Cultural Landscape Zoning of Traditional Villages in Southwest Hubei Based on Multi-attribute Weighted k-modes Clustering

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Abstract Cultural landscape zoning research of traditional villages is the basic premise for carrying out overall protection and regional development. Through the clustering algorithm, cultural area zoning research of traditional villages can provide objective basis for its overall protection and development. Based on the field research, drawing on the theory of cultural landscape, southwest Hubei is taken as the research object, and the index system of cultural landscape type division of traditional villages is constructed from three levels of culture, geography and village carrier. Adopting the multi-attribute weighted k-modes clustering algorithm, 92 traditional villages in southwest Hubei are divided into three major types, which are the western Tujia cultural characteristic area, the southern Tujia - Miao cultural penetration area, and the northern multi-ethnic cultural mixed area, and the characteristics of each area are summarized. The regional characteristics of traditional villages in southwest Hubei at the cultural landscape level are analysed from a macro point of view, which provides a reference for more objective cognition of the distribution law of traditional villages in southwest Hubei, and carrying out the contiguous protection of traditional villages.

Key words Multi-attribute weighted k-modes clustering; Cultural landscape; Southwest Hubei; Traditional village

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In 2024, the Ministry of Finance and the Ministry of Housing and Urban Rural Development jointly organized and carried out demonstration work on the centralized and contiguous protection and utilization of traditional villages. In order to actively respond to the policy and promote the protection and development of traditional villages, numerous experts and scholars have extensively conducted relevant researches. By evaluating the historical, cultural and tourism, artistic and other values of traditional villages, the active inheritance and utilization protection are conducted[1-5]. Based on the research on spatial characteristics and patterns of villages, the comprehensive protection of traditional villages is conducted[6-8]. Starting from the characteristics of human-land relationship and landscape maps, villages are classified into different types, to provide ideas for contiguous protection[9-12]. Adopting clustering algorithm, entropy method, AHP analysis method and other methods, a multi-level system is constructed. Using ArcGIS for visual analysis, it could promote the transformation of more comprehensive and multi-dimensional quantitative classification methods for traditional villages[13-15]. Overall, current research on the protection of traditional villages mainly focuses on spatial features, value activation, and other aspects. Moreover, it focuses more on typical villages, and there is insufficient understanding of the overall characteristics of regional traditional villages, which cannot provide objective basis for centralized and contiguous protection.

Traditional villages are the product of the interaction between history, humanities, and natural geography. It is an important way to continue the cultural context of traditional villages by interpreting the characteristics of traditional villages and dividing them into regions from the perspective of cultural landscape theory, and has guiding significance for the diversified and clustered development of villages. How to scientifically formulate a more objective division of cultural landscape areas? There are also various methods of classification studied by relevant scholars, such as developing a distribution map of village landscapes for layer overlay analysis[16-18]. Based on the single element features of village geographic space, a single element model embedded by professional platforms such as ArcGIS is used for clustering and cluster identification and analysis[19]. Considering the multiple influencing factors of village cultural zoning attributes, principal component factor analysis is used for village clustering[20]. Using k-means and k-modes clustering analysis methods, zoning research on traditional village landscapes is conducted[21-25], promoting a shift in classification methods from qualitative to quantitative. The southwestern region of Hubei Province is located in the hinterland of the Wuling Mountain, where multiple ethnic groups living together and the unique geographical environment has created a unique cultural landscape. The closed environment of the mountainous area has also reduced the loss of its village characteristics to a certain extent. Therefore, 92 traditional villages in six batches in south-

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west Hubei are taken as the research object. Based on the cultural landscape theory, a multi-source heterogeneous feature index system is constructed, and a multi-attribute weighted k-modes clustering method is used on this basis, to enrich local cultural landscape research and provide more detailed and accurate basis for the formulation of regional contiguous protection strategies.

