Research Paper

Spatial Morphological Analysis and Renewal Strategy of Small-scale Traditional Villages Based on Space Syntax

A study of Lvtao Village in Dali City, Yunnan Province in China

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Abstract

In recent years, space syntax has been used by many studies to solve large-scale urban spatial planning problems, and it is worth discussing whether it is suitable for small-scale spaces. As a representative of small-scale space, the spatial form of traditional villages is an important factor in the development and changes of traditional villages. Taking Lvtao Village in Dali City, Yunnan Province as an example, this paper introduces space syntax theory and configuration method, analyzes its current situation, and explores the development of small-scale traditional streets under space syntax from the overall to local spatial form. The synergy between "natural activities" and villagers' daily life, and explores village problems through structured interviews to draw inspiration. The results show that space syntax is suitable for the study of small-scale space combined with field investigation. Finally, the research proposes a local update design strategy for traditional village spaces with Lvtao Village as a typical example, and with the help of space syntax, it provides effective strategies for the historical protection and development of small-scale traditional village spatial forms in the future.

Keywords

Space syntax, Small-scale space, Lvtao Village, Conservation and development, regeneration strategy

1. Introduction

With the acceleration of the new urbanization process, the mobility of urban and rural population factors is large, which is mainly manifested in the large-scale transfer of rural areas to cities and towns. Cities have also become regional economic and social cores of gravity, while traditional villages have begun to appear serious hollowing. For a long time, top-down plannings and reconstruction methods such as gentrification and elite transformation have brought continuous impact on the spatial form of villages. Traditional villages are faced with the decline of cultural space, backward living space, and destruction of ecological space. China mentioned in an important document on the construction of new countryside that the traditional village space carrying historical and cultural values should be protected (Teng 2020), and the protection and development of traditional village space forms have received more and more attention. However, the spatial form of Chinese villages has the shortcomings of many individual studies and few comprehensive studies, and it is easy to make "model" plans that go against the status quo. The application of new methods and new technologies should be strengthened. Therefore, this paper attempts to study the spatial form of small-scale historical traditional villages based on space syntax, and

discusses its synergy with the daily behavior of residents, aiming to provide an exploration path for the renewal and protection of traditional villages in the future.

2. Study area and method

2.1. Study area

(1) Space layout of streets and alleys

Lvtao Village maintains the typical traditional street and alley pattern of "street-alley-courtyard-home", and the sequence from open space to private space (Figure 1). At the entrance of the base, there is the main temple that has been around for a long time and every village has the Longmu Temple. After entering the main street from the Longmu Temple, the height-to-width ratio is maintained at about 0.5, and the typical space with gradual width and narrowness continues to give people a sense of depression. Daqingshu Square in the center of the village is open, suddenly enlightened, and has a strong historical atmosphere.
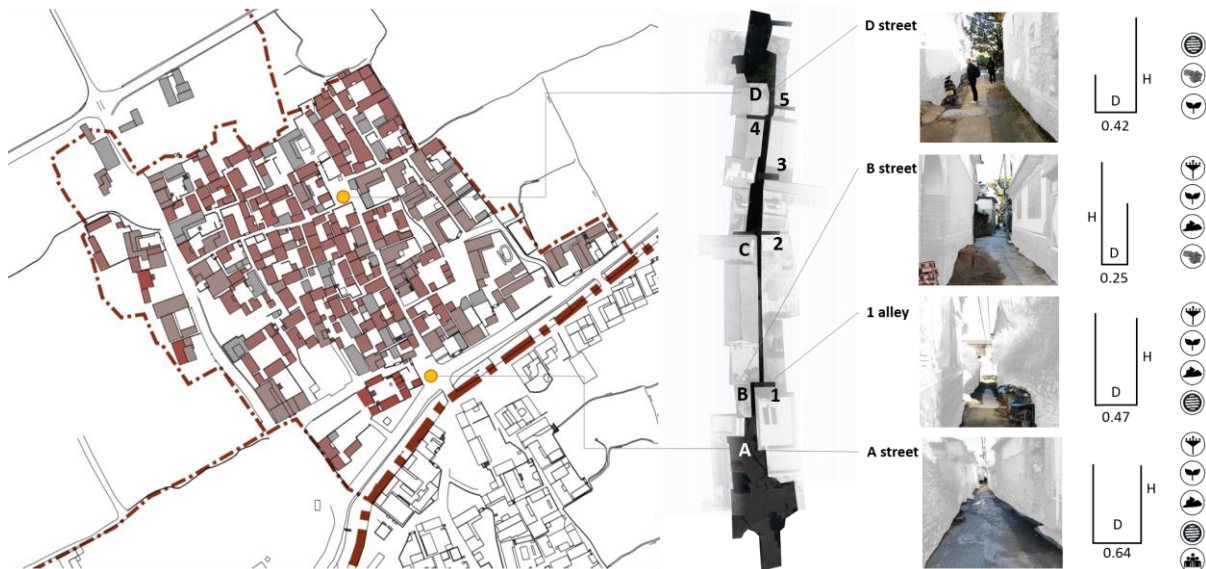

