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Characteristics of the Spatial Structure of Traditional Villages in the Xinjiang Uygur Autonomous Region in China and Their Influence Mechanisms

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Abstract: Traditional villages are one of the basic types of rural revitalisation and one of the important carriers of cultural inheritance. This research is based on the data of 53 traditional villages in the Xinjiang Uyghur Autonomous Region with the aid of the ArcGIS10.8.1 spatial analysis platform. The study identifies the spatial evolution characteristics from the spatial distribution type, distribution direction, distribution density, distribution balance, etc., and explores their influence mechanisms. The study shows that 1. the spatial structure of traditional villages in Xinjiang was analysed as a cohesive structure type by using the nearest neighbour index method, which shows the evolutionary characteristics of the agglomerative tendency to increase gradually. Among them, Changji Hui Autonomous Prefecture and Turpan City have the highest degree of concentration. 2. The establishment and development of traditional villages in Xinjiang is mainly influenced by natural factors such as geographical features and hydrography. Social factors such as population distribution, transport conditions and economic progression have very important implications for the preservation and continuation of traditional villages.

Keywords: traditional villages; distribution characteristics; protection value; Xinjiang

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1. Introduction

Traditional villages are repositories of the unique memories of the Chinese people, condensing the wisdom of the people's production and survival and the crystallisation of vernacular art [1]. Nowadays, with the rapid development and progress in the economy, the quality of life of Chinese nationals and the construction level of society have been greatly improved [2]. But in the meantime, with the swift progress in urban expansion and industrial progression, many rural workers have left the countryside to seek survival and development in the towns and cities. The massive transfer of people and labour to the cities has caused an impact on the old patterns of life in the traditional villages [3,4]. Traditional villages are facing the problems of ageing, conflict between preservation and progression and the disappearance of village culture [5–7].

In response to the problems facing traditional villages, the Chinese government has made many endeavours to protect the culture of traditional villages and established a Chinese traditional village protection list system in 2012. The implementation of the system has strengthened the conservation of traditional villages and brought them to the centre of attention, allowing more people to engage in the conservation of traditional villages. Traditional villages are not only the carrier of many people's memories and their spiritual home, but also an important part of cultural heritage [8]. The study of traditional villages is of far-reaching significance, because it is only through the preservation of traditional villages that the culture of villages can be continued and their development promoted.

With the growing awareness of traditional village preservation, the field of traditional villages as a research area is receiving more and more attention from scholars from all walks of life. The quantity of publications on the theme of traditional villages has been increasing. Many academics have researched the topic of traditional villages, sustainable development [9–12], spatial distribution [13–17], tourism development [18–21] and so on. Studies on the relationship between climate change and traditional villages have also been discussed and explained more specifically by some scholars, which favours anthropological and environmental protection perspectives. For example, Kumar, P., Kumar, N., and Sarthi, P. P. have analysed the climate change experienced by the rural population of India and the adverse effects on the psychological well-being of the rural population [22].

On the whole, due to the late start of economic development in the Xinjiang Uygur Autonomous Region, the research conducted by scholars in China on its traditional villages has also been carried out relatively late. The number of research articles published on traditional villages in Xinjiang is relatively small. As of today, there are 53 traditional villages in Xinjiang among the six batches of traditional villages currently announced. In the first five batches, a total of 18 traditional villages in Xinjiang were approved. In the sixth batch and the latest announced, a total of 35 traditional villages in Xinjiang were approved. Although the number of traditional villages in Xinjiang does not compare favourably with that of other regions, they are still of great research value due to the huge distinctions in topography and the large number of national minorities in the region.

As an important hub of the ancient Silk Road, Xinjiang is an area where many ethnic groups migrated and gathered, and where many ethnic cultures coexisted. The close intermingling of cultures has further promoted the formation and development of traditional villages. The Xinjiang Uyghur Autonomous Region has a larger land area than any other province in China. Its terrain is complex and varied, with high mountains, basins, deserts, rivers, plateaus and other terrain [23]. In addition, the Xinjiang Uighur Autonomous Region is far from the ocean and deeply inland [24]. Precipitation is low and the climate is dry; Xinjiang has developed a typical temperate continental climate. The overall temperature difference in the local air temperature is large, and the sunshine is relatively abundant; the annual sunshine time can reach 2500 h to 3500 h. Precipitation varies greatly from region to region, with temperatures in the northern part of Xinjiang generally lower than the southern part of Xinjiang, while precipitation in the southern part of Xinjiang is lower than the northern part of Xinjiang [25]. As far as the conservation and development of traditional villages are concerned, there has also been less extensive excavation of their spatial distribution characteristics, and relatively few systematic studies on the influencing factors leading to their spatial distribution characteristics [26].The intention of this research is to identify spatial evolution features from the spatial distribution types, distribution direction, distribution density and distribution equilibrium and explore their influencing factors based on the data of traditional villages in the Xinjiang Uygur Autonomous Region. By using ArcGis10.8.1, this study analysed the scope of locations of traditional villages in Xinjiang (Figure 1) and explored different factors affecting the location features of the region under study. The intention is to offer more grounds for the preservation and the continuation of traditional villages in Xinjiang.

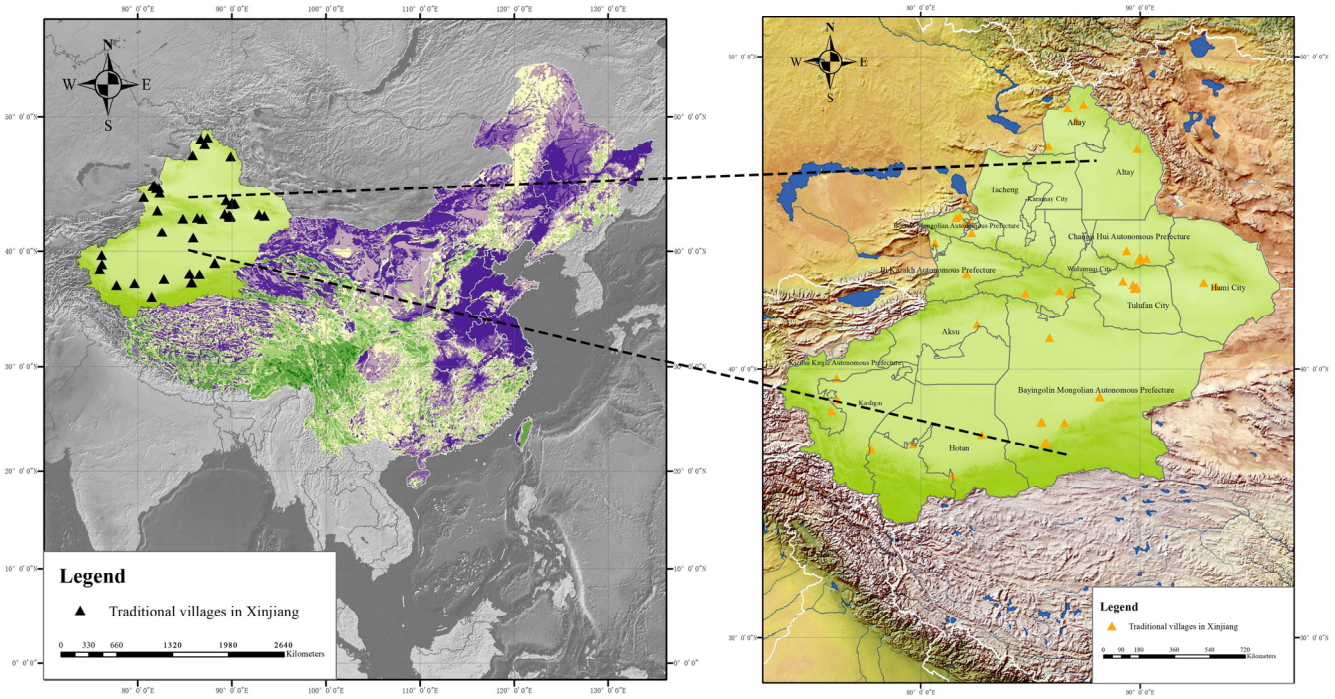

Figure 1. Scope map of Xinjiang Uygur Autonomous Region.

2. Sources of Data and Methods of Analysis

2.1. Scope Data Sources

The Chinese literature data source was obtained through the Knowledge Network, and the core journals in Web of Science were used as the English literature data source [27,28]. The data of traditional villages in Xinjiang come from the latest statistics of six batches of Chinese traditional villages and ancient villages across the country, in which traditional villages in Xinjiang accounted for a total of 53. The administrative maps of Xinjiang used for the analysis were obtained from the AliCloud data visualisation platform.

2.2. Data Processing Methods

The geospatial data of Xinjiang were obtained through the AliCloud data visualisation platform and the geospatial data cloud website. ArcGis 10.8.1 software was used to import the specific geographic location, topographic map and other information on traditional villages in Xinjiang. Combined with the information on the elevation, kernel density, slope and hydrography in the administrative region of the Xinjiang Uygur Autonomous Region, the analysis was carried out, and the final analysis results were obtained.