1 Overview of the research area and sample selection

1.1 Overview of the research area The southwestern region of Hubei Province is also known as Enshi Tujia and Miao Autonomous Prefecture. It is characterized by high mountains and steep hills, and its terrain can be summarized as "eight mountains, one water, and one field". The rivers and streams in the area are distributed in a tree like pattern, forming nine major river basins[26-27]. The mountain and water systems divide the prefecture into clusters with different geographical environments. In history, the filling of Huguang in Jiangxi, Huguang in Sichuan, and the conversion of land to rivers have led to a diversification of the settlement core in southwest Hubei, with 29 ethnic groups including Tujia, Miao, Dong, Han, and Mongolian[28]. It is a truly ethnic minority settlement area that has created and inherited the culture of the Wuling Mountain area with the characteristics of the Qingjiang River basin.

1.2 Overview of data samples 92 villages listed in the Chinese traditional village directory in southwest Hubei are taken as the research objects. Using API spatial positioning technology of Baidu Map, spatial positioning and visualization processing of traditional villages are conducted. Open source StreetMap is used to obtain the data of road traffic, water system and administrative boundary, and DEM data is obtained through the data center of the Chinese Academy of Sciences. Using ArcGIS to analyze the kernel density of village point elements, the results indicate that the spatial distribution of traditional villages in southwest Hubei has agglomeration, showing an east – west trend and uneven distribution within the jurisdiction of each county and city. Overall, there is a trend of more in the southwest and less in the northeast, which is correlated with the terrain distribution (Fig. 1).

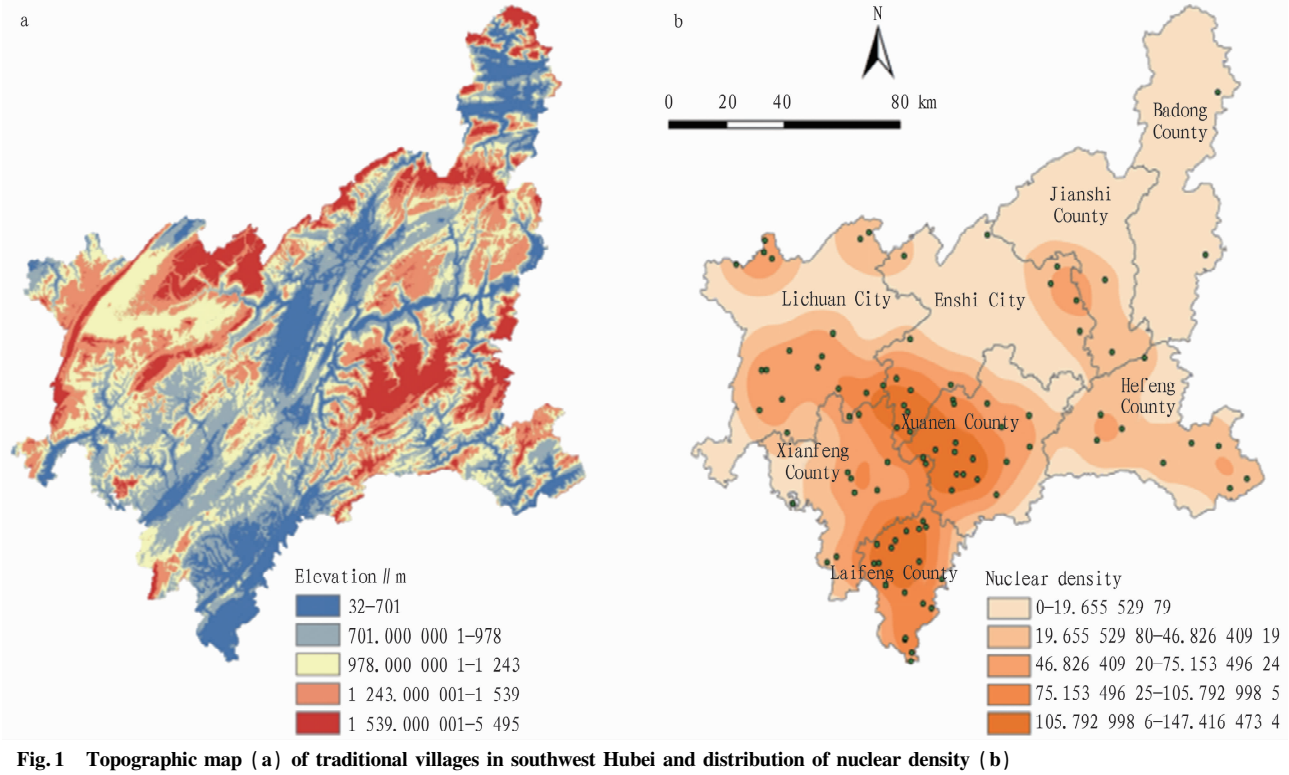

Fig. 1 Topographic map (a) of traditional villages in southwest Hubei and distribution of nuclear density (b)

