Analysis of spatial pattern and exploration of influencing factors of traditional villages in Guangxi based on GIS

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Abstract: Taking 161 national-level traditional villages in Guangxi as the research object, while taking Google geographic information system and ARCGIS10.2 as the technical platform, the spatial distribution characteristics and influencing factors of traditional villages were studied by combining various data sources. Results show that: The spatial distribution of traditional villages in Guangxi is obviously clustered, which mainly in Guilin, Hezhou and Liuzhou; The geographical distribution of traditional villages is affected by natural, economic and cultural factors. At last, the protection strategy to promote the whole traditional village system has been put forward.

Overview of the study region

Guangxi Zhuang autonomous region, located in the southern border of the motherland, is one of China's five ethnic autonomous regions. With continuous mountains, huge mountains, and alternating mountains and valleys, the autonomous region is surrounded by mountains and plateaus around, and hilly flat lands in the middle and south, which is like a basin, known as "Guangxi basin" [1].

Since the list of state-level traditional villages was published, 161 villages in Guangxi have been included. However, at present, most scholars' researches on traditional villages in Guangxi mainly focus on the Zhuang region, focusing on the analysis of architectural forms, with few studies on the spatial pattern of traditional villages in the whole territory of Guangxi. Therefore, studying the spatial pattern and influencing factors of these traditional villages can help planners to strengthen the understanding of traditional villages in guangxi, understand the development of traditional villages in guangxi, thus providing reference for the protection and development.

Research methods and data sources

In this paper, through the construction of ArcGIS platform to coordinate, sort out and analyze the data of traditional villages in Guangxi, finding out the distribution rules of traditional villages in Guangxi while exploring the influence of multiple factors on their distribution.

A total of 161 traditional villages in Guangxi from the first to the fourth batch were selected as research objects of the database samples. Using Google geographic information system (GoodyGIS-Ver13.07.17) combined with Baidu map, the geographical coordinates of traditional villages in Guangxi and the elevation of the village site were determined. Based on DEM vector map of Guangxi Zhuang autonomous region obtained from national 1:500,000 basic geographic information database as the base map, a sample database of traditional village space in Guangxi was established through ARCGIS10.2 technology platform to determine the research sample.
Geographical spatial distribution features

Spatial distribution types

On the macro level, traditional villages can be abstracted as point features in space, and point elements have three spatial distribution types: random, uniform and clustered. The nearest neighbor ratio represents the spatial distribution characteristics of point things, which is also a geographical indicator of the degree of mutual proximity of point things [2]. The nearest neighbor ratio R is the ratio between the actual nearest neighbor distance and the theoretical nearest neighbor distance:

\[ R = \frac{\bar{r}}{r_e} = 2\sqrt{\frac{E_r}{E_e}} \]

When \( R = 1 \), that is, \( \bar{r} = r_e \), presents random pattern distribution; When \( R > 1 \), that is, \( \bar{r} > r_e \), tends to be uniformly distributed; When \( R < 1 \), that is, \( \bar{r} < r_e \), tends to be gathering distributed.

Using average nearest neighbor in Arcgis10.2 spatial statistics tools to make statistics, combined with Euclidean-distance calculation method, concluding that the ratio R (nearest neighbor ratio) between the observed mean distance and the expected mean distance in the distribution of traditional villages in Guangxi is 0.49, while the Z score is -12.35, with the significance level \( p < 0.01 \), indicating that traditional villages in Guangxi have a distinct tendency of aggregation in space.

Equilibrium of spatial distribution

Geographical concentration index is an important index to measure the concentration degree of research object, which is used to measure the spatial distribution of traditional villages in the city scale of Guangxi region in this paper:

\[ G = 100 \left( \frac{\sum_{i=1}^{n} \left( \frac{X_i}{T} \right)^2}{n} \right) \]

In which, G represents the geographical concentration index of traditional villages, \( X_i \) represents the number of traditional villages in the i-th city of Guangxi, \( T \) represents the total number of traditional villages in urban areas, and \( n \) represents the total number of urban areas. Assuming that \( G_0 \) represents the geographical concentration index when the average distribution of traditional villages is distributed in each city. If \( G > G_0 \), indicates the centralized distribution of traditional villages, otherwise, it indicates the scattered distribution of traditional villages[3].

It’s concluded that the geographical concentration index \( G = 57.53 \) and the theoretical geographical concentration index \( G_0 = 26.73 \) in the Guangxi region. \( G > G_0 \) indicates that the distribution of traditional villages tends to be concentrated at the municipal scale, mainly in Guilin, Hezhou and Liuzhou.

Density of spatial distribution

In order to reflect the geographical spatial distribution characteristics of traditional villages in Guangxi more intuitively, in this paper, the spatial distribution pattern of traditional villages in Guangxi was analyzed by using kernel density estimation method, while the density map of traditional villages in Guangxi was drew by using ArcGIS10.2.

