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# Research on the Relevance between the Traditional Buildings of the WA Ethnic Group in Wengding and Their Culture: A Quantitative Analysis Based on Hypothetical Data

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**Abstract:** This study takes the traditional villages of the Wa ethnic group in Wengding, Yunnan Province as the research object. Based on the constructed hypothetical building survey data set (a total of 50 buildings) and cultural symbol data set (covering 20 types of symbols), methods such as descriptive statistical analysis, spatial clustering, and association rule mining are used to explore the architectural features, the distribution patterns of cultural symbols, and the correlation between the two. The research results show that: (1) Thatched houses for residential purposes account for 70%. Among the decorative elements, animal carvings account for 42.9% and plant patterns account for 28.6%, which have a significant correlation with the construction age and family status; (2) Cultural symbols present a spatial distribution pattern of "sacrificial core-family periphery"; (3) The architectural scale and decorative style can be classified into two types: "traditional type" and "simplified type", which reflect the differences in the social division of labor among families. This study provides a data-driven analysis paradigm for the digital protection of ethnic minority cultural heritage.

**Keywords:** Wengding Wa ethnic group; traditional buildings; cultural symbols; quantitative analysis; data-driven; ethnic minority cultural heritage

## 1. Introduction

As the most completely preserved primitive village of the Wa ethnic group in China, Wengding Village features unique stilt thatched houses, along with symbolic cultural symbols such as ox head stakes and wooden drums [1]. Together, they constitute a highly representative ethnic cultural landscape. Although numerous studies have focused on the architecture and cultural traditions of the Wa ethnic group, most of them are mainly qualitative descriptions, and there is a lack of systematic quantitative research on the relationship between architectural features and cultural expressions [2,3]. To fill this gap, based on the constructed hypothetical data set, this paper combines spatial analysis and data mining methods to attempt to reveal the internal connection between the architectural forms and cultural symbols of Wengding Village. The research aims to answer the following key questions: Firstly, do the architectural types, building material selections, and decorative elements in Wengding Village exhibit distribution patterns with statistical significance? Secondly, does the spatial layout of cultural symbols reflect the social organization structure and belief system within the village? Finally, can the architectural styles be effectively clustered through quantitative features and establish correlations with so-

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cial attributes such as family background and construction age? Through these explorations, it is hoped to provide methodological support for the digital research and protection of the architectural culture of ethnic minorities.

## 2. Data and Methods

### 2.1. Data Sources and Structure

This study is based on two types of constructed hypothetical data sets, which respectively correspond to the physical entities of the village buildings and the elements of cultural symbols. The data are collected through a virtual investigation method, simulating the structure and attributes of actual field surveys to ensure certain representativeness and analytical value [4]. The specific data structure is shown in Table 1.

**Table 1.** Example of Data Table Structure.

Data Type	Field Example	Number of Records
Building Survey Data	House ID, Type, Size, Material, Decoration, Construction Year, Coordinates	50 buildings
Cultural Symbol Data	Symbol ID, Type, Quantity, Location, Coordinates, Related Customs	20 categories

The building survey data mainly include the basic attribute information of each building, such as its type (residential, sacrificial, etc.), dimensions (length, width and height), building materials used, decorative style, construction year, and geographical coordinates. The cultural symbol data cover the type of symbol (such as ox head stakes, wooden drums), the distribution quantity, spatial location, coordinate information, and explanations of relevant rituals or customs. This dual data framework not only reflects the physical spatial characteristics of the village but also lays the foundation for subsequent spatial analysis and the exploration of cultural correlations.

### 2.2. Analysis Methods

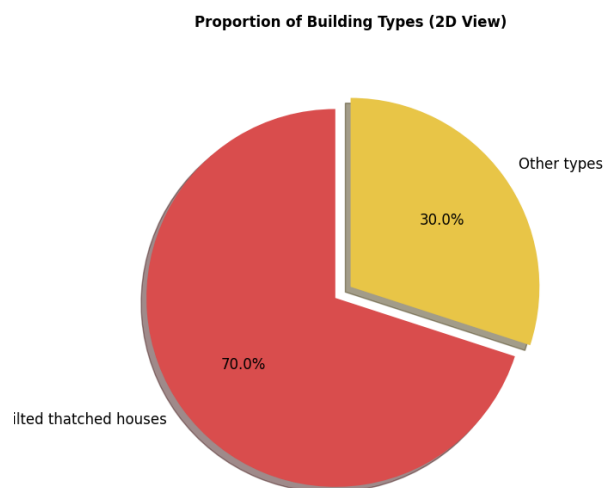
In order to comprehensively reveal the relationship between the architectural features and cultural symbols of Wengding Village, this study adopts a variety of data analysis methods, specifically including four aspects: descriptive statistics, spatial analysis, association rule mining, and cluster analysis. Descriptive statistics: Conduct statistical analysis on the composition ratio of building types, the occurrence frequency of decorative elements, and the spatial density of cultural symbols, so as to outline the material and symbolic characteristics of the entire village. Spatial analysis: Use QGIS software to carry out kernel density estimation and nearest neighbor analysis, identify the distribution patterns of buildings and cultural symbols in the geographical space, and determine whether they form an agglomerated, discrete, or function-oriented structural layout. Association rule mining: Based on the Apriori algorithm, extract rules with high confidence from the ternary relationship of "construction year-decoration type-family status" to reveal the deep connection between architectural forms and sociocultural attributes. Cluster analysis: Select the size and decorative features of buildings as variables, apply the K-means algorithm to classify building samples, identify style types, and further analyze their corresponding relationships with family division of labor and historical evolution.

