

## Article

# Research on the Sustainable Development of Traditional Dwellings

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Received: 30 July 2019; Accepted: 24 September 2019; Published: 27 September 2019



**Abstract:** Balustrade architecture is mainly distributed in south and southwest China and southeast Asia. Dai dwellings in Yunnan, China, are a typical balustrade dwelling. Traditional dwellings of Dai contain the concepts of architecture, physics, ecology, and sustainability in space planning, building materials, and construction methods. At a time when the global climate environment is deteriorating and energy saving, emission reduction, and low-carbon life are advocated, Dai dwellings should be studied from the perspective of sustainable development, from which we can draw lessons and inspiration. This paper investigated plane layout, space structure, and materials of Dai dwellings, and found that traditional Dai dwellings are wooden frame structures with wood and bamboo; the roof has two layers and long overhang eaves, which is good for diverting rain water, shading and shelter, and integrating the building with the natural landscape as well. Analyzing the spatial characteristics and problems of Dai dwellings at present, discussing the sustainable development ideas of Dai dwellings, constructing Dai dwellings with low energy consumption and high quality of life, combining traditional culture with ecological technology, and designing a sustainable new green living model are beneficial to the inheritance of Dai residence culture.

**Keywords:** balustrade architecture; sustainable development; architectural feature; spatial analysis

## 1. Introduction

The way in which early humans lived was mainly influenced by natural environment. There are two main types of Chinese traditional dwellings: balustrade architecture and courtyard architecture. Due to the humid climate and floods in southern China, humans live in trees, which is commonly referred to as “nest.” *Han Fei-zi*, *Wuchun* records: “in ancient times, people were few, but animals were many, human beings could not defeat beasts. A saint appeared and built a nest in a tree to protect them from animals.” It evolved into balustrade architectures later. Owing to the arid climate in northern China, people used natural caves to shelter from the storm, and protect themselves from beasts. As a result, “troglodytism” appeared and developed into courtyard architecture. *Huai Nan-zi*, *Xiuxun*: “emperor Shun built houses and earthen walls, and roofed them with thatch and reeds, so that people would no longer live in caves in the wild, but would have homes and families.”

The building was originally designed to meet actual needs and rely on the natural geographical environment. The shape and structure of the building were closely related to the natural ecology. Dai people live in the humid and hot basin area of Xishuangbanna Dai Autonomous Prefecture (between latitude 21°08′–22°36′ and longitude 99°56′–101°50′) and Dehong Dai and Jingpo Autonomous Prefecture (between longitude 97°31′–98°43′ and latitude 23°50′–25°20′), Yunnan province, China, where summer is very long, there is heavy precipitation, strong sunlight, and temperature can reach more than 40 degrees. The year is divided into two seasons, rainy season and dry season. The rainy

season lasts for five months (from late May to late October), and precipitation in rainy season accounts for more than 80% of annual precipitation. The modelling and function of the balustrade architecture of Dai folk houses are well adapted to the hot and humid climate in the Dai area. The building is a monomer house, with empty space at the bottom and people living on the upper floor, a large roof and low eaves, which form a mask to keep the building in the shade. The large roof is well adapted to heavy rainfall in summer and the low eaves ensure that strong sunlight cannot shine indoors, to reduce the temperature.

The evolution has gone through three stages: Thatched architecture (before 1950), in the early days of the primitive society, the ancestors of Dai used the wood to make nests as shelters for sheltering from storms and beasts, which were extremely simple in terms of shape and spatial. Wood structure (1950–2000) is the traditional Dai folk house discussed in this paper which is often a wood frame, the ground floor of the building is empty space and the second floor is inhabited, plank as the wall, with wooden frame and beam, gray tile roof. Since 2000, due to changes of habitat lifestyle, construction techniques, building materials and other factors, the newly built Dai dwellings are mainly brick–concrete structures.

This paper takes Xishuangbanna Dai Autonomous Prefecture, Yunnan, China as a research object. Xishuangbanna Dai Autonomous Prefecture is located in the southern part of Yunnan Province of China (Figure 1), south of the tropic of Cancer, with abundant heat, small annual temperature difference, and large daily temperature difference. It borders Myanmar and Laos and belongs to the northern and southern subtropical climate, which is hot and rainy, with many rivers, and many fertile dams are formed along the banks of the river. Dai people mainly live in these areas, which is conducive to the cultivation of rice and other crops.

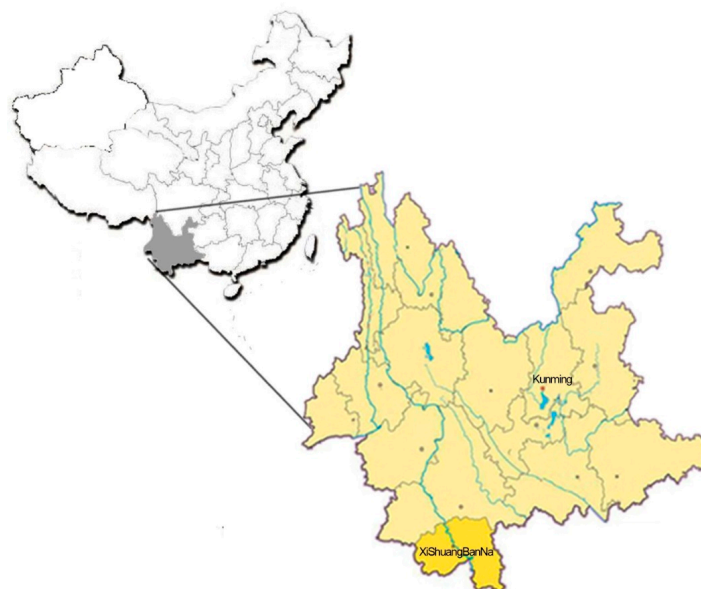


Figure 1. The location of Xishuangbanna.

