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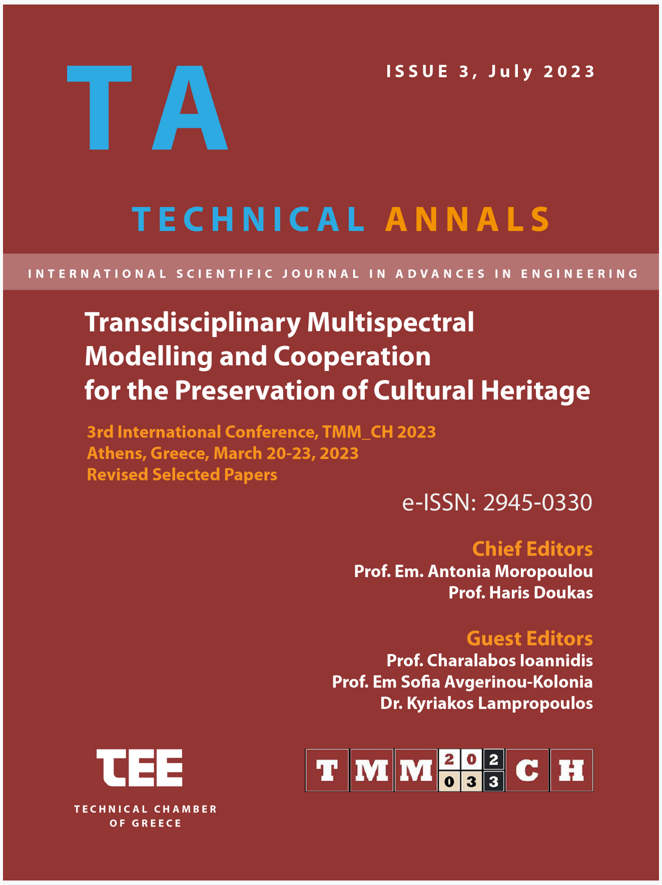

The Analysis of the Spatial Distribution of Traditional Villages in Guizhou

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Analysis of the Spatial Distribution of Traditional Villages in Guizhou

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Abstract. Guizhou's traditional villages are gradually disappearing as rural urbanization accelerates. However, there has been little in-depth research into how village dwellers are coping with spatial changes caused by resource relocation and modernization. Prior to that, it is critical to determine the villages' distribution characteristics and geographic features. This study focuses on the spatial distribution characteristics of Guizhou traditional villages using the software ArcGIS. The findings show that (1) Guizhou Province's traditional village distribution is "dual-core" intensive. (2) The topography of Guizhou Province is characterized by a "high in the west, low in the east" trend. In Guizhou Province's western and central zones, there are very few traditional villages with higher altitudes beyond Anshun City. (3) The slope analysis of this study shows that the slope of these two regions, Qiandongnan and Tongren with densely populated villages, are diametrically opposed.

Keywords: Distribution Characteristics, Geographic Features, Traditional Villages, ArcGIS.

1 Introduction

Chinese traditional villages, previously known as ancient villages, are villages built earlier than the founding of the Republic of China. The customary declaration "ancient village" was changed to "traditional village" in September 2012 by the decision of the first meeting of the Traditional Village Protection and Development Expert Committee. Traditional villages are the most meaningful legacy of Chinese farming civilization, containing rich historical information and cultural landscapes.

As a consequence, village research projects centered on revitalization, development, and cultural inheritance have emerged as a prominent theme. Simultaneously, with the strengthening of the research, theories from other related disciplines, such as history, anthropology, sociology, and so on, began to be incorporated into village research. This was especially true in Guizhou province. With the discovery of more traditional villages, there is one issue we must consider and resolve: the majority of traditional villages in Guizhou are located in the mountains, which has some drawbacks. For instance, education and medical facilities are insufficient, economic conditions are subpar, and population loss is severe. The ultimate source of these flaws is the fact that village space design is unacceptably comprehensive.

Since then, this paper has used ArcGIS as a research tool to analyze and summarize the spatial distribution characteristics and geographic features of traditional villages in Guizhou. Meanwhile, it can serve as the foundation for proposing a widespread spatial optimization design strategy for Guizhou traditional villages and laying the groundwork for future research on Guizhou traditional villages.