2.3. Study Methodology

2.3.1. Superposition Analysis Approach

The overlay analysis method is a kind of analysis method to overlay the elements of different layers, so as to analyse the new element layer. In this paper, the specific geographic location information of traditional villages in Xinjiang and local spatial data such as elevation maps, kernel density and hydrography were superimposed in ArcGis 10.8.1 software. Thereby, the association between the location characteristics of traditional villages in Xinjiang and elements such as the topography, slope and hydrography were analysed to derive the location features of traditional villages in Xinjiang as well as the factors influencing them.

2.3.2. Kernel Density Estimation Methods

Kernel Density Estimation (KDE) is one of the methods used to represent the density of spatial distribution in ArcGis 10.8.1, which is used to calculate the density of a given numeri-

cal probability. The kernel density analysis can facilitate the understanding of the clustering of data points and the relative concentration between spatial elements [29]. This approach can also be used for many aspects of visualisation processing and identification [30], using Formula (1):

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

Within the equation, $f(x)$ is the kernel density; $K()$ is the kernel function and h is the bandwidth; and $x - x_i$ denotes the distance from the point x to the point x_i.

2.3.3. Nearest Neighbour Index Method

The nearest neighbour index method is a geographical norm that analyses the spatial proximity between points. It is a method of determining the type of spatial dispersion of the object of study [31]. It can indicate the degree of mutual proximity between the study objects within a certain spatial range, thus illustrating the type of spatial distribution of traditional villages in Xinjiang. The formula is as follows (2):

$$R = \frac{R_0}{R_r} = \frac{R_0}{1/2\sqrt{n/A}} = 2R_0\sqrt{n/A} \quad (2)$$

Within the equation, if the calculation result $R < 1$, it shows a clustering model that exhibits convergent aggregation; if $R > 1$, it shows a dispersion model that tends to spread [32]. If $R = 1$, the point distribution is random.

2.3.4. Standard Deviation Ellipse Model

The standard deviation ellipse can reveal the overall characteristics of spatial distribution and migration trends of traditional villages in Xinjiang, which is one of the commonly used methods to analyse the directionality of the spatial distribution of point data, and has been widely used due to its intuition and effectiveness [33]. Its formula is as follows (3)–(5):

$$tan\theta = \frac{\left(\sum_{i=1}^{n} w_i^2\tilde{x}_i^2 - \sum_{i=1}^{n} w_i^2\tilde{y}_i^2\right) + \sqrt{\left(\sum_{i=1}^{n} w_i^2\tilde{x}_i^2 - \sum_{i}^{n} w_i^2\tilde{y}_1^2\right)^2 + 4\sum_{i=1}^{n} w_i^2\tilde{x}_i^2\tilde{y}_i^2}}{2\sum_{i=1}^{n} w_i^2\tilde{x}_i\tilde{y}_i^2} \quad (3)$$

$$\sigma_x = \sqrt{\frac{\sum_{i=1}^{n}\left(w_i\tilde{x}_i cos\theta - w_i\tilde{y}_i sin\theta\right)^2}{\sum_{i=1}^{n} w_i^2}} \quad (4)$$

$$\sigma_y = \sqrt{\frac{\sum_{i=1}^{n}\left(w_i\tilde{x}_i sin\theta - w_i\tilde{y}_i cos\theta\right)^2}{\sum_{i=1}^{n} w_i^2}} \quad (5)$$

Within the equation, the rotation angle is θ, and the standard deviations along the x and y axes are σ_x and σ_y, respectively.

3. Space Distribution Features

3.1. Geographic Distribution Features

By importing the distribution data of traditional villages in Xinjiang into ArcGis 10.8.1 software and analysing them with the topographic map of the Xinjiang Uyghur Autonomous Region, the geographic location characteristics of traditional villages in Xinjiang were derived (Figure 2). According to the geographical location distribution characteristics map, it can be observed that traditional villages in Xinjiang are situated in several directions including east, west, south and north, but they are not balanced.

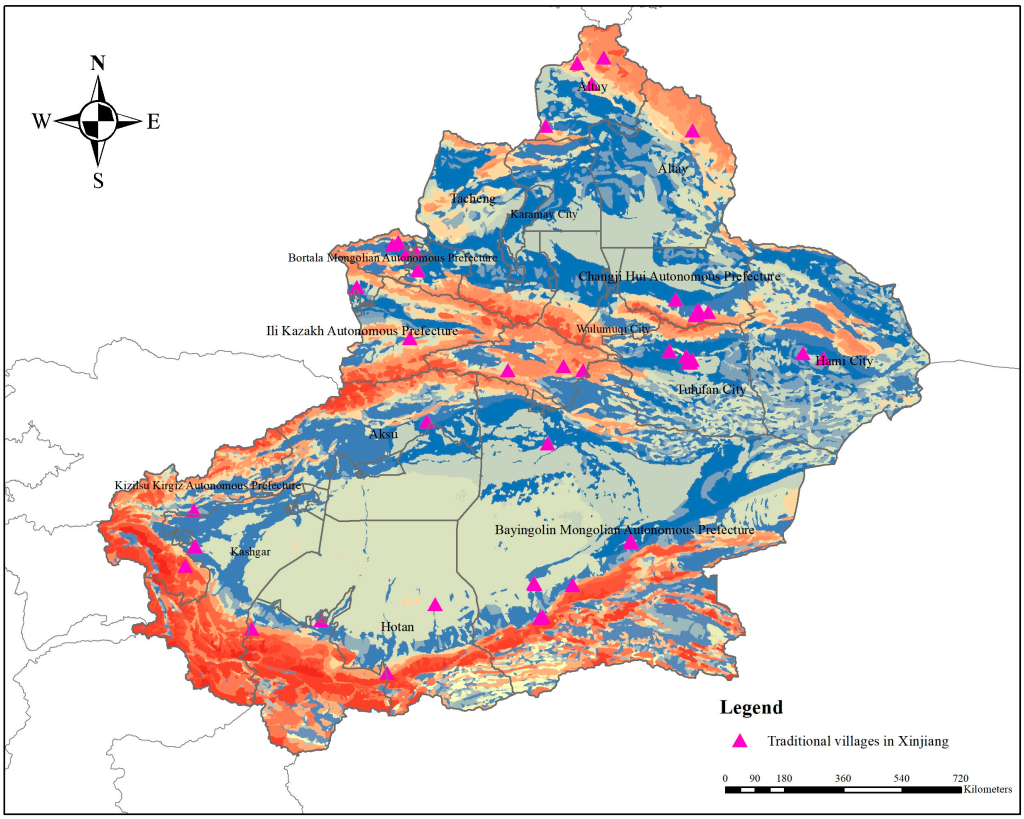

Figure 2. Location of traditional villages in Xinjiang.

Among them, traditional villages are more densely distributed in Bayingolin Mongolian Autonomous Prefecture, Tulufan City and Changji Hui Autonomous Prefecture, while traditional villages are less distributed in other cities and prefectures (Figure 3). Xinjiang is a quintessential drought region [34], with an inhomogeneous distribution of water resources [35] and an imbalance in the geographical location of traditional villages. And it is greatly influenced by topography, the natural environment and climatic conditions.

3.2. Kind of Spatial Distribution

The space distribution models of traditional villages within the Xinjiang Uygur Autonomous Region were analysed using the average nearest neighbour index analysis tool in ArcGis 10.8.1 software. According to the average nearest neighbour processing results (Figure 4), the index $R = 0.65$ for 53 traditional villages within Xinjiang was less than one. According to $R = 1$, $R > 1$ or $R < 1$, it can be classified into three pattern types, random, uniform and agglomerated [36], indicating that the observed elements belong to the agglomerated distribution pattern; the critical value z score and the significance level p value are used to determine whether the hypothesis is valid. The test parameter z-value and p-value are, respectively, −4.913254 and 0.000001, indicating that the probability that the distribution is randomly generated is extremely low. This shows that the traditional villages in Xinjiang are classified as the convergent distribution type.