2 Cultural landscape zoning of villages in southwest Hubei Province

2.1 Determination of cultural landscape indicators of villages The cultural landscape of a village reflects the balance of "human – land" game under the collision of natural environment and human forces. In this paper, it specifically refers to the complex of natural and human factors that constitute the regional characteristics of a village in a specific historical period, such as village form, site selection, residential building form, *etc.* From the perspective of cultural landscape theory, the analysis on the landscape characteristics of traditional villages can be understood from three aspects: cultural dissemination, cultural ecology, and cultural landscapes. Cultural dissemination mainly focuses on the historical evolution of villages, immigration changes, and other diachronic studies that contain their development mechanisms; cultural ecology mainly reflects the mutual influence between cultural

phenomena and their environment, such as the dependence of village distribution on the natural environment; cultural landscape presents a composite landscape subjectively transformed by human activities on the basis of natural landscapes, which can be divided into settlement and architectural landscapes from broad to detailed.

Taking into account the above three characteristics and following the principles of regionalism, representativeness, and differentiation in selecting cultural landscape indicators[30], it plans to construct a cultural landscape feature system of traditional villages consisting of eight indicators at three levels: culture, geography, and village carrier. The specific indicators are as follows: ① the age of village formation and ethnicity are selected to determine the cultural level attribute of traditional villages. The age division is based on Chinese chronicles, and the ethnicity division is based on single ethnic and multi-ethnic settlement villages. ② The three indicators of terrain, watershed, and site selection are selected to reflect the landscape characteristics of traditional villages at geographical level. Based on terrain DEM data, the terrain is divided according to the "altitude as the main factor, relative height as the auxiliary factor" proposed by domestic and foreign scholars, as well as the combination of absolute elevation value and elevation difference[31-32]. The watershed and site selection are qualitatively divided based on Google Earth observations and field investigations. ③ By selecting spatial form, street layout, and ethnic type as qualitative indicators at the level of village carrier from broad to detailed, and integrating existing literature research, the spatial form[33], street layout[33-34], and residential type[35-37] of villages are classified.

2.2 Construction of indicator system for cultural landscape zoning of traditional villages Based on the qualitative judgment criteria of the above indicators, field investigations and data collection are conducted on 92 traditional villages in southwest Hubei, and a cultural landscape indicator attribute system for traditional villages is constructed (Table 1).

Table 1 Attribute system of cultural landscape indicators for traditional villages in southwest Hubei Province

Level A	Indicator a	Attribute a_i	Indicator description
Culture	Year	Y-1 before the Yuan Dynasty; Y-2 the Yuan Dynasty; Y-3 the Ming Dynasty; Y-4 the Qing Dynasty	Chinese chronicles and county annals
	Ethnic	E-1 Tujia Nationality; E-2 Tujia Nationality and Miao Nationality; E-3 Tujia Nationality and Han Nationality; E-4 Tujia Nationality and Dong Nationality; E-5 Tujia Nationality, Miao Nationality and Han Nationality; E-6 Miao Nationality; E-7 Dong Nationality; E-8 Tujia Nationality, Miao Nationality and Dong Nationality; E-9 Han Nationality; Y-10 Han Nationality and Miao Nationality; E-11 Bai Nationality; E-12 Qiang Nationality; E-13 Mongolian Nationality; E-14 Tujia Nationality, Miao Nationality, Han Nationality, Dong Nationality, Yi Nationality	Literature review and on-site investigation
Geography	Topography	T-1 hills; T-2 small undulating low mountains; T-3 medium undulating low mountains; T-4 medium mountains	DEM data
	Watershed	W-1 Qingjiang River basin; W-2 Yandu River basin; W-3 Loushui basin; W-4 Youshui basin; W-5 Apengjiang basin; W-6 Yujiang basin	Field investigation and map observation
	Place	P-1 near mountains and waters; P-2 near mountains and far waters; P-3 far mountains and near waters; P-4 far mountains and waters	Field investigation and map observation
Village carrier	Space	S-1 endocentric type; S-2 group type; S-3 extension type; S-4 scattered type; S-5 clustered type; S-6 free type; S-7 step type	Field investigation and literature review
	Road	R-1 net-like; R-2 banding; R-3 finger-like; R-4 free	Field investigation and aerial photography
	Houses	H-1 "一"-shaped; H-2 L-shaped; H-3 U-shaped; H-4 "口"-shaped; H-5 "一"-shaped and L-shaped; H-6 "一"-shaped and U-shaped; H-7 "一"-shaped and "口"-shaped; H-8 "一"-shaped, L-shaped, and U-shaped; H-9 "一"-shaped, L-shaped, and "口"-shaped; H-10 "一"-shaped, U-shaped, and "口"-shaped; H-11 "一"-shaped, L-shaped, U-shaped, and "口"-shaped; H-12 L-shaped and U-shaped; H-13 L-shaped, U-shaped, and "口"-shaped; H-14 U-shaped and "口"-shaped	Field investigation and aerial photography

