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Spatial Agglomeration Characteristics of Rural Settlements in Poor Mountainous Areas of Southwest China

Guanglian Luo [1,2], Bin Wang [3], Dongqi Luo [4] and Chaofu Wei [1,*]

1 College of Resources and Environment, Southwest University, Chongqing 400715, China; lglzyx@163.com
2 College of Tourism and Land resources, Chongqing Technology and Business University, Chongqing 400067, China
3 Chongqing Zhiheng Land Planning and Design co., LTD, Chongqing 400067, China; wangbinchqzlpd@163.com
4 Research Center of the Economy of the Upper Reaches of the Yangtze River of the Key Research Base of Humanities, Ministry of Education, Chongqing Technology and Business University, Chongqing 400067, China; luodongqi@ctbu.edu.cn
* Correspondence: weicf@swu.edu.cn

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Abstract: The rural settlements in poverty-stricken mountainous areas are the "living fossils" of an economic society with the characteristics of spatial dispersion and are slowly changing. Spatial agglomeration is the development direction of rural settlements. In-depth exploration of the spatial agglomeration characteristics and influencing factors of rural settlements in poverty-stricken mountainous areas is a way to provide a basis for rural settlement restructuring. We selected Pengshui County, a national poverty-stricken county in the southwestern mountainous area of China, as the research area. Spatial buffer and kernel density analysis were used to analyze the agglomeration characteristics of rural settlements and influencing factors. The results show that: (1) The rural settlements are small in scale and the space is evenly dispersed. 55.63% of the rural settlements' sizes are less than 1000 m^2, 84.15% of the rural settlements' sizes are less than 2500 m^2, and 92.81% of the rural settlements are within 200 m. (2) The elevation and slope of topographic factors have a significant agglomeration effect on rural settlements. However, the slope direction has no agglomeration effect. 85.41% of rural settlements (52.75% of rural settlements are gathered between 400 and 800 m above sea level) are gathered at an altitude of 1000 m or less, and 77.59% of rural settlements are gathered with a slope of 6~25°. Additionally, there are few rural settlements with a slope of 0~2°. Moreover, the distribution of residential areas has no agglomeration effect on rural settlements. (3) The cultivated land exerts the most significant effect on rural settlements followed by roads and water sources, while the role of urban land is weak. 99.48% of rural settlements are concentrated in the 100 m area of cultivated land. Therefore, in the poverty-stricken mountainous areas in the southwestern mountainous areas of China, convenient farming is the primary condition for production and living. Rural settlements are highly correlated with cultivated land. Rural settlements are scattered and concentrated with the scattered cultivated land. The rural settlements were leaded by the distribution of cultivated land. Less high-quality cultivated land with less slope were occupied or not by rural residential areas' people.

Keywords: poor mountainous areas; rural settlements; spatial agglomeration; mountainous area; southwest China

1. Introduction

China is a mountainous country, with mountains accounting for two-thirds of the land area (http://www.gov.cn/guoqing/2005-09/13/content_2582624.htm#1) [1]. At the end of 2018, the total population of mainland China was 1395.38 million, the permanent population of urban areas was 831.37 million (accounting for 59.58% of the total population), and the resident population of rural areas was 564.01 million (accounting for 40.42% of the total population). There are 16.60 million rural poor people and 585 national poverty-stricken counties, mostly distributed in mountainous areas (data from the *National Rural Poverty Monitoring Survey of the National Bureau of Statistics of China*) (http://www.stats.gov.cn/) [2]. In poor, mountainous areas, rural settlements are small in scale and scattered in space. It is not conducive to the infrastructure's construction and limits the full use of public resources, which has great obstacles to the development of agricultural industry and the healthy and comfortable life of rural residents. The spatial agglomeration of rural settlements can meet the needs of industrialized urbanization. The population succession at the county level includes five rising sequences of courtyards in China. They are village groups, villages, townships (towns), and counties (cities), forming two types of information transfer methods: administrative management and market economy. The rural settlements in the mountains have a long history. They have experienced dynasty changes, historical vicissitudes, and slow changes in the system, which have become the "living fossils" of the mountain economy and society. Spatial dispersion, living by mountain products on the mountain, staying away from economic centers, and staying away from cities are common development patterns for rural settlements in poor mountainous areas [3]. Residential areas include urban and rural settlements. Towns are generally surrounded by rural settlements. The difference between urban and rural areas is mainly reflected in the size and concentration of population. Moreover, the degree of agglomeration is the most significant difference between urban and rural areas. Studying the spatial agglomeration characteristics of rural settlements in poverty-stricken mountainous areas has important theoretical and practical significance for clarifying the status quo, exploring the causes and clarifying the development direction.

