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A Study on Sustainable Design of Traditional Tujia Village Architecture in Southwest Hubei, China

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Abstract: The rapid urbanization in China in the past four decades has significantly affected traditional villages, resulting in a series of problems such as limited space, damaged style, weak sense of place, and loss of skills. This paper aims to establish a new paradigm for the sustainable development of village architecture in the Tujia ethnic area of southwestern Hubei province in order to address the issues of development and renovation of village architecture in this region. To achieve this goal, first, through field investigations and records of typical villages in the Tujia ethnic area of southwestern Hubei province, the characteristics of Tujia ethnic villages and the real challenges faced by village architecture are summarized. Secondly, the Delphi method is used to conduct expert interviews, construct a multi-level evaluation index system for sustainable development, and use the analytic hierarchy process to determine the weights of each index. Based on this, four design paradigms for sustainable development are proposed, including flexible layout, integrated interface composition, localized housing construction, and modular unit construction. These four paradigms cover the entire design stage from function to form, and from overall scene to structure. At the same time, multiple modular options are provided for each stage. Compared to the traditional experience-based construction model, the comprehensive benefits and promotability are greatly improved. Therefore, the research findings provide a reference for the sustainable development of traditional village architecture in other ethnic areas of China.

Keywords: Tujia; traditional village architecture; sustainable design; analytic hierarchy process

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1. Introduction

A traditional village is a spatial unit comprising a community of farmers who live and reproduce in a specific area for generations [1]. Traditional villages are a product of Chinese agricultural civilization and they have extremely high historical and cultural values [2]. Most traditional villages are rich in cultural heritage, including traditional architecture and folk crafts [3]. However, due to urbanization over the past decades, traditional villages have been exposed to impacts, damages, and eventually degradation. According to the results of field investigations conducted by the Research Center of China Village Culture, the total number of traditional villages in the basins of the Yellow River and Yangtze River decreased substantially from 9707 to 5709 from 2004 to 2010 (7.3% per annum and 1.6 villages per day) [4]. For example, various traditional villages are distributed in the Tujia zone of southwest Hubei, China, and the unique stilted buildings vividly showcase the local ethnic style. However, the wooden stilted buildings, which are a valuable tangible cultural heritage, are in danger because they can no longer meet the needs of modern society [5,6].

At the same time, the Ministry of Housing and Urban-Rural Development and the Ministry of Culture and Tourism of China issued The Notice on the Survey of Traditional Villages and published six batches of the List of Chinese Traditional Villages in 2012, 2013, 2014, 2016, 2019, and 2022. A total of 8155 villages were designated as national traditional villages [7]. Meanwhile, the Central Committee of the Communist Party of China and the State Council put forward in the Opinions on Doing a Good Job in the Key Work of Comprehensively Promoting Rural Revitalization in 2023 the overall requirement of "constructing modern, livable demonstration buildings for farmers and improving the style of villages based on local characteristics, regional characteristics, and ethnic characteristics" [8]. Moreover, Enshi Tujia and Miao Autonomous Prefecture emphasized in the Notice on Promoting the 14th Five-Year Plan for Agricultural and Rural Modernization in 2023 that village construction should adapt to local conditions, preserve the local ecological style of mountains, water, rivers, and fields, and encourage the design and promotion of residence building prototypes that have regional characteristics, meet various functional requirements, and have different construction cost levels [9]. The above initiatives provide policy support for the protection and utilization of traditional villages in the new era, making sustainable development of traditional villages a widely discussed research topic.

In summary, it is evident that the development of Tujia ethnic village architecture in southwestern Hubei province is facing numerous practical challenges. How to overcome these obstacles and achieve sustainable design in village architecture has become a pressing issue that needs to be addressed. In light of this, this paper analyzes the typical characteristics and current issues of Tujia ethnic village architecture in southwestern Hubei province from the perspective of sustainable design. It then identifies various factors that influence sustainable design and determines key elements through a comprehensive evaluation method. Finally, it proposes corresponding paradigm references for the sustainable design of village architecture in this region.

2. Literature Review

Protection and utilization are two key research topics for the sustainable development of traditional villages. Previous studies mainly focused on three aspects: Firstly, from the perspective of tangible spatial forms, studies have been conducted on the formation and evolution patterns of village spaces and corresponding strategies for conservation and utilization have been proposed; such research is primarily concentrated in the fields of spatial geography or rural planning, with a macroscopic view and a predominance of quantitative analysis; For instance, Li [10] conducted research on villages in the Xiangjiang River Basin, exploring the evolutionary patterns and driving factors of village forms from both the horizontal spatial (upstream, midstream, downstream) and vertical temporal (late 20th century to the present) dimensions, providing data support for spatial layout optimization and regulation. Secondly, from the perspective of abstract cultural value, studies have been conducted on village social governance and cultural transmission; this type of research is mainly focused on cultural heritage or anthropology, with a primary emphasis on qualitative studies of individual cases. For example, Ji [11] conducted a case study on Zhaoxing Dong Village, exploring the comprehensive protection model and measures for the intangible cultural heritage of the Dong ethnic group from a cultural heritage perspective. Thirdly, research in this area focuses on studying the optimization paths for the living environment of traditional villages from an ecological and energy-saving perspective. This type of research primarily concentrates on architectural energy-saving technologies, with a predominant emphasis on experimental simulation and quantitative analysis. For instance, Chen [12] extracted construction techniques from traditional dwellings, including layout and materials, and employed software such as Phoenics (v.2019) and Ecotect (v.2010) for simulation and verification, ultimately proposing strategies for spatial adaptive transformation. The aforementioned studies have approached the tangible forms or abstract values of traditional villages from various fields and perspectives, conducting research on qualitative or quantitative aspects. However, there is a lack of comprehensive research from a sustainable design perspective that combines qualitative and quantitative methods simultaneously.

Furthermore, research on traditional Tujia villages in southwestern Hubei province has mainly focused on qualitative aspects such as cultural arts and traditional skills, while quantitative research has been relatively limited and primarily focused on green and energy-saving aspects. For instance, Zhang [13] analyzed the formation, evolution, and connotation characteristics of Tujia stilted buildings in-depth from the perspective of regional culture, providing a solid foundation for subsequent scholars in this field. Gong et al. [14] utilized qualitative research methods to analyze the construction techniques of the keyhead-shaped timber structure, which is commonly found in Tujia stilted buildings in western Hubei. Peng [15] and Li [16] conducted energy-saving analysis and optimization of the living environment of Tujia stilted houses from the perspectives of the water environment and wind environment, respectively. These studies made achievements in aspects of both tangible and intangible elements of traditional villages and provided reference paths for their sustainable protection and utilization from macroscopic dimensions to microscopic dimensions.

In conclusion, sustainable research on traditional villages in southwestern Hubei province tends to focus on tangible forms or abstract cultural aspects, with research methods leaning towards either qualitative or quantitative aspects. Overall, there is a lack of comprehensive research conducted from the perspective of sustainable design (Table 1). In light of this, this paper selects typical traditional village architecture in southwestern Hubei province as the research subject, including both macro-regional and micro-case studies. By combining qualitative and quantitative research methods and deeply analyzing the current challenges, a new paradigm for sustainable design is proposed, aiming to provide a paradigmatic reference for the future inheritance and design of Tujia traditional village architecture.

Table 1. Summary of current research on the sustainability of traditional villages.

Regional Scope	Perspective	Sample Type	Critical Path	Methodology	Disciplinary	Summary (Limitations)
General region	Spatial form (concrete manifestation)	Regional community (macro-level)	Research on the formation and evolution of space, and propose strategies for conservation and utilization.	Quantitative analysis	Spatial geography or rural planning	There is a tendency to focus more on concrete forms or abstract cultural domains, and the research methods often lean towards qualitative or quantitative studies in specific areas. Overall, there is a lack of comprehensive research conducted from the perspective of sustainable design.
	Cultural value (abstract)	Typical case study (micro-level)	Study of village social governance and cultural inheritance	Qualitative analysis	Cultural heritage or anthropology	
	Ecological energy conservation	Typical case study (micro-level)	Study of the optimization path of residential environment	Quantitative analysis	Building energy efficiency	
Tujia region in southwestern Hubei province	Cultural arts and skills inheritance	Regional community/typical case study	Study of the formation, evolution, techniques, and environmental improvement	Qualitative analysis	Cultural arts, architectural energy-saving	

3. Characteristics and Practical Difficulties of Traditional Tujia Villages in Southwest Hubei, China

The regional scope of the Tujia areas in southwest Hubei, China, includes Enshi Tujia and Miao Autonomous Prefecture, Wufeng Tujia Autonomous County, and Changyang Tujia Autonomous County, which are collectively referred to as "one prefecture and two counties". Specifically, there are ten counties, including Enshi, Laifeng, Xianfeng, Xuan'en, Lichuan, Hefeng, Jianshi, Badong, Wufeng, and Changyang [17]. The traditional village samples are the first six batches of traditional villages in the Tujia areas in southwest Hubei, China, published by the Ministry of Housing and Urban-Rural Development of China, with 106 villages in total. The spatial distribution of these villages is shown in Figure 1.

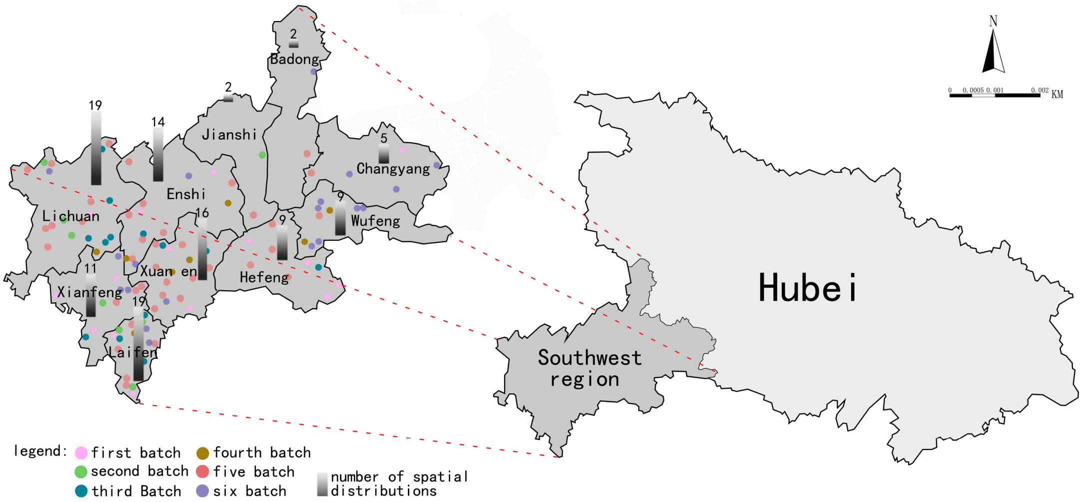


Figure 1. The spatial distribution of traditional Tujia villages in southwestern Hubei.