2.3 Selection of research methods Cluster analysis is a method of dividing elements into several classes with similar features, and the commonly used methods include k-means algorithm, k-modes algorithm, *etc.* Among them, k-means is one of the practical and easy to operate clustering algorithms in the field of data collection, but it is only suitable for numerical data with continuous attributes and is not applicable to the sample dataset of villages in southwest Hubei Province, which mainly consists of categorical data. k-modes, as an extension of the k-means clustering analysis algorithm[38], can be applied to datasets containing categorical attributes compared to the k-means algorithm[39], which can only handle numerical data. However, this algorithm adopts a simple matching difference method, treats all attributes as equal status, and ignores classification errors between attributes, resulting in a non-uniform clustering center. The k-modes algorithm with multiple-attribute weights is adopted. Based on the traditional k-modes algorithm, it fully considers the distribution characteristics of attribute values in the dataset and the differences in attribute values themselves. By utilizing the frequency of attribute values and the weights of each attribute value, a clustering center update

approach is proposed to effectively improve the accuracy of clustering.

① Using the concept of rough set, comprehensive weight of attribute is calculated, consisting of single-attribute weight and multi-attribute weight[40-41]:

The formula for single-attribute weight is as follows:

$$W_{ai}(x_{ki}) = \frac{|[x_k]a_i|}{n} \times \lg\left\{|[x_k]a_i| \times \left(1 - \frac{|[x_k]a_i|}{n}\right) + 1\right\} \quad (1)$$

The formula for multi-attribute weight is as follows:

$$W_{aj}(x_{ki}) = \frac{|[x_k]a_j \cap [x_k]a_i|}{|[x_k]a_i|} \quad (2)$$

The formula for comprehensive weight is as follows:

$$W(x_{ki}) = \frac{W_{ai}(x_{ki}) \times [\sum_{j=1, j\neq i}^{d} W_{aj}(x_{ki})]}{\sum_{k=1}^{n}\{W_{ai}(x_{ki}) \times [\sum_{j=1, j\neq i}^{d} W_{aj}(x_{ki})]^2\}} \quad (3)$$

Here, n is number of sample data (92 in this paper); $|[x_k]a_i|$ reflects occurrence times of attribute value x_{ki} in attribute a_i (for example, $|[x_5]a_1|$ reflects occurrence times of attribute value of the fifth sample x_{51} in the first attribute a_1 in all a_1 attribute values); $|[x_k]a_j \cap [x_k]a_i|$ reflects co-occurrence frequency of attribute values x_{ki} and x_{kj} ($|[x_2]a_3 \cap [x_2]a_2|$ shows co-occurrence frequency of attribute values x_{22} and x_{23} of sample x_2 in the attributes a_2 and a_3 in all samples), the larger the proportion of co-occurrence times to $|[x_k]a_i|$, the larger the x_{ki} clustering function reflected from a_i angle.