Figure 1.Streets and alleys of Lvtao Village. (Graphic by Author)

(2) Humanities and resident Life

Lvtao Village has the folk cultural heritage of Bai nationality——marble craftsmanship. Bai nationality masonry craftsmen who have lived with the three pagodas for generations are indispensable life wisdom in Lvtao culture. Local residents integrate marble craftsmanship into their lives. Marbles interspersed in Dali dwellings can be seen everywhere in the village, gradually forming a beautiful Bai Village of marble culture for thousands of years. The annual "Dragon Mother Festival" and "Sea Playing Club" reflect the simple regional cultural characteristics, and also provide a basis for analyzing residents' behavior and vitality space in space.

(3) Humanities and resident Life

As the user of space, people's spatial cognition and behavior not only directly reflect the effect of space form on their physiological and psychological needs, but also affect the space itself (Song 2014). The author observes and counts the behaviors of the main users of space (residents and a small number of tourists) in Lvtao Village through the behavioral observation method, and predicts and evaluates the local lifestyle that the residents are most familiar with by means of interviews and conversations. Through the

comparison, it provides the basis and support for the results obtained by the quantitative analysis of space syntax.

2.2. Study method

Space syntax is the primary method for the study of urban form and behavior. It is a quantitative tool used to analyze the spatial morphological composition of cities, blocks, and buildings (Chen 2020). It uses mathematical methods to standardize the measurement, which can solve the problem of subjectivity in research and analysis and horizontal comparison of cases (Dai et al. 2020).

For many years, space syntax has been relatively mature in the analysis of urban street space. However, for small-scale villages, we want to explore its synergy with the rural humanistic wisdom reflected by the traditional street space, and to test the accuracy and value of the application of space syntax in traditional villages.

3. Syntactic analysis of overall spatial morphology

3.1. Creation of the axis model

The configuration methods of space syntax include three methods: axis method, convex space method and viewshed method (Yuan et al. 2020). The author adopts the first configuration method, the axis method, to quantitatively analyze the integration, choice, intelligibility, and sight range of the village, and describe the village space through the results and on-site investigation behavior.
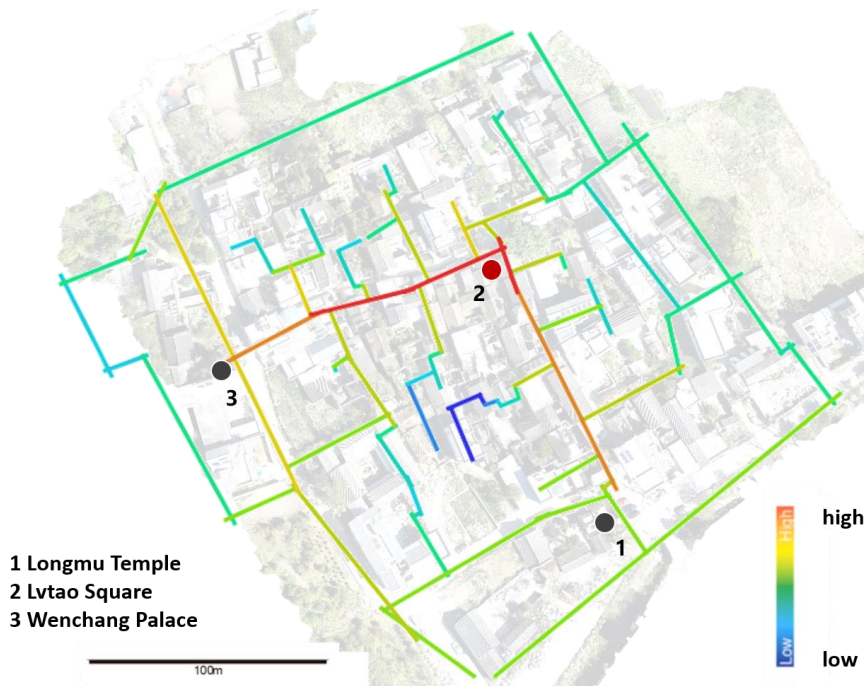