3.1. Characteristics of Traditional Tujia Villages in Southwest Hubei, China

The primary characteristic of traditional Tujia villages in southwest Hubei, China, is the ecological nature of their locations. Most of the villages are located in "dragon caves" at the foot of mountains or on the mountainside, which are favorable sites that serve as natural shelters and gather wind and gas. Specifically, in the front, there is a "Zhuque" mountain facing each other, and in the back, there is a "Xuanwu" main mountain peak leaning against each other, with "Qinglong" and "Baihu" secondary mountain peaks embracing each other on both sides. This site selection concept is mainly derived from the Feng-shui theory from the Central Plains area; it incorporates the romantic traits of the Bachu area and expresses the simple wish of Tujia residents for protection from the "Five Directions and Four Deities" [18,19]. Moreover, due to limited land area, villages are often situated in alignment with the terrain, forming a cascading rhythmic sense of jumping on the porch and hanging on timber stilts. This site selection is not only conducive to resisting cold winds, obtaining sunlight, and enjoying irrigation convenience but also forms an organic entity of "human-village-environment" in harmonious symbiosis with surrounding mountain and forest vegetation and the community of houses.

The orderliness of the community is another important characteristic of traditional Tujia villages, which shows a sense of clan consciousness and spiritual belief [20] (Figure 2). As the focal point and symbol of a village, ancestral shrines are primarily used for ancestor worship and festive activities, and they gather the community of buildings in a potential order. The "orderliness" of buildings is mainly reflected in the fact that the living hall is the most public; the bedroom is the most private; the fire pit is the banquet area; and other rooms are allocated according to ethical order, with distinct inside and outside hierarchies [21].

Architectural territoriality is also an important characteristic of traditional Tujia villages. The primary architectural form is stilted buildings. From a planar view, these buildings can be roughly categorized into the "-" shape, "L" shape, concave shape, and quadrangle shape, and they are combined randomly and grow naturally [22] (Figure 3). From a façade view, the most distinctive feature of the buildings is the angled cornice roof, and the buildings are suspended over the ground, which not only meets the needs of "people living above and livestock kept below" but also adds a sense of lightness and elegance. Moreover, these buildings are mostly made of local wood and rock, with the main structure being a through bucket wooden frame and partially suspended overhanging, forming various structures such as “single-sling”, “double-sling”, and “flat ground sling” [23,24] (Figure 4).

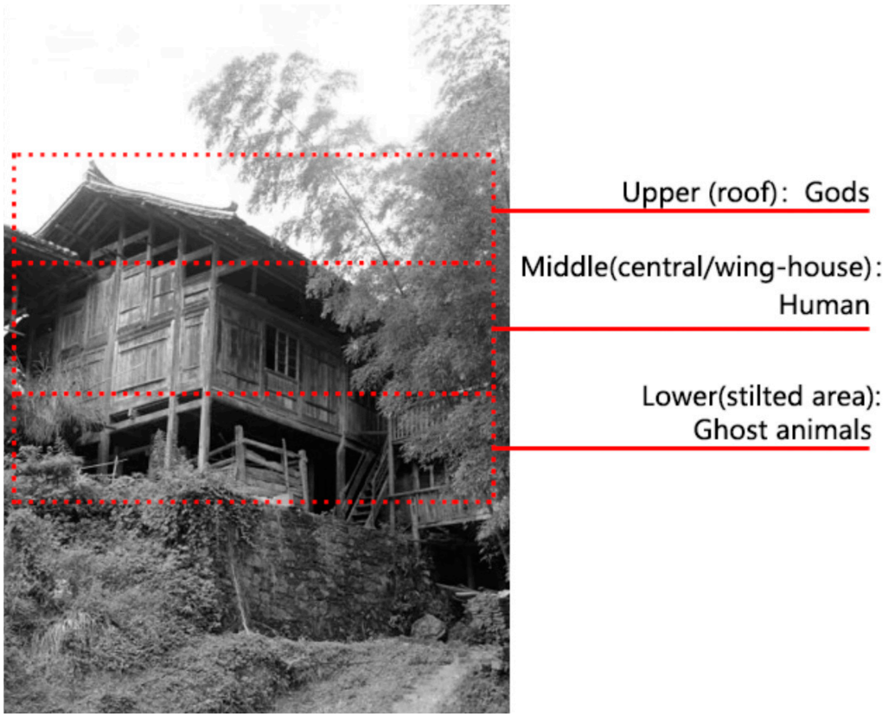


Figure 2. Vertical structure of Tujia stilted buildings.

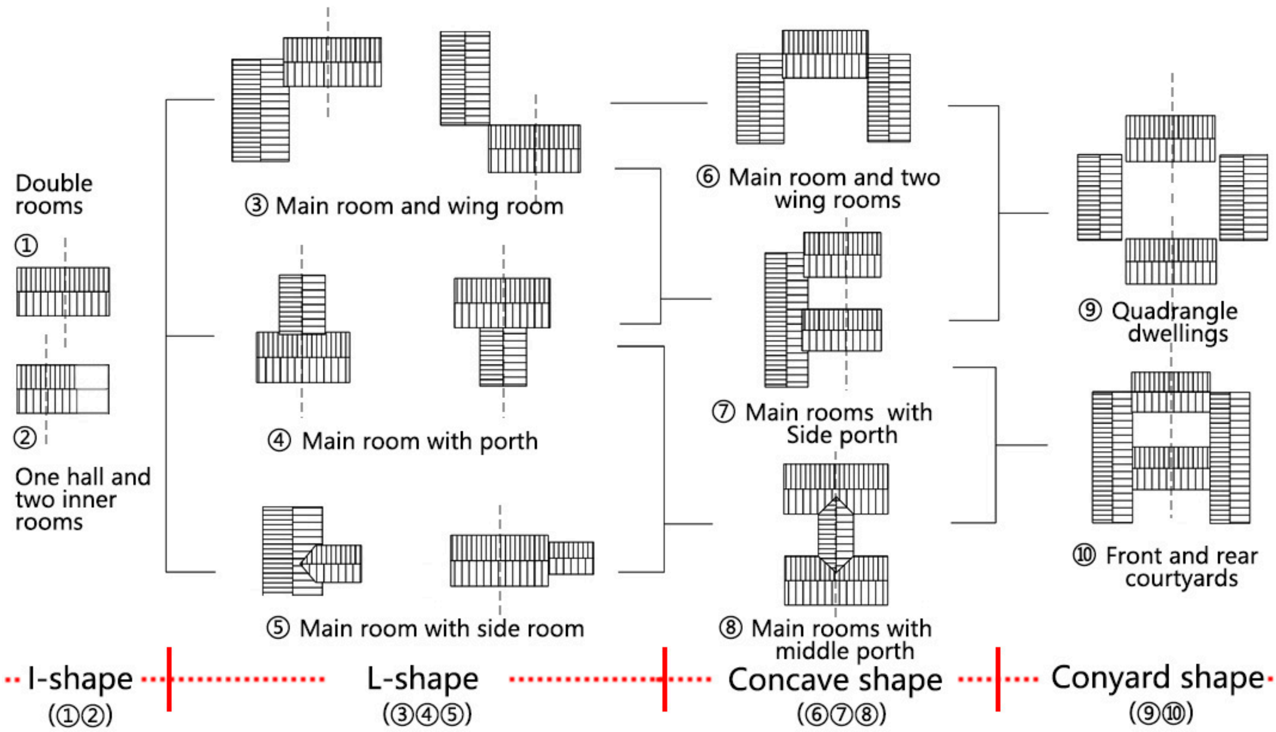


Figure 3. Evolution of the layout of Tujia stilted buildings.

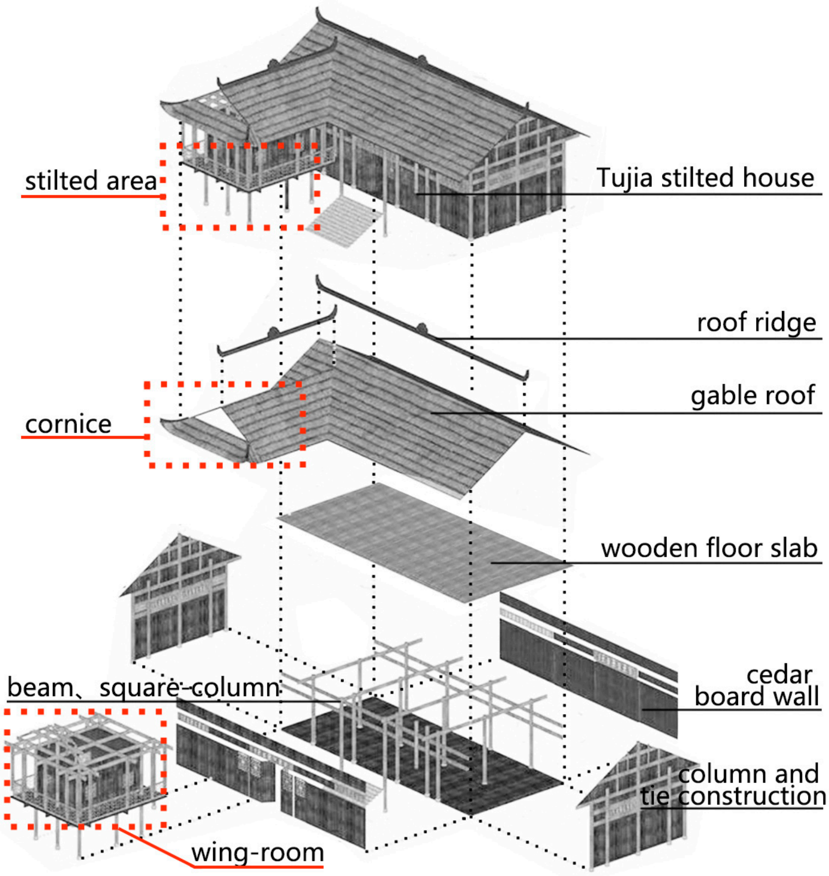


Figure 4. Schematic diagram of the structure of a "single-sling" stilted building.