2. Literature Review

Arboreal, burrowing, housing, and settlement are the four stages in the evolution of human habitation [3]. In 1841, J.G. Kohl made a comparative study of different types of settlements, such as metropolis, market town and rural settlements, and introduced them into the study of geography, laying a foundation for the geography of settlements [4]. However, settlement geography remained a marginal subject until the end of the 20th century [5]. The most representative of rural development is the symbiotic model: namely agriculture-industrialization, post-production and rural sustainable development [6]. The spatial agglomeration of rural settlements is influenced by industrialization, reverse urbanization, globalization, tourism activities and emerging media [7]. In the western United States, the spatial agglomeration of rural settlements is influenced by immigration, the development of science and technology and the change of human-land relationship [8]. Rural settlements are no longer pure rural spaces [9]. The development of network and information technology shortens the distance between rural areas and the market, improves the opportunity of external learning, and thus promotes the development of rural areas [10]. With the integration of new disciplines and new technologies, the spatial agglomeration of rural settlements has become a research hotspot [11–19].

In China, around 100 BC, "living in one place in a year will become a settlement; two years will become a city and three years will become a metropolis" was noted in the "Records of the Grand Historian". Before and after A.D., "a settlement will be settled when building some rooms with no any disasters in a long time" was said in "Book of Han". At Qinba mountains in central China, rural settlements are mainly scattered and small in scale, and are also clustered along roads and rivers [20–22]. In western China, rural settlements in the western mountainous areas of Sichuan province are mainly affected by farming, most of which are below an altitude of 3500 m and distributed mostly in the alluvial fan area of the river valley, and the scale increases with the height decreasing and the area of the

alluvial fan area expanding. The larger ones are distributed mostly at the confluence of the two rivers and distributed along the river valley (in a linear pattern) [23–25]. In west China, the density of rural settlements in the hilly and gully region of the Yilin Loess plateau in the north of Shanxi province is characterized by the spatial distribution along the geomorphic type, water source, elevation, traffic line and city (town) [26,27]. In western China, rural settlements in mountainous areas of Guizhou province are scattered along road branches and rivers in mountain and valley areas [28–30]. Rural settlements in mountainous areas of Yunnan province in western China are relatively small and scattered [31]. In a word, rural settlements in mountainous areas in China are small in scale and scattered in distribution. Affected by multiple factors, most of them are close to cultivated land and convenient for nearby planting [32].

Based on the relevant research results, Pengshui County is taken as an example, which is a national poverty-stricken county in Chongqing. In order to revitalize rural areas and realize spatial adjustment and reconstruction, the characteristics of rural settlement agglomeration and its influencing factors are studied by spatial buffering and kernel density analysis. Our study will provide a basis for providing similar ideas for conducting similar research in other regions.