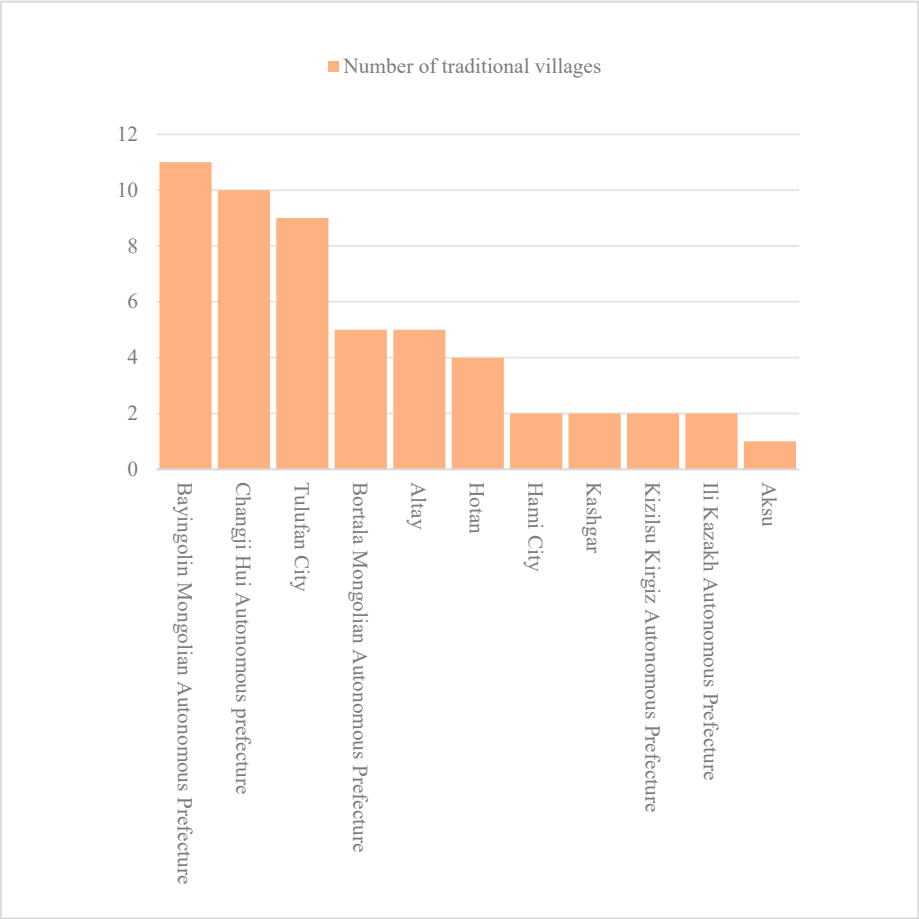

Figure 3. Distribution of the number of traditional villages in each region of Xinjiang.

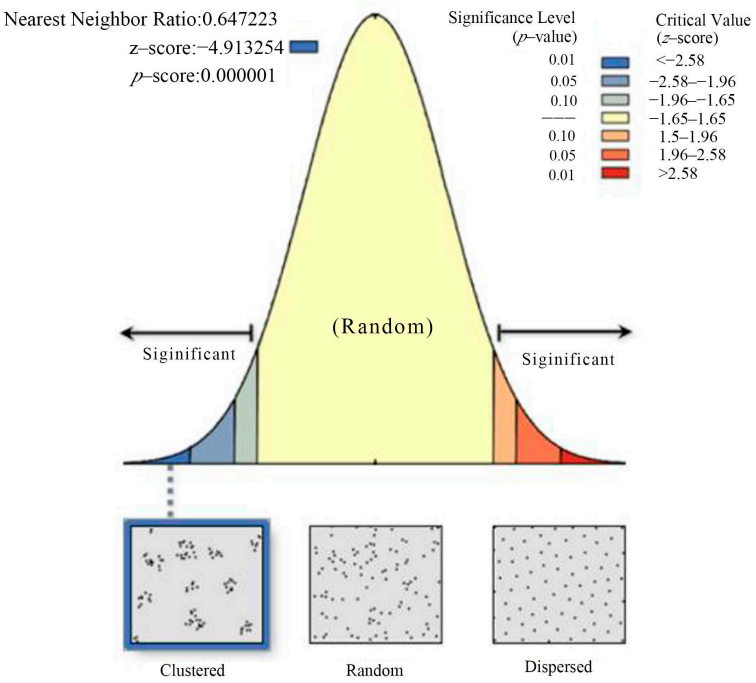

Figure 4. Nearest neighbour index analysis of traditional villages in Xinjiang.

3.3. Space Distribution Density

By using the method of kernel density analysis, the agglomeration core area and agglomeration influence area in Xinjiang were analysed. It can observe the distribution among different regions in Xinjiang more clearly. By using the ArcGis 10.8.1, the space distribution density of the 53 traditional villages in Xinjiang was processed to obtain the kernel density analysis map of traditional villages in Xinjiang.

The traditional villages in Xinjiang showed regional clustering distribution characteristics (Figure 5). Changji Hui Autonomous Prefecture and Tulufan City formed the core areas with the most concentrated distribution and the highest distribution density of traditional villages in Xinjiang, owing to their close proximity and the larger number of traditional villages. Although there are traditional villages in other areas, the relatively small number of traditional villages and their large distances from each other result in a low kernel density and do not make it possible to form areas with a high distribution density.

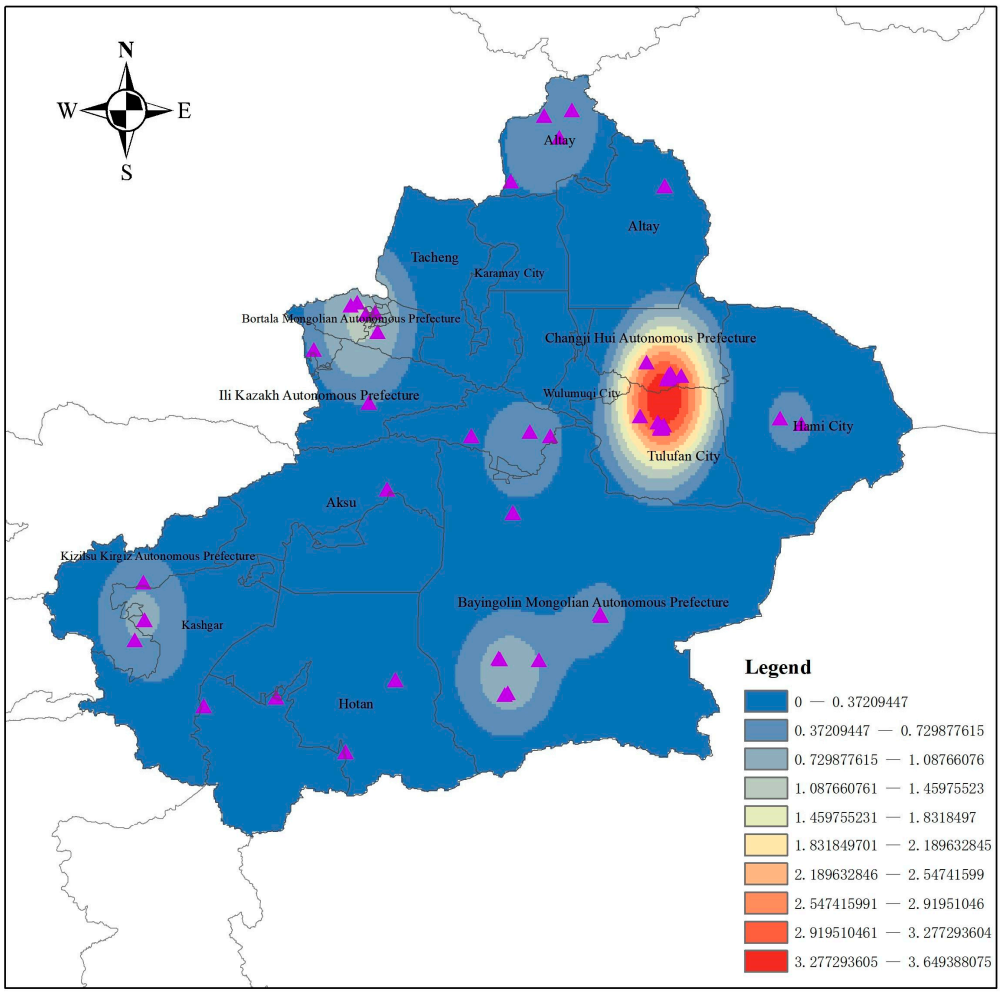

Figure 5. Kernel density analysis of traditional villages in Xinjiang.

3.4. Imbalance Index Analysis

The extent of the equilibrium between traditional villages in different parts of Xinjiang was expressed by using the imbalance index. According to the equation, using Excel to figure out and obtain the imbalance index s = 0.728 > 0 demonstrated that the distribution of traditional villages in Xinjiang is not balanced. According to the Lorenz curve of the areas where traditional villages are situated in Xinjiang (Figure 6), Bayingolin Mongolian Autonomous Prefecture, Changji Hui Autonomous Prefecture and Tulufan City are the locations of most of the traditional villages in Xinjiang. A total of 75% of the traditional

villages in Xinjiang are located in these places. On the other hand, there are no traditional villages in Wulumuqi City, Karamay City and Tacheng, reflecting the uneven distribution of traditional villages in Xinjiang.