Figure 2. Scope of the study area and integration degree R=n axis diagram. (Author self-made by depthmap)

Aiming at the research on the topological relationship of the traditional village walking axis, the median line of the streets and alleys in the village is extracted as a traffic axis in the space, and the relationship between the axes reflects the road network connection of the streets and alleys in the village (Figure 2). as the basic data for the study. This study selects the street width of traditional villages as the research object. Because the street width of traditional villages is narrow, the spontaneous activity is high, and the

spatial form is greatly disturbed by human beings. So human behavior activities are compared to verify the feasibility of quantitative analysis of space syntax in traditional villages.

3.2. Parametric interpretation of syntactic analysis results

(1) Integration analysis

The meaning of integration is the degree of agglomeration or discreteness between an element and other elements in a space system. It is an important indicator reflecting the spatial relationship and is positively correlated with the spatial accessibility. It can be divided into global integration degree and local integration degree, the former reflects the degree of association between a single space and the whole system, and the latter reflects the degree of association between individual spaces in the system (Guo et al. 2013).

The parameter R of the integration degree is selected as the analysis radius. When R=n, it is the global integration degree, which expresses the possibility of each node reaching all points in the space. When R=3, 5, 7, the integration degree of different topological distances is obtained, which means the reachability of each node to the node whose topological radius is less than or equal to 3 (Yuan et al. 2020). The author abstracts the street and road network of Lvtao Village into a spatial axis, and uses the HH algorithm to analyze it in combination with the software, and obtains the results shown in Figure 3.
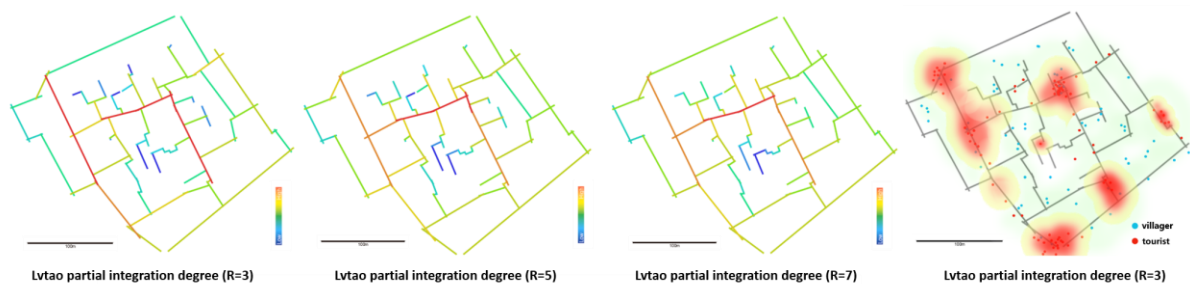

Lvtao partial integration degree (R=3)　　Lvtao partial integration degree (R=5)　　Lvtao partial integration degree (R=7)　　Lvtao partial integration degree (R=3)

Figure 3. Analysis of Lvtao Village's integration degree and tourist residents' behavior activities. (Author self-made by depthmap)