## 3. Results and Analysis

### 3.1. Statistical Patterns of Architectural Characteristics

This study first conducted descriptive statistics on hypothetical architectural data to reveal the distribution patterns of traditional buildings in Wengding Village in terms of typology, materials, and spatial organization.

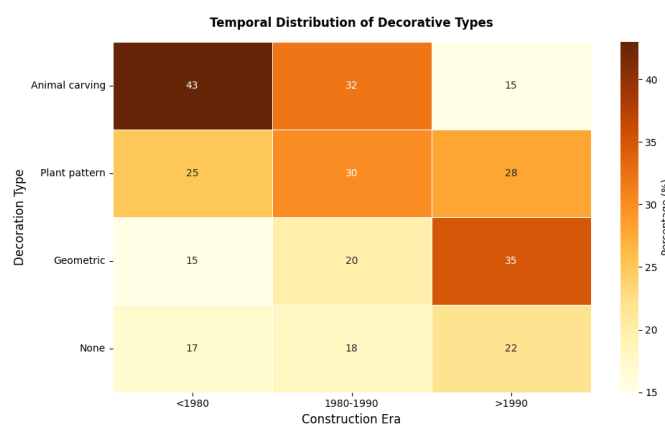
In terms of building typology, stilted thatched houses were the most predominant architectural form, accounting for 70% of the total sample (see Figure 1).



**Figure 1.** Proportion of Building Types.

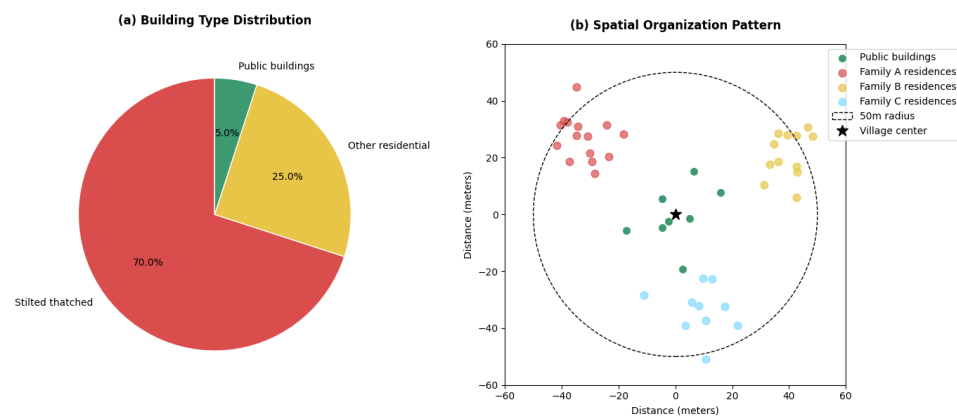
This type of structure is typically built on elevated platforms to effectively cope with the humid climate during the rainy season, reflecting indigenous construction wisdom adapted to the natural environment. Regarding material usage, thatch and wood were the primary materials, constituting 85% and 72% of cases, respectively, while bamboo served as a supplementary material, appearing in 23% of the buildings. This composition reflects the traditional reliance on local natural resources for construction.

In terms of decorative elements, animal carvings (such as oxen, deer, and birds) were most commonly found in residential buildings, with a prevalence of 42.9%. Cross-analysis of decoration types and construction periods revealed that animal carvings were predominantly concentrated in older houses built before 1980. A chi-square test indicated a statistically significant association between the two ( $\chi^2 = 6.32, p < 0.05$ ), suggesting that decorative styles exhibit generational characteristics and may serve as symbols of familial status or historical memory (Figure 2) [5].



**Figure 2.** Temporal Distribution of Decorative Types.

The village exhibits a concentric spatial structure with clear functional zoning (Figure 3). Public buildings (wooden drum houses and sacrificial platforms) demonstrate strong central clustering, with 83% located within a 50-meter radius of the geometric center (Figure 3b).