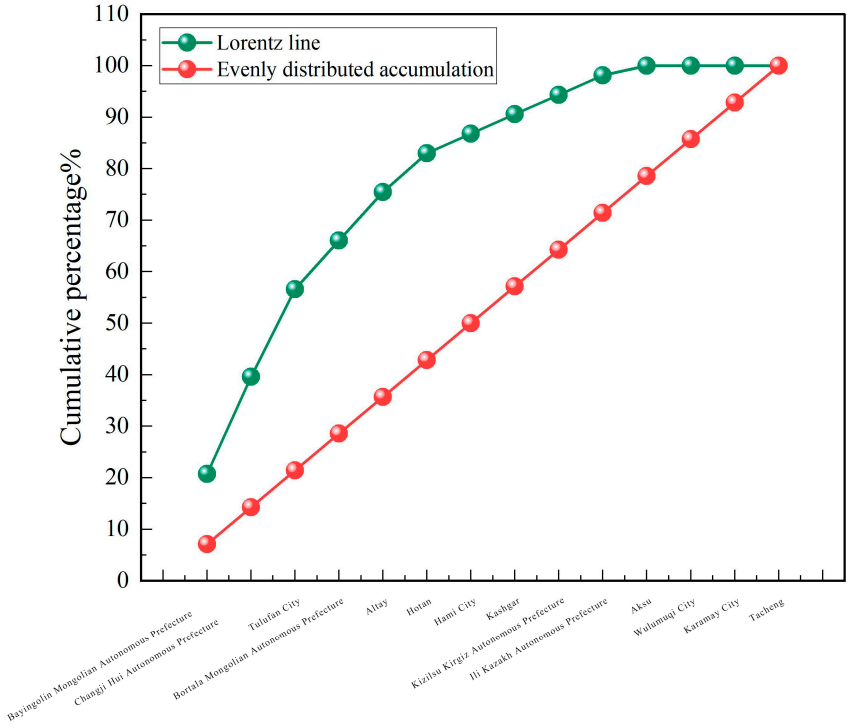

Figure 6. Lorentz curve of distribution of traditional villages in Xinjiang.

3.5. Spatial Directivity

The standard deviation ellipses can be used to analyse the direction of the centre of gravity migration in traditional villages [37]. Specifically for the research content of this paper, the main area of the standard deviation ellipse is the area of the spatial distribution of traditional villages in Xinjiang. Classifying traditional villages in Xinjiang according to dynasties, the historical record of some villages is unclear due to historical changes. As seen from the overall centre-of-mass ellipse distribution map (Figure 7), the distribution of traditional villages in Xinjiang shows a general spatial direction from northeast to southwest. The migration trajectory of the centre of gravity of traditional villages in Xinjiang goes from south to north, eventually returning to the centre of Xinjiang. Compared to the Yuan and Ming Dynasties, the distribution of traditional villages in the Qing Dynasty and later is denser, and the number of traditional villages has also increased. There is also a relationship between this and the historical policies of the time. For example, in order to consolidate its rule, the Qing government recruited a large number of rural workers from the mainland to move into Xinjiang. Different ethnic groups worked together to build water conservancies, reclaim wasteland and gather together to take root and live in the area, playing an important role in the social stability of Xinjiang. This has favoured the formation and development of traditional villages in Xinjiang and reflects the influence of historical factors on traditional villages.

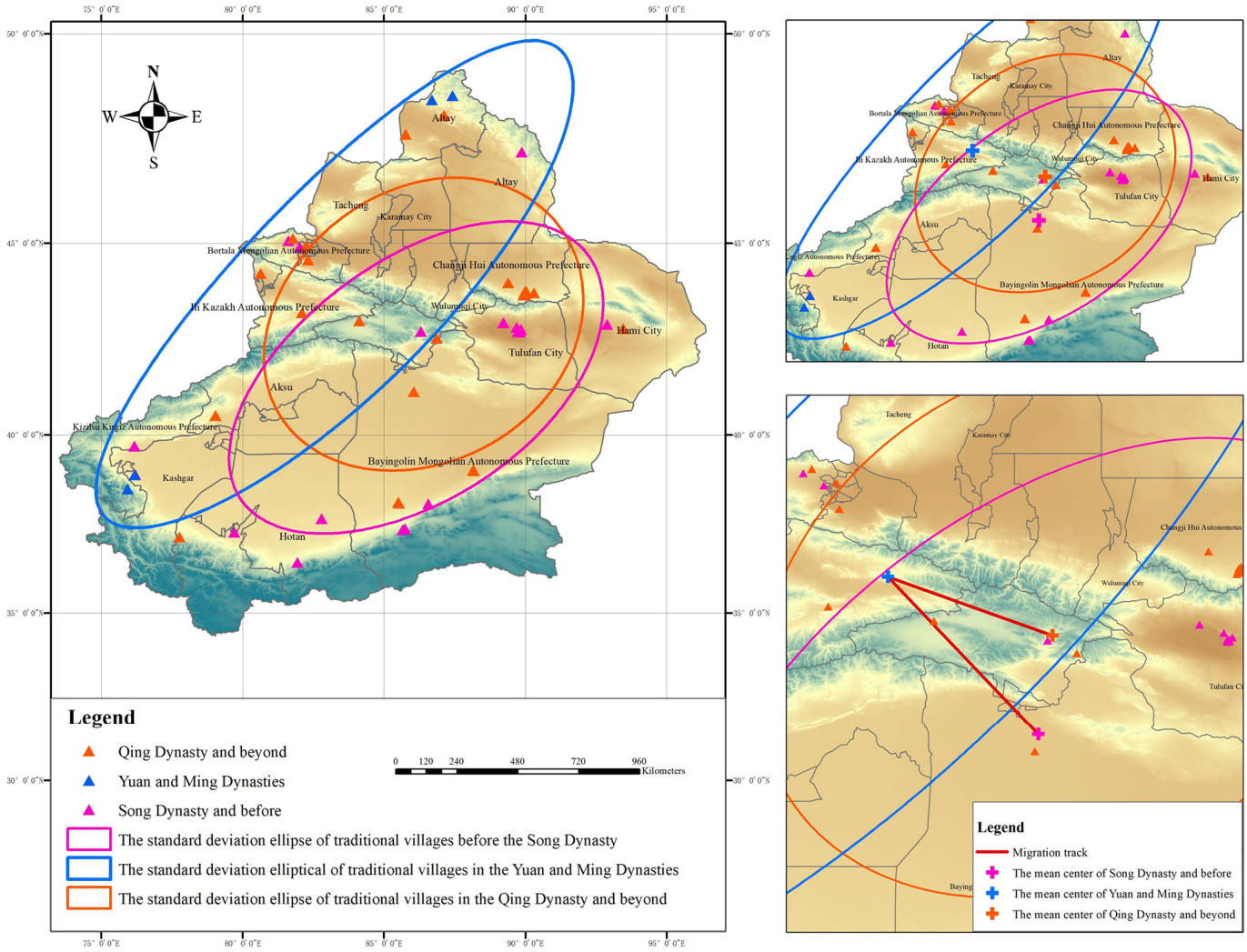

Figure 7. Standard deviation ellipse analysis of traditional villages.

4. Study on Impact Mechanisms

Natural geographic considerations have an impact on the location of traditional villages in Xinjiang. Different landforms, hydrological characteristics and climates may result in different agricultural production methods [38–40], which in turn will influence the locations of villages. The topography of Xinjiang is very complex, with high mountains, basins, deserts, rivers, plateaus and other terrain [41]. In addition, social factors also have an impact on the distribution of traditional villages in Xinjiang, and the following section analyses the influences on the location of traditional villages in Xinjiang from three aspects include topography, hydrography and social factors.

4.1. Factor of Topography

4.1.1. Elevation Factor

Elevation is one of the natural environmental factors affecting the location of traditional villages; it directly determines the topography in which the traditional villages of Xinjiang are located and influences their distribution locations [42]. In Xinjiang, there are large differences in altitude and the terrain is also complex [43]. These natural factors influence the location of traditional villages in Xinjiang (Figure 8).