2 The State of the Art

The phrase "village" was derived from the Latin word "villa" in the 15th century. It is a community made up of a cluster of houses that is larger than a hamlet but smaller than a town. It is occasionally termed as "rural area" or "rural settlement" in research. Griffith Taylor published *Urban Geography* in 1949, which outlined typical settlements on each of the seven continents as well as their size and pattern changes[1]. This is a more in-depth book on villages around the world than previous studies. At the same time, there were other books published that provided more detailed information about villages.In 1963, Maretzki explained the Taira's development history in terms of economy, politics, religion, education, and social organization[2]. Lewis also established a typical life cycle in Tepoztlan, with the basis of village history and other specifications[3]. With the proliferation of information, basic research in the village became densely packed, and it progressed to the stage of classification and comparison. In order to achieve astable development, a portion of the research conducted classification studies on village population[4], residence scale[5], cultivated landmass[6], and so on. Studies also compared the differences between several villages with similar characteristics to investigate the reasons for the formation[7]. Village research has also advanced rapidly as a result of the advancement of computer technology. Scholars began to investigate the village's cultural characteristics from the viewpoints of cultural protection[8], tourism development[9], and spatial layout[10], as well as the village's environmental characteristics from the perspectives of architectural soundscape[11], light environment[12], and thermal environment[13].

The term "Chinese traditional villages" was coined around this time. The majority of these villages have kept their original architectural and spatial patterns. Every traditional village has a unique feature due to geographical and cultural differences. For example, villages in Fujian have Hakka buildings [14], while villages on the Loess Plateau have cave dwellings[15] and villages in Guizhou have stilted buildings[16]. The study of traditional villages in Guizhou began when the academic community became interested in this topic in general. However, because of the complex terrain, research was more difficult, and subsequent development was slower than in other regions. Guizhou is the site of numerous ethnic festivals, each having its own cultural connotations and presentation style. Using the Guizhou Miao Sisters' Festival as an example, early research focused on the festival process[17] and clothing characteristics[18]; the festival's development history[19] and social value[20] were gradually recognized in the subsequent period; after the simplicity of public transit and the emergence of tourism, studies on the festival's impact can be separated into music[21], handicrafts[22], and economy[23], etc. Rural development study is concerned relatively late, and the theoretical level was primarily focused on the assessment of the spatial distribution of traditional villages in Guizhou, specifically on various spatial attributes such as public space[24], indoor space[25], and cultural space[26]. The findings of interdisciplinary research are based on the user's past[27], ongoing[28], and potential future[29] behavioral activities. Due to the huge large differences between individuals in Guizhou's traditional villages, there is still a relative lack of overall sorting and comparative research on them.

Spatial distribution is a dispersion of geographic observations that represent the values of a particular phenomenon's or characteristic's behavior across many locations on the Earth's surface[30]. It was first mentioned in geography research. It also can be used in various disciplines such as anthropology, economics, medicine, architecture, and so on. In *Anthropology, Space, and Geographic Information Systems*, Mark Aldenderfer discussed the concept of geographic information systems in relation to anthropological inquiry[31]. Combes and Overman investigated the spatial distribution of economic activities in the European Union in order to describe available data, present descriptive evidence, and consider the nature of agglomeration and dispersion[32]. Researchers monitor dengue vectors and viruses using satellite imagery and statistical models in the paper *Dengue vectors and their spatial distribution*[33]. The village spatial distribution studies were conducted in various locations around the world, particularly in China[34] and other Asian countries[35]. Academics can evaluate the effects of spatial distribution from topographic factors[36], cultural features[37], and development direction[38] based on its characteristics. In the meantime, several methodologies can be used. Xu established the evaluation model using Geographical Detector and Absorbent Hygiene Product methods to provide a reference for the precise development and protection of minority villages[39]. In Greece, Sevenant used a geographical information system to investigate the relationship between settlement patterns, land use zoning, and landscape visibility[40]. Carrão evaluated the relative usefulness of MODIS imagery data with high spectral and temporal resolutions for land cover classification[41].

Existing studies provide a solid foundation for the subsequent stage, although there are some inconsistencies. To begin with, when compared to other plains provinces, Guizhou Province has more distinct village characteristics and relatively more basic research but does not previously emphasize the advantages of its terrain. Second, increased research data allows for more precise analysis results. A total of 1352 new villages were added to the traditional village lists of the sixth batch, which was announced in 2022. Guizhou Province has 33 new ones, the majority of which are in Anshun. At the same time, the findings of this study should be generalizable enough to assist governments at all levels in allocating resources wisely.