## 2. Literature Review

### 2.1. The Origin of Dai Balustrade Architecture

Dai people belong to the descendants of the Baiyue nationality from their ethnic origin. According to legend, balustrade architecture was created by the Baiyue nationality. *Tang Shu, Nan Man Biography* records: “people live in the building, step on the ladder, which named barricade.” The main features are empty space of the bottom, living upstairs, livestock downstairs; the structure adopts column bearing; the piles, floors and walls of a house made of bamboo. Balustrade architecture is one of the earliest architectural forms in China and one of the most representative architectural forms in south China. It

is an indigenous architectural form widely existing in the Yangtze River basin and its south, which was created by the ancient Baiyue and Baipu. It is one of the most prominent cultural characteristics of the ancient Baiyue and a part of social and cultural heritage of the group [1]. Fang (1935) is the first who pursued research in barricade architecture, focusing on the local conditions and customs of Wa settlements and describing their living patterns. Dai (1948) had systematic study from the perspective of history and ethnology and discussed from the aspects of name interpretation, category characteristics, function, distribution, and dissemination, which is mainly based on text description to present barricade buildings and their customs. An (1963), in terms of archaeology, inspected the bronze model and site of the barricade architecture unearthed, and based on large amounts of historical materials, demonstrated the structure and form of the barricade building, and pointed out that some of the remains may belong to barricade building [2].

## 2.2. Research on Residential Environment

“Dwelling” is generally understood as the same concept of “house,” while the titles of “vernacular architecture” and “regional architecture” also include “dwelling.” Literally, it is the housing of ordinary working people, which is different from official buildings such as palaces, government offices, temples. It contains certain regional and cultural characteristics and is inseparable from the carving of the natural environment, and social and humanities; it is also a space object that reflects the wisdom of working people. Amos Rapoport, a well-known American architect, called it “a collection of users, builders and designers; buildings are based on tradition and use indigenous materials; buildings are not built to please the other, but based on functional needs, reflecting the public values of society” [3]. American architect and social historian Bernard Rudofsky summarized the characteristics of residential houses as: “endemic, anonymous, naturally formed, native, rural” [4]. In the 1950s, Constantinos Apostolos Doxiadis proposed Ekistics; the theory of Ekistics believes that human settlements consist of five elements: people, society, buildings, nature, and interconnected networks. They are related to each other. The study of Ekistics mainly includes the following three aspects: analysis characteristics of human settlement, and relationship of human settlement, evolution of settlements and their interrelation and causes; research on basic laws of human settlement; research on living demand, resident structure, construction mode of human habitation. Wu (2001) put forward a basic framework and methodology of sciences of human settlement and explored the design concept of construction of human settlements in a complex system. It is pointed out that the science of human settlement is a systematic, overall, and comprehensive science for studying human settlements [5]. In 1963, V. Ogoya proposed the design theory of “bioclimatic regionalism,” which will meet the needs of human biocomfort such as cold, heat, dryness, and wetness, focusing on the relationship of climate, region, and human biocomfort and architectural design should follow the process of climate–biology–technology–architecture, which are: (1) investigate various climatic conditions of design area; (2) evaluate the impact of each climatic on human biocomfort; (3) adopt technological means to solve the contradiction between climate and human biocomfort; (4) combine specific locations and the importance of conditions, and adopt corresponding technical means to design and seek optimal solutions [6].

## 2.3. Study on Balustrade Architecture of Dai Nationality

There are also many theoretical achievements in the study of balustrade architecture, such as the *Structure of Balustrade architecture*, *Human body and architecture*, and *From barn to Temple*, which contain a large number of data on folk houses of the Yunnan minority. Suke Nakao, a famous Japanese scholar, has recorded the real situation of balustrade dwellings of the minority nationalities in Yunnan in his works *Architecture of the Culture of Laurilignosa* and *A melting Laurilignosa – a journey of Yunnan province in China*, and made scientific analysis and discussion of balustrade dwellings in southwest China.

The study of Dai dwellings began in the first half of the 20th century. Most research has used balustrade buildings as an entry point, and the theoretical system of balustrade buildings was used to explain the Dai dwelling buildings. Around the 1930s, the balustrade dwellings in China attracted

the attention of domestic scholars. In the 1940s, Dai wrote the *Study on the balustrade: the Original Residence of Southwest China*, which opened the prelude to the study of balustrade buildings in China. The theoretical achievements of the research on southwestern villages from the 1950s to the 1980s were published successively, such as *Yunnan Folk House* and *The History of Ancient Chinese Dwellings*. In the 1990s, benefiting from the expansion of research methods and cross-disciplinary research, the balustrade dwellings of southwest Chinese have systematic research. Zhu, Si, Chen, Jiang, Dai and Yang, Shi and Hu, Yang, Yang and other scholars focused on Yunnan folk houses [7]. *Analysis of Southeast Asian and Southwest China's Minority Architectural Culture* incorporates balustrade architecture of southwest China into the balustrade architectural culture circle of Southeast Asia, and conducts comparative research, which is of great reference for the study of balustrade architecture of Dai. Yang (1997) presented the form, culture, technology, and art of minorities' folk houses in Yunnan and illustrated the historical origin and evolution of traditional housing forms of minorities, interaction and influence of housing culture and related factors by analyzing and contrasting. Jiang (1997) systematically examined the history of Yunnan architectural development and elaborated the origin and architectural culture of Yunnan architecture. Che and Mao (2002) studied the reconstruction of Dai residences in Xishuangbanna and the protection, development of Dai architecture [8]. Gao (2003) conducted a more detailed study of Dai dwellings in Xishuangbanna and Dehong, and studied development of Dai dwellings and changes of social structure of Dai, the relationships between dwellings and space. However, it only related to aspects such as plane and orientation system, and the systematic analysis of interior was rarely done. Yang (2004) studied the relationships between the construction of Yunnan Dai architecture in China and the balustrade architecture in Southeast Asia. The research on balustrade architecture in the architectural circle began to show the trend of diversification, multi-angle and single nationality. Huang (2006) mainly studied Dai dwellings in Xishuangbanna from the perspective of culture. Fan (2008) analyzed the influence of natural, geographical, and social factors on the space of Dai dwellings from individual buildings and concept of space, and recorded the traditional residential structure and village form of Dai. Wang (2014) explored the intrinsic derivative mechanism of Dai dwellings space from spatial form by comparing the spatial imagery of Dai [9].