According to the Depthmap axis diagram, it can be seen from the legend that the core node of the global integration is located at the center corner of the first-level streets and alleys of the entire village - Green Peach Square, which has the highest accessibility. center. This shows that the secondary streets and alleys of the entire village converge at the first-level streets, and the integrity of the village is better. According to the survey of residents' behavior activities, it is found that the village square is densely populated and is the center of village vitality, and the vitality of the first-level alleys of the village is also high, indicating that the first-level streets and alleys have important social attributes within the radius of local villagers' activities. The analysis results are consistent. As shown in Figure 3, Wenchang Palace is located on the site of the original Tea-Horse Road. According to the space syntax, when R=3, the spatial integration of the village square and Wenchang Palace is high, showing strong centrality. According to the field investigation, the street where Wenchang Palace is located occupies an important traffic space in the life of the local residents, and plays a role in communication between the branches of the village. When R=5, 7, the integration degree of the secondary roadway where Wenchang Palace is located decreases, but it can be seen that the village square is still the center of the village.
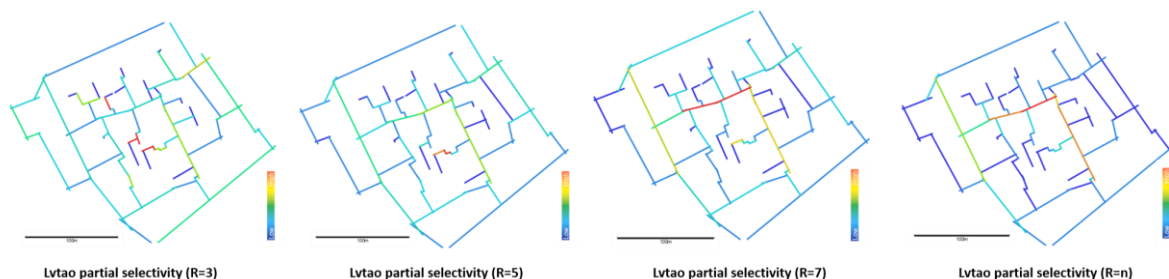
In order to verify the synergy between the quantitative results of space syntax and the main behaviors of residents in daily life, we conducted a statistical analysis on the behavior of tourists and villagers in Lvtao Village based on field research (Figure 3. R=n), the activities of the villagers are mainly located in the

secondary streets and courtyards of the village, there is no obvious concentrated area, and the activities of the people are wide and the mobility is strong. The activities of the villagers mainly affect the spatial form of the village, which is mainly the living space for the villagers. However, the tourism industry of Lvtao Village is not as mature as the surrounding tourist attractions such as the ancient city of Dali and Chongsheng Temple. There are few tourists and the equipment is not perfect. It is basically used to undertake tourists overflowing from surrounding tourist attractions. It can be seen that tourists are mainly concentrated at the entrance of Lvtao Village, the village square and the space nodes of Cuiqiao Square. Although the square in front of Wenchang Palace is at the intersection, there is not much passenger flow. Through the analysis, the results of the space syntax analysis are in good agreement with the social activities of the residents, which pave the way for the next step in the analysis of selectivity and comprehensibility.

(2) Selectivity analysis

The degree of selectivity is expressed as the number of times the shortest topological path between any two units in the system is traversed, and it examines the advantages of the spatial unit as the shortest path of travel in the system (Guan 2019). It is the probability that a space in the system is traversed by other shortest paths. For villagers, the walking path is affected by their living habits; for tourists, they prefer to choose a path with high accessibility.

Like the integration analysis, in the Depthmap selectivity analysis, its radius is also divided into global and semi-spherical (Yuan et al. 2020). The local selectivity indicates that when the travel radius is less than or equal to the topological radius, the space within this range will be selected as the shortest travel. The possibility of the path; the global selectivity expresses the possibility that all spaces in the entire village system are easily selected as the shortest path. Therefore, the selection degree analysis of the village axis model with radii of 3m, 5m, 7m and n is carried out (Figure 4).

| Lvtao partial selectivity (R=3) | Lvtao partial selectivity (R=5) | Lvtao partial selectivity (R=7) | Lvtao partial selectivity (R=n) |

Figure 4. Selectivity Analysis Chart of Lvtao Village. (Author self-made by depthmap)

As shown in Figure 2-3, in the selectivity analysis diagram where R is 3m, the area with higher selectivity is the third-level roadway in the street. With the continuous increase of the selectivity radius, it can be found that the higher the grade of the street, the higher the selectivity, and when R=n, that is, when the global range is selected, the first-class streets and alleys have a higher degree of passing, the value of which is 1.04, and the potential for passing through outside and in the village is greater. The selectivity area is completely transformed into the first-level lanes of the whole village, which just corresponds to the integration degree analysis, and is the skeleton of the streets and lanes of the village and the core of traffic. To a certain extent, the overall choice of Lvtao Village reflects that the overall connectivity of the village is moderate. It is necessary to strengthen the connection of street boundaries, such as the northern and eastern lanes, and strengthen the connectivity of secondary lanes in the village, so as to lay a foundation for the future development of commerce and service industries.