3. Study Area

Pengshui County of Chongqing City is located in the southeast of Chongqing City (Figure 1), in the lower reaches of the Wujiang River, a tributary of the Yangtze River, between E107°48′–108°35′, N28°57′–29°50′. Pengshui County is connected with the Shizhu Tujia Autonomous County at north and bordered the Lichuan City, Enshi Tujia and Miao Autonomous Prefecture, Hubei Province at northeast. At east, this country is adjoined with Chongqing Qianjiang District. At southeast, it is Chongqing Youyang Tujia and Miao Autonomous County. At south, it is Guizhou Province along the river Tujia Autonomous County and Wuchuan Gelao and Miao Autonomous County. At southwest, it is Daozhen Gelao and Miao Autonomous County, Guizhou Province. At west, it is Wulong County, Chongqing. At northwest, it is bordered by Chongqing Fengdu County. Pengshui County is 77.88 km wide from east to west and 96.40 km distance from north to south, with a total area of 3903 km^2. Pengshui County has 3 sub-district offices, 18 towns, 18 townships, 296 villages (residential). Pengshui County belongs to the Wuling Mountain System. It is high in the northwest and low in the southeast. The landform is characterized by "two mountains and one trough"; the hilly valley area accounts for 13.39%, the low mountain area accounts for 52.88%, and the middle mountain area accounts for 34.03%. The highest elevation point of Pengshui County is 1859.60 m, the lowest point is 190m, and the relative height difference is 1669.60 m, which is the middle and low mountain topography of structural erosion. The Wujiang River traverses the whole territory from the southeast to the west, with a length of 64 km in the territory; there are more than 20 tributaries of Yujiang, Changxi River, Furong River and Mu Brown River. It belongs to the mid-subtropical humid monsoon climate, with mild climate, abundant rainfall, average annual temperature of 17.5 °C, annual average precipitation of 1228.7 mm, annual sunshine duration of 1035.5 h, and frost-free period of 311 days. The geological structure in Pengshui County belongs to Xinhua tectonic system. The outcrops mainly include Proterozoic Simian, Paleozoic Cambrian, Paleozoic Ordovician, Paleozoic Silurian, Paleozoic Devonian, Paleozoic Permian, Mesozoic Triassic, Mesozoic Jurassic and Cenozoic Quaternary. In Pengshui County, the surface is broken, the mountain slopes are steep and the soil erosion is serious. The main soil types are hilly and valley tidal soil, purple soil, yellow soil area (11.90%), low, Zhongshan yellow soil area (81.02%) and Zhongshan yellow-brown soil area (7.08%) (http://www.psx.gov.cn/) [33].

At the end of 2016, the total registered population of Pengshui County was 702,900, and the urban population was 203,100 (accounting for 28.89% of the total population), the rural population was 499,800 (accounting for 71.11% of the total population), and the ethnic minorities with Miao nationality accounted for 62.40% of the total population. The quantity of households is 228,564, which is a typical mountainous agricultural county. The GDP of the county is 12.87 billion yuan, and the per capita disposable income of rural residents is 9294 yuan. It ranks 31st in 38 districts (counties) in

Chongqing, far below the average level of city, and its economic development is backward. It belongs to Wuling Mountain Area, a national poverty-stricken county in a particularly difficult area. Influenced by topography, river roads, economic level, and ideological concepts, the spatial difference of rural settlement areas in Pengshui County is significant.