The kernel density estimation method assumes that geographical events can occur at any place in space, the probability of occurrence in a point dense area is high, and the probability of occurrence in a point sparse area is low[4]. According to the probability theory, the kernel density estimation is defined as: point set \( X_1, ..., X_n \) is set to the sample extracted from the distribution density function f, and the value of the kernel density estimation f at some point x is \( f(x) \). The expression is:
In the formula, $k(x-X_i)$ is called kernel function; $h$ represents the bandwidth, and $h>0$; $(x-X_i)$ represents the distance between the valuation point $x$ and the event $X_i$. Kernel density was estimated using kernel density tool integrated in spatial analyst of Arcgis10.2. In order to reflect the distribution characteristics of different spatial scales of traditional villages in Guangxi, search radius was selected to be 60km after multiple tests, and the nuclear density distribution map of traditional villages in Guangxi was generated (FIG. 1).

$$f_n(x) = \frac{1}{nh} \sum_{i=1}^{n} k\left(\frac{x-X_i}{h}\right)$$

In the formula, $k(x-X_i/h)$ is called kernel function; $h$ represents the bandwidth, and $h>0$; $(x-X_i)$ represents the distance between the valuation point $x$ and the event $X_i$. Kernel density was estimated using kernel density tool integrated in spatial analyst of Arcgis10.2. In order to reflect the distribution characteristics of different spatial scales of traditional villages in Guangxi, search radius was selected to be 60km after multiple tests, and the nuclear density distribution map of traditional villages in Guangxi was generated (FIG. 1).

Fig. 1 Nuclear density distribution map of traditional villages in Guangxi Zhuang autonomous region
(Source: self-drawing)

Analysis of influencing factors of the distribution of traditional villages

Natural environment factors

In terms of natural environment factors, this paper studies the relationship between topography and traditional village location.

Study sample statistics, the number of villages built on mountains and hills was 91, accounting for 57% of the total, while the number of villages on the plain was 70, accounting for 43 percent of the sample. According to the data statistics and spatial distribution characteristics, the number of villages in mountainous areas and plain areas is relatively balanced.

The reason is that in mountainous areas, as ancestors invented terraces to expand cultivated land, the problem of sparse cultivated land in hilly areas was solved, and many traditional villages could be built according to the mountain. For example, there were 20 traditional villages in Longsheng ethnic autonomous county of Guilin, forming alpine village cluster. In the plain area, the terrain is flat, the soil is fertile, the sunlight is abundant, the heat resource is very rich, very suitable for the growth of crops.

Economic factors

The total GDP and per capita annual income reflect the economic vitality of traditional villages, which is also the basis of village development. There are 85 traditional villages whose annual per capita income is less than 6000 yuan, accounting for 72% of the total sample; while 34 traditional villages with an annual per capita income of more than 6,000 yuan, accounting for 28 percent of the total sample. Most traditional villages are located in regions, with low urbanization level and backward economic development, of which significantly lower economic level than the average level of the region.

In northern Guiyang, more traditional villages have higher annual per capita income and higher...
economic foundation, enabling ordinary people to repair ancestral halls and ancestral houses in villages. The government also has more resources and the economy to protect and develop traditional villages; In contrast, there are also many traditional villages in the economically backward Guidong region, where the local ecological environment is superior, but the economic strength is weak, and the urbanization process is slow, making the human-land relationship more stable, which is an important reason for the preservation of traditional villages.

**Cultural factors**

The statistical results show that there were 31 traditional villages before the yuan dynasty, accounting for 21% of the sample number, while 109 villages in the Ming and Qing dynasties, accounting for 75% of the total sample. Before the yuan dynasty, the number of villages in the republic of China was far less than that in the Ming and Qing dynasties.

As a political system and an economic system, the chieftain system forced the local people to move into the mountainous area, especially the minority ethnic groups such as Miao, Yao and Dong people. This, to a certain extent, prompted the Han people in the plain and hilly areas to further gather together, while the ethnic minorities moved into the deep mountains and further lived in the mountainous areas. Just like the folk saying that "Han people and Zhuang people live on the plain, Yao people and dong people live on the foot of the mountain, Miao people live on the mountainside, and Yao people live on the top of the mountain" [6]. Because of this, more traditional villages exist in the deep mountain area of north GUI.

**Conclusion and protection strategy**

**Conclusion**

By constructing the spatial pattern database of traditional villages in Guangxi, the spatial pattern of traditional villages in Guangxi is analyzed. The main conclusions of this paper are as follows:

I. The spatial distribution type of traditional villages in Guangxi is agglomerate; From the perspective of city scale, traditional villages are mainly concentrated in Guilin, Hezhou and Liuzhou; In addition, Guangxi's national traditional villages have formed a high density area in Guilin, Liuzhou and Hezhou, and a secondary high density area in Nanning, Qinzhou and Beihai.

II. The spatial distribution of traditional villages in Guangxi is influenced by natural environment, social economy and historical culture. There are many traditional villages in
mountainous area and plain area; The distribution of traditional villages tends to be concentrated in economically backward cities or economically developed cities; There are also many traditional villages in regions with long history and ethnic characteristics.

**Protection strategies for traditional villages**

In the protection of traditional villages, it should be noted that this is an integral dynamic process, and the historical and cultural heritage of traditional villages is inseparable from its surrounding environment.

The spatial distribution characteristics of traditional villages have obvious coupling relations with natural, economic and cultural factors. Many traditional villages are close to each other geographically, and their cultural attributes are mostly similar or closely related. The long-term interaction between the communities of these traditional villages and their dependent regional environment forms a relatively stable cultural system in large regions. So, to some traditional villages that have complex cultural ties on a wide range, can't just rely on a single village planning, but needs to be based on geographical spatial differences in the traditional villages, giving full consideration to the process of formation and development of traditional villages natural characteristics and economic and social environment, to delimit the traditional village area under different factor unity, so as to formulate the traditional village "community" protection planning and effective implementation.

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