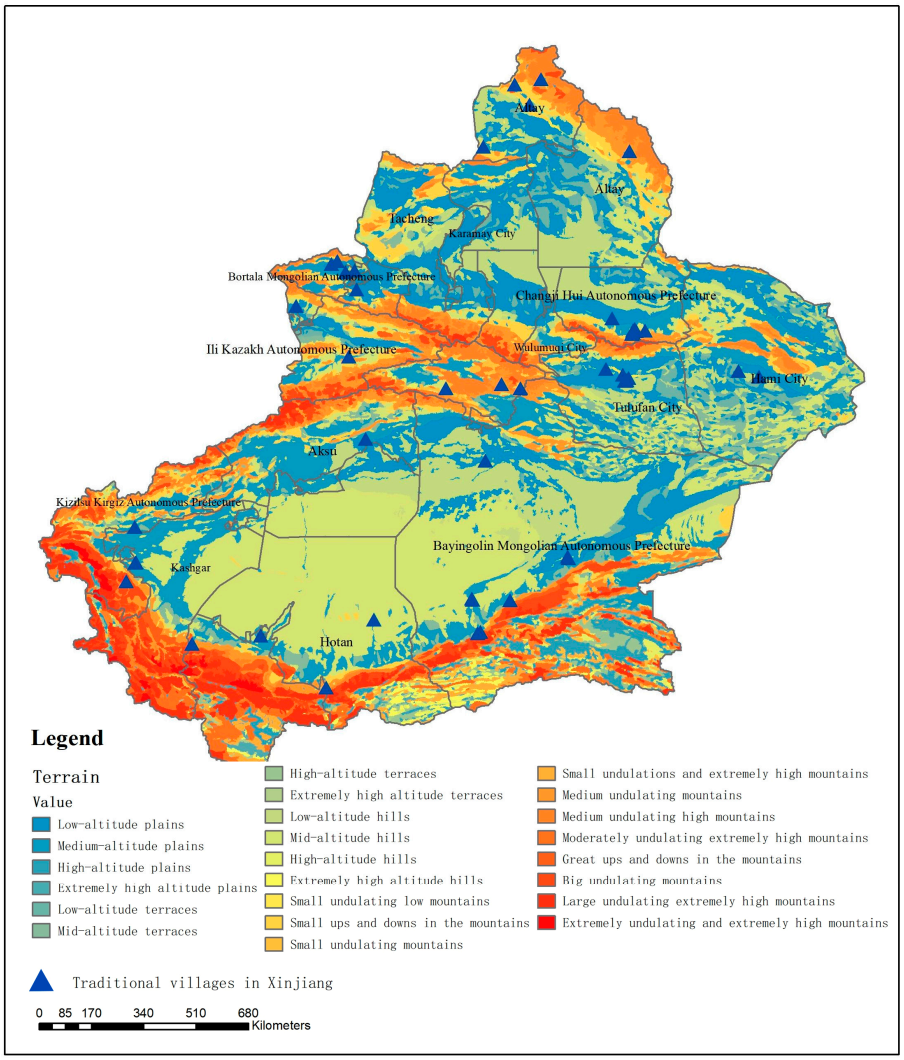

Figure 8. Distribution of traditional villages and topography in Xinjiang.

Using ArcGis, the location of traditional villages at different elevations in the Xinjiang Uygur Autonomous Region was obtained by overlaying the traditional villages with topographic and elevation maps (Figure 9a). From the distribution data, there are fifty-three traditional villages in Xinjiang, among which there are nine villages in regions with an altitude of 200 m and lower, two villages are 200 m to 500 m in elevation, ten villages are 500 m to 1000 m in elevation, twenty-three villages are 1000 m to 1500 m in elevation, four villages have an elevation of 1500 m to 2500 m and 5 villages have an elevation of 2500 m and above. A total of 91% of traditional villages were built lower than 2500 m in elevation. Traditional villages are more concentrated at altitudes between 1000 m and 1500 m in elevation. When the altitude is higher than 2500 m, the density of traditional villages decreases significantly and their numbers decline sharply.

Tulufan City and Changji Hui Autonomous Prefecture, which have relatively large numbers of traditional villages, are both located in regions with an altitude of 1500 m and lower. It can be visualised that topography is a crucial element that impacts the location of traditional villages. This is because areas below 1500 m above sea level are more accessible and more suitable for agricultural production than areas above 1500 m above sea level.

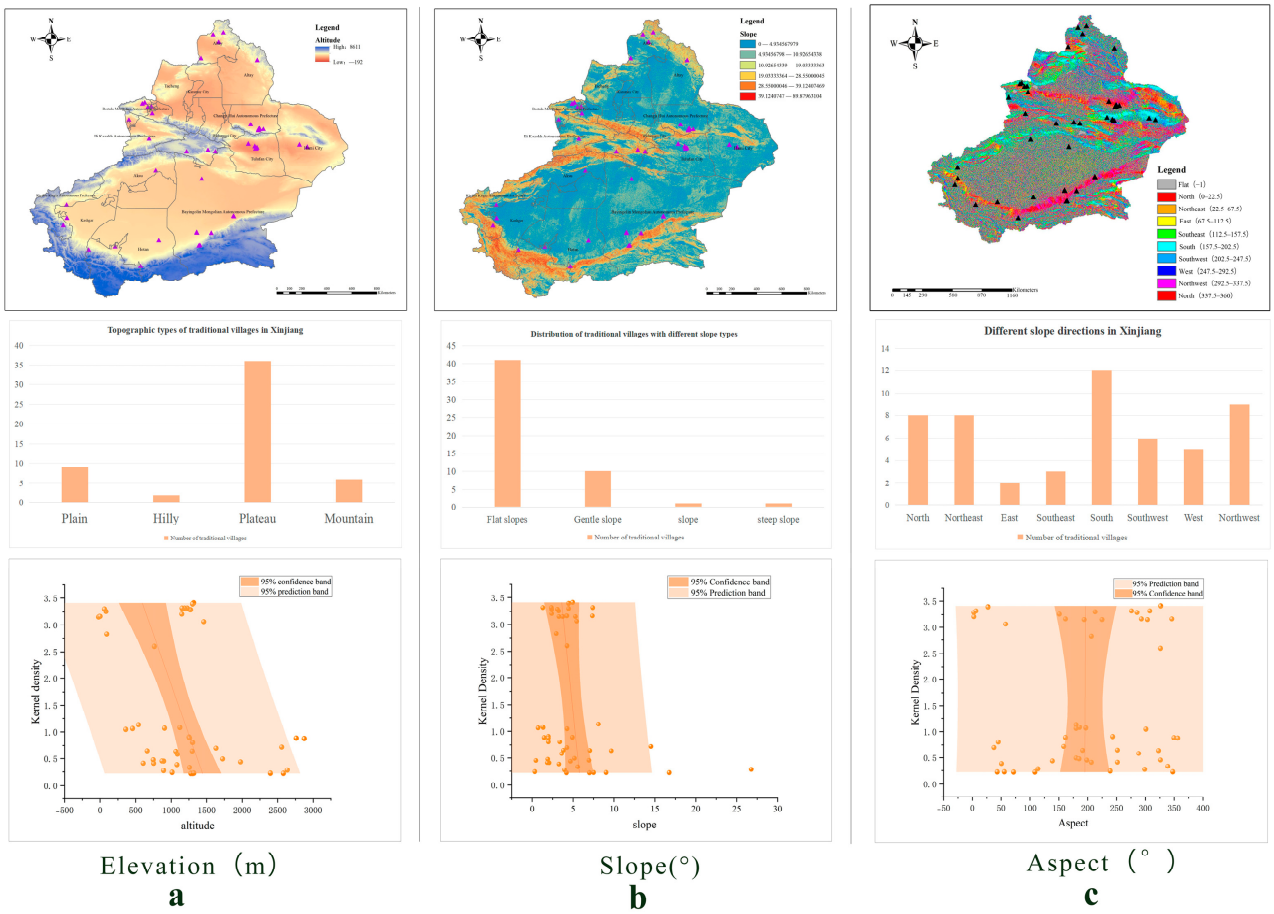

Figure 9. Distribution of traditional villages in relation to (**a**) altitude, (**b**) slope and (**c**) aspect factors.

4.1.2. Slope Factor

Slope represents the degree of undulation of the terrain of a certain place and influences the character of the location and the overall appearance of traditional villages. Relatively flat and less sloping areas are more suitable for village construction and development, agricultural production, the promotion of foreign exchange and the conduct of daily activities [44]. In Xinjiang, because of the complexity and diversity of its topography and landscape, the terrain has a large variation of ups and downs. As a general rule, slopes are flat when they range from 0° to 5°; gentle slopes from 6° to 15°; slopes from 16° to 25°; and steep slopes from 26° to 35° [45].

By importing the various data from Xinjiang for analysis and deriving an intuitive slope map (Figure 9b), it can be noted that most of the traditional villages in Xinjiang are located in areas with slopes between 0° and 20°, which are relatively gentle compared to other areas, with a higher density of villages located in areas with slopes between 0° and 10°. There are 41 villages located in areas with slopes between 0° and 5°, accounting for 77.36% of the whole number. There are 10 traditional villages located in areas with slopes between 6° and 15°, accounting for 18.87% of the whole number. The number of villages located in areas with slopes between 16° and 25° is one, accounting for 1.89% of the whole number. The number of traditional villages decreases sharply when the slope is greater than 15°, with two traditional villages located in that area, accounting for only 3.77% of the whole number. The reason is that areas with slopes greater than 15° have poorer ecological conditions, and soil erosion is more serious, which has a more unfavourable impact on the villages.

The interaction between the location and slope of traditional villages in Xinjiang shows that slope influences the location and distribution of traditional villages in Xinjiang. Most

traditional villages preferred to be located in areas with relatively gentle slopes, as gently sloping areas facilitated farming and travelling by villagers and also helped to reduce the impact of natural disasters. Conversely, areas with higher slopes have a higher potential risk of natural disasters and are more likely to limit village maintenance and development. The location of traditional villages in areas with lower slopes is a good example of the influence of topographical features in the formation and development of villages [46].