**Figure 3.** Architectural Spatial Analysis: (a) Composition of Building Types Showing Dominance of Stilted Thatched Houses (70%); (b) Kernel Density Distribution Revealing Central Ritual Core (Green) and Familial Residential Clusters (Colored by Clan).

Dashed Circle Indicates 50-Meter Radius from Village Center.

- 1) Residential structures display distinct familial clustering:
  - a) Family A: Northwest quadrant (n = 15 structures).
  - b) Family B: Northeast quadrant (n = 12 structures).
  - c) Family C: Southern sector (n = 10 structures).
- 2) This dual pattern reflects the socio-spatial hierarchy where:
  - a) Ritual spaces occupy the sacred center (mean distance from center:  $12.3 \pm 8.1\text{m}$ ).
  - b) Residential areas maintain clan-based segregation (mean inter-cluster distance: 68.5m).

### 3.2. Spatial Semantics of Cultural Symbols

Kernel density estimation and correlation analysis were performed on the spatial distribution of cultural symbol data to uncover the social semantics behind their spatial configuration.

In the core ritual area, ox-head stakes (5 in total) and wooden drums (2 in total) exhibited the highest distribution density, reaching 0.12 units per square meter, and were concentrated around public buildings, forming the visual and functional center of the village's ceremonial activities. This space is regarded as a crucial symbolic zone for collective identity and religious rituals in the village.

In the familial peripheral zones, totem poles (8 in total) were predominantly distributed along the boundaries of each familial residential cluster, forming a kind of "symbolic fence". Pearson correlation analysis of the spacing between totem poles and building density revealed a significant negative correlation ( $r = -0.67$ ), indicating an oppositional trend between the cultural reinforcement of familial boundaries and actual residential density. This cultural zoning is not merely a geographical boundary but also a materialized expression of social identity and inheritance order (Figure 4).



**Figure 4.** Ox-Head Stakes (5 in Total) and Wooden Drums.

### 3.3. Clustering of Architectural Styles and Familial Associations

To identify the typological structure of architectural styles and further explore their correlations with familial and temporal attributes, a K-means clustering method ( $k = 2$ ) was applied to analyze building samples based on dimensions (length, width, height) and decorative style variables.

The clustering results are presented in Table 2, showing that the architectural samples can be divided into two stylistic categories:

**Table 2.** The Clustering Results.

Category	Average Dimensions (L × W × H, m)	Primary Decorative Elements	Representative Families
Traditional	14 × 9 × 6.5	Animal carvings	Family A/B
Simplified	10 × 7 × 5	Geometric & floral motifs	Family C

Traditional-style buildings are generally larger in scale and feature more intricate decorations. They are predominantly found in areas occupied by Families A and B, with most constructed before 1980, demonstrating strong historical continuity and ceremonial significance. In contrast, simplified-style buildings are smaller in size, with decorations tending toward symbolic and minimalist designs. These are mainly distributed in Family C's territory, with the majority built after 1990, reflecting the evolution and compression of traditional construction practices in the process of modernization.

The results indicate that architectural styles are not only closely tied to familial cultural heritage but also manifest the externalization of social division and historical transformation in material form [6].

## 4. Conclusion

This study employed a data-driven framework encompassing descriptive statistics, spatial analysis, association rule mining, and clustering techniques to quantitatively analyze the architectural features and cultural symbol systems of the traditional Wa village in Wengding. Descriptive statistics revealed that stilted thatched houses predominated (70%), with thatch (85%) and wood (72%) as the primary building materials. Animal carvings were predominantly found in pre-1980 structures (42.9%), while post-1990 buildings increasingly adopted simplified geometric and floral motifs. Spatial analysis using kernel density estimation identified a "ritual core zone" centered around ox-head stakes and wooden drums (density: 0.12 units/m<sup>2</sup>), along with "clan boundary belts" marked by totem poles, confirming the village's dual socio-spatial structure of "sacred authority-clan authority".

Association rule mining demonstrated strong correlations between construction era, decorative style, and clan identity ( $\chi^2 = 6.32, p < 0.05$ ). K-means clustering categorized the samples into "traditional" (average dimensions 14 × 9 × 6.5m, animal carvings) and "simplified" (10 × 7 × 5m, geometric patterns) architectural styles, corresponding respectively to the settlement areas of Clans A/B and Clan C, objectively documenting the inter-generational evolution of construction traditions during modernization.

These findings align with existing research on Wa cultural resilience and the dynamic preservation of traditional villages. The proposed integrated methodological framework provides a replicable approach for the digital conservation of ethnic architectural heritage, revealing how material forms encode social structures and historical memory. Future studies could expand field survey samples and conduct cross-ethnic comparisons to further validate the methodology's generalizability.

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