② The core of k-modes clustering algorithm is to calculate the distance between the sample and the cluster center, which is called dissimilarity. The measurement function is defined as follows[42]:

$$d(x_{it}, x_{jt}) = \frac{1}{2}d_1(x_{it}, x_{jt}) + \frac{1}{2}d_2(x_{it}, x_{jt}) \quad (4)$$

$d(x_{it}, x_{jt})$ is dissimilarity of samples x_i and x_j in the attribute a_t, and is commonly determined by internal dissimilarity and external dissimilarity[43]. Internal dissimilarity $d_1(x_{it}, x_{jt}) = \begin{cases} 1, & x_{it} \neq x_{jt} \\ 0, & x_{it} = x_{jt} \end{cases}$, and external dissimilarity $d_2(x_{it}, x_{jt}) = |W(x_{it}) - W(x_{jt})|$. Here, $W(x_{it})$ and $W(x_{jt})$ are the comprehensive weights requested above of the attribute values x_{it} and x_{jt}. After the calculation, each sample is assigned to the nearest class.

③ The traditional k-modes algorithm selects the attribute value with the highest frequency of occurrence under each attribute in the class as the value of the class center on this attribute. Based on the frequency of occurrence, the weight of attribute value is added to update the class center, avoiding the phenomenon of multiple class centers caused by the same frequency of attribute values, and effectively improving clustering accuracy. The weight of attribute value is based on the average weight, which is the average value for the sum of the weights of all attribute values in the class.

④ By repeating steps ② and ③, the total distance from the update class center is minimized (the sum of distances between each sample in the class and the class center), and the result is obtained.

2.4 Clustering results Based on the multi-attribute weights mentioned above, k-modes clustering operation is performed, and the results objectively reflect the three traditional village landscape types possessed by 92 traditional villages in southwest Hubei, with significant class centers (Table 2). This plays an important role in accurately identifying and mining the regional advantages of traditional villages in southwest Hubei.

Table 2 Clustering results of traditional villages in southwest Hubei based on multi-attribute weighted k-modes algorithm

Attribute a	Cluster_k-modes		
	Cluster_I	Cluster_II	Cluster_III
Year	Ming Dynasty Y-3	Qing Dynasty Y-4	Qing Dynasty Y-4
Ethnic	Tujia Nationality E-1	Tujia Nationality and Miao Nationality E-2	Tujia Nationality and Han Nationality E-3
Topography	Medium mountains T-4	Small undulating low mountains T-2	Medium undulating low mountains T-3
Watershed	Apeng River basin W-5	Youshui River basin W-4	Qingjiang River basin W-1
Place	Near mountains and waters P-1	Near mountains and waters P-1	Near mountains and far waters P-2
Space	Endocentric type S-1	Extension type S-3	Free type S-6
Road	Net-like R-1	Banding R-2	Free R-4
Houses	"—"-shaped and L-shaped H-5	"—"-shaped H-1	L-shaped and U-shaped H-12

To facilitate the intuitive display of clustering results, ArcGIS is used to visualize the clustering results. Based on geography and administrative divisions[44], artificial adjustment is made to the edge data points, and finally the spatial distribution of three types of cultural landscape areas in traditional villages in southwest Hubei is obtained (Fig. 2). The third type of villages are distributed in the western and southwestern parts of southwest Hubei; the second type of villages are the most common, distributed in the southern and southeastern parts of southwest Hubei near the Hunan border; the first type of villages have the smallest number, distributed in the northern and northeastern parts of southwest Hubei.

3 Characteristics identification of cultural landscape areas in villages in southwest Hubei Province

The traditional villages in southwest Hubei have a rich cultural heritage, which is closely related to their natural geographical conditions and historical development background. Located in the hinterland of the Wuling Mountain, they are less affected by external interference, and historical population migration has brought them diverse ethnic cultures. Various cultures infiltrate and integrate with each other, ultimately forming villages with unique