3 Research Material

3.1 Overview of the Study Area

Guizhou Province (103°36′ E-109°35′ E, 24°37′ N-29°13′ N) is in the southwest part of China (see Fig. 1). The land area is 176,167 square kilometers, accounting for 1.8% of the total in the country. Guizhou Province is located in the Yunnan-Guizhou Plateau's eastern region. The province's landforms can be broadly classified into three types: plateau mountains, hills, and basins, with mountains and hills accounting for 92.5% of the total area.From the first batch to the present, the total number of Chinese traditional villages is 8171. Guizhou has 757 traditional villages (see Fig. 1), ranking second in China, with Yunnan province having the most. Qiandongnan prefecture ranks first in Guizhou province for the number of traditional villages, and Table 1 shows the statistics on the number of traditional Chinese villages in Guizhou.

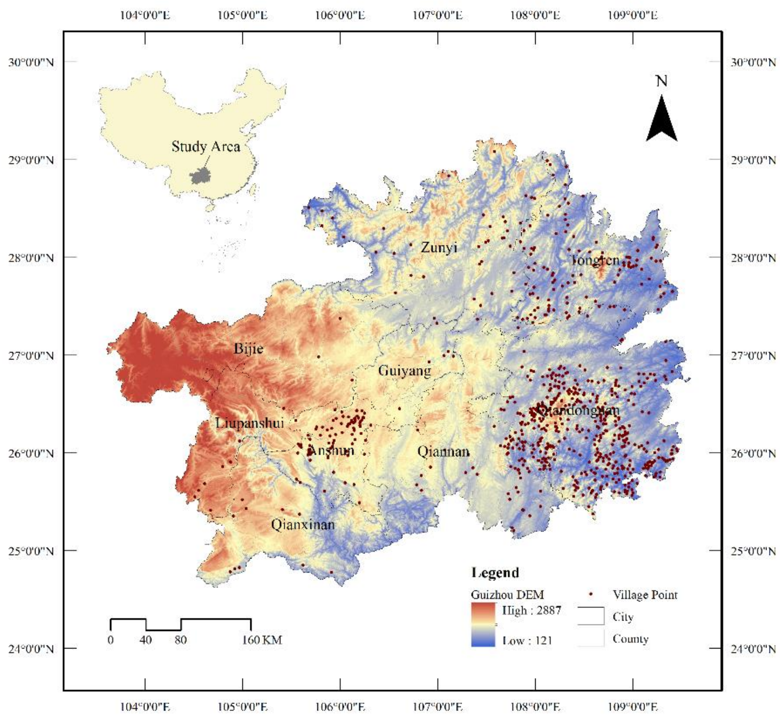

Fig. 1. Location of Guizhou province and 757 traditional villages, and Guizhou digital elevation model (DEM).

Table 1. Statistics on the number of traditional Chinese villages in batches 1-6 of each city in Guizhou Province.

Batches	Qian dong nan	Tong ren	An shun	Qian nan	Zun yi	Liu pan shui	Qian xi nan	Gui yang	Bi jie	Total
1	60	12	4	7	3	-	1	3	-	90
2	165	29	3	1	3	-	-	-	1	202
3	51	33	27	8	7	5	3	-	-	134
4	33	25	22	20	12	4	3	-	-	119
5	100	11	11	32	14	1	4	4	2	179
6	6	4	11	10	1	1	-	-	-	33
Total	415	114	78	78	40	11	11	7	3	757

3.2 Data Sources

The subjects of this study are 757 traditional villages at the national level in Guizhou province, with data sourced from the Traditional Chinese Villages Digital Museum (http://www.dmctv.cn, sourced on December 15, 2022). To facilitate research, villages can be decimated into points from a macro perspective. The geographic information database of traditional villages in Guizhou was created using ArcMap 10.8 after counting the latitude and longitude information of the villages. It also contains Guizhou digital elevation model (DEM) data from Geospatial Data Cloud (http://www.gscloud.cn, accessed on December 18, 2022) and Guizhou province boundary data from National Catalogue Service For Geographic Information (http://www.webmap.cn, accessed on December 18, 2022).