In addition, the continuity of architectural styles is another distinctive characteristic of traditional Tujia villages in southwest Hubei, China. This region is located between the two major cultural areas of Jingchu and Bashu, and it is culturally influenced by their diverse influences [25]. The villages exhibit undulating terrain, resembling a picturesque landscape painting. These buildings feature overlapping overhanging eaves and emphasize harmony with the environment. During site selection and construction, villagers often observe celestial phenomena to choose an auspicious date for holding a ceremony such as singing praises and delivering blessings when placing beams to beg for divine and ancestral protection. This unique regional culture endows the villages with a distinct cultural atmosphere and has served as the spiritual core of traditional Tujia villages for centuries [26].

3.2. Practical Difficulties Facing by Traditional Tujia Village Architecture in Southwest Hubei, China

Over the past four decades, the urbanization rate in China increased from 17.9% (1978) to 65.2% (2022) [27]. In this process, some local governments unilaterally pursued performance goals and promoted rural development with industrialized thinking, resulting in the demolition of a large number of traditional buildings and the disappearance of distinctive architectural styles. Meanwhile, due to sluggish economic development, some villages have experienced significant population outflows, leading to "hollowing out", and many village buildings are abandoned due to lack of maintenance. Figure 5 shows the number of natural villages in mainland China in 2011 and 2021. It can be seen that the number of natural villages decreased sharply in most provinces, with nearly 50,000 villages in Hubei Province, indicating that the sustainable development of village buildings is facing huge challenges in the following aspects.

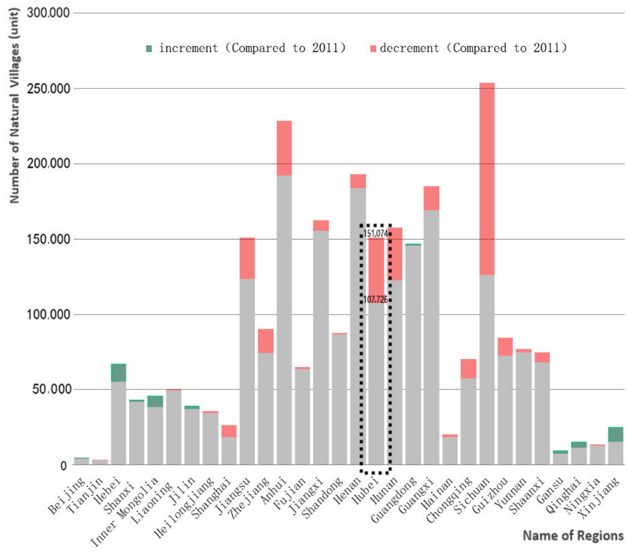


Figure 5. Statistical changes in the number of natural villages in major provincial capitals of the Chinese mainland (comparison between 2011 and 2021).

(1) Limited space and poor functional adaptability. First, the village buildings often use column and tie construction, with a large living hall but small side rooms at two sides, and space separation relies on roof truss spacing, leading to poor flexibility. Second, kitchens are usually located inside rooms on both sides, and smoke often flows into bedrooms due to the use of a fire pit. To address this issue, some residents replaced the fire pit with a kitchen stove. Although this improves thermal insulation, it leads to the loss of a family gathering place. Third, there is a lack of separate bathrooms. Usually, the bathroom is far from the main room and built near livestock, leading to a smelly odor in the bathroom and poor use experience. In addition, stilted buildings usually use thick cedar wood plates of 3 cm as wall materials, which have poor thermal insulation and fire resistance, and their adaptability to modern society is also weak [28,29] (Figure 6).

(2) A chaotic mix of architectural styles and abusive use of symbolic elements. Due to a lack of investigation of distinctive culture, traditional Tujia villages often have a wide range of architectural styles. One example is the antique style of "wearing clothes and hats" [30]: decorative wooden plate "clothes" are added to concrete exterior walls, and traditional roof "hats" are added to the top floor, leading to a shoddy, chaotic, and disorderly style. Another example is the modern style of the "small western-style villa" [31]. Such buildings are incongruous with the surrounding environment of Tujia villages and lack the connotation of traditional architecture. In addition, affected by external commercial capitals, some villages have shown chaotic architectural styles and have lost their real architectural styles.

(3) Context alienation and weak sense of identity. Recently, although the material environment of traditional Tujia villages has been greatly improved, their spiritual space has gradually become alienated, which is mainly reflected in a decrease in vitality and a weak sense of identity [32]. In existing traditional Tujia villages, due to a large number of young adults going out for work, the houses are abandoned and deteriorating, thereby leading to a prominent trend of "hollowing out" and a loss of village vibrancy [33]. As lifestyles change, the emotional connection of Tujia residents to their land has gradually faded. For example, Tujia residents have a deep admiration for fire, and the fire pit serves as a place for daily gatherings and communications. However, due to hygiene and safety concerns, the fire pit has gradually been replaced by the modern stove, resulting in the disappearance of the communal gathering space in memory [34]. In addition, the space for ancestral shrines in the living hall has

been gradually replaced by modern furniture, leading to a weakening of religious beliefs [35].

(4) Complex construction skills and low construction efficiency. The construction of Tujia stilted buildings requires intricate and complex construction skills, which are mainly taught orally. From site selection and material preparation to construction and decoration, the entire building process is mainly coordinated and controlled by the construction master [36]. Throughout the construction process, manual labor coordination and cooperation are crucial, and the process is often disrupted by external factors such as weather and materials, resulting in long construction periods and uncontrollable costs (Table 2). For instance, the wood and bamboo used in the construction of stilted buildings are relatively limited in supply, and the number of skilled craftsmen experienced in building stilted buildings is decreasing due to the impact of industrial civilization, resulting in increased labor costs [37]. Furthermore, stilted buildings are fully wooden structures and are highly susceptible to corrosion in the humid climate of southwest Hubei, so their lifespan is greatly reduced [38]. In contrast, modern concrete houses have lower construction costs and longer lifespans, making them more acceptable to the younger generation of villagers.

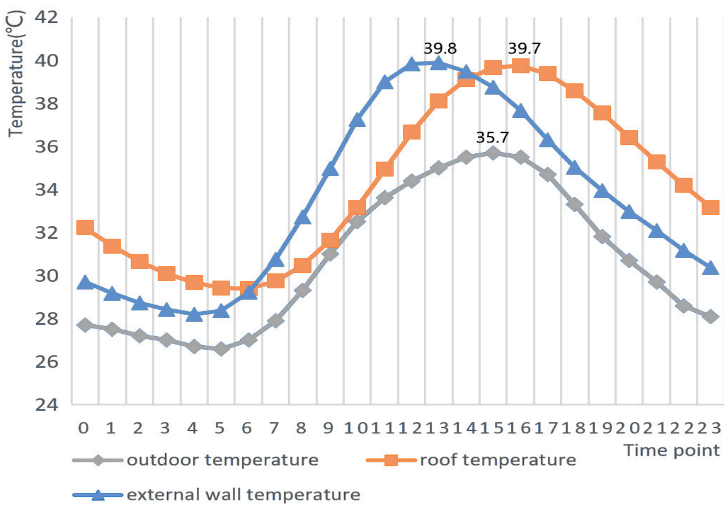


Figure 6. Schematic diagram of indoor environmental comfort of Tujia stilted buildings in southwest Hubei, China (natural ventilation state in summer).

Table 2. Summary of main construction procedures for Tujia stilted buildings in southwest Hubei Province.

Step	Main Content	Participants	Main Tools	Average Duration (Days)
1	Select the site, place the frame, and determine the orientation	Feng Shui master and house owner	Compass and tape measure	2
2	Level foundation and prepare timber	Construction master and carpenter	Shovel, hoe, and stone hammer	20–30
3	Prepare incense paper and pay tribute to mountain deities	Houseowner and construction master	Incense paper and ritual liquor utensils	0.5
4	Open punt pole, make ink drawing, and prepare rough materials	Construction master and carpenter	Punt pole, axe, saw, chisel, set square, and ink bucket	45–60

Table 2. *Cont.*

Step	Main Content	Participants	Main Tools	Average Duration (Days)
5	Sequentially arrange beams and strike with a resonating hammer	Construction master and carpenter	Punt pole and resonating hammer	1–2
6	Pay tribute to Luban (god of carpenters) and worship ancestors	Construction master and carpenter	Incense paper and ritual liquor utensils	0.5
7	Make main beams, create beam openings, and wrap beams	Construction master and house owner	Axe, saw, chisel, red cloth, and ropes	1
8	Install beam rows, add horizontal braces, and hoist beams	Construction master, carpenter, house owner, and relatives and friends	Wooden ladder, ropes, and resonating hammer	1–2
9	Adjust eaves for water drainage	Construction master and carpenter	Punt pole, saw, and hammer	5–7
10	Decorate house	Carpenter	Saw, plane, set square, and ink bucket	90

Note: the content related to the construction procedures of stilted buildings in this table is compiled from interviews with Enshi Xianfeng stilted building intangible cultural heritage inheritors Wan Taoyuan, Xiong Guojiang, and construction master Liu Ya. It is obtained from the interviews that the average duration of the stilted building construction procedure is significantly affected by timber supply and weather conditions. The information provided here indicates the typical duration under normal conditions.

4. Materials and Methods

4.1. Research Materials

To obtain authentic data and first-hand information, the research team conducted multiple field research activities, resident interviews, and questionnaire surveys in traditional Tujia villages located in the southwestern region of Hubei to investigate local resources (Architectural style, construction techniques, folk culture, etc.) from May 2018 to March 2021 (Appendix A). The research sample primarily consisted of typical representatives from the 1st to 6th batches of traditional villages in southwestern Hubei, such as Dabaixi Village, Shadaogou Town, Xuan'en County (2018.5), Maliuxi Village, Huangjindong Town, Xianfeng County (2019.7), Liangxihe Village, Changtanhe Town, Xuan'en County (2020.7), Chuanxinyan Village, Yesanguan Town, and Badong County (2021.3). Among them, a month-long on-site investigation was conducted specifically for the Tujia suspended wooden houses in Maliuxi Village, Xianfeng County. The research primarily focused on the entire process of craftsmanship carried out by the inheritors of intangible cultural heritage, and a relatively comprehensive set of sample data was obtained.