With the development of the economy, the lifestyle and social structure of Dai have undergone major changes and the original ecological and aesthetic characteristics of Dai residential buildings are gradually dying out. There is no outstanding research result on the internal spatial structure, scientific analysis, and sustainable development of traditional Dai folk houses.

#### 2.4. Foreign Research on Balustrade Architecture

Japanese scholars paid more attention to balustrade architecture in China and started earlier. At the beginning of the 20th century, Japanese scholar Torii Ryuzo investigated in southwestern China and his travel diary entitled *Southwest China from Anthropology* was published in 1906, which detailed a description of residential buildings in southwest China. In the late 1970s, Sarano Koizum proposed the hypothesis that "The origin of Japanese is in Yunnan." Professor Koizum and other Japanese scholars visited southwestern China several times, during which detailed research was carried out on the buildings in the southwest. After the 1980s, Takeshi Tanaka, from the Institute of Humanities of Kyoto University, organized the joint research class of Chinese science and technology history to research on ancient Chinese architectural techniques. His works, such as the *Tradition of Balustrade Architecture—Japan from the history of ancient Chinese architecture*, *Chinese traditional wooden architecture* and *Chinese Housing Type*, have analyzed and compared the balustrade dwellings of ethnic minorities in China [10]. Waterson (1990) gave a detailed description of the symbolic significance of southeast Asian dwellings, ascertained type and space of the balustrade residential buildings in southeast Asia, and believed that Dai architecture was the embodiment of local social relations.

### 3. Research Methods and Process

#### 3.1. Research Methods

##### 3.1.1. Documents Analysis

This paper studied the traditional residences of Dai in Xishuangbanna, collected relevant information according to the research direction and contented to understand the research status and dynamics at home and abroad, and integrated and analysed the data. The literature research is divided into two aspects. One is the humanity history related to Dai dwellings, lifestyle and national culture of Dai. Dai ethics text has *Manshu* (Fan, Tang Dynasty), *Yunnan Zhilue* (Li, Yuan Dynasty), *Local customs of Water Baiyi* (Yao, 1938), *Study of Baiyi in Western Yunnan* (Jiang, 1939), *Life Culture of Baiyi* (published by China Book Bureau, 1950), and *Data Series of Investigation of Social History of Chinese Minorities* (revised editorial board, 1979), etc. The other is to study the surveying and mapping materials of Dai dwellings, which is obtained with the help of the land administration department of the Xishuangbanna Dai Autonomous Prefecture. The collation and collection of these materials in the literature research enriched the research, and also solidified the basic research, broadened the horizon, and made the research more in-depth.

##### 3.1.2. Field Investigation

Valuable information was obtained by in-depth interviews with local residents and detailed records and analysis of survey data are made at the same time. In-depth interview is an interview method that guides the direction of access in a natural situation, giving respondents more freedom. The most outstanding advantage is that they can provide rich and detailed information and get answers to sensitive questions. Interviews were conducted based on the interview outline, which included government workers, tourists, village officials, and villagers. The second is to participate in the observation and in-depth study of the object's life situation. The author has repeatedly visited Xishuangbanna several times, each time for 10 to 15 days, and observed and recorded in the process of daily life and work with the research subjects; in the common life, by observing their behavior and combining with interviews, seeking explanations of their own behaviors, so as to obtain the real picture of the society in which they live, and searching for changes. In the field research, Dai dwellings are mapped in detail from the flat and structure, to further understand Dai dwellings and think about the problems they face. The first-hand materials of Dai residences are compiled by field survey, recording, and measurement. The measured instruments include testo 435 Anemometer, testo 175 Temperature and Humidity recorder, infrared thermometer and self-meter hygrometer. Recorded data include temperature, humidity, wind speed, and so on. The data of air temperature and humidity are collected every half hour and the data of wind speed are collected every two hours. Continuous measured points of air temperature include outdoor, empty space in the bottom, bedroom in second floor, front porch (1 m height, 2.5 m height, 4 m height). The wind speed monitoring points are outdoors, empty space in the bottom, front porch, bedroom, and hall [11].

The author visited Manting village, Manbie village, and Manla village for further research. The research focuses on semi-structured interviews through the "snowball" sampling method. From 2015 to 2018, there are 22 key interviewees (Table 1). The interview data in this paper are coded as 20151112CVN-I, the first eight are interview years and dates; "C" means survey city; "JH" means Jinghong; "MH" means Menghai; "ML" means Mengla; "V" means survey village; "GLB" means Ganlanba. "MJ" means Manjiang; "MT" means Manting; "MB" means Manbie; "ML" means Manla, etc.; "N" means the number of the interviewee; "I" means the identity of interviewee; "A" means government staff; "B" means traditional craftsman; "C" means local resident; and "D" means tourist. For example, "20151012JHMT01-C" represents the first interviewee in Jinghong Manting, June 10, 2015, whose identity is a local resident. Secondly, the author participated in the traditional village designs. Through discussions with colleagues and customer feedback, the author has a certain

understanding of the traditional village culture and construction, and comprehensive understanding of the Dai people's living environment development [12].