4 Methodology

4.1 Average Nearest Neighbor Analysis

In ArcGIS, the average nearest neighbor tool calculates the nearest neighbor index based on the average distance between each feature and its nearest neighboring feature. The following are the formulas:

$$R = \frac{D_O}{D_E} \tag{1}$$

$$D_O = \frac{1}{n} \times \sum_{i=1}^{n} d_i \tag{2}$$

$$D_E = \frac{0.5}{\sqrt{n/A}} \tag{3}$$

Where R is the average nearest neighbor, D_O is the observed mean distance between each feature and its nearest neighbor, and D_E is the expected mean distance for the features given in a random pattern. And where n is the total number of research objects, d_i is the nearest neighbor distance for point i, A is the area for research scope. When $R = 1$, traditional villages are randomly distributed throughout space; when $R < 1$ traditional villages tend to cluster spatially; and when $R > 1$ traditional villages are uniformly distributed spatially.

4.2 Thiessen Polygons Analysis

There is only one point input feature in each Thiessen polygon (Voronoi diagram). The location of a Thiessen polygon is closer to its associated point than any other point input feature. Since then, Guizhou traditional village points' distribution can be assessed. Following the GIS analysis, Excel can be used to calculate the coefficient of variation(C_V), which is the ratio of the graphic standard deviation to the mean deviation. The following is the formula:

$$C_V = \frac{R}{S} \times 100\% \tag{4}$$

Where R is the graphic standard deviation, and S is the graphic mean deviation. When $C_V < 33\%$, traditional villages are evenly distributed; when $33\% < C_V < 64\%$ it means that traditional villages are randomly distributed; when $C_V > 64\%$, it means that traditional villages are clustered and distributed.

4.3 Kernel Density Analysis

Kernel density analysis is a non-parametric method for estimating a random variable's probability density function using kernels as weights. It can assist in evaluating the spatial distribution characteristics from the perspective of the overall scope of research, and it can be more intuitive to discover the unique layout of traditional villages in Guizhou. The formula is as follows:

$$f(x) = \frac{1}{nh}\sum_{i=1}^{n} k\left(\frac{x - x_i}{h}\right) \tag{5}$$

Where n is the total number of traditional villages in Guizhou, h is the search radius for research scope, $k(\ )$ is the kernel smoothing function, and x_i is a random sample from an unknown distribution. The higher the kernel density, the more traditional villages per unit area, and the denser the distribution. The lower the kernel density, the fewer traditional villages per unit area, and the distribution is dispersed.

5 Result and Discussion

5.1 Guizhou Traditional Villages Distribution Characters

From an overall perspective. In ArcMap 10.8, the average nearest neighbor tool can be used to justify distribution type based on the latitude and longitude of the points. The final output of it returns five values: Observed Mean Distance (D_O), Expected Mean Distance(D_E), Nearest Neighbor Index (R), z-score (standard deviation), and p-value (probability). Its output (see Fig. 2) indicates that this result cannot be shown randomly due to $z < -2.58$ and $p < 0.01$. In the meantime, $R \approx 0.68 < 1$ implies that the distribution of Guizhou traditional villages is clustered. This finding also provided evidence for the next steps.

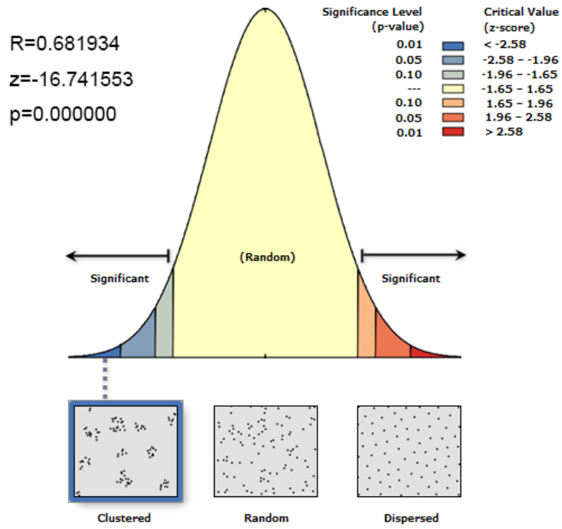

Fig. 2. Average nearest neighbor index of Guizhou traditional villages.

From a regional perspective. The tool of Thiessen polygons analysis can show the distribution from the regional level through the Voronoi diagram (see Fig. 3). The figure illustrates that graphics distribution in Qiandongnan and Anshun is highly imploded, whereas it in Tongren is relatively uniform. Although there are fewer villages in Anshun than in Qiandongnan, they are more inextricably distributed and have the highest C_V when combined with Table 2. However, in Guiyang, Qianxinan, and Bijie, their C_V is less than 64%, and the distribution of villages is more random. As a result, when selecting specific case studies in the future, traditional villages in these three cities should be avoided.