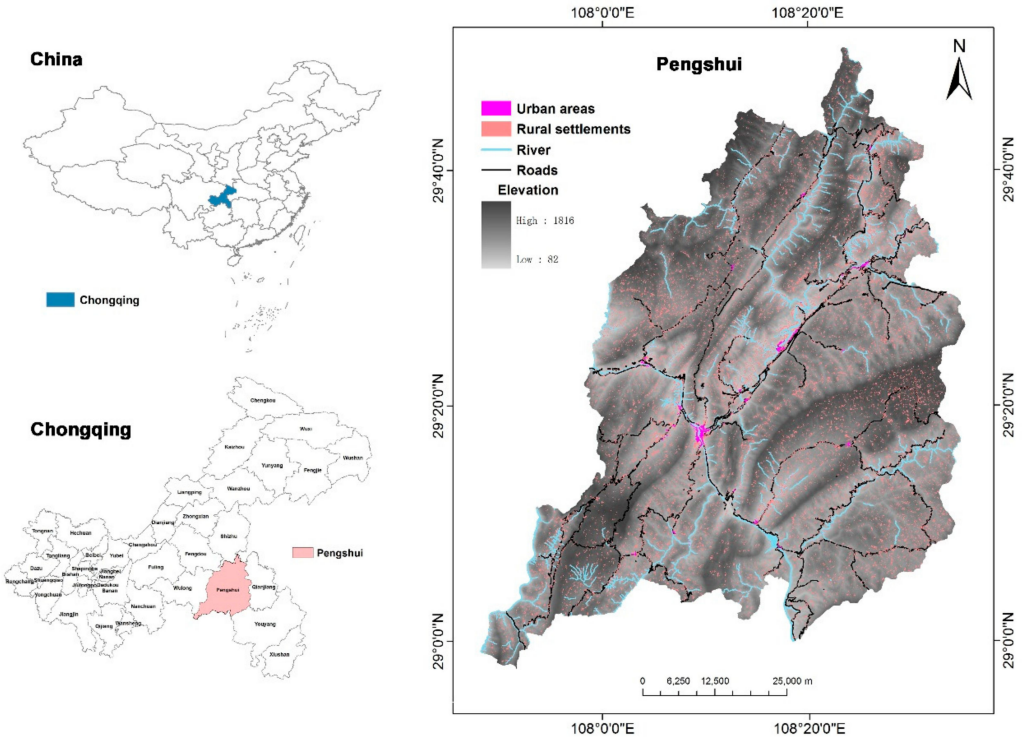

Figure 1. Geographical location of Pengshui County, Chongqing, China.

4. Data Sources and Research Methods

4.1. Data Source and Processing

This paper reveals the spatial agglomeration characteristics of rural settlement areas in Pengshui County, Chongqing, from the county level. By combining with research needs and data availability, rural settlements, towns, cultivated land and rivers, roads, etc., (Figure 1) were extracted based on the 2016 land use utilization database of Pengshui County. Grading, and superposition analysis were used for hierarchical statistics. The terrain data was derived from the digital elevation data of 30 m spatial resolution of the Geospatial Data Cloud Platform (http://www.gscloud.cn) [34] of the Computer Network Information Center of the Chinese Academy of Sciences. The economic data used in the study was derived from the *2017 Pengshui Statistical Yearbook*.

4.2. Research Methods

4.2.1. Spatial Buffer Analysis

Spatial buffer analysis is the determination of their neighborhood for a given spatial object or set. The size of the domain is determined by the neighborhood radius R. Therefore, the buffer of object O_i can be defined as [35]:

$$B_i = \{x : \mathrm{d}(x, \mathrm{O}_i) \leq R\} \quad (1)$$

That is, the buffer of object O_i with the radius R is a collection of all points with a distance d from O_i less than the distance R. d is usually the minimum Euclidean distance, but it can also be defined distances. For object collection:

$$O = \{O_i : i = 1, 2, \cdots, n\} \quad (2)$$

The buffer, whose radius R is the sum of the buffers of each object, that is:

$$B = \bigcup_{i=1}^{n} B_i \quad (3)$$

4.2.2. Kernel density analysis

Kernel density analysis is used to calculate the spatial distribution of the observed object by calculating a certain regular area around any point in the space as the calculation range of the density. Data points that are closer to the center point are given a higher weight, while the further points are given a lower weight. The estimated density of each point is the weighted average density of all points in the area [36].

Among them, the kernel density P_i at any point i in the space is defined as the function of the highest at the center and decreasing outward. When the distance R reaches a certain value, the density is 0:

$$P_i = \frac{1}{n\pi R^2} \times \sum_{j=1}^{n} K_j \left(1 - \frac{D_{ij}^2}{R^2}\right)^2 \quad (4)$$

In Equation (4): K_j is the weight of the research object j; D_{ij} is the distance between the spatial point i and the research object j; R is the bandwidth of the selected regular region (D_{ij}<R); n is the quantity of research objects j within the bandwidth R.

5. Results and Analysis

5.1. Scale Agglomeration Characteristics of Rural Settlements

(1) The average quantity of households is 3, and more than half of the rural settlements have only 1~2 households and 1~6 people.

At the end of 2016, the total population of the study area was 702,949, with a total of 228,564 households, including 203,141 urban population, 499,808 rural population, and about 3 persons per household. The per capita rural settlement land was 158.70 m^2; the rural settlement should be 476.09 m^2 (about 500 m^2) per household. The average size of rural settlements is only about 3 households; the coefficient of variation (standard deviation/average) is 1.70, and the overall size difference is large (see Table 1).

Table 1. The scale characteristics of rural settlements in the study area.