(3) Intelligibility analysis

Intelligibility represents the relationship between local variables and global variables, and measures whether the local space observed in a certain space is conducive to constructing the structural characteristics of the overall space, that is, whether it can become a guide to lead the entire space (Huang et al. 2014). The intelligibility is represented by the regression curve R2, which reflects the complexity of the village space. In order to explore the comprehensibility of the traditional streets and alleys of Lvtao Village, the author analyzed the regression analysis of the village's global integration and local integration in the Depthmap software, and obtained the regression curve and the correlation coefficient value.

In the space syntax, when the intelligibility value (R2) exceeds 0.5, it means that the street space has a better understanding, and the connection value of the street space system is highly correlated with the integration degree, and vice versa. As shown in Figure 5, the results of syntactic data analysis show that its linear regression equation is y=3.94.2x-0.7119. The y-axis is connectivity and the y-axis is global integration. The fitting degree R^2=0.446, indicating that the whole village has a good sense of order and logic. At the same time, in the block, the orientation of the local space is general. Pedestrians have a low understanding of the traditional street and alley space except the first-level lanes, and the remaining second- and third-level lanes. It is not easy to have a systematic and perceptual understanding of the overall space through local streets.
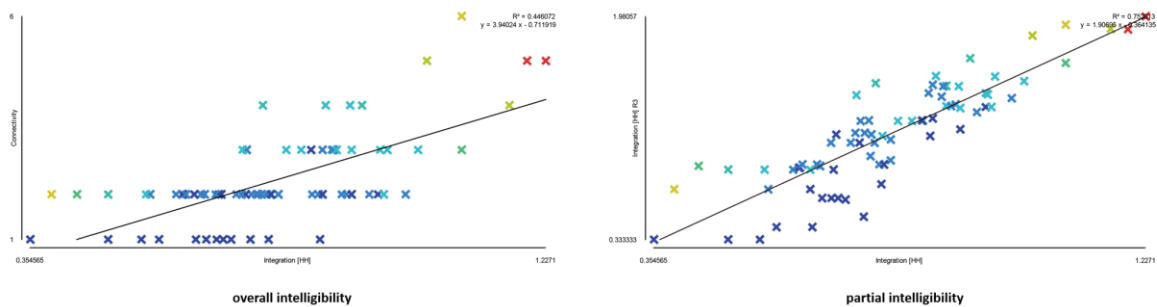

Figure 5. Lvtao Village intelligibility. (Author self-made by depthmap)

According to on-site interviews and investigations, the author found that only the first-level lanes in the village are relatively straight and unobstructed, and intersect the village square. Other secondary lanes are narrow and complex, and the sense of direction is not clear, especially when only local residents are familiar with the traditional streets and alleys are prone to negative space, for tourists, it is impossible to predict the next direction and reduce the sense of interest. At the same time, it can be seen from Figure 1 that there are many broken roads in the village, and there are two roads that are close to each other but cannot be reached. This situation makes it easier for villagers and tourists to lack awareness of the road system.

4. Syntactic analysis of partial spatial morphology

4.1. Public space

The traditional village public space represents the vitality inside and outside the entire village, including the streets and squares of it. We define the public space outside the residence through on-site survey, and uses Depthmap to quantitatively analyze the village space from the perspective of sight, line of sight, integration, and compactness, so as to provide a basis for finding space nodes and vitality spaces.

