills should be inherited. In the process of creating objects with craftsmanship together with the villagers, integrate the historical legends and famous deeds of Linlue Village.

Tell the cultural story of Linlue Village well, activate the modern adaptability of local culture, and jointly build a cultural village. For example, by picking up blank wasteland and idle homestead resources, renovating old dwellings and building an art base in Linlue Village, priority is given to the use of artists, cultural and creative enterprises in all walks of life. In the creation of calligraphy, painting, poetry, prose, drama and sketches of the resident artists, the spark of the collision between the trend of the times and the local culture is ignited, and the new vitality of cultural development is activated. At the same time, it can also carry out flower viewing and picking festivals in combination with seasonal fruits and vegetables to enrich the cultural life of villagers.

By introducing a suitable operation mechanism, new villagers are encouraged to actively participate in the renovation and protection of their houses. During the implementation process, the village committee and tenants fully communicated, signed long-term lease contracts at low prices, and attracted all parties to participate in the protection and restoration of ancient villages. At the same time, the functions of ancient dwellings are replaced and transformed into cultural and creative spaces such as museums, coffee shops, reading rooms and art galleries. In this way, all kinds of tertiary industries can continue to develop in the village while preserving the ancient village culture, enhancing the spatial vitality of traditional villages.

Conclusions

Through the axis analysis method, we have a further understanding of the spatial accessibility, perception and other characteristics of the village from the level of material space, and strengthen the understanding of the spatial pattern of the village from a quantitative point of view, laying the foundation for subsequent transformation and improvement. The spatial analysis in this paper shows that most of the buildings with high utilization degree in Linlue Village are located near the main street and the Drum Tower of the Dong nationality and the traffic accessibility shows a decreasing trend from the centre to the edge.

The villagers have a high awareness of the traffic structure with a clear hierarchical organization in space, which is convenient for the villagers to carry out life and production activities, and can also better condense the village resources and attract tourists' interest in visiting. The special geographical resource conditions enable it to maintain a relatively complete spatial structure and maintain its specificity, which provides favourable conditions for the protection of traditional village spaces and future resource development.

Due to the complexity of a series of factors such as nature, traffic, and human environment in traditional villages, there is no specific evaluation scale and method for the segmentation of convex space and the connection of axes in the process of quantitative model building and there are many subjective interference factors, and space division is not completely objective.

Even if the interference of these factors is eliminated as much as possible in the calculation, they cannot be completely ignored. Therefore, the research conclusions of this paper can reflect the research problems of the spatial structure of traditional villages to a certain extent but there is still room for improvement.

References

Hillier B., (1996), *Space is the Machine: A Configurational Theory of Architecture*, Cambridge University Press, Cambridge.

Wang Q., (2019), *Research on the Structure and Spatial Form of Traditional Villages of Dong Nationality*, MA thesis, Guangxi University for Nationalities.

Li Z., Feng L., Shen R., (2019), *Scientific Knowledge Mapping of the Evolution and Frontier Fields of Space Syntax Research in Foreign Countries*, 'Planners', vol. 35, no. 8, pp. 5 – 11.

Wu L., Liu C., Gong J., Jiao L., (2020), *The Syntactic Analysis on the Evolution and Characteristics of Traditional Village Spatial Morphology: A Case Study of Jiaoxi Village*, 'Journal of Geomatics Science and Technology', vol. 37, no. 6, pp. 628 – 635.

Chen C., Li B., Yuan J., Yu W., (2018), *Spatial Morphology Cognition of Traditional Village Based on Space Syntax: A Case Study of Qinchuan Village of Hangzhou*, 'Economic Geography', vol. 38, no. 10, pp. 234–240.

Huang C., Wu Y., (2021), *A Study on Spatial Form and Cognition of Clan Settlement Based on Space Syntax Taking Banliang Village in Chenzhou City as an Example*, 'Journal of University of South China(Science and Technology)', vol. 35, no. 6, pp. 90–96.

Wang Q., Lu H., Cheng S., Yu D., (2020), *A Study on the Spatial Structure of Traditional Villages Based on Space Syntax Taking Shanxi Jie Village in Shandong Province as an Example*, 'Development of Small Cities & Towns', vol. 38, no. 6, pp. 83–91.

Gao H., Li Z., Guo Y., Zeng Z., Li X., (2018), *Study on Spatial Form and Protection Strategies of Songkou Ancient Town in Fuzhou*, 'Journal of Shandong Agricultural University(Natural Science Edition)', vol. 49, no. 2, pp. 267–271+277.

Liu Y., Li B., Zhou X., Yang J., Chen C., (2017), *Research on the Spatial Form and Optimization of Traditional Villages Based on Space Syntax Taking Zhang Guying Village as an Example*, 'Resource Development & Market', vol. 33, no. 11, pp. 1289–1294.

Dawson P.C., (2002), *Space syntax analysis of Central Inuit snow houses*, 'Journal of Anthropological Archaeology', vol. 21, no. 4, pp. 464–480.

Kim Y.O., Penn A., (2004), *Linking the spatial syntax of cognitive map to the spatial syntax of the environment*, 'Environment and Behaviour', vol. 36, no. 4, pp. 483–504.