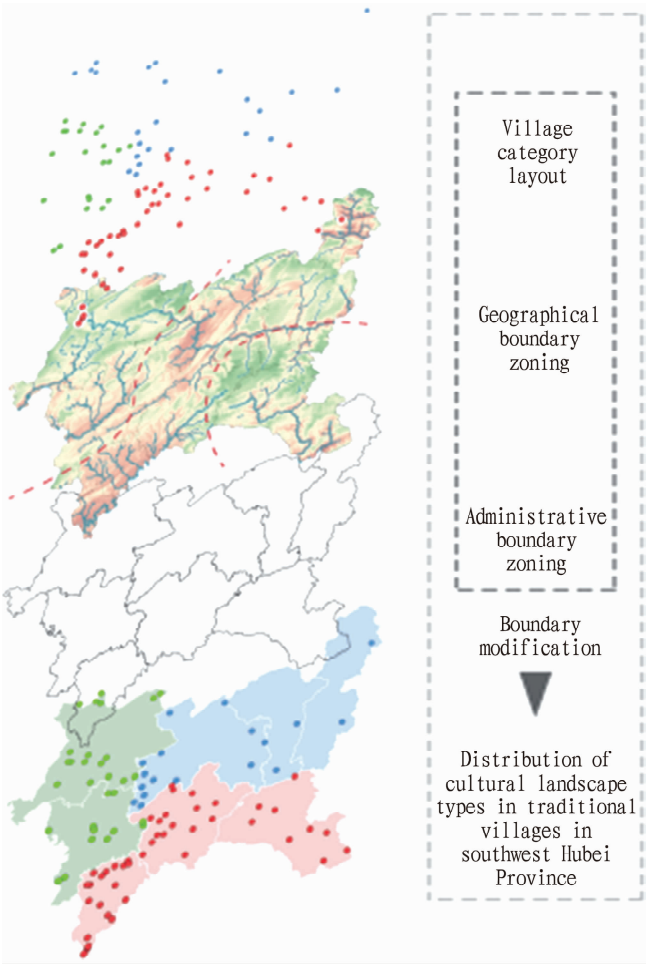

Fig. 2 Revised map of the spatial distribution of the three types of villages

regional characteristics. Based on the clustering results, the characteristics of three types of cultural landscape areas are identified and summarized, in order to propose personalized strategies suitable for the subsequent protection and development of each area, and provide more effective ideas for the construction of beautiful countryside and the promotion of contiguous protection work.

Based on the clustering results and the landscape characteristics of each area, the naming method of "relative location" + "dominant ethnic culture" is adopted for three types of cultural landscape areas, namely the western Tujia cultural characteristic area, the southern Tujia and Miao cultural infiltration area, and the northern multi-ethnic cultural mixed area (Fig. 3). The southern Tujia and Miao cultural infiltration area contains the most villages, distributed in the southern and southeastern parts of southwest Hubei, bordering Hunan Province. There are a total of 30 villages in the western Tujia cultural characteristic zone, followed by the southern Tujia and Miao cultural infiltration area, adjacent to Chongqing, located in the western and northwestern parts of southwest Hubei Province. The number of villages in the northern multi-ethnic cultural mixed area is the smallest, distributed in the central, northern, and northeastern parts of southwest Hubei (Table 3).

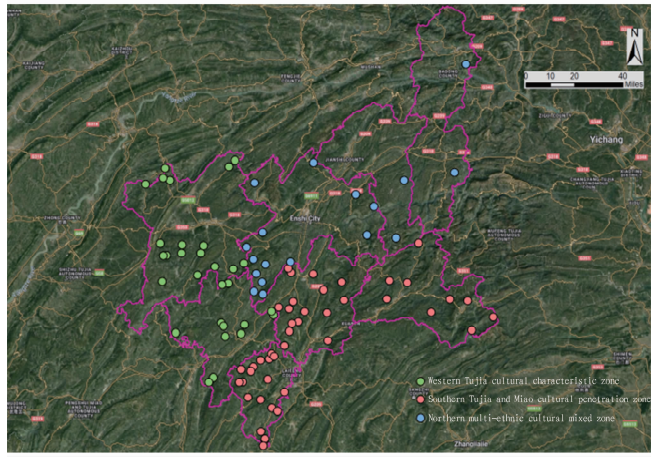

Fig. 3 Cultural landscape zoning of traditional villages in southwest Hubei Province

Table 3 Characteristics of cultural landscape area of traditional villages in southwest Hubei