From the viewport connection value (Figure 6. a), it can be seen that the location of the warm color - Cuiqiao Square has a higher connection value, indicating that these two areas have more connection

viewpoints, a wider viewport, and space penetration. higher rate. The second is the entrance square of the village in the south, and the streets and alleys in the village are blue, indicating that the connection value of the visual field in this area is the lowest, and there are relatively few viewpoints that can be connected in the space. However, according to field research and analysis, the order of village space vitality is main street > village entrance square > Cuiqiao square. Contrary to the quantitative results, we believe that the results of the viewshed connection value need to consider many factors such as the research space scale, type, surrounding area. environment, etc.

a. Viewshed Connectivity Analysis   b. Line of sight penetration analysis   c. Viewshed Integration Analysis   d. Pedestrian Trajectory Analysis
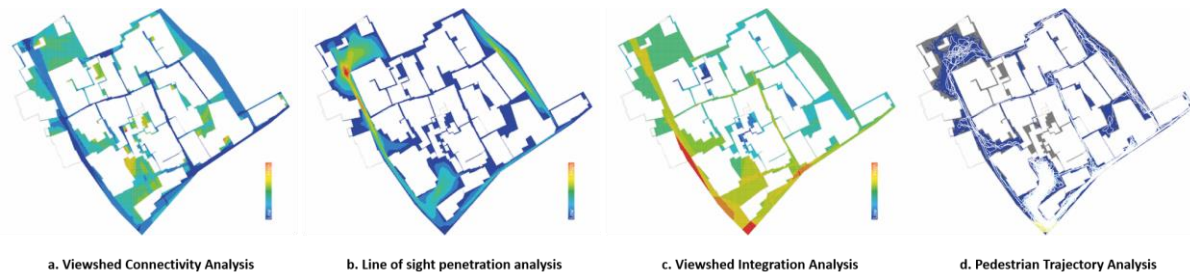
Figure 6. Spatial syntax analysis of Lvtao Village node space. (Author self-made by depthmap)

However, we can look for spatially active nodes based on the results. Through the analysis of the integration degree of sight (Figure 6. b), it can be concluded that the integration of the village entrance square and the original Tea-Horse Road in the west is relatively high. This point is the main entrance for tourists and villagers, and it is also connected to the surrounding supporting service facilities. The accessibility of the area is relatively high, which is consistent with the field survey. You can select the vitality point of the internal space to enlarge, connect the inside and outside, infiltrate the space into the village, and enhance the vitality of the village. According to the analysis of the lines of sight penetration (Figure 6. c), the better line of sight corridor in the village is the original Tea-Horse Road in the west, with a street width of 4-7m and a wide line of sight. On the contrary, the main streets and alleys of the village have poor visibility (green) due to their narrow width. We believe that wide and narrow alleyways can enhance the fun of walking, so the penetration of sight lines and traditional villages should be analyzed in inverse proportion. From the analysis of pedestrian trajectory (Figure 6. d), the area with better sight line has a larger flow of tourists, which can be designed as a landmark node for the entrance and exit.

4.2. Waterfront space

A waterfront space is a space that consists of a body of water and its associated elements. It consists of "land or buildings adjacent to rivers, lakes and seas, and areas adjacent to water bodies of towns" (Huang et al. 2014). The study selects the river section that flows through Lvtao Village as the local spatial linear element analysis of urban spatial form.