4.1.3. Slope Orientation

Slope orientation is defined in geography as the projection direction of the normal of the slope surface on the horizontal plane. Different slope directions with different sunshine, airflow and other climatic factors have a more important impact on the natural ecological environment of traditional villages. Slope orientation analyses were performed on the Xinjiang terrain elevation data using the slope orientation tool in the spatial analysis tool in ArcGis software. Starting from the north direction, the slope direction is represented by the angle of clockwise rotation and is divided into eight directions in a hierarchical system with 45° intervals [47]. According to these eight directions, the extraction results of slope direction were classified and superimposed on the geographical location of traditional villages in Xinjiang. The number of traditional villages in Xinjiang in the different types of slope direction was counted (Figure 9c). In the Xinjiang Uighur Autonomous Region, there are 24 traditional villages on sunny slopes (90° to 270°) and 29 on shady slopes (270° to 360°, 0° to 90°), with the distribution ratio of shady slopes to sunny slopes being 1.21:1, and the general distribution of traditional villages on slopes has no obvious directionality.

4.2. Hydrological Factors

Water is the source of life on which human beings depend for survival, and the location of traditional villages is largely influenced by hydrological elements. The choice to live closer to water resources is very typical of the way in which people in ancient times chose their places of residence and is a common principle in the formation of ancient mountain villages [48]. When people choose a site for village construction, they not only need to consider the production problem but also need to consider the water they need for their livelihoods. In addition, in ancient times, the water flow could be used as a natural defence barrier, so the advantage of the village's proximity to water was obvious.

Xinjiang is located in an area deep in the hinterland of the Asian and European continents, encircled by mountains. Most of the moisture from the Indian Ocean is blocked by the Himalayan Mountains and the Tibetan Plateau, resulting in a dry climate with high evaporation in Xinjiang, a typical temperate continental dry climate [49]. Taking one year of the annual rainfall in Xinjiang in recent years as an example, it is evident that Xinjiang has less average annual rainfall in the national context (Figure 10b). There are 23 traditional villages situated in regions where the mean yearly rainfall is less than 50 mm, accounting for 43% of the whole number. The kernel density of traditional villages is higher in the range of average yearly rainfall of 100 mm to 150 mm. Looking at the location of traditional villages superimposed on the average annual rainfall, the distribution of rainfall in Xinjiang is uneven.

Average yearly temperatures in Xinjiang are relatively high compared to some provinces (Figure 10a). Areas with average annual temperatures between 5 °C and 10 °C have the highest number of traditional villages in Xinjiang, with 22 villages and accounting for 42% of the whole number. There are 20 traditional villages located in the 10 °C to 15 °C region, accounting for 38% of the whole number. It is apparent that traditional villages in Xinjiang are mostly situated in regions with higher temperatures of 5 °C to 15 °C, but the number of traditional villages in areas above 15 °C decreases significantly. Xinjiang has a large geographical area and fewer water resources. Dividing the distance to water sources into six classes of 2 km, 4 km, 6 km, 8 km, 10 km and 12 km and above (Figure 10c), it can be clearly seen that the choice of settlement sites for most traditional villages in Xinjiang is characterised by their proximity to water sources. There are 51 traditional villages in

Xinjiang located within 10 kilometres of water sources, accounting for 96% of the whole number. Of these, 28 traditional villages are located within 2 kilometres of water sources, more than half of the total. The density of traditional villages located more than 10 km from a water source decreases significantly; their numbers also fall sharply. In a relatively arid region such as Xinjiang, waterfront distribution is conducive to meeting the survival and production needs of villagers and greatly improves their lives, providing them with a secure livelihood.

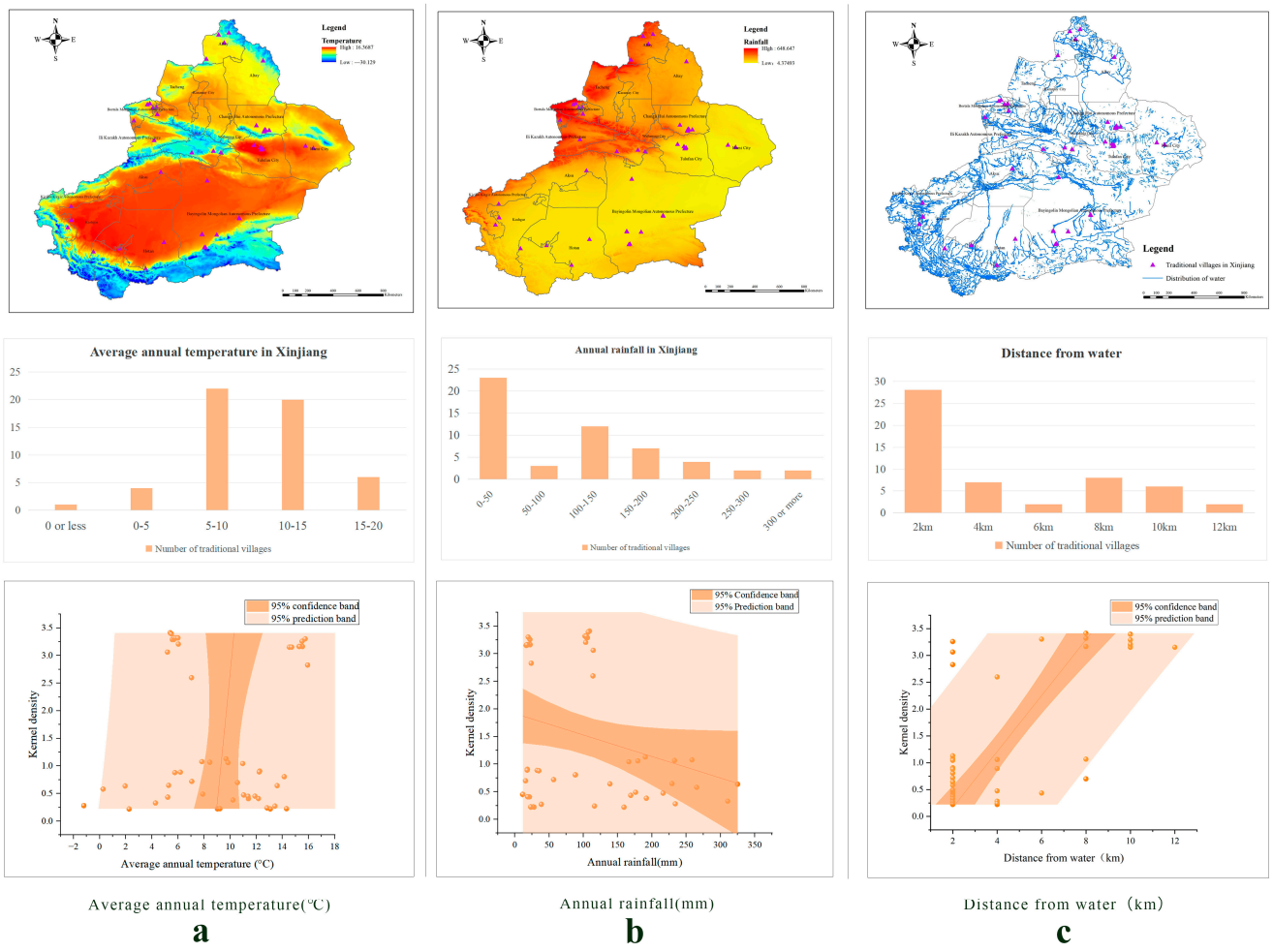

Figure 10. Distribution of traditional villages in relation to mean (**a**) yearly temperature, (**b**) annual rainfall and (**c**) water distribution factors.

4.3. Social Factors

4.3.1. Economic Factors

The location of traditional villages in Xinjiang is largely influenced by the level of economic development. A higher density of traditional villages is located in areas with an annual GDP of CNY 50 billion to CNY 75 billion and CNY 225 billion to CNY 250 billion. The density of traditional villages is lower in areas with an annual GDP below CNY 50 billion and above CNY 250 billion (Figure 11c).

In one respect, the high level of economic development can provide adequate economic sustain for the conservation and continuation of traditional villages. As the people's living standard improves, they have enough energy and the ability to repair their houses and dwellings. At the same time, the government will also consciously strengthen the restoration and protection of traditional villages when it has sufficient economic strength, which is to a certain extent conducive to the protection of traditional villages. The annual GDP of Changji Hui Autonomous Prefecture is as high as CNY 232.952 billion (Figure 12),

and it is the second highest among the prefectures and cities in Xinjiang which have traditional villages. It also has the greatest number of traditional villages outside of Bayingolin Mongolian Autonomous Prefecture, with 10 traditional villages, representing 19% of the overall number. On the other hand, the distribution of traditional villages in economically backward areas is also higher, such as Tulufan City, with an annual GDP of only CNY 58.811 billion but nine traditional villages, representing 17% of the whole number. It can be seen that due to the relative economic underdevelopment, transport and information exchange also lag behind other regions. The urbanisation process was slow, and the relationship between people and land was relatively stable, which have also contributed to some degree to the conservation of traditional villages.