4.2. Research Method

As mentioned above, there are many factors that influence the sustainable development of traditional Tujia villages in southwestern Hubei. This study aims to select key influencing factors in order to propose sustainable design strategies. The Analytic Hierarchy Process (AHP) is suitable for this purpose as it allows experts to determine the weightings and prioritize various factors, providing a quantitative basis for the subsequent strategies. The Analytic Hierarchy Process (AHP) was introduced by American mathematician Saaty [39] in the 1970s and has been widely applied in the field of design. For instance, Chen, et al. [40] utilized the AHP method to assess the sustainable development indicators of the Qianfeng Community in Guangzhou and proposed effective development strategies. Lu, et al. [41] conducted an evaluation of the development indicators of six traditional villages in Guangxi using the AHP method, and subsequently proposed corresponding development strategies. In addition, the research of Kiptom et al. [42] and Cao et al. [43] on the use of AHP evaluation methods in urban sustainable development has also provided inspiration for the methodological path of this article. The latter adopts a comprehensive research method of interviews and quantitative questionnaires, which has greatly inspired the research method of this study. Furthermore, the research of Bhat [44] and Bouuraima et al. [45] has been of great help in establishing the AHP evaluation model in this article. Therefore, considering that the evaluation scheme is not complex, the AHP method is suitable. The specific steps are as follows:

Firstly, the research objectives and questions were clarified through a literature review and field research (questionnaires and semi-structured interviews), and preliminary indicators were proposed. Next, interviews were conducted with experts or scholars in the field to adjust and optimize these indicators and establish an indicator system. The expert group members consist of industry representatives, scholars, and policymakers who have extensive experience or research background in this field. Subsequently, a Likert scale-designed questionnaire was distributed to collect assessment scores. The research sample was randomly selected from individuals involved in traditional village research in Hubei province, representing different socioeconomic backgrounds, including village representatives, government officials, and relevant design professionals. The weights of the indicators were calculated using the Analytic Hierarchy Process (AHP), and sustainable design strategies for traditional village architecture in the Tujia ethnic area of southwestern Hubei province were proposed based on the analysis results.

4.2.1. Construction of the Evaluation Index

Based on a review of relevant literature on the sustainable development of traditional villages and field research data from traditional villages in southwestern Hubei province, a preliminary evaluation framework is proposed with four dimensions as primary indicators: Spatial functions, Exterior style, Scene imagery, and Construction mode. Building upon this preliminary framework, 30 experts and scholars from relevant fields were consulted using the Delphi method to adjust and optimize all indicators. As a result, an evaluation index system consisting of 4 primary indicators, 11 secondary indicators, and 31 tertiary indicators was established (Table 3).

4.2.2. Construction of the Judgment Matrix and Calculation of Index Weights

Based on the aforementioned, once all the indicators that influence the sustainable development of Tujia village architecture have been identified, this study adopts Saaty's 1–9 ratio scale method for evaluation. The evaluation process is conducted online, with a total of 33 questionnaires distributed, resulting in 30 valid responses (3 incomplete) (Appendix B). The participants include architects, village conservation scholars, policy planners, craftsmen, and village representatives. Subsequently, the evaluation results are summarized and analyzed to obtain the assigned values for each indicator. Finally, using the AHP model in conjunction with Matlab (v2020) software, the weight values for each indicator are calculated. The specific process is as follows:

Compute the multiplication of each row in the judgment matrix to obtain the product Mi.

$$M_i = \prod_{j=1}^{n} a_{ij} \quad i = 1, 2 \cdots n \tag{1}$$

Calculate the nth root Wi of Mi.

$$W_i = \sqrt[n]{M_i} \tag{2}$$

Normalize Wi to obtain the eigenvector. ωi represents the weight of the i-th indicator.

$$w = [w_1, w_2, \cdots, w_n]$$

$$w_i = \frac{w_i}{\sum_{i=1}^{n} w_i} \quad (3)$$

Calculate the maximum eigenvalue $\lambda_{\max}$ of the judgment matrix A, where A is the judgment matrix, n represents the order of the matrix, and wi denotes the weight assigned to the i-th criterion.

$$\lambda_{\max} = \frac{1}{n}\sum_{i=1}^{n} \frac{(Aw)_i}{w_i} \quad (4)$$

Table 3. Evaluation indicators for sustainable development of traditional Tujia village architecture in southwest Hubei.

Target	Level 1	Level 2	Level 3
The evaluation indicators for the sustainable development of traditional Tujia ethnic village architecture in southwestern Hubei province	Spatial functions *B1*	Diverse types *C1*	Living type *D1* (Hall, dining room, etc.) Ceremonial type *D2* (Shrine, Fire pit, etc.) Auxiliary type *D3* (Bathroom, feeding area, etc.)
		Flexible layout *C2*	Space sharing *D4* (Hall and shrine, etc.) Flexible combination *D5* Compact layout *D6*
		High comfort *C3*	Indoor environmental comfort *D7* Semi-outdoor environmental comfort *D8* (stilted area, etc.) Outdoor environmental comfort *D9*
	Exterior style *B2*	Unique style *C4*	Modern style *D10* Traditional style *D11* Transitional style *D12*
		Diverse elements *C5*	Local elements *D13* Foreign elements *D14* Mixed elements *D15*
		Rich interface *C6*	Multiple flat elements *D16* Rich spatial hierarchy *D17* Abundant decorative details *D18*
	Scene imagery *B3*	Abundant landscape *C7*	Spatial scenes *D19* Greenery arrangement *D20* Landscape facilities *D21*
		Regional association *C8*	Morphological analogy *D22* Decorative extrapolation *D23* Local construction *D24*
	Construction mode *B4*	Monomer modularization *C9*	Modular combination of forms *D25* Modularization of components *D26*
		Process modularization *C10*	Drawing-based management *D27* Menu-based process *D28*
		Cost efficiency *C11*	Simplify the construction process *D29* Improvement of craftsman skills *D30* favorable market environment *D31*

Finally, a consistency check needs to be performed. The consistency index *Cl* is calculated using the eigenvector and eigenvalue. *A* smaller value of *CI* indicates higher consistency. If the consistency test is passed, it means that the judgment matrix is reasonable and has explanatory value. The consistency index is defined as

$$CI = \frac{\lambda_{\max} - n}{n - 1} \quad (5)$$

The consistency ratio (*CR*) is calculated using the average random index (*RI*) value (Table 4) to determine the level of consistency [46].

$$CR = CI/RI \quad (6)$$

Table 4. Random index (RI) value.

n	3	4	5	6	7	8	9	10	11
RI Value	0.52	0.89	1.12	1.26	1.36	1.41	1.45	1.49	1.51

According to $CR < 0.1$, the judgment matrix is considered to pass the consistency check. Otherwise, it does not possess satisfactory consistency.

For the Level 1 indicators, the specific calculation method for determining the weights of these three indicators is as follows:

The judgment matrix for the Level 1 indicator layer is established based on the scoring results (Table 5).

Table 5. Level 1 indicator layer judgment matrix.

Level 1	B1	B2	B3	B4
B1	1.0000	1.2353	0.3962	1.9633
B2	0.8095	1.0000	0.5600	1.6800
B3	2.5238	1.7857	1.0000	1.0825
B4	0.5094	0.5952	0.9238	1.0000

Calculate the eigenvectors and eigenvalues using Formulas (1)–(4).

$$Bi \Rightarrow \begin{bmatrix} 1.0000 \times 1.2353 \times 0.3962 \times 1.9633 \\ 0.8095 \times 1.0000 \times 0.5600 \times 1.6800 \\ 2.5238 \times 1.7857 \times 1.0000 \times 1.0825 \\ 0.5094 \times 0.5952 \times 0.9238 \times 1.0000 \end{bmatrix} \Rightarrow \begin{bmatrix} 0.9609 \\ 0.7616 \\ 4.8786 \\ 0.2801 \end{bmatrix} \Rightarrow \begin{bmatrix} 0.9901 \\ 0.9342 \\ 1.4862 \\ 0.7275 \end{bmatrix} \tag{7}$$

The eigenvectors are obtained standardized as

$$wi = \begin{bmatrix} 0.2393 \\ 0.2258 \\ 0.3592 \\ 0.1758 \end{bmatrix} \tag{8}$$

Calculate the maximum eigenvalue.

$$\lambda_{\max} = \frac{1}{n}\sum_{i=1}^{n} \frac{(Aw)_i}{w_i} = 4.2346 \tag{9}$$

Calculate the consistency index (CI) using Formula (5).

$$CI = \frac{\lambda_{\max} - n}{n-1} = \frac{4.2346 - 4}{4-1} = 0.0782 \tag{10}$$

The average random index (RI) for the judgment matrix can be determined as $RI = 0.52$ according to Table 3. Using this value, the random consistency ratio (CR) can be calculated as $CR = 0.0879$.

$$CR = \frac{CI}{RI} = \frac{0.0782}{0.89} = 0.0879 < 0.10 \tag{11}$$

Since $CR < 0.1$, which satisfies the consistency check criterion, it indicates that the judgment matrix is reasonable. The weights for the remaining key indicators can be obtained using the same method, and a consistency check can be performed. The specific results are presented in Tables 6–8.

(1) Level 1 indicator weight

Table 6. Level 1 indicator weight.

Level 1	B1	B2	B3	B4	Wi	CR
B1	1.0000	1.2353	0.3962	1.9633	0.2393	0.0879
B2	0.8095	1.0000	0.5600	1.6800	0.2258	
B3	2.5238	1.7857	1.0000	1.0825	0.3592	
B4	0.5094	0.5952	0.9238	1.0000	0.1758	

(2) Level 2 indicator weight

Table 7. Level 2 indicator weight.