Table 2. Statistics on C_V of traditional villages in Guizhou Province.

City	Graphic Standard Deviation(km²)	Graphic Mean Deviation (km²)	Cv (%)
Bijie	2148.5556	5221.5499	41.15
Qianxinan	522.3809	1188.0009	43.97
Guiyang	1001.9074	1593.8608	62.86
Tongren	143.0454	187.3407	76.36
Zunyi	661.0724	801.3753	82.49
Liupanshui	3441.2394	2066.5219	166.52
Qiannan	376.3887	222.0990	169.47
Qiandongnan	127.6533	73.6184	173.40
Anshun	465.8271	213.0041	218.69

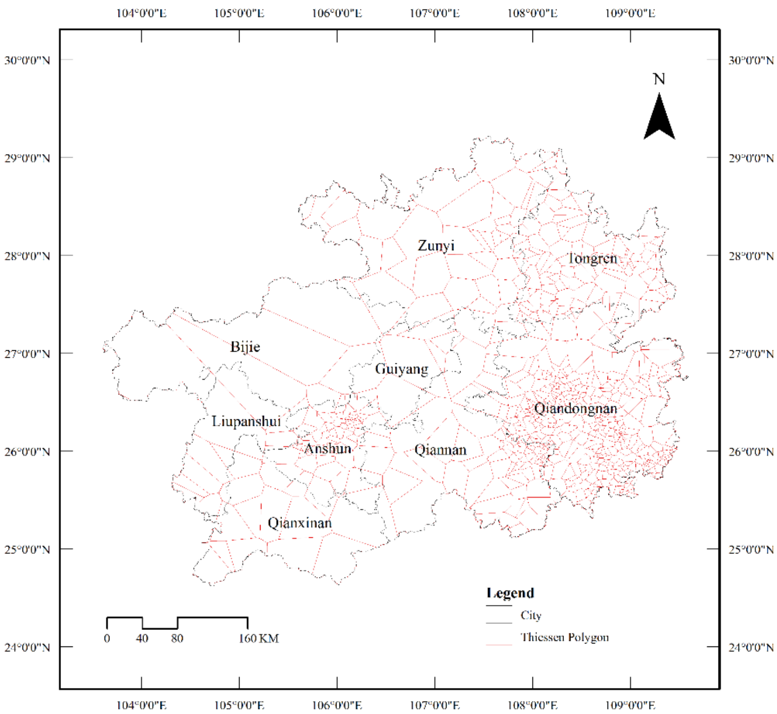

Fig. 3. Thiessen polygons analysis of Guizhou traditional villages.

From the villages' density perspective. TheKernel density analysis tool is used for analyzing the distribution density of all these village points in Guizhou. The outcome shows (see Fig. 4) that traditional villages in Guizhou are densely distributed in a "dual-core" pattern. To come up with, it is a concentrated area, with Qiandongnan prefecture at its heart. It has the most number of traditional villages in Guizhou Province, with 415, far outnumbering other cities. The second sub-core agglomeration area is Anshun. Despite having 78 traditional villages and ranking third in Guizhou Province, Anshun's distribution is denser when compared to Tongren City (ranked second) and Qiannan prefecture (tied for third). Furthermore, the distribution of Tongren City is relatively dense in other regions.