The viewshed connection analysis is performed on the waterfront space (Figure 7). The more connected points are, the more red the color is, and vice versa, the blue-green color. From the analysis results, it can be seen that the No. 1 Longmu Temple has the highest connection value, indicating that its spatial permeability is high and the area that can be visually covered is large. The second is the village entrance of No. 2 and the village committee of No. 3, and the connection value of the parking lot of village No. 4 is the lowest. It is worth noting that the quantitative results are highly consistent with the current situation of the village, so the open space design and activity planning of the Longmu Temple and the human history of the village can be combined with the results to continue the historical context.
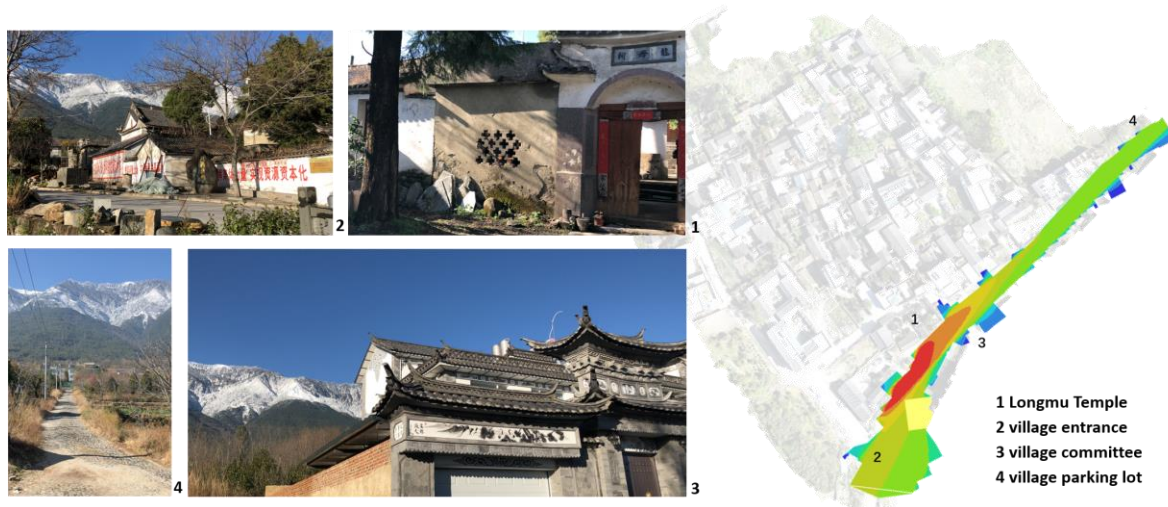
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Figure 7. Waterfront space viewshed connection analysis and survey photos. (Photos and graphic by Author)

5. Space Renewal Strategy—Enlightenment to the Village Development of Lvtao Village

5.1. Overall space

(1) The continuation and activation of traditional streets

The traditional streets and alleys of Lvtao Village and the open spaces at different scales are the embodiment of the local wisdom of the village. The traditional "street-alley-courtyard-home" constitutes a unique "Hui"-shaped texture, which can be viewed from the interface. Continuation, space extraction, courtyard integration and combination of quantitative results to form a street network to refine and inherit it (Figure 8). The streets and alleys of traditional villages have diverse functions such as freight, markets, conversations, and activities. The integration degree of the syntactic quantification results shows that the vitality of the first-level streets is significantly higher than that of the second- and third-level streets, which is highly synergistic with the current situation survey. However, it is worth noting that the simple spatial form cannot fully reflect the real life behavior of residents. For example, the weekly fixed market and the space for neighbors to talk are located in the second- and third-level streets. In-depth interviews and investigations can be combined to optimize the spatial form and activation.

(2) The connection of the village space skeleton

Build a spatial skeleton network to enhance the vitality of the village space. The vitality of space can be reflected by the integration and selection of streets and alleys. Combined with the actual investigation, it is found that Lvtao Village should sort out all levels of streets and alleys. In addition to the first-level streets, the connections between the second-level streets and alleys should be connected in series to form a public space skeleton network, so as to improve the choice of the whole space, activate the experience route of each activity, so that tourists can choose a variety of paths. At the same time, according to the quantitative analysis, a variety of public space nodes such as cultural nodes, traffic nodes, and landscape nodes are obtained. Combined with field research and analysis of people flow, the space design is carried out to enhance the vitality of the core space.
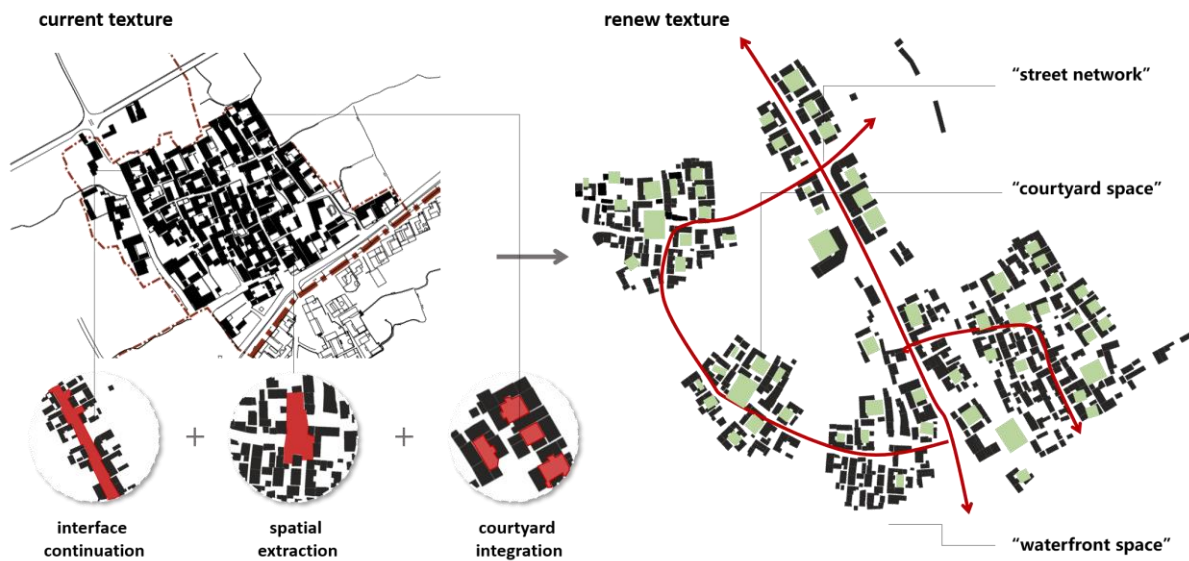
Figure 8. Traditional streets and alleys renewal strategy. (Graphic by Author)