**Table 1.** Survey interview samples.

Number	Gender	Age	Occupation Status	Usual Residence
20151012JHMT01-R	F	36	Farmer	Manting
20151013JHMT02-A	M	52	Farmer	Manting
20151014JHMT03-G	F	40	Staff	Jinghong
20151016JHMT04-T	M	25	Staff	Jinghong
20151020JHMT05-G	M	48	Staff	Manting
20151020JHMT06-A	M	70	Staff	Manting
20151021JHMB07-R	M	67	Farmer	Manbie
20151021JHMB08-R	F	32	Farmer	Manbie
20151022JHMB09-G	M	41	Staff	Manbie
20151022JHMB10-T	M	33	Staff	Kunming
20151024JHMB11-G	M	44	Staff	Manbie
20151024JHMB12-R	F	27	Farmer	Manbie
20151025JHMB13-A	M	46	Farmer	Manbie
20151025JHMB14-R	M	67	Farmer	Manbie
20180727MHML01-R	F	55	Farmer	Manla
20180727MHML02-R	M	40	Farmer	Manla
20180728MHML03-G	M	46	Staff	Manla
20180728MHML04-A	M	66	Farmer	Manla
20180729MHML05-G	M	37	Staff	Manla
20180729MHML06-R	F	31	Farmer	Manla
20180729MHML07-R	M	50	Farmer	Manla
20180802MHML08-A	M	48	Farmer	Manla

When the author investigated Manla village in Menghai county, they found that the house of the village chief, Wen Ai, was a traditional Dai wood structure before 1998 and it is a brick-concrete structure now which was rebuilt on the original land. The village chief is also a craftsman who could build wooden structures. He said that the newly built house should be flattened in the construction process, while the traditional wooden structure house was built according to the topography to save land. Zhi-qin Ouyang, graduated from Yunnan University, has been engaged in the design and planning of traditional Dai dwellings for many years. In the interview, Mr. Ouyang said that in the past ten years, almost all the residences of Dai have adopted brick-and-concrete houses. From the heights to the villages, they all look like blue roofs instead of the traditional wooden houses. Blue roof, white brick walls, and the surrounding environment are very abrupt, and Ms. Gong is a tourist in Jinghong. Ms. Gong likes to travel and is very familiar with Xishuangbanna Dai Autonomous Prefecture. She said that the destruction of traditional residences of Dai in recent years is serious. The newly built Dai residence is the form of city's foreign buildings, which is very unharmonious with the surrounding environment.

### 3.1.3. Comprehensive Analysis

In view of the current complex and diverse humanities and social environment in Xishuangbanna, the study of Dai traditional residences should be based on humanities, geography, social and cultural communication, in addition to case studies, materials and construction techniques in the field of architecture, to analyze the evolution process of Dai traditional residences from many angles; exploring the causes of the natural and social environments that formed the evolution of Dai traditional residence form buildings.

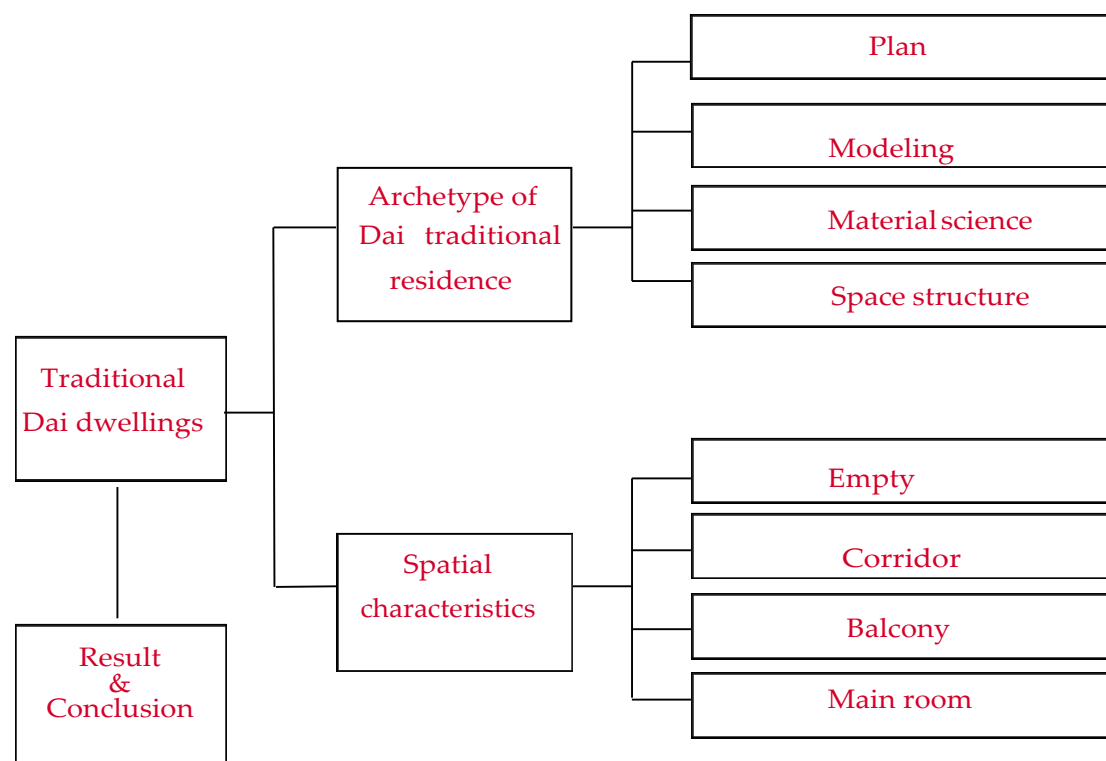
### 3.2. Research Process

(1) The author investigated Dai residences in Ganlanba Dai nationality park in Jinghong city, Mengla village and Manting village in Menghai county, Xishuangbanna Dai Autonomous Prefecture. When arriving at the village, the author visited the local village committee to obtain their support and observe the entire village and the surrounding environment; live with local residents and observe their daily habits and customs; visiting every household to obtain first-hand information on residential houses through on-the-spot measurement, recording, and hand-painting; in the understanding of regional culture, the origin and change of villages, the organizational structure of Dai nationality, folk beliefs and operation mechanism of public affairs were systematically investigated.

(2) For Dai dwellings, analyzed the spatial composition, including exterior features, layout of the building, architectural structure, and humanized design concept. The drawings and photo information on site ensure the accuracy and authenticity of the research objects, and record the overall layout of residential sites, the plan and profile of typical residential building and plastic decoration.

(3) Analysis of current situation and problems in the development of Dai dwellings. Summarized the evolution and composition characteristics of Dai residential space, discussed the sustainable development ideas and proposed feasibility suggestions.