Clustering area	Number of villages	Regional feature
Western Tujia cultural characteristic zone	30	In the medium mountain area of the Apeng River basin in the west, many villages were built in the Ming Dynasty. The villages are near the mountains and waters, and the form is varied, with a heart-shaped spatial layout and a network of streets and alleys. The Tujia Nationality is the main ethnic group, and there are many "—"-shaped and L-shaped stilted houses
Southern Tujia and Miao cultural penetration zone	44	In the low mountain and hilly areas of the Youshui River basin in the south and southeast, many villages were built in the Qing Dynasty. The villages are near the mountains and water, and the layout is relatively regular. The spatial form is extension type, and the layout of streets and alleys is banding. The Tujia Nationality and Miao Nationality are the main. The residential buildings are mostly "—"-shaped and stilted houses, with many gable and hip roofs due to influenced by Miao culture
Northern multi-ethnic cultural mixed zone	18	In the medium undulating low mountain terrain area of the Qingjiang River basin in the north, the layout of villages is freely scattered. The spatial form is free, and the layout of streets and alleys is scattered. The villages were mostly built during the Qing Dynasty, with a diverse range of ethnic groups including Tujia, Han, and other ethnic groups such as Mongolian and Hui. Influenced by Han culture, the residential buildings in this area are mostly semi enclosed L-shaped and U-shaped or "口"-shaped, with mixed wood, stone, and soil structures

3.1 Western Tujia cultural characteristic zone It mainly includes the entire Apeng River basin from Lichuan City to Xianfeng County. As a connecting zone between Chongqing and Hubei, traditional villages have been influenced by Youyang in eastern Chongqing and Shizhu Tujia Autonomous County, and a characteristic cultural area dominated by the Tujia Nationality is formed. Therefore, most of the residential buildings are "一"-shaped (seat houses) or L-shaped (keyhead) stilted houses with original Tujia characteristics. There are two major water systems in the scenic area: the Apeng River and the Yujiang River, both of which are first-class tributaries of the Wujiang River. Combined with the undulating terrain of medium mountains, a unique landscape of mountains and waters is formed. The villages are often located near mountains and waters, and the undulating terrain makes the villages irregularly distributed. The streets and alleys are mostly interwoven in a network, with a spatial shape oriented towards the heart, and the layout is tailored to local conditions. The village center often sets up gathering places for Tujia Nationality spiritual activities such as the Bashou Hall and Niuwang Temple.

3.2 Southern Tujia and Miao cultural penetration zone This area has the largest number of traditional villages among the three types of landscape areas, located in the three counties of Laifeng, Xuan'en, and Hefeng, which are adjacent to southwest Chongqing and Xiangxi Tujia and Miao Autonomous Prefecture. The Tu Miao culture has blended and formed a cultural infiltration zone in the historical evolution. Reflected in the residential architecture form, it is manifested as "一"-shaped plane as the main feature. Influenced by Miao culture, the roofs are mostly gable tops. The landscape area mainly belongs to the Youshui River basin, where the Youshui River and the Loushui River are respectively the tributaries of the Lishui River and the Yuanjiang River, main streams of Dongting Lake. The low mountain and hilly terrain has less restrictions, and villages are built near mountains and rivers. The layout is relatively regular, distributed along waterways and transportation arteries, forming a clear linear distribution feature. The spatial form of villages is presented in a strip like pattern with small tributaries in the watershed as the unit, fully reflecting the concept of harmonious coexistence between humans and nature. The layout of streets and alleys is mostly strip like, conforming to the village layout and terrain environment. The ethnic groups are mainly Tujia and Miao, but there are also Han, Dong, Qiang and other ethnic groups living in the villages. Compared to the western area dominated by Tujia, there are more Miao drum towers, Qiang tower villages and other buildings in the villages. The construction of these buildings is a witness to the integration of Tujia and Miao cultures.