Level 2/B1	C1	C2	C3	Wi	CR
C1	1.0000	0.3471	0.2675	0.1255	0.0461
C2	2.8810	1.0000	0.4000	0.2906	
C3	3.7381	2.5000	1.0000	0.5839	
Level 2/B2	**C4**	**C5**	**C6**	**Wi**	**CR**
C4	1.0000	1.6154	0.6667	0.3138	0.0048
C5	0.6190	1.0000	0.3333	0.1809	
C6	1.5000	3.0000	1.0000	0.5054	
Level 2/B3	**C7**	**C8**		**Wi**	**CR**
C7	1.0000	0.2386		0.1926	0
C8	4.1905	1.0000		0.8074	
Level 2/B4	**C9**	**C10**	**C11**	**Wi**	**CR**
C9	1.0000	0.4730	3.0000	0.2914	0
C10	2.1143	1.0000	6.1765	0.6106	
C11	0.3333	0.1619	1.0000	0.0980	

(3) Level 3 indicator weight

Table 8. Level 3 indicator weight.

Level 3/C1	D1	D2	D3	Wi	CR
B1	1.0000	0.8235	1.3125	0.3420	0.0575
B2	1.2143	1.0000	0.7664	0.3254	
B3	0.7619	1.3048	1.0000	0.3326	

According to the calculation method of C1 indicator weights, all Level 3 indicator weights are obtained in Figure 7.

Finally, the weights of each hierarchical indicator in the evaluation framework for the sustainable development of traditional Tujia ethnic villages in southwestern Hubei province are presented in Table 9.

Table 9. Comprehensive evaluation results of all indicators.

Level 1	Level 2	Weights	Rank	Overall Weights	Overall Rank	Level 3	Weights	Rank	Overall Weights	Overall Rank
B1 (0.2393)	*C1*	0.1255	3	0.0300	10	*D1*	0.3420	15	0.0102	25
						D2	0.3254	19	0.0098	27
						D3	0.3326	17	0.0100	26
	C2	0.2906	2	0.0695	6	*D4*	0.2028	28	0.0141	21
						D5	0.4459	9	0.0310	12
						D6	0.3513	14	0.0244	16
	C3	0.5839	1	0.1397	2	*D7*	0.4057	11	0.0567	6
						D8	0.3379	16	0.0472	7
						D9	0.2564	23	0.0358	8

Table 9. *Cont.*

Level 1	Level 2	Weights	Rank	Overall Weights	Overall Rank	Level 3	Weights	Rank	Overall Weights	Overall Rank
						D10	0.1532	31	0.0109	24
	C4	0.3138	2	0.0709	5	*D11*	0.3781	12	0.0268	14
						D12	0.4687	7	0.0332	9
B2 (0.2258)						*D13*	0.3314	18	0.0135	22
	C5	0.1809	3	0.0408	9	*D14*	0.1643	29	0.0067	29
						D15	0.5043	4	0.0206	20
						D16	0.2085	26	0.0238	17
	C6	0.5054	1	0.1141	3	*D17*	0.5843	2	0.0667	4
						D18	0.2072	27	0.0236	18
						D19	0.4781	6	0.0331	10
	C7	0.1926	2	0.0691	7	*D20*	0.3590	13	0.0248	15
B3 (0.3592)						*D21*	0.1629	30	0.0113	23
						D22	0.2109	25	0.0612	5
	C8	0.8074	1	0.2900	1	*D23*	0.3022	21	0.0876	2
						D24	0.4869	5	0.1412	1
	C9	0.2914	2	0.0512	8	*D25*	0.4430	10	0.0227	19
						D26	0.5570	3	0.0285	13
	C10	0.6106	1	0.1073	4	*D27*	0.2897	22	0.0311	11
B4 (0.1758)						*D28*	0.7103	1	0.0762	3
						D29	0.2390	24	0.0041	31
	C11	0.0980	3	0.0172	11	*D30*	0.3122	20	0.0054	30
						D31	0.4488	8	0.0077	28

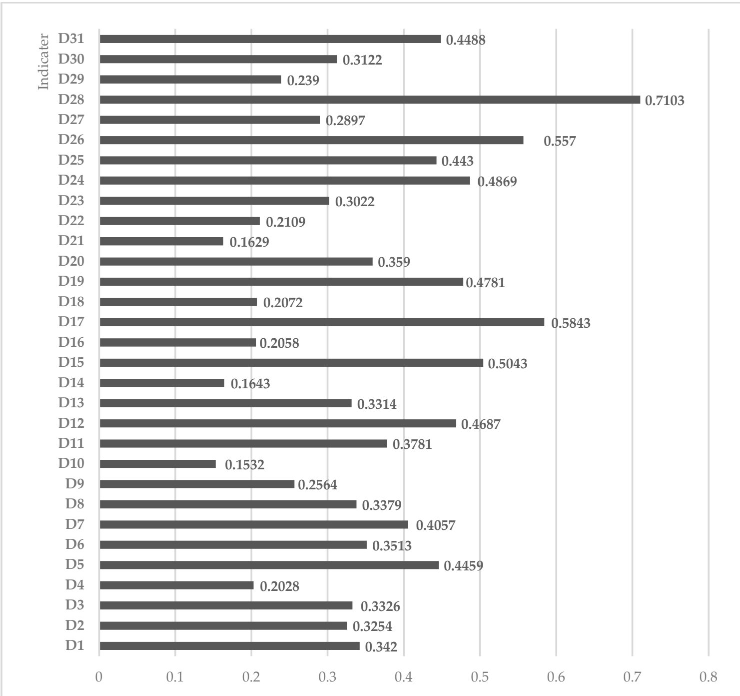


Figure 7. The weight value of Level 3 indicators.

5. Results and Discussion

5.1. Research Results

The weights of the indicators reflect their importance in the evaluation process and serve as a comprehensive measure of subjective evaluation and objective reflection. From the results in Table 9, it can be observed that among the four indicator weights at the Level 1 index, Scene imagery (*B3*) > Spatial functions (*B*) > Exterior style (*B2*) > Construction mode (*B4*). This implies that in the process of sustainable development of traditional Tujia village architecture in southwestern Hubei province, particular emphasis should be placed on creating scene imagery and enhancing the spatial functionality of the buildings. Secondly, attention should be given to the treatment of exterior style, and finally, optimization of construction methods should be considered. Furthermore, among the eleven indicator weights at the Level 2 index, *C8* > *C3* > *C6* > *C10* > *C4* > *C2* > *C7* > *C9* > *C5* > *C1* > *C11*. This indicates that in the creation of scene imagery, it is crucial to establish a strong connection with the local region. In enhancing spatial functionality, the improvement of comfort is of utmost importance, while also considering flexibility in layout. Regarding the aspect of exterior style, particular attention should be given to the richness of interfaces. In terms of construction methods, emphasis is placed on the standardization of the overall process. Lastly, among the 31 tertiary indicators, the 3 indicators (*D22*, *D23*, and *D24*) associated with the regional scene are highly valued. Among them, the utilization of indigenous structures (*D22*) holds the highest proportion, indicating that the distinctive features of Tujia ethnic traditional architecture (such as the Suspension frame) should be fully preserved and expressed in sustainable design. Furthermore, the spatial hierarchy (*D17*) in the interface, the flexible combination (*D5*) in functionality, and the menu-based process (*D28*) in construction also hold relatively high proportions. These aspects should be given significant attention and representation in sustainable architectural design strategies.

5.2. Sustainable Design Strategies for Traditional Tujia Village Architecture in Southwestern Hubei Province

Based on the analysis of the results above, and in consideration of the typical characteristics and current issues of traditional Tujia ethnic village architecture in southwestern Hubei province, this study proposes four new paradigms for future sustainable architectural design in this region. Namely, sustainability of spatial function—flexible layout, sustainability of appearance and style—integrated interface composition, sustainability of perceptive scene—localized home building, and sustainability of construction mode—modularized unit construction. These four design paradigms cover various stages of village architecture, from site selection and layout to architectural style, and even to the overall scene and practical construction. Each stage is accompanied by diverse modular options for strategies, allowing for adaptation to diverse village environments. The modular process of the entire design strategy significantly improves comprehensive effectiveness compared to the traditional model of purely experiential knowledge transmission by craftsmen, and it is more sustainable in its applicability.

5.2.1. Sustainability of Spatial Function—Flexible Layout

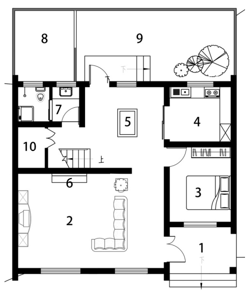
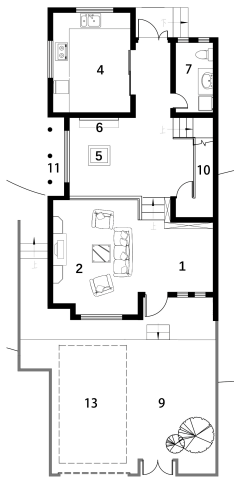
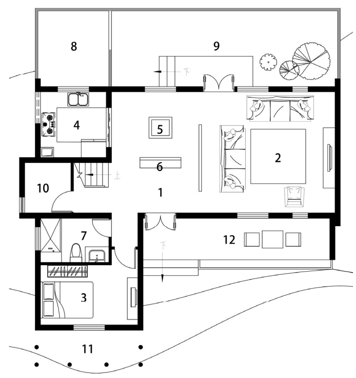
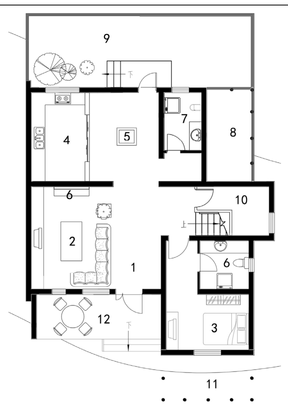
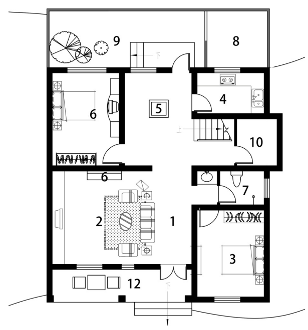
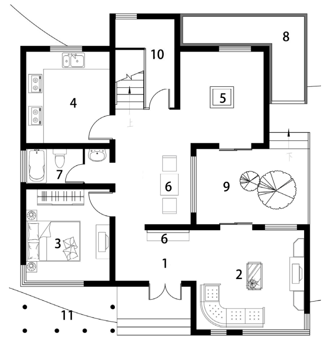
The term “flexible” in architectural design refers to a building’s adaptability to changing societal needs and user requirements [47]. Traditional Tujia buildings in southwest Hubei, China, have evolved with special functional structures. However, in the face of diverse modern demands, traditional buildings often have limited functionality. Herein, this study introduces the concept of a “flexible” layout and proposes six feasible layout design solutions to achieve sustainability of spatial function (see Table 1).