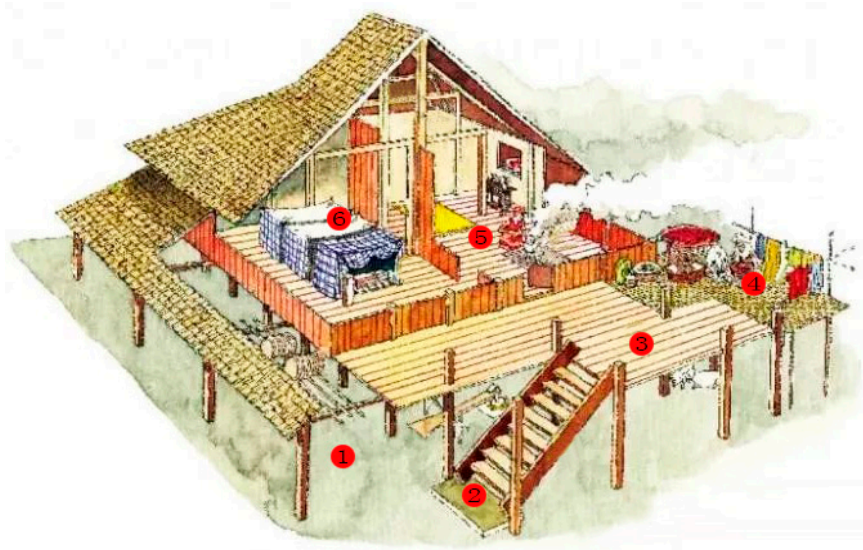
### 3.3. Research Framework



## 4. Results

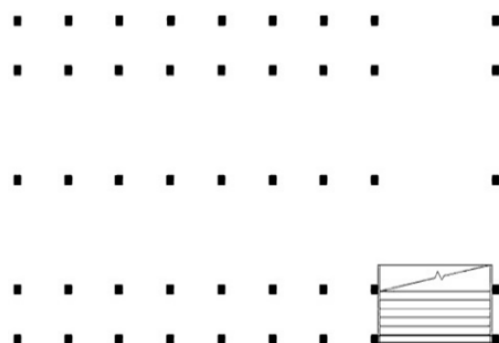
### 4.1. Plane Function and Composition

The plane consists of two parts: the main body of the building and the flat roof. The flat roof is usually connected to the building, the shape and size vary depending on the terrain. Dai dwellings are mainly rectangular planes, which are composed of empty space of the bottom, stairs, front porches, halls, bedrooms, etc.; they are divided into two floors, one floor is overhead, and the second floor is living space (Figure 2).



**Figure 2.** Spatial structure of Dai folk houses. 1 is empty space of the bottom, 2 is stairs, 3 is front porch, 4 is flat roof, 5 is hall, 6 is bedroom [13].

(1) The structural form of the empty space of the bottom is generally first set up with the bottom piles, and the bamboo and wood beams in the vertical and horizontal directions are staggered on the piles. Generally, 40–50 wood columns are used to support the upper load-bearing structure. The height of the column is about 0.8–1.2 meters and the distance between columns is about 1.5 meters, arranged in 5–6 rows (Figure 3). There is no wall, which is mainly used for livestock keeping and large-scale farm storage, and can also prevent floods.



a

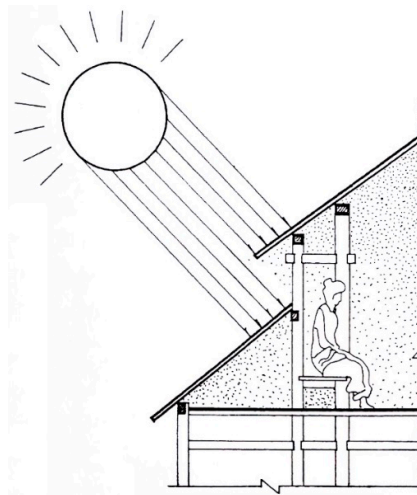


b

**Figure 3.** (a) is wooden pole position; (b) is empty space of the bottom.

(2) Stairs are the only passage between upstairs and downstairs, usually located on one side of the house. The stairs of Dai residences are generally 9–11 steps, and the number is singular.

(3) Along the stairs to the second floor is the front porch, which is an excessive space with seats for rest (Figure 4).



**Figure 4.** Front porch [1] (p. 161).

(4) The flat roof is located on the side of the front porch and has no roof covering, which is mainly used for drying crops, laundry, etc.

(5) The hall is the main space for meeting, entertainment, and reunion. There is a fire pit in the hall. Three stones are placed on the fire pit in a triangle with cooking utensils and a hanger above the fire pit. The hall is the center of family activity, while the fire pit is the center of the hall. The daily gatherings, meetings, and receptions of the family are all around the fire pit.

(6) The bedroom is the most intimate part of the second floor. The wall of the bedroom does not open the window, the interior is noninvasive, a mattress is placed on the wooden floor, and a mosquito net is hung above.

#### 4.2. Spatial Structure and Function

(1) The roof is good for sunshade

The roof of a Dai residence is a gable and hip roof, with steep slope and mostly multiple eaves, and is rich in contours. The slope of a traditional residential roof is about  $45^\circ$ , which is beneficial to roof drainage in rainy areas such as Xishuangbanna. The roof is mainly made of gray tiles, which are laid on the grid-shaped battens and are not easy to slip. Direct sunlight is an important cause of overheating in the room. Xishuangbanna is around  $22^\circ$  latitude, and the direct sunlight is very serious. Shoulder eaves are low and stretched. The large part of the roof acts as a maintenance wall to two-layer, which reduces the solar radiation directly acting on the exterior wall, playing a role in shading (Figure 5).