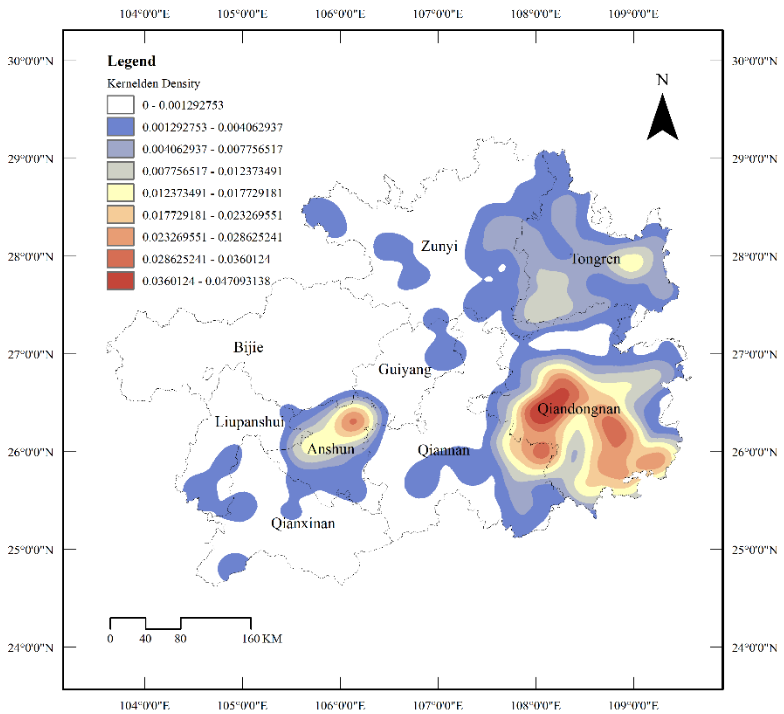

Fig. 4. Kernel density analysis of Guizhou traditional villages.

5.2 Guizhou Traditional Villages Geographic Features

About altitude. From the DEM of Guizhou province (see Fig. 1), it is easy to find that the topography of Guizhou Province exhibits a "high in the west and low in the east" trend. The western part of Guizhou sits on the Yunnan-Guizhou Plateau, with a maximum elevation of 2887 meters. Beyond Anshun City, there are very few traditional villages with higher altitudes in Guizhou Province's western and central zones. The eastern section is lower in average altitude, with the lowest point being 121 meters. Local high-altitude areas have emerged in Qiandongnan and Tongren. Traditional villages in this area are dispersed outwards, with the high-altitude area serving as the focal point.

About slope and aspect. ArcMap 10.8 includes a 3D analysis tool that displays slope and aspect based on the DEM. The slope analysis (see Fig. 5) of this study shows that the slope of these two regions, Qiandongnan and Tongren with densely populated villages, are diametrically opposed. Qiandongnan has a comparatively high overall slope, whereas Anshun has a relatively low one. These two locations can be chosen for comparative study in the future to explore the possible impacts of the allocation. However, due to space constraints, the analysis results of the aspect do not have an obvious trend and will not be described in detail.

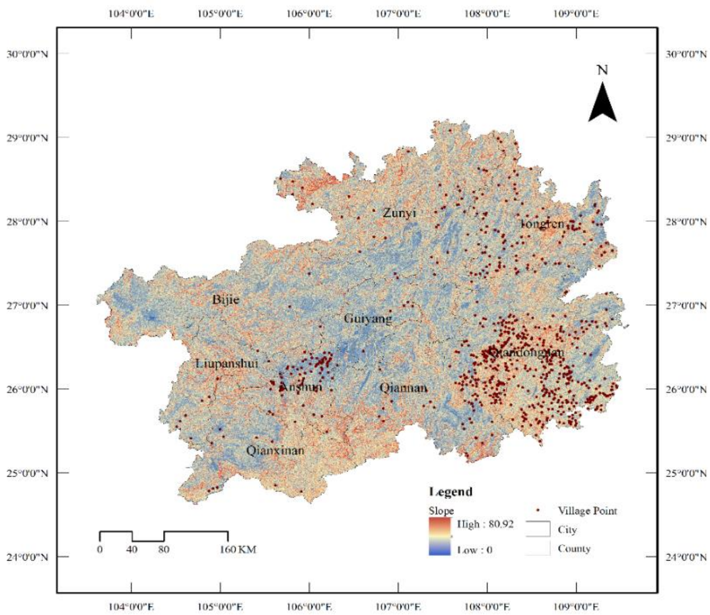

Fig. 5. Slope analysis of Guizhou traditional villages.

6 Conclusion

According to the observations of this project's analysis, the distribution of traditional villages in Guizhou Province is "dual-core" intensive. Traditional villages in

Qiandongnan prefecture are the most tightly distributed, with low altitude and high slope terrain characteristics; Anshun City is the second densest center, with a high altitude but a gentle slope; Tongren City has relatively more villages than the other cities, and the villages are relatively dense, with more gentle terrain features.

As a result, in the subsequent research, geographical factors and human factors, as well as other factors that affect the distribution of villages, should be combined and analyzed in an attempt to establish a scientific and reasonable consideration system for influencing factors, so that designers can propose design strategies corresponding to traditional villages in Guizhou.

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