(1) In terms of plane shape, the sustainable solutions preserve the four basic shapes of traditional Tujia stilted buildings and evolve from them. For instance, Layouts A and B are in the “-” shape, with the former having a smaller depth and the latter having a larger depth; Layouts C and D are in the “L” shape, with the former being horizontally arranged and the latter vertically arranged; and Layouts E and F are in the “凹” shape and the quadrangle shape, respectively. In practice, villagers can flexibly choose an appropriate layout according to site conditions. Meanwhile, during the research process, it was found that the base area of traditional Tujia buildings is mostly around 80–120 m^2, so the new solutions should also limit the base area within this range. With 100 m^2 as the boundary, Layouts A, B, C, and D have a base area smaller than 100 m^2, while Layouts E and F have a base area larger than 100 m^2, allowing for flexible selection according to actual needs.

(2) In terms of functional combinations, the new solutions mainly address the coordination of special functional spaces such as living and ritual spaces. Taking the kitchen

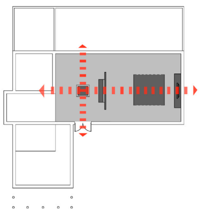
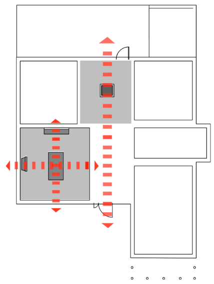
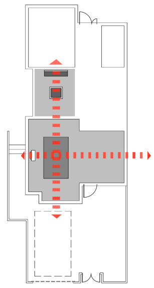
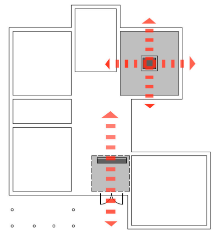
and bathroom as examples, these two spaces are taken into consideration in the main space. Specifically, the kitchen is situated on the northern side to reduce the interference of cooking fumes on the master bedroom, while the bathroom is situated adjacent to the living hall and bedrooms for convenience in daily use; the livestock space is situated on the northern side near the bathroom or kitchen (Table 10, Layouts A and C); for the ritual space, the fire pit, memorial site, and living hall are arranged in coordination, forming four different arrangements: horizontal, vertical, horizontal and vertical intersection, and horizontal and vertical separation, which inherit the horizontal or vertical ritual arrangements of traditional stilted buildings (Table 11). Moreover, special spaces such as the elderly bedroom are typically situated on the sunny southern side of the first floor, as illustrated by Layouts A and C in Table 10, while stilted spaces are situated on the southern side of the master bedroom (Layouts C, D, and F) or entrance or side hall (Layouts A, B, and E). The specific location of these spaces is determined according to site conditions or architectural layout.

Table 10. Conceptual plan for sustainable design of Tujia stilted buildings in southwest Hubei, China.

Plane Type	**Layout A**	**Layout B**	**Layout C**
Plane sketch			
Plane shape Construction base	"-" shape (B/D ≈ 1) ~82.3 m^2 (Face width 9.8 m/Depth 8.4 m)	"-" shape (B/D ≈ 2) ~80.5 m^2 (Face width 6.6 m/Depth 12.3 m)	"L" shape (B/D > 1) ~88.7 m^2 (Face width 11.4 m/Depth 8.8 m)
Plane type	Layout D	Layout E	Layout F
Plane sketch			
Plane shape Floor area	"L" shape (B/D < 1) ~98.5 m^2 (Face width 9.9 m/Depth 11.7 m)	Concave shape (B/D ≈ 1) ~102.5 m^2 (Face width 10.5 m/Depth 10.8 m)	Quadrangle (B/D < 1) ~115.4 m^2 (Face width 11.2 m/Depth 12.9 m)

Notes: 1. Entrance Hall 2. Living Room 3. Elderly Bedroom 4. Kitchen 5. Fire Pit/Dining Room 6. Shrine 7. Bathroom 8. Feeding Area 9. Yard 10. Storage Room 11. Overhead Area 12. Porch 13. Parking Area.

Table 11. Elastic combination of "ritual space" in the conceptual plane.

Type	Horizontal	Vertical	Horizontal and Vertical Intersection	Horizontal and Vertical Separation
Ritual space combination sketch				
Space relation	The fire pit and the memorial site overlap and are horizontally connected to the living hall.	The fire pit misaligns with the memorial site and the memorial site and the living hall overlap.	The fire pit and the memorial site overlap and are vertically connected to the living hall.	The fire pit and the memorial site are independent from each other and the memorial site and the lobby overlap.
Axis relation	Horizontal axis (master): fire pit; memorial site; living hall. Vertical axis (auxiliary): entrance; fire pit.	Vertical axis (master): entrance; lobby; fire pit. Vertical axis (auxiliary): living hall; fire pit. Horizontal axis (auxiliary): living hall; furniture.	Vertical axis (master): living hall; fire pit; memorial site. Horizontal axis (auxiliary): living hall; furniture.	Vertical axis (master): entrance; lobby; memorial site. Vertical axis and horizontal axis (auxiliary): fire pit (center).

(3) In terms of spatial separation, the new layouts use lightweight partitions for partial interior spaces to realize "separation without isolation", thereby achieving the diversity of spatial utilization and the richness of the flow lines. For instance, the living hall is separated from the dining room or lobby by the lightweight partition, as illustrated by Layouts A–F in Table 10; the external wall enclosure mainly considers the demand for residential quality, and it adopts the brick concrete structure while ensuring the cost-effectiveness of construction, thereby achieving flexible space division and enclosure and sustainable functional layouts.

5.2.2. Sustainability of Appearance and Style—Integrated Interface Composition

"Integrated interface" refers to an organic integration of multiple spatial interfaces [48]. In Tujia stilted buildings, colonnades, courtyards, and stilted spaces serve as intermediate spaces bridging the interior and exterior, have many composite functions, and demonstrate distinctiveness and a strong sense of place [49]. "Integrated interface" is reflected in the design of sustainable solutions as follows:

(1) Integration of interface elements. In the design of sustainable solutions, integrated interface elements are incorporated into facade and roof areas. Specifically, facade elements mainly include terraces, colonnades, minor yards, and stilted spaces. As illustrated in Figure 8, in the south and east facades of Layouts A–F, terraces and colonnades not only enrich the facades and contribute to spatial transitions but also play a certain role in shading and energy saving in the southern direction. The minor yard in Layouts B and F and the courtyard in other layouts not only enrich interfaces but also regulate microclimates and help to create ecologically sustainable microenvironments. In all layouts, the stilted space is located on the ground floor of the auxiliary room, terrace, and minor yard; it can not only flexibly adapt to topography but also provide semi-open composite functional areas between indoors and outdoors. In addition, as the "fifth interface", the sloped roof element in the conceptual design so-

lutions is deconstructed and reassembled, and by incorporating the "tiger windows" element, it can not only regulate the climate but also create rich interface meanings.

(2) Integration of space levels. The integrated interfaces in the conceptual solutions often create three different levels of spatial atmosphere: black, white, and gray. The "stilted space" of traditional Tujia buildings is the "gray space" that serves as an intermediary [50]. However, in the past, it was often used for raising poultry or storing miscellaneous items and did not play a transitional role. In the designed solutions, the "stilted space" is integrated with the lobby, colonnade, and minor yard to truly play its role of interface media. For instance, in Layouts A–E in Figure 8, the space under the terraces at the entrances or the colonnade space not only enriches the interface hierarchy but also contributes to a smooth transition between indoors and outdoors as a "circulation space". Moreover, the minor yard and inner courtyard in Layouts B and F and the stilted space in other layouts are all integrated interface spaces that serve diverse functions and reflect the profound meaning of "interdependence and coexistence" in Eastern philosophy.

Figure 8. The schematic diagram of integrated interfaces for conceptual solutions.

5.2.3. Sustainability of Perceptive Scene—Localized Home Building

The key to the sustainable development of traditional village architectures lies in the active inheritance of the "perceptive scene", and the key to inheritance is to create a sense of localization with a deep connection to the local environment, i.e., create an emotional connection with the local residents and create a local ambiance with a sense of belonging. Localization refers to regional architectural strategies that utilize local construction and materials to preserve original memories following sustainability principles in the context of the environment and culture [51]. The Tujia area in southwest Hubei, China, is located in a special geomorphic area with steep peaks, rugged terrain, and winding streams. This makes Tujia residents emphasize adaptation to local conditions without excessive decoration and pursue a simple and romantic ethnic character in the construction of perceptive scenes. This character is mainly manifested in the stilted framework, roof, and detailed decorations, and it is inherited and extended in the proposed sustainable solutions in the following three aspects:

(1) The utilization of local construction. The “stilted framework” of traditional buildings, which resembles a hanging foot and has an elegant posture of the human body, which is commonly found in traditional architecture, is the most distinctive and cherished construction element in Tujia ethnic architecture and has been validated through the analysis of AHP. Therefore, it should be carefully preserved and expressed in sustainable design solutions. For instance, it can be creatively translated into sustainable design features such as entrance canopies, suspended balconies, elevated courtyards, and suspended minor yards. Therefore, within the diverse functional forms, the construction charm of the suspended foot frame is creatively interpreted and expressed, ultimately achieving the graceful and diverse imagery beauty of contemporary Tujia buildings. (Figure 9, left).
(2) Form simulacrum. The roof of stilted buildings is similar to a “gable-on-hip roof” consisting of double-sloped roofs and single-sloped roofs on gables. The overall roof is curved in the opposite direction with the corners tilted upwards, resembling a bird flapping its wings and ready to fly. Therefore, the proposed solutions deconstruct this lively form in a modernized way, evolve it into a “long-short hipped roof” and “single-sloped roof”, and randomly combine it with a modern “flat roof”, which not only preserves the traditional imagery but also while reflecting the model atmosphere. (Figure 9, left).
(3) Decoration association. The detailed decorations of traditional Tujia buildings have rich emotional connotations, with woodcarving decorations on doors, windows, and railings being typical representatives. These decoration patterns can remind people of beautiful things and express their good wishes. For example, the “Bubujin” and “Guibeiwen” paper-cut window decorations in Figure 9 (right) have rich connotations. Specifically, in the “Bubujin”, the mullions gradually tighten from the outside to the inside, which symbolizes “tightening step by step” and later implies “becoming better step by step”; in the “Guibeiwen”, the window mullions form a pattern resembling a turtle’s back (hexagonal shape), conveying the meaning of health and longevity. Similar symbolic patterns have been extended to the detailed design of the proposed solutions to evoke associations with traditional cultural symbols and create a sustainable sense of home space.