**Figure 5.** Gable and hip roof.

The temperature of the space is vertically distributed. Due to the good heat dissipation of the roof, the vertical temperature of the roof does not change much at night, but does so significantly at noon. From 10:00 to 19:30, the temperature in the 1 m height area of the front porch is 1 °C higher than the 4 m height area. At 15:00, the temperature in the 4 m height area is 2.6 °C–3.7 °C higher than the 1 m height area. It has a good thermal buffering effect, so that the temperature of the front porch is not too high, and the building is cooler in the hot summer (Figure 6) [11]. At the same time, the roof with shoulder eaves protects the bamboo and wood components from rainwater immersion and prolongs the use of building components.

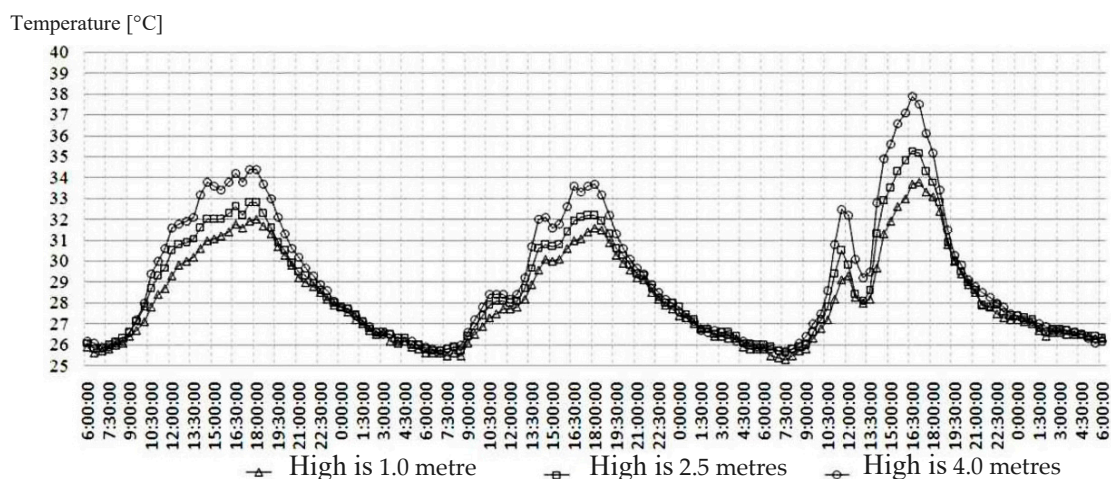


Figure 6. Vertical Temperature Diagram.

## (2) Wooden frame for ventilation

The traditional Dai residential buildings are overhead, which increases the ventilation area and reduces the obstruction of physical buildings (Figure 7). The floor between the first and second is spliced with wooden boards, leaving gaps in the middle for ventilation and forms a horizontal and vertical wind environment to increase the flow of air and effectively reduce the temperature in the room. At 14:00, the inner surface of the roof is 40.4 °C and the outer surface 49.2 °C, while the ground floor is 27.6 °C, with a difference of 21.6 °C. According to calculation formula of thermal pressure:  $\Delta P = gH(p_e - p_i) = 0.043H(t_i - t_e)$ , such a large temperature difference enhances the role of hot pressure ventilation (Figure 8) [11].

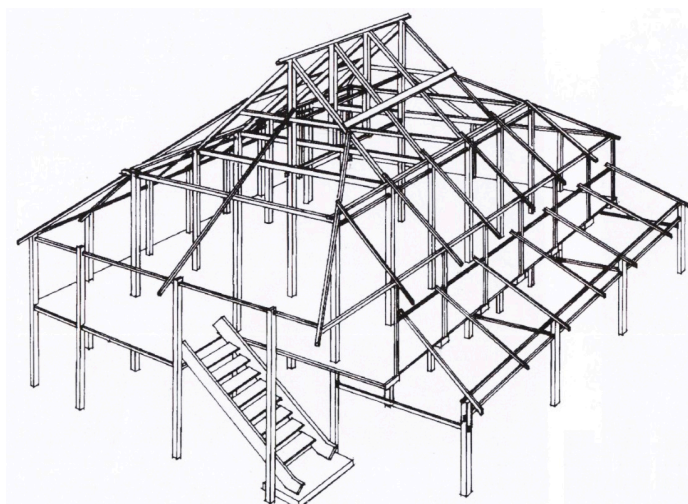


Figure 7. Wood frame [1] (p. 202).

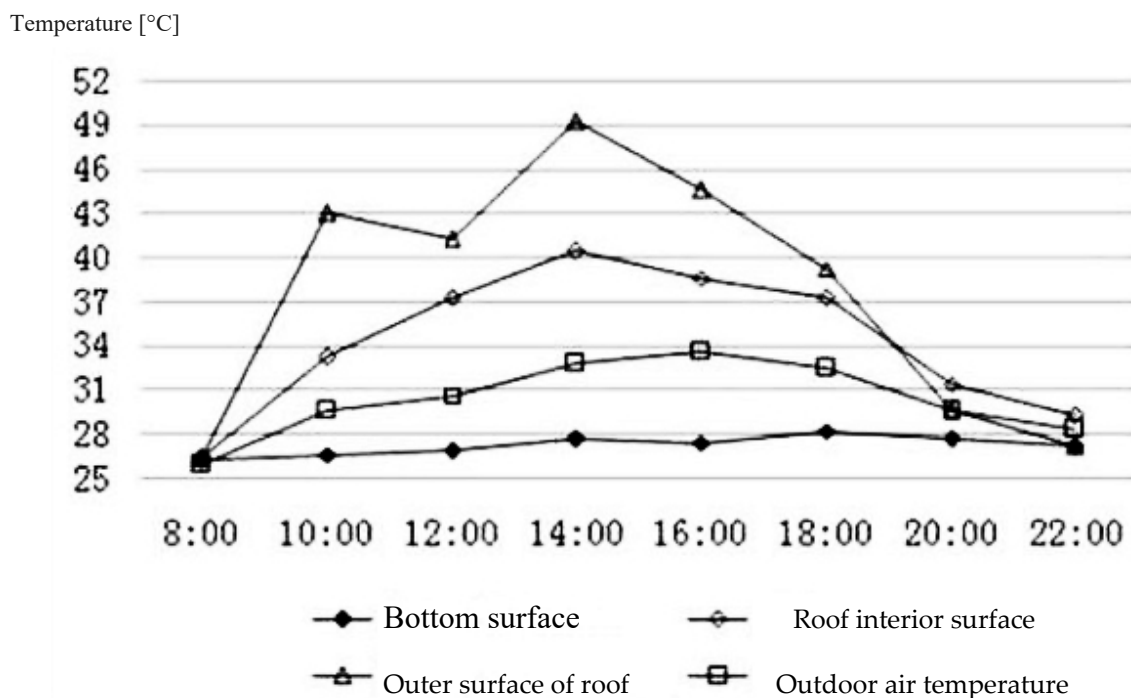


Figure 8. Vertical surface temperature comparison.