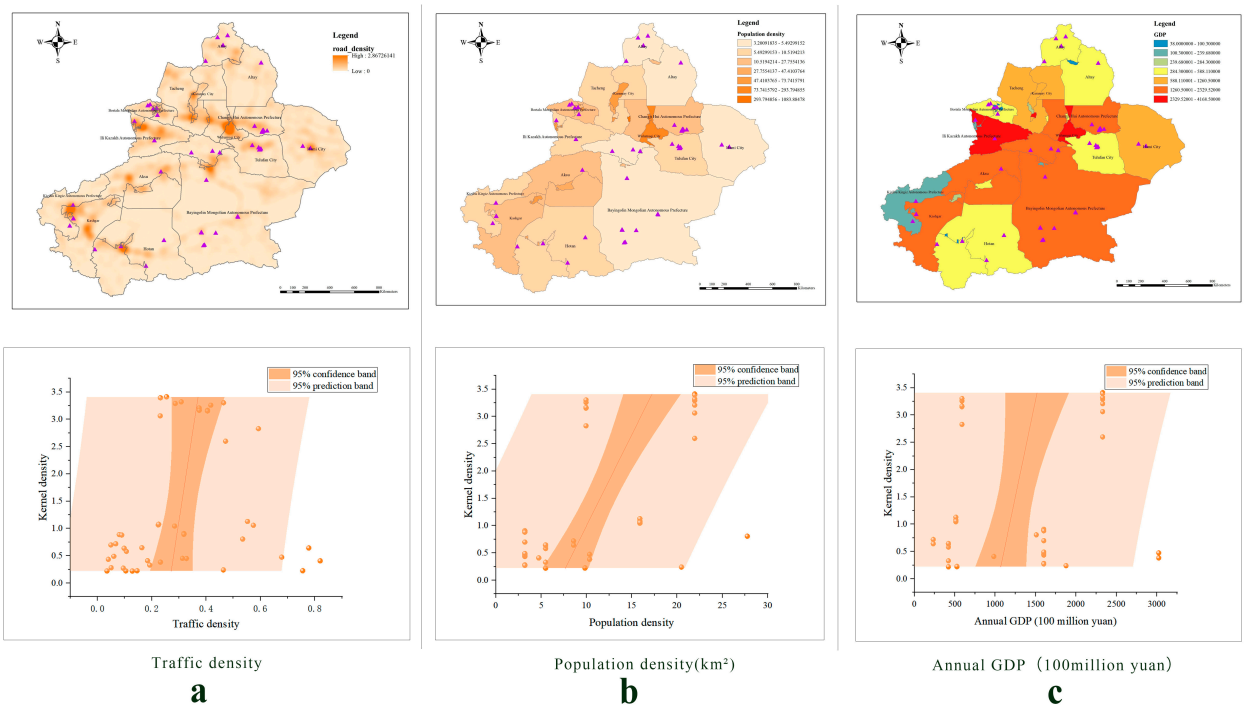

Figure 11. Traditional villages in relation to (**a**) traffic density, (**b**) population density and (**c**) annual GDP factors.

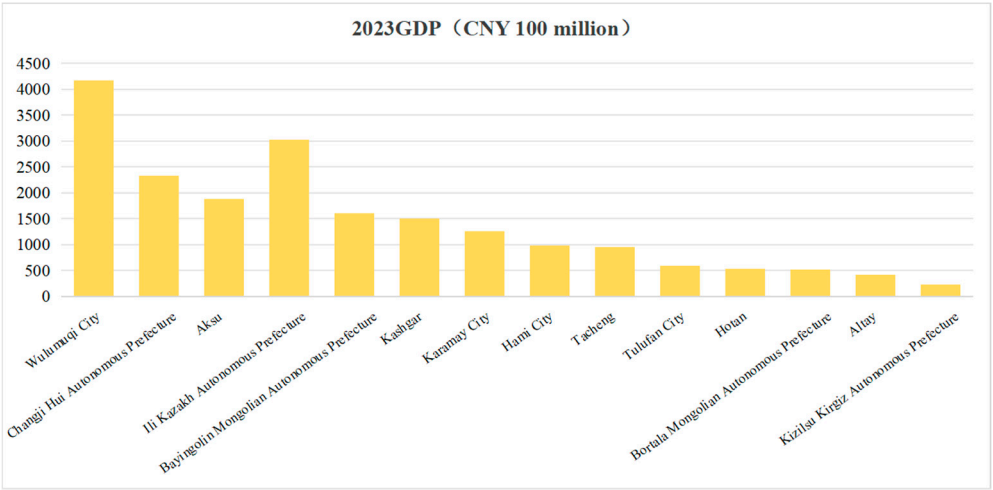

Figure 12. GDP of prefectures and cities in Xinjiang.

4.3.2. Transport Factors

Transport connects economic and social activities between regions, is an important element of regional development and plays an important role in the conservation and continuation of traditional villages [50]. Traditional villages are generally located near roads. So, the transport network determines the possibilities for the village to interact with other areas and also influences the extent of the economic advancement of the village. After superimposing road data on the location of traditional villages in Xinjiang, it was discovered that the distribution of traditional villages in Xinjiang has different qualities from that of general rural settlements, and their distribution has a negative correlation with roads. The more developed the roads are, the more the villages are influenced by the progress of towns and cities, and the higher the level of modernisation.

According to the relationship between the road density and space location of traditional villages in the Xinjiang Uygur Autonomous Region (Figure 11a), as can be seen, traditional villages form more obvious clusters in areas with a road density of 0.2 to 0.5, with a high distribution density, and villages with a road density of more than 0.6 have a more obvious decrease in density. There are 44 traditional villages in Xinjiang located in areas with a road density less than 0.5, accounting for 83% of the whole number. This suggests that most traditional villages in Xinjiang are located in areas with low road density. The less developed the transport, the less the areas with traditional villages will be influenced by outside cultures. Because of their difficulty in reaching out to the outside world, they have limited contact with the outside world and are less open in the long term. The preservation of a relatively large number of traditional villages and the slowing down of the urbanisation process have objectively provided favourable conditions for the conservation of traditional villages in the Xinjiang Uighur Autonomous Region.

4.3.3. Demographic Factors

Population is an essential factor in the existence and continuation of the village. In an attempt to study the association between locational features and the population density of traditional villages in Xinjiang, the space location plot of traditional villages was superimposed on the population density plot of prefectures, cities and districts in Xinjiang. On the basis of the population statistics of the seventh population census of Xinjiang in 2020, a visualisation method was used to generate a plot of the relationship between site selection and the population density of traditional villages in Xinjiang (Figure 11b). The population density was divided into seven levels. The average population density of the Xinjiang Uygur Autonomous Region in 2020 was 15.6 people/km^2. Wulumuqi City, as the capital of Xinjiang, has a population density of 294 people/km^2, while Bayingolin Mongolian Autonomous Prefecture has a population density of 3 people/km^2 (Figure 13). In areas where the population density is higher than the average population density of Xinjiang (e.g., Changji Hui Autonomous Prefecture, Aksu, Kashgar, etc.), there are 16 traditional villages, representing 30.2% of the whole number. In areas where the population density is less than the mean value of population density of Xinjiang (e.g., Altay, Kizilsuzgolgiz Autonomous Prefecture, Hami City, etc.), there are 37 traditional villages, representing 69.8% of the whole number. In areas where the population density is higher than 25 persons per square kilometre, there is a significant decrease in the density of traditional villages and a reduction in their number.

This suggests that population density has a negative impact on the formation and development of traditional villages in the Xinjiang Uygur Autonomous Region. The site locations of traditional villages in Xinjiang are mostly in cities and prefectures with low population densities, reflecting that lower population densities are favourable to alleviate the problem of tensions between people and land, and to a given extent are favourable to the protection and development of traditional villages.

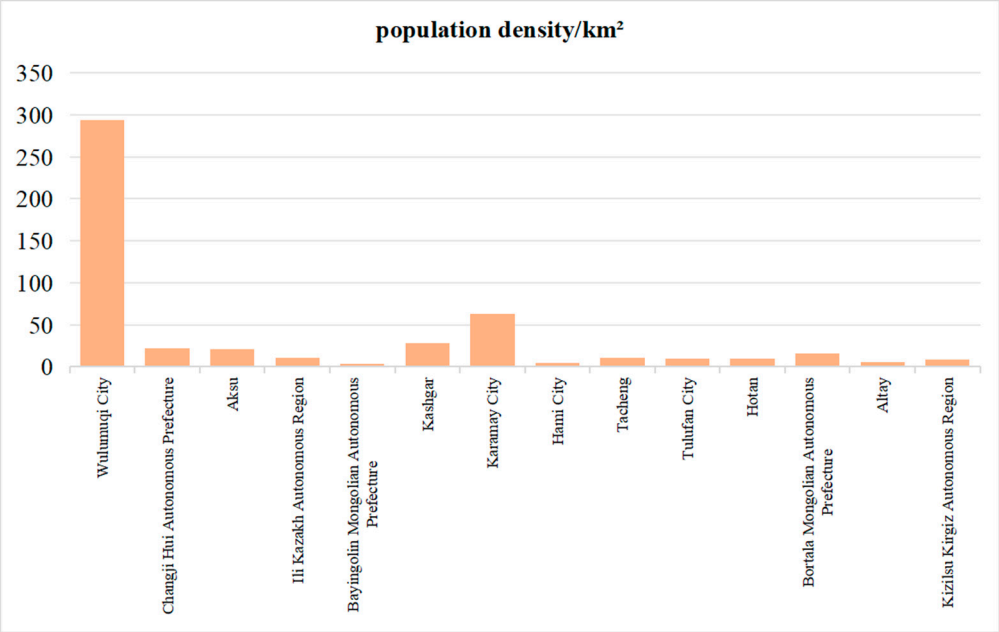

Figure 13. Population density by prefecture and city in Xinjiang.