The Total Quantity	Minimum Area (m^2)	Maximum Area (m^2)	Average Area (m^2)	Total Area (hm^2)	Standard Deviation (m^2)	Density
47,844	29.62	127,087.84	1708.77	8175.43	2892.60	12.26

Taking households as a unit (1 household, 3 persons, 150 m^2 per person, and 500 m^2 per household), the data of rural settlements in the study area are extracted and classified (Table 2), with an area of less than 500 m^2 (approximately 1 household). There are 10,371 rural settlements, accounting for 21.68% of the total; rural areas with an area of less than 1000 m^2 (about 2 households) have 26,615, accounting for 55.63% of the total. Most rural settlements are small in size, with only 1 or 2 households living, only as a base for production, with few living facilities. In terms of quantity: the proportion of rural households with 2 households and 4~6 people is the largest (accounting for 33.95%), and the cumulative proportion of rural households with 1~5 households and that with 1~15 people is 84.15%;

The proportion of rural residents with 6~10 households and 16~30 people is the largest (accounting for 19.67%), and the cumulative proportion of rural households with 2~50 households and 4~150 people is 90.70%.

Table 2. Classification statistics of the rural settlements in the study area.

Quantity of Households	Quantity of People	Scale (m^2)	Area Summary (hm^2)	Area Ratio Summary (%)	Quantity Summary	Proportion of Quantity (%)
1	1	≤150	1.98	0.02	178	0.37
1	2–3	150–500	342.16	4.19	9247	19.33
2	4–6	500–1000	1193.32	14.60	16,553	34.60
3	7–9	1000–1500	948.73	11.60	7761	16.22
4–5	10–15	1500–2500	1250	15.29	6527	13.64
6–10	16–30	2500–5000	1628.59	19.92	4726	9.88
11–20	31–60	5000–10,000	1381.22	16.89	2024	4.23
21–50	61–150	10,000–25,000	1030.55	12.61	723	1.51
51–100	151–300	25,000–50,000	306.11	3.74	92	0.19
101–200	301–600	50,000–100,000	68.63	0.84	11	0.02
201–300	601–900	100,000–150,000	24.14	0.30	2	0.00

The above results indicate that most of the rural settlements in the study area are under 5 households and 15 people. No scale space agglomeration has yet been made.

5.2. Spatial Agglomeration Characteristics of Rural Settlements

(1) Most rural settlements are no more than 200 m apart.

According to the buffer analysis of rural settlements, when the buffer radius is 100 m, 92.81% of rural settlement points gather; while the buffer radius is 200 m, 99.18% of rural settlement points gather; and when the buffer radius is 700 m, 100% of rural settlement points gather. That is, all rural settlement point buffers are completely superimposed (Table 3). The above results show that the distance between most rural settlements is less than 200 m, and only 7.19% of rural settlements are more than 200 m apart.

Table 3. Classification statistics of the rural settlements in the study area.

Buffer Radius (M)	Agglomeration Area (hm^2)	Area Ratio (%)	Agglomeration Quantity	Proportion of Quantity (%)
0–100	7866.71	96.22	45,893	95.92
100–200	268.97	3.29	1716	6.45
200–300	33.81	0.41	189	5.65
300–400	4.86	0.06	40	4.77
400–500	0.83	0.01	5	4.71
500–600	0.00	0.00	0	4.13
600–700	0.25	0.00	1	3.87

(2) The overall spatial dispersion of rural settlements, local agglomeration.

The total area of the study area is 3903 km^2, including 47,844 rural settlements and an area of 81.75 km^2. After the total area of the study area is deducted from the rural settlement, if the square is evenly distributed, the radiation area of each rural settlement (i.e., the agricultural production base) is 79,868.95 m^2, and the ideal side length should be 282.61 m. Combining with (Figure 1) and (Tables 1–3), 99.51% of the rural settlements in the study area are no more than 200 m apart, which is less than the ideal side length. The above results show that although the rural settlements in the study area are generally spatially dispersed, there is still agglomeration in the local area.

Using the *Feature To Point* module of ArcGIS 10.2 software, the center point of the rural settlement map is extracted, and the density map was generated by the kernel method (Figure 2). The high-density

area of the rural settlement presents the "Northeast-Southwest" strip phenomenon. It is in line with the terrain and is in the trough area of "two mountains and one trough".