It can be seen from Table 2 that the outdoor, empty space, and front porch wind speeds are relatively large, ranging from 0.15 m/s to 0.26 m/s. The space of the bedroom and the house is enclosed by the space, the wind speed is small. Due to the effect of hot wind speed on the front porch, the vertical wind speed is more obvious [11].

Table 2. Dai dwelling space average wind speed.

Site	Empty Space	Front Porch	Bedroom	Outdoor	Hall	Front Porch (Vertical)
Wind speed	0.25	0.15	0.05	0.26	0.04	0.04

#### 4.3. Changes of Dai Dwellings

##### 4.3.1. Changes of Plane Layout

With the rapid development of the economy and the acceleration of urbanization, more and more people in the Dai area had been influenced by foreign cultures and the ideology and value of Dai had also changed significantly. The relatively stable balance of the formation of Dai dwellings was broken, so there were a variety of western-style buildings and brick-concrete bungalow buildings. The layout of the internal space structure is more and more humanized and emphasis is on the comfort and privacy of human settlements. Compared with traditional dwellings, the newly Dai dwellings have greatly improved in functional division and sanitation, and are in line with the modern people's lifestyle; that is why people choose modern buildings.

##### 4.3.2. Boundary Change

The boundary is the spatial indicator of the container. The ground, walls, eaves are all borders, and the dwellings are containers made up of these boundaries, and the boundary is the main determinant of the spatial order [14]. Since the evolution of Dai dwellings, the materials range from thatch and bamboo to the residential buildings with wooden structures and reinforced concrete structures. Their "boundary" has also changed. In different periods, the different understandings of border space of

the Dai people reflect the transformation of national culture and thinking consciousness. From the perspective of communication, the areas with inconvenient transportation and information occlusion are less affected by external culture, so the individuality and characteristics of the national original ecological culture are more complete. However, with the development of the economy, the frequent exchange of culture, the application of new materials and new technologies, the changes in family structure and lifestyle, the structure of Dai dwellings has also undergone tremendous changes.

#### 4.3.3. Changes in the Modeling of Dai Dwellings

Since the evolution of Dai residences, the building materials have been changing, and the colors of buildings are constantly changing. From the pale yellow of bamboo to the khaki of wood to blue, red and white of modern reinforced concrete materials, the color environment gradually evolves from harmony to opposition. In the new period, Dai dwellings not only changed the building materials, but also the color. The new Dai dwellings blindly imitated the architectural form of modern urban dwellings, and built western-style buildings and brick–concrete bungalow buildings that lack the architectural features of Dai dwellings. The roofs of newly built houses are blue or red and the walls are white limes, which are inconsistent with the color environment of traditional Dai residential settings. From the perspective of the entire settlement space environment, the newly built dwellings have destroyed the unique beauty of the landscape and are incompatible with the entire space landscape.

### 5. Discussion

Dai dwellings are related to geography, building materials, construction techniques, economic life, production relations, and other factors, among which geography include topography, landform, water system, traffic, climate, and other conditions; construction techniques include building structure, construction, equipment, and appearance; economic life refers to lifestyle and requirements; production relations include communication, religion, institutions, and geomancy [15]. Thatched architecture is closely related to the construction technology, lifestyle, and mastery of materials. Dai dwellings with bamboo and wood structure have many scientific factors of human settlements, such as flood control, ventilation, and heat dissipation, and resisting earthquakes. The building is based on nature and blends in with the surrounding environment, which is a true “green building.” The main factors affecting the transformation from wood to brick–concrete are construction costs, construction techniques, and changes of lifestyle. Since the government banned the cutting of timber after 2000, the cost of purchasing timber has increased. At the same time, because of the service life of wood, as well as the popularity of brick–concrete and construction techniques, the new residential buildings are dominated by brick–concrete structures.

For the quality of wood and brick–concrete houses, people in different ages hold different opinions. The head of the village enumerated the advantages of wooden structures, such as comfortable living, ventilation, and integration of people and environment, while his son, Yan Ai, believed that the brick–concrete structure is better, because it is sturdy, durable, and has a separate kitchen, which makes them live like people in the city. Differences in lifestyles between people in different ages make a difference in the demand for architecture. It is worth noting that the wooden structure of Dai dwellings has evolved from thatched architecture and the construction methods and spatial structure have changed little. Both of them are built with natural materials, and the folk dwellings are integrated into nature, which is a summary of the collective wisdom of the Dai people. From wood structure to brick–concrete structure, building materials and construction techniques have changed a lot. Brick–concrete structures require a large amount of steel, sand, stone, cement, etc., which not only consumes a lot of energy, but also damages the environment; secondly, there would be a large amount of construction waste that cannot be recycled and reused during the construction and demolition of brick–concrete structures; the floor slab of cement cannot be ventilated and heat-dissipated, and the advantages of traditional balustrade architecture have been obviously lost.