5.2. Partial space

(1) Shaping of space features

People's perception of behavior is affected by the environment. Therefore, for the space construction of traditional villages, it is necessary to highlight its cultural connotation to highlight the spatial characteristics, so as to enhance the overall impression (intelligibility) of the village. Lvtao Village should rely on its alleys, square spaces, courtyards and other spaces, implant creative and characteristic cultural commerce in the streets and alleys, create local cultural elements with strong locality, and improve the quality of the space, so as to improve tourists' perception of the streets and alleys. In terms of perception level, planning can draw tourism maps to improve the image of the village and shape its IP (Figure 10). For the local space nodes of Lvtao Village, such as the original Tea-Horse Road, waterfront space, etc., it is necessary to strengthen the shaping of characteristics and reproduce the cultural scene.

(2) Spatial line of sight integration

Due to the mixed space of traditional villages, it is not easy to form a unified line of sight in the space. Lvtao Village should take advantage of its location advantages and use the surrounding good sight control points such as the Three Pagodas of Chongsheng Temple, Cangshan Mountain, and Erhai Lake to integrate the sight line of the village space. Village markers are set up in places with transparent and open sight (the entrance to the ancient village) and in the core space (landscape observation deck), so as to unify the main body of the space. In the open sight of the village (Figure 9), looking at the Three Pagodas of Chongsheng Temple, with the mountain as the scene, gives people a flawless yearning.
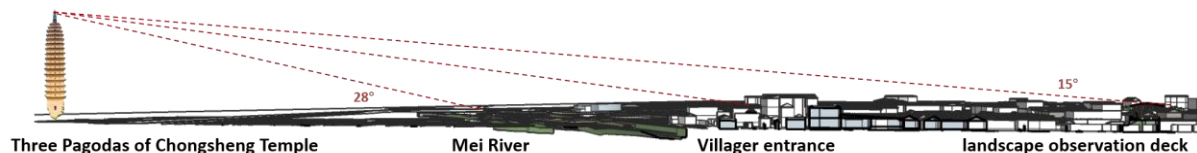

Figure 9. Line of sight guidance analysis. (Graphic by Author)

Figure 10. Lvtao Village image map and IP. (Graphic by Author)

6. Conclusion and discussion

Traditional villages are easily forgotten in the era of rapid development, but the humanistic wisdom behind them is a process that requires continuous exploration and exploration. At the same time, new technologies and methods should be used to inject new impetus into the villages. We made an objective quantitative analysis of the overall and local spatial forms of small-scale traditional villages through the science of space syntax, and through the comparison with the observation and cognition of the main behavior activities of villagers and tourists in the field research, the spatial updating strategy of the streets and alleys of traditional villages was obtained and applied to the design. However, the author found in the analysis that the "natural activity" of space syntax is carried out from the spatial logic structure, and the actual utilization of street space will be affected according to the time and space of the user. As a result, adding multi-factor evaluation criteria and comprehensive analysis to strengthen the correlation between spatial "natural activities" and human behavior activities will help to better understand and analyze the spatial form of traditional villages in the future.

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