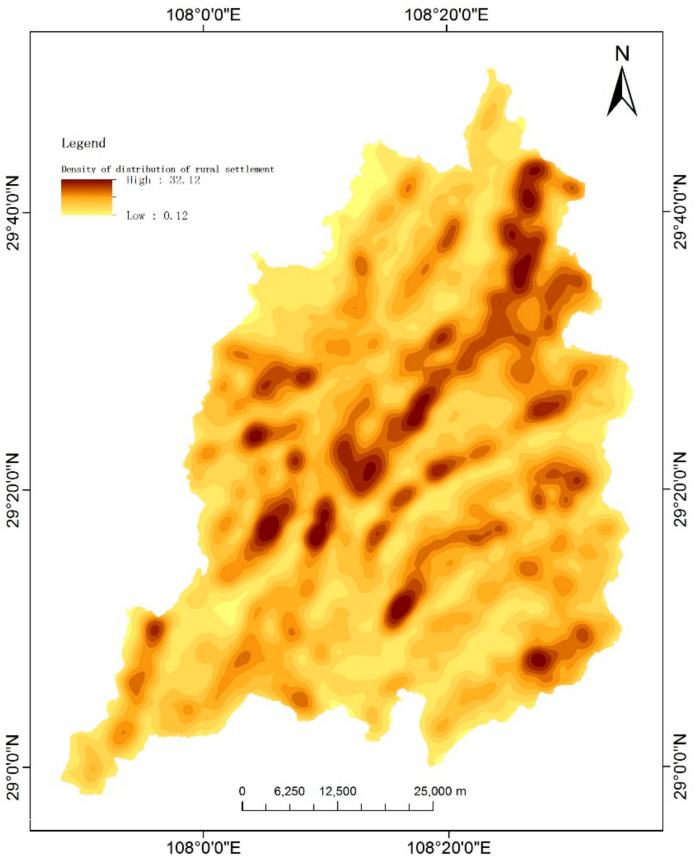

Figure 2. Density of distribution of rural settlement in the study area.

5.3. Topographical Agglomeration Characteristics of Rural Settlements

(1) The rural settlements are concentrated between the elevation of 400~800 m.

By using the software, ArcGIS 10.2, the rural settlements and elevations (DEM) were superimposed to extract the elevation values of each rural settlement and carry out hierarchical statistics (Table 4). From the area, 85.41% of the rural settlements in the study area are distributed below 1000 m above sea level, especially at an altitude of 400~800 m, accounting for 52.75% of the total area. In terms of quantity, 84.28% of the rural settlements in the study area are distributed at an altitude of 1000 m or less, especially at an altitude of 400~800 m, accounting for 52.69% of the total. Therefore, regardless of the area or quantity, rural settlements are mainly concentrated in the area of 400~800 m above sea level.

Table 4. Distribution of the rural settlements to elevation in the study area.

Elevation (m)	Area Summary (hm^2)	Area Ratio (%)	Quantity Summary	Proportion of Quantity (%)
0–200	20.91	0.26	69	0.15
200–400	1170.29	14.31	5597	11.70
400–600	1697.84	20.77	10,278	21.48
600–800	2614.68	31.98	14,932	31.21
800–1000	1478.55	18.09	9446	19.74
1000–1200	680.55	8.32	4326	9.04
1200–1400	456.08	5.58	2705	5.66
1400–1600	56.36	0.69	489	1.02
1600–2000	0.17	0.00	2	0.00

(2) The rural settlements are concentrated at the slope of 6~25°, especially between 6~15°.

By using the software, ArcGIS 10.2, elevation analysis module was used to generate the slope map based on elevation (DEM). The rural settlements and slope maps were superimposed to extract the slope values of each rural settlement and rank statistics (Table 5). From the area, 77.59% of rural settlements are concentrated in the range of 6~25°, especially 6~15°, accounting for 46.65%. In terms of quantity, 76.75% of rural settlements are concentrated in the range of 6~25°, especially 6~15°, accounting for 43.17%. Therefore, regardless of the area or quantity, rural settlements exhibit the same agglomeration pattern on the slope. At the same time, the rural settlement has the least spatial distribution in the 0~2° slope, and there are still about 10% rural settlement points in the area above 25°. The above results show: 1) In poor mountainous areas, agricultural farming is at the forefront, and cultivated land is the most valuable production resource, and construction is not occupied as much as possible. 2) The layout of rural settlements can be selected in a wide range, and cultivated land is mainly affected by natural factors. 3) In the poverty-stricken mountainous areas dominated by the rural areas, the Pingba area with good soil and water is mainly used for agricultural production, and rural areas with poor production conditions are used to build rural settlements.