Affected by geographical environment, climatic factors and construction technology, the site selection and construction of Dai dwellings should focus on local conditions, so as to save manpower and material resources. On the other hand, the layout and spatial composition emphasize the purpose of livability by adopting reasonable construction techniques and measures. The architectural form and space composition of Dai dwellings are the crystallization of the collective intelligence of the Dai people in the long process of life and production, which contain the ecological concept, religious beliefs, and national customs of Dai and is a non-renewable national material heritage. With the acceleration of urbanization, the building materials, construction techniques, architectural forms, and spatial layout of residential buildings are also changing. In the field investigation, the author found that the brick and concrete structure replaced the traditional wooden structure of Dai folk houses. New residential buildings are not in harmony with the surrounding environment. When people need to get a more comfortable living environment, they should pay more attention to the coordination of “human, building and environment” [16]. Nowadays, the settlement’s ecological wisdom contained in the traditional residential buildings of Dai is disappearing as the world advocates resource conservation and sustainable development of ecological environment. Based on rescuing and protecting traditional Dai folk houses, this paper analyzed the challenges faced by Dai folk houses in the new era according to the spatial evolution of Dai folk houses and the humanized living concept, putting forward the idea of sustainable development of Dai dwellings to provide reference for the design of dwelling houses in the Dai area of Xishuangbanna.

## 6. Conclusions

The problem facing the development of national culture is how to make the nation and region maintain cohesion and vitality and make new contributions to global civilization, while the development of global civilization is beneficial to the development of national culture, and does not weaken or engulf the culture of ethnic, regional, and local aspects at the same time [17]. Residential architecture is the carrier of national culture. Dai residences have a long history. Influenced by ecological environment, social structure, national culture and other factors, Dai residences have distinct regional characteristics which are an important manifestation of Dai culture. Dai dwellings reflect the production mode, lifestyle, and social structure of Dai society from the aspects of settlement layout, architectural form, and spatial structure, which are the characteristics of Dai civilization and non-renewable historical and cultural heritage.

The construction of Dai dwellings is constantly changing, especially the rapid economic development, the change of lifestyle, the improvement of building technology, the emergence of new materials, and the globalization of the economy, which would definitely affect the development of Dai dwellings. This paper analyzed the origin of the balustrade architecture and expounded the scientific, rational, and livable spatial structure of the traditional Dai dwellings. The sustainable development of Dai dwellings is a long-term exploration process; on the basis of ensuring that Dai dwellings conform to the regional culture and national culture, adapt to local conditions, suitable for materials, eclectic, integration development. This is not only to be convenient for living, comfort, but also to meet people’s psychological and spiritual needs to the maximum extent. This paper analyzed the overall ecological space system of Dai dwellings, excavated the ecological experience contained in the dwellings, paid attention to the application of regional culture and technology, and applied the concept of sustainable development to guide the green recycling design practice of the dwelling houses.

**Author Contributions:** All authors contributed to the paper. H.-f.W. wrote the manuscript with supervision from S.-c.C., and H.-f.W. acted as a corresponding author.

**Funding:** This research received no external funding.

**Acknowledgments:** Thanks for the help of Xue Ai, Wen Ai, Hong Yu, and Yan Ai, etc. Especially grateful to Xue Ai, as he has given us an enthusiastic reception, recommended interviews, accompanied inspections, and provided detailed introductions. We sincerely thank the anonymous reviewers for their detailed and valuable suggestions for revision.

**Conflicts of Interest:** The authors declare no conflict of interest.

## References

1. Jiang, G.C. *Yunnan Ethnic Housing Culture*; Yunnan University Press: Kunming, China, 1991; p. 141.
2. Zhou, Q. The Research On the Pedigree of Pile Dwelling in Western Yunnan. Master's Thesis, Beijing University of Civil Engineering and Architecture, Beijing, China, 2018.
3. Rapoport, A.; Chang, Q. *House Form and Culture*; China Building Industry Press: Beijing, China, 2007; p. 7.
4. Fujii, A. *Settlement Visit*; Ning, J., Ed.; China Building Industry Press: Beijing, China, 2003; pp. 1–10.
5. Wu, L.Y. *Introduction to Sciences of Human Settlement*; China Building Industry Press: Beijing, China, 2001; pp. 10–200.
6. Liang, J.K. On the Climate Adaptability Design of Dai Dwellings. Master's Thesis, Kunming University of Science and Technology, Kunming, China, 2014.
7. Yang, L.F. Construction, Field and Style of Craftsmen. Ph.D Thesis, Tongji University, Shanghai, China, 2005.
8. Che, Z.Y.; Mao, Z.R. The balustrade is still there, the old look is new—study on the experimental building of new Dai dwelling houses. *Huazhong Archit.* **2002**, *20*, 29–31.
9. Wang, D.; Ye, J.F.; Gao, L. Settlement scenario C. *Proc. Chin. Acad. Conf. Resid. Archit.* **2014**, *9*, 12–14.
10. Shi, T. Research on Balustrade Architecture of the South China. Ph.D. Thesis, South China University of Technology, Guanzhou, China, 2013.
11. Zhen, B.; Chen, X.Y. Analysis of thermal environment of Dai bamboo house in summer. In Proceedings of the 2010 International Conference on Building Environment Science and Technology, Nanjing, China, 7 May 2010.
12. Wang, H.F.; Chiou, S. Study on the Sustainable Development of Human Settlement Space Environment in Traditional Villages. *Sustainability* **2019**, *11*, 4186. [CrossRef]
13. National Architecture Institute of China. Available online: [http://www.naic.org.cn/html/2017/gjjy\\_1023/29800.html](http://www.naic.org.cn/html/2017/gjjy_1023/29800.html) (accessed on 8 May 2019).
14. Hara, H. *Teaching of the World Settlement 100*; China Building Industry Press: Beijing, China, 2003; p. 134.
15. Lu, Y.D. *Chinese Residential Architecture*; South China University of Technology Press: Guangzhou, China, 2003; p. 544.
16. Zhou, H.M.; Zhang, X.D. *Ecological Architecture, Future-Oriented Architecture*; Southeast University Press: Nanjing, China, 2002; p. 8.
17. Wu, L.Y. *UIA Beijing Charter, the Future of Architecture*; Tsinghua University Press: Beijing, China, 2002.



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