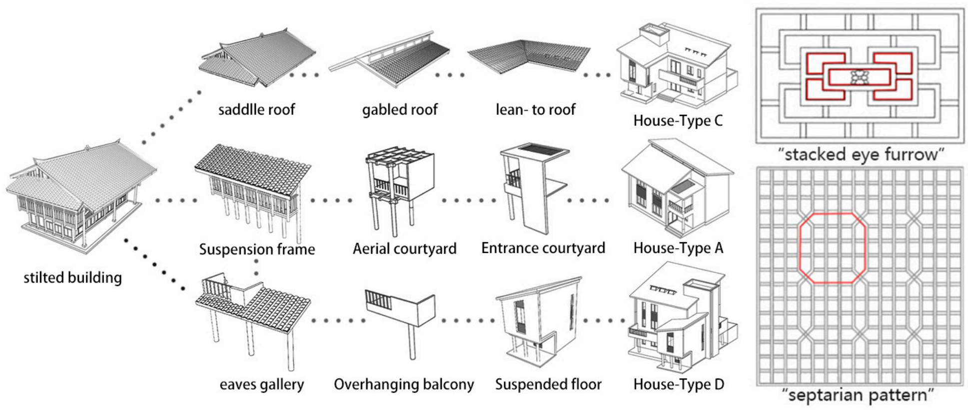


Figure 9. Morphological extraction and deduction of the image of the stilted building (**left**), meaningful window decorations (**right**): stacked eye furrow; septarian pattern.

5.2.4. Sustainability of Construction Mode—Modularized Unit Construction

The construction of traditional Tujia buildings mainly relies on the expertise of craftsmen, and the construction process is greatly influenced by human and environmental factors. On the contrary, the proposed sustainable solutions emphasize the use of “modularity” strategies to achieve efficient and human-centric construction [52].

(1) In terms of constituent elements, like game rules, modularization provides unified limiting factors, including the area range of the homestead, the layouts for differ-

ent sites, consistent roof and door/window styles, and choices of color and materials, allowing for the harmonious integration of traditional architectural design with modern construction. As illustrated in Figure 10, taking Layout D as an example, various elements of the architectural appearance are classified and deconstructed, and their material combinations are modularized and finely controlled to a certain extent, thereby achieving high construction efficiency.

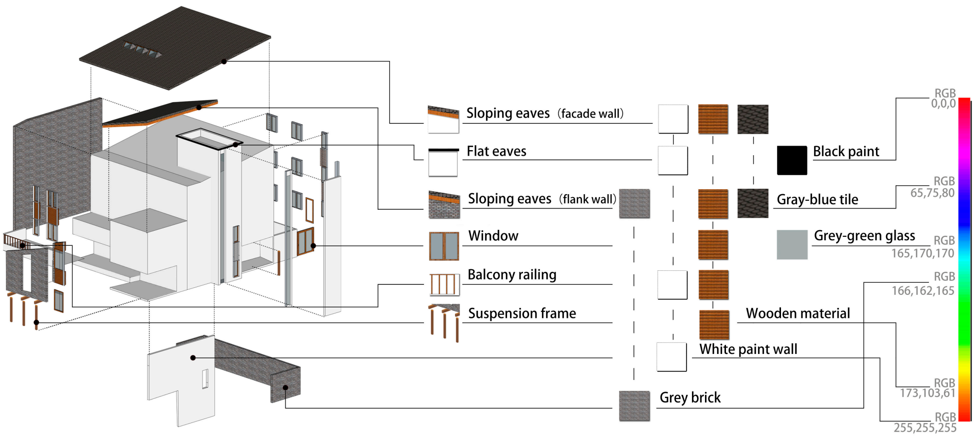


Figure 10. Modularization of constituent elements (Layout D).

(2) In terms of unit combination, the random combinations of Layouts A–F are investigated to determine if they can enclose a common communication space. Two feasible combinations are obtained eventually: (a) parallel combination (Layouts A and B in Figure 11), where neighboring households have a certain degree of privacy while being arranged side by side, and (b) symmetrical combination, where two units are symmetrically arranged to form a large entrance yard (Layouts C, D, and E) or a central courtyard (Layout F), both of which can create diverse neighborhood communication spaces. In addition, different layouts can be grouped and assembled according to actual conditions to meet individual requirements while harmonizing the overall aesthetic and improving construction efficiency, thereby creating a novel and diverse neighborhood atmosphere.

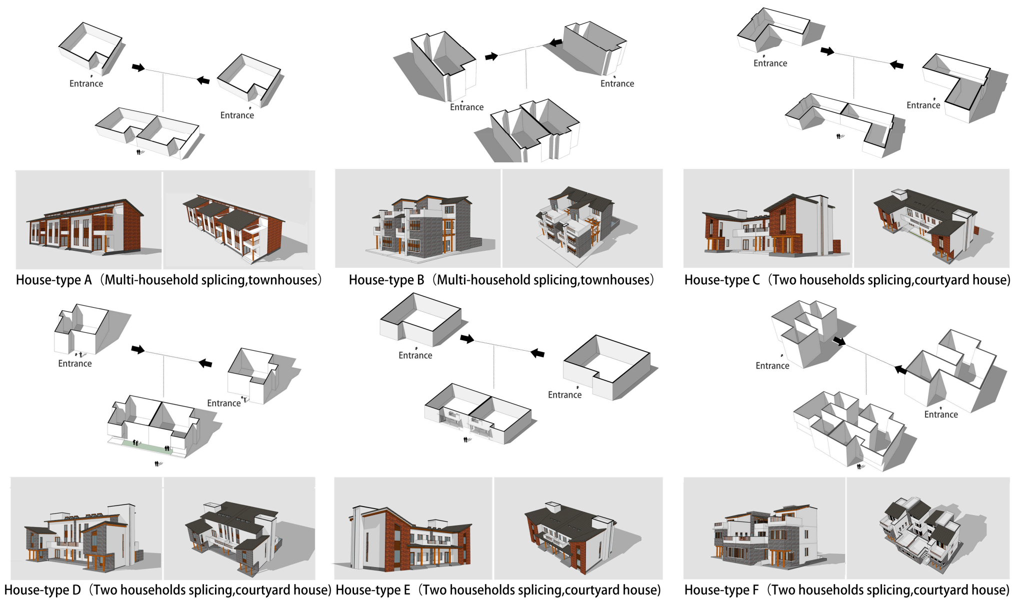


Figure 11. Modularization of unit combination.

(3) In terms of the construction process, compared to traditional construction that heavily relies on the personal experience of craftsmen, the proposed sustainable solutions standardize the entire construction process into "menu-style" modules for selection, enabling villagers to flexibly choose according to their needs. This modularized construction process not only facilitates the process control and management of building construction but also saves construction time and costs. For Layout D in Figure 12, a series of standard modules is available for the selection of site, layout, basic form generation, doors, windows, and special components, which are flexible and meet the functional and emotional needs of different residents.

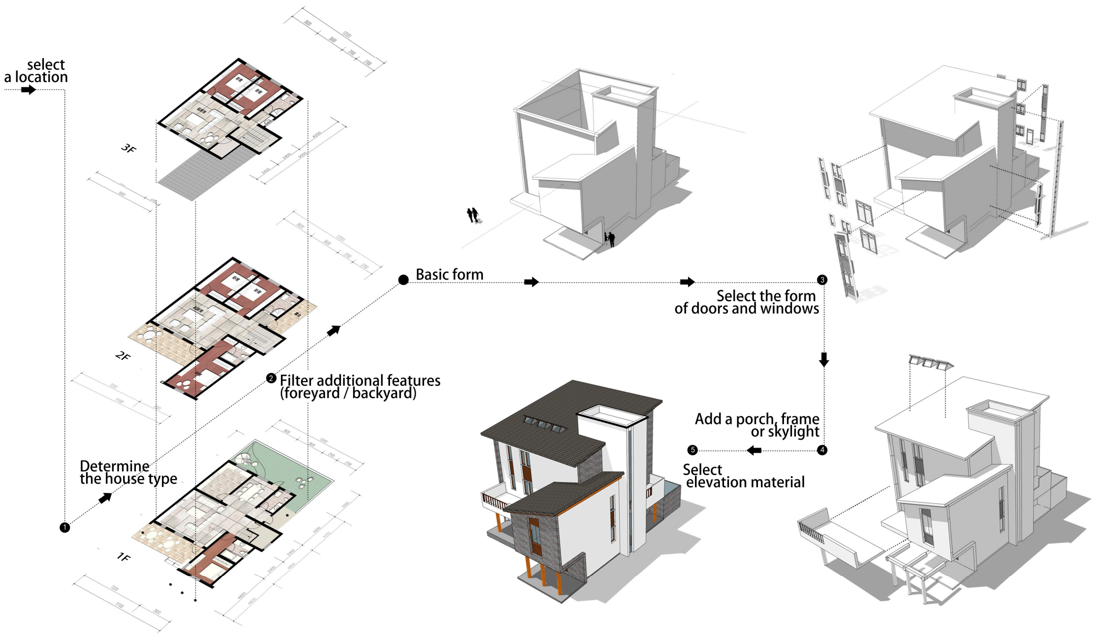


Figure 12. Modularization of the construction process (Layout D).