3.3 Northern multi-ethnic cultural mixed zone The area has a large geographical span, including Enshi City, Badong County and Jianshi County, indirectly enhancing the richness of the cultural core in the landscape area. Adjacent to the central part of Hubei, it is close to the traditional Han cultural area. In addition, there are Mongolian, Bai, Hui and other ethnic groups, making it the region with the largest number of ethnic groups among the three scenic areas, truly a multi-ethnic settlement area. Influenced by the Han Nationality, the residential buildings are mostly constructed with rammed earth and stone, with L-shaped, U-shaped, and "口"-shaped buildings as the main styles, slightly highlighting the characteristics of Han courtyard houses. The vast area combined with the low mountain terrain of medium undulating results in scattered distribution of villages, forming a free spatial form, and the layout of streets and alleys is also relatively scattered without strict specifications. The main area within the territory is the Qingjiang River basin, with only a small number of villages distributed in the Yandu River basin in the northeast. Both basins are composed of first-level tributaries of the Yangtze River. The overall village site selection is close to the mountains and far from the water, and the influence of the mountains on the site selection is greater than that of the water system. The geographical location near the historical power center of this area provides conditions for economic development and population migration, allowing for the preservation and inheritance of multi-ethnic folk cultures such as grass pulling gongs and drums, southern opera, grass dragon, and hand waving dance, forming a highly distinctive cultural fusion landscape.

4 Conclusions

The cultural landscape of traditional villages contains rich historical information. It is of great significance for exploring the relationship between people and land in the Wuling Mountain area, as well as national rural revitalization strategies and local cultural and tourism development by using multi-attribute weighted k-modes clustering algorithm to study the zoning at cultural landscape level of traditional villages in southwest Hubei. The conclusions are as follows.

(1) Based on disciplines such as cultural landscape, ecology, urban-rural planning, and humanities, a index system for cultural landscape characteristics of traditional villages is constructed. Taking southwest Hubei as an example, a dataset of cultural landscape characteristic attributes of traditional villages in southwest Hubei is identified through field research and visits.

(2) Compared with traditional k-modes algorithm, multi-attribute weighted k-modes clustering algorithm is more accurate for the selection of clustering centers. The results objectively reflect the three types of traditional village cultural landscapes possessed by 92 traditional villages in southwest Hubei, and the cluster centers are significant: the western Tujia cultural characteristic area, the southern Tujia and Miao cultural infiltration area, and the northern multi-ethnic cultural mixed area.

Based on the above research content, relevant strategies are proposed to fully explore the spatial style and characteristics of traditional villages, orderly inherit the village context, and deepen the protection of traditional villages. This study is a beneficial exploration of clustering protection and development for traditional settlement, and a set of zoning system of "cultural characteristic attribute indicators – multi-attribute weighted k-modes clustering algorithm – administrative region correction" is constructed. It can effectively promote the precise protection and sustainable development of villages, and also provide experience and reference for zoning study of other villages. In addition, the selection of indicators for the cultural landscape attribute system in this paper still has certain limitations, and further research is needed on how to

objectively select indicators.

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ural education bases, it could increase the types and quantity of natural education resources. Second, it should promote information exchange and cooperation among various fields, and improve the utilization efficiency of natural education resources by building a information sharing platform for nature education.

4.2.2 Enriching the content and form of nature education. In order to meet the diverse needs of different groups, it needs to continuously enrich the connotation and methods of nature education. First of all, according to the age and gender differences, combined with the individuals with educational background, a targeted natural education plan should be formulated. Additionally, modern scientific and technological means such as virtual reality and augmented reality can be used to innovate the forms and methods of nature education, enhance the interest and interactivity of educational activities, and combine knowledge with fun[13].

4.2.3 Improving participation in interactive nature education activities. In order to improve the participation and effect of nature education activities, it should pay attention to the improvement of activity participation and interaction. First, it can stimulate individuals' enthusiasm for participation by setting tasks, challenges and teamwork. Second, feedback mechanism and interactive communication can be constructed to enhance the interaction and communication between individuals and deepen the understanding and experience of nature education[14].

4.2.4 Strengthening the construction of teaching staff for nature education. The construction of teaching staff for nature education is the key link to promote the development of nature education. For the cultivation and evaluation of teaching staff for nature education, on the one hand, it needs to increase support to improve the professional level and teaching ability; on the other hand, it should strengthen the training of teaching staff for nature education. It should encourage all teachers to actively participate in educational practice and accumulate rich experience, so as to improve the quality of teaching. In addition, it can introduce outstanding talents, build an incentive system, and encourage them to participate in nature education.

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