5. Impact Mechanism Analysis

The emergence of the spatial pattern of traditional villages in Xinjiang is an evolving and complex process, which is mainly composed of three factors, including topographical, hydrological and social factors. Factors affecting the location features of traditional villages were analysed using a geodetector (Table 1), showing the results of a single-factor test influencing the location of traditional villages in Xinjiang.

Table 1. Single-factor detection data affecting the distribution of traditional villages in Xinjiang.

	Slope	Aspect	Altitude	Annual Average Temperature	Annual Rainfall	Road Density	Distance from Water	GDP	Population Density
q statistic	0.11689	0.078163	0.538	0.493579	0.361122	0.459958	0.585069	0.533461	0.50691
p value	0.331186	0.630385	0.000	0.000	0.003007	0.000	0.000	0.000	0.000

The outcome of the one-way test analysis (Table 1) shows that the distance to the water source is the factor with the strongest interpretive force for the location features of traditional villages in Xinjiang (q = 0.585), followed by elevation (q = 0.538) and annual GDP (q = 0.533). From the correlation analysis graph (Figure 14), we can understand the correlation between natural and social dual factors, where the direction of the ellipse represents the positive or negative correlation between the factors. The main ones are altitude and slope (0.42), mean annual temperature and road density (0.55) and population density and distance from water (0.35). From the correlation analysis of these factors, we can learn that there is a strong connection between the natural environment and the social economy. It reveals the fact that the social and natural environments interact with each other and together form a vital impact on the siting of traditional villages in Xinjiang.

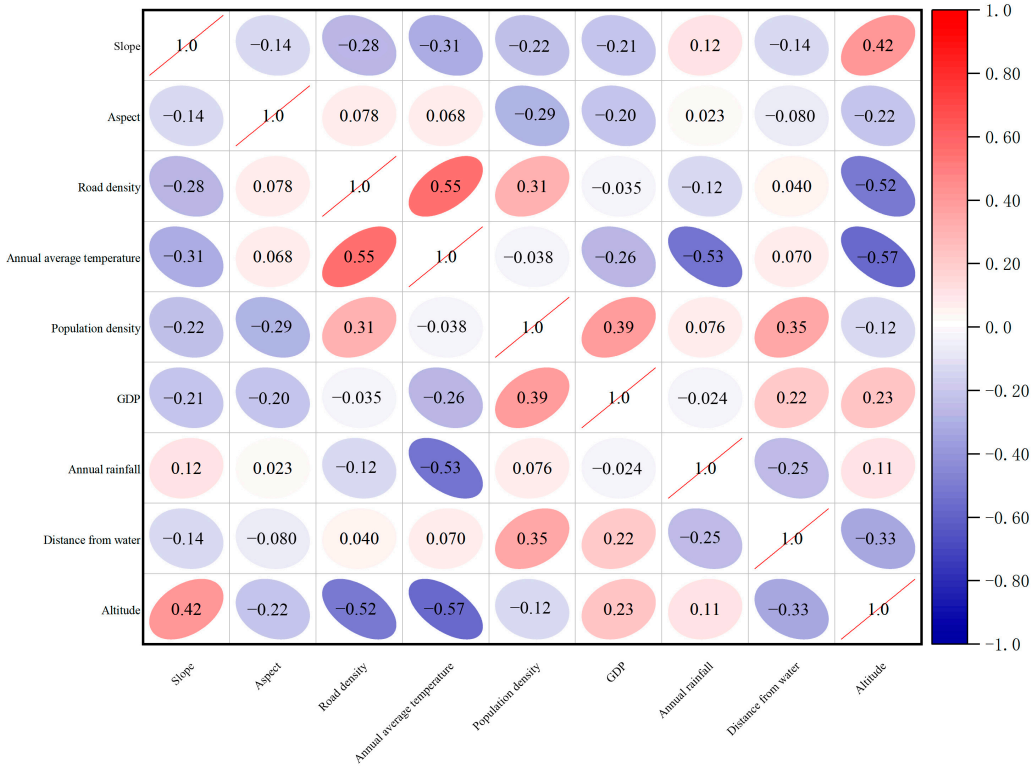

Figure 14. Analysis of dual factors affecting the distribution of traditional villages in Xinjiang.

Human and social factors are intrinsic drivers of the spatial location distribution of traditional villages in the Xinjiang Uygur Autonomous Region, which further strengthens the underlying pattern of uneven location features of the region under study. The correlation analyses of the factors show that, in addition to natural factors, there is a correlation between human and social factors. For example, population density and GDP (0.39) and population density and road density (0.31), which shows that there is a strong connection between population density, GDP and road density. Low population density will affect the local GDP and road development, and to a certain extent, it will also affect the continuation and conservation of traditional villages.

6. Conclusions

This research analyses the location features and their affecting factors in Xinjiang with the help of statistical analysis tools and software such as ArcGis 10.8.1. It identifies the spatial evolution features and explores their influence mechanisms in terms of the spatial distribution type, distribution direction, distribution density, distribution balance, etc., in an attempt to provide more basis for the preservation and continuation of traditional villages in Xinjiang. In the analysis of influencing mechanisms and factors, the three dimensions of topography, society and hydrography are explored, which can help to provide more basis for the conservation of traditional villages in Xinjiang.

In terms of the overall pattern, there is an obvious cluster distribution of traditional villages in Xinjiang. Traditional villages form clusters centred on the Changji Hui Autonomous Prefecture and Tulufan City. The location of traditional villages avoids as far as possible the unfavourable effects of topography, reflecting the constraints imposed by the natural environment on traditional villages. The space distribution of traditional villages in Xinjiang generally shows a spatial direction from northeast to southwest.

In terms of the formation mechanism, the location of traditional villages in the Xinjiang Uygur Autonomous Region is affected by multiple factors. These include the socio-economic environment, geographic environment and historical and cultural environment, all of which have an impact on the formation of cluster distribution. From the correlation

analysis of these factors, it can be learnt that there is a strong connection between the natural condition and social condition, reflecting that the social condition and the natural condition interact with each other and jointly influence the location of the establishment of traditional villages in Xinjiang. For example, in terms of natural factors, the distance to the water source is the factor with the strongest interpretive force for the location features of traditional villages in Xinjiang (q = 0.585), followed by elevation (q = 0.538). At the same time, distance to water sources has a positive correlation with the population density factor of social factors. They are related to each other and together have an impact on the traditional villages in Xinjiang. This suggests that the protection of traditional factors requires that both natural and social factors be taken into account.

How to preserve traditional villages while seeking economic advancement is an issue that deserves attention and discussion. For the protection of traditional villages, the relevant department should continue to respond positively and attach great importance to the protection of traditional villages, and actively carry out the protection and declaration of traditional villages. At the same time, the promotion of traditional village conservation should be intensified, and more diversified publicity methods can be adopted to mobilise all sectors of society to participate in traditional village conservation.

Traditional villages in Xinjiang are important carriers of traditional cultural heritage in Xinjiang, but they are also fragile and need to be protected. Especially in contemporary times of rapid industry and economic progression, the problem of the loss of traditional villages is gradually exposed. How to preserve traditional villages while seeking economic advancement, has an important discussion value and social meaning. Although this study has made some important findings, there are some limitations. Firstly, the precision of the research on traditional villages in Xinjiang needs to be improved. This research mainly focuses on the influence of macro-factors on the distribution characteristics of traditional villages in Xinjiang. Due to historical changes, some traditional villages do not have clear historical records, so the specific role characteristics of the historical and cultural inheritance of traditional villages have not yet been explored in detail. In addition, important variables such as the population, climate, and economic situation have been changing. This research is limited by the time point of the data acquisition and does not fully capture the latest impacts of these dynamic factors. However, previous studies have amply proved the practicability and reliability of using available data resources to study the location features of traditional villages and their affecting elements within an administrative geographic framework.

In the future, researchers in related fields can explore more perspectives, and try to conduct a longitudinal study by focusing on one of these areas instead of analysing from multiple perspectives. By exploring in depth the correlation between a certain type of factor and traditional villages, the impact of this one factor on the formation and development of traditional villages can be further analysed to make the research more specific, such as history, ethnic culture and other factors. Traditional villages are carriers of traditional culture and their history and culture are of great value, and researchers should focus on the protection and inheritance of village clan culture. By using different methods and finding unique perspectives, the humanistic background aspects of traditional villages are explored in greater depth and detail, with a view to revealing the value of traditional villages in a more comprehensive and in-depth manner, and to jointly promote the protection and development of traditional villages in Xinjiang.

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