6. Conclusions

The sustainability of traditional village architecture has been a research hotspot. Rather than focusing on the sustainability of construction and energy saving of buildings, the sustainable development of traditional architectures in the future was investigated from the perspective of architectural design in this study. Specifically, typical traditional Tujia villages in southwest Hubei, China, were studied by field survey and interview, and a comprehensive analysis was conducted by Integrating the Analytic Hierarchy Process (AHP). The following conclusions can be obtained:

(1) The literature review, field survey, and interview suggested that the practical difficulties faced by typical traditional Tujia villages mainly included poor function adaptability (space), mixed elements and styles (symbol), weak sense of identity and belonging (scene), and low construction efficiency (technique).

(2) The Analytic Hierarchy Process (AHP) method was used to conduct a comprehensive evaluation of the sustainable development of traditional village architecture in southwestern Hubei. Among the four primary indicators, the results indicate that the scenario imagery and spatial functionality are relatively more important compared to the exterior style and construction mode. Furthermore, among the eleven secondary indicators, the regional relevance of the scene, spatial comfort, richness of interfaces, and standardization of the construction process are relatively significant aspects. Lastly, among the thirty-one tertiary indicators, the utilization of indigenous structures holds the highest proportion, indicating that the distinctive features of Tujia ethnic traditional architecture (such as the Suspension frame) should be fully preserved and expressed in sustainable design.

(3) Based on the characteristics of traditional Tujia village architectures in southwest Hubei, China, and practical difficulties, this study proposed four sustainable design paradigms, namely sustainability of spatial function—flexible layout, sustainability of appearance and style—integrated interface composition, sustainability of perceptive scene—localized home building, and sustainability of construction mode—modularized unit construction.

However, this research has certain limitations as it is still exploratory. Firstly, the sample of traditional villages in this study is limited. Although the selected typical villages have undergone in-depth research for a considerable period of time, future research should include a larger sample size to summarize their common characteristics. Secondly, although the evaluation method of the criteria in this study is based on quantitative analysis of questionnaire data, it is inevitable that subjective factors may interfere with the results. This requires further optimization and improvement in future studies. Secondly, although the evaluation method of the criteria in this study is based on quantitative analysis of questionnaire data, it is inevitable that subjective factors may interfere with the results. This needs further verification and improvement. Furthermore, sustainable design is a dynamic process, and its evaluation system and design strategies should be continuously adjusted and updated with the development of the times. Therefore, future research needs to continue optimizing the evaluation system and strategies for sustainable design and follow up on the previous field research in order to obtain more extensive and in-depth research results, providing references and guidance for the sustainable development of traditional villages in ethnic minority areas in China and the creation of a beautiful rural living environment.

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Data Availability Statement: The data presented in this study are available on request from the corresponding author. The data are not publicly available due to some of it relates to other further research results.

Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A

Table A1. Record of the research activities on traditional Tujia village architecture in southwestern Hubei province.

Date	Location	Objective	General Content	Participants
January 1 to 3, 2018	Dabaixi Village, Shadaogou Town, Xuan'en County	Preliminary understanding of the characteristics and current status of Tujia stilted houses.	The team undertook research on the stilted house in Pengjiazhai, Sandaogou Town, the traditional village of Dabaixi, and the architectural remains of the Tangya Chieftain in order. Additionally, interviewed local residents to understand the historical evolution of these sites.	Di Wang, the Historical Architecture Research Team at Yangtze University (Professor Zheng, Professor Peng).
July 1 to 30, 2019	Maliuxi Village, Huangjindong Town, Xianfeng County	Immersed in the intricate process of constructing Tujia stilted houses.	The team undertook field research on the craftsmanship and process of constructing stilted houses in Malixi Village, and conducted interviews with inheritors of intangible cultural heritage, such as Wan Taoyua and Xiong Guojiang.	Di Wang, Xiaodong Wei, the Rural Revitalization Team at Hunan University (Professor Yan, Professor Sohaib).

Table A1. *Cont.*

Date	Location	Objective	General Content	Participants
July 5 to 8, 2020	Liangxihe Village, Changtanhe Town, Xuan'en County	In-depth understanding of the functional scale and spatial structure of Tujia stilted houses.	The group undertook research on well-preserved traditional buildings in Liangxihe Village, including field measurements of certain architectural components. Additionally, we investigated the newly constructed ancient-style architectural scenic area in Changtanhe and residential communities with regional characteristics.	Di Wang, Xiaodong Wei and others.
March 20 to 21, 2021	Chuanxinyan Village, Yesanguan Town, Badong County	Familiarity with the architectural styles of newly constructed residential buildings in traditional villages.	The group undertook research on the traditional overall appearance of Chuanyanshi Village, as well as the distinctive architectural style of newly constructed residences.	Di Wang, Xiaodong Wei and others.

Appendix B

Questionnaire on the key factors for the sustainable development of traditional Tujia village architecture:

Respected Sir/Madam,

Hello! I am a doctoral student at Central South University. Our team is conducting research on traditional village architecture. We would like to seek your opinions on the key factors influencing the sustainable development of traditional Tujia village architecture through a questionnaire. Your feedback based on real experiences will greatly help us identify the crucial elements. Thank you for taking the time to participate in this survey.

Part One: basic information (Please place a checkmark "√" in the corresponding box.)

1. Gender：☐Male ☐Female
2. Age: ☐20-30 years old ☐30-45 years old ☐45-60 years old ☐60 years old or above
3. identity: ☐Architect ☐Village protector ☐Policy planner ☐Construction artisan ☐Villager

Part Two: Comparison of Indicators:

The questionnaire adopts 1–9 ratio scale method. Please place a checkmark "√" below the corresponding number. The meanings and explanations of the numerical scale are as follows:

Level of Importance	Meaning	Description
1	Equally important	Comparing two factors, they have equal importance.
3	Slightly important	Comparing two factors, one factor is slightly more important than the other.
5	Significantly important	Comparing two factors, one factor is significantly more important than the other.
2,4	—	The midpoint between the adjacent judgments mentioned above.

1) Comparison of Level 1 indicators:

1.Please compare the importance of the four Level 1 indicators related to the sustainable development of traditional Tujia village architecture in pairs:

Indicators	1	2	3	4	5	Indicators
Spatial functionality						Exterior style
Spatial functionality						Scene imagery
Spatial functionality						Construction mode
Exterior style						Scene imagery
Exterior style						Construction mode
Scene imagery						Construction mode

2) Comparison of Level 2 indicators:

1.In the aspect of "spatial functionality", please compare the importance of the following indicators in pairs:

Indicators	1	2	3	4	5	Indicators
Diverse types						Flexible layout
Diverse types						High comfort
Flexible layout						High comfort

Figure A1. *Cont.*

2.In the aspect of " Exterior style", please compare the importance of the following indicators in pairs:

Indicators	1	2	3	4	5	Indicators
Unique style						Diverse elements
Unique style						Rich interface
Diverse elements						Rich interface

3. In the aspect of "Scene imagery", please compare the importance of the following indicators in pairs:

Indicators	1	2	3	4	5	Indicators
Abundant landscape						Regional association

4. In the aspect of "Construction mode", please compare the importance of the following indicators in pairs:

Indicators	1	2	3	4	5	Indicators
Monomer modularization						Process modularization
Monomer modularization						Cost efficiency
Process modularization						Cost efficiency

3）Comparison of Level 3 indicators:

1. In the aspect of " Diverse types ", please compare the importance of the following indicators in pairs:

Indicators	1	2	3	4	5	Indicators
Living type（Hall, dining room, etc.）						Ceremonial type（Shrine, Fire pit, etc.）
Living type（Hall, dining room, etc.）						Auxiliary type（Bathroom, feeding area, etc.）
Ceremonial type（Shrine, Fire pit, etc.）						Auxiliary type（Bathroom, feeding area, etc.）

2. In the aspect of "Flexible layout ", please compare the importance of the following indicators in pairs:

Indicators	1	2	3	4	5	Indicators
Space sharing（Hall and shrine, etc.）						Flexible combination
Space sharing（Hall and shrine, etc.）						Compact layout
Flexible combination						Compact layout

3. In the aspect of "High comfort", please compare the importance of the following indicators in pairs:

Indicators	1	2	3	4	5	Indicators
Indoor environmental comfort						Semi-outdoor environmental comfort
Indoor environmental comfort						Outdoor environmental comfort
Semi-outdoor environmental comfort						Outdoor environmental comfort

4. In the aspect of "Unique style", please compare the importance of the following indicators in pairs:

Indicators	1	2	3	4	5	Indicators
Modern style						Traditional style
Modern style						Compromising style
Traditional style						Compromising style

5. In the aspect of "Diverse elements", please compare the importance of the following indicators in pairs:

Indicators	1	2	3	4	5	Indicators
Local elements						Foreign elements
Local elements						Mixed elements
Foreign elements						Mixed elements

Figure A1. *Cont.*

6. In the aspect of "Rich interface", please compare the importance of the following indicators in pairs:

Indicators	1	2	3	4	5	Indicators
Multiple flat elements						Rich spatial hierarchy
Multiple flat elements						Abundant decorative details
Abundant decorative details						Abundant decorative details

7. In the aspect of "Abundant landscape", please compare the importance of the following indicators in pairs:

Indicators	1	2	3	4	5	Indicators
Spatial scenes						Landscape facilities
Spatial scenes						Greenery arrangement
Greenery arrangement						Landscape facilities

8. In the aspect of "Regional association", please compare the importance of the following indicators in pairs:

Indicators	1	2	3	4	5	Indicators
Morphological analogy						Local construction
Morphological analogy						Decorative extrapolation
Decorative extrapolation						Local construction

9.In the aspect of "Monomer modularization", please compare the importance of the following indicators in pairs:

Indicators	1	2	3	4	5	Indicators
Modular combination of forms						Modularization of components

10. In the aspect of "Process modularization", please compare the importance of the following indicators in pairs:

Indicators	1	2	3	4	5	Indicators
Drawing-based management						Menu-based process

11. In the aspect of "Cost efficiency", please compare the importance of the following indicators in pairs:

Indicators	1	2	3	4	5	Indicators
Simplify the construction process						Improvement of craftsman skills
Simplify the construction process						favorable market environment
Improvement of craftsman skills						favorable market environment

Figure A1. Questionnaire on the key factors for the sustainable development of traditional Tujia village architecture.

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