Table 5. Distribution of the rural settlements to gradient in the study area.

Slope (m)	Area (hm^2)	Area Ratio (%)	Quantity	Proportion of Quantity (%)
0–200	20.91	0.26	69	0.15
200–400	1170.29	14.31	5597	11.70
400–600	1697.84	20.77	10,278	21.48
600–800	2614.68	31.98	14,932	31.21
800–1000	1478.55	18.09	9446	19.74
1000–1200	680.55	8.32	4326	9.04
1200–1400	456.08	5.58	2705	5.66
1400–1600	56.36	0.69	489	1.02
1600–2000	0.17	0.00	2	0.00

(3) The effect of slope direction accumulation is not obvious.

By using the software, ArcGIS 10.2, elevation analysis module was used to generate the aspect map based on elevation (DEM), and the rural slope points are superimposed with rural settlements to extract the slope value of each rural settlement and perform hierarchical statistics (Table 6). Regardless of the area or the proportion of the population, the slope characteristics of rural settlements in the study area are not significant, and the distribution of the slope direction is relatively uniform, and the proportion of the eastward and southeast directions is slightly larger than other directions. Compared to the analysis results with the field survey, the rural settlements in poor mountainous areas are inclined to back the mountain, and the orientation is not fixed due to the situation of the mountain.

Table 6. Distribution of the rural settlements to slope direction in the study area.

Slope Direction	Area (hm^2)	Area Ratio (%)	Quantity	Proportion of Quantity (%)
North	774.40	9.47	4681	9.78
Northeast	941.66	11.52	5674	11.86
East	1288.49	15.76	7442	15.56
Southeast	1357.84	16.61	7748	16.19
South	985.56	12.06	5648	11.81
Southwest	913.59	11.17	5406	11.30
West	970.69	11.87	5693	11.90
Northwest	943.20	11.54	5552	11.60

5.4. Water Source Agglomeration Characteristics of Rural Settlements

By using the software, ArcGIS 10.2, buffer analysis module was used to generate buffers based on rivers and to superimpose statistics with rural settlements (Table 7). In terms of area ratio, 49.56% of

the rural settlements in the study area are concentrated in the area 1000 m away from the river, and only 11.27% of the rural settlements are concentrated in the area 100 m away from the river. In terms of the proportion, 48.77% of the rural settlements in the study area are concentrated in the area 1000 m away from the river, and only 8.80% of the rural settlements are concentrated in the area 100 m away from the river. Therefore, regardless of the area or quantity, the water source agglomeration characteristics of rural settlements in the study area are more significant, but 30% of rural settlements are still distributed in areas other than 2000 m from the water source.

Table 7. Distribution of the rural settlements to water source in the study area.

Distance (m)	Area (hm^2)	Area Ratio (%)	Quantity	Proportion of Quantity (%)
0–100	921.43	11.27	4211	8.80
100–200	501.18	6.13	3085	6.45
200–300	440.00	5.38	2705	5.65
300–400	389.51	4.76	2281	4.77
400–500	384.46	4.70	2247	4.71
500–600	327.22	4.01	1978	4.13
600–700	300.99	3.68	1853	3.87
700–800	287.91	3.52	1795	3.75
800–900	252.81	3.09	1674	3.51
900–1000	245.94	3.02	1499	3.13
1000–1100	211.31	2.58	1397	2.92
1100–1200	215.12	2.63	1321	2.76
1200–1300	184.72	2.26	1101	2.30
1300–1400	168.53	2.06	1075	2.25
1400–1500	144.37	1.77	887	1.85
1500–2000	663.52	8.12	3997	8.35
2000–3000	957.86	11.72	5932	12.40
3000–4000	623.37	7.62	3662	7.65
> 4000	955.18	11.68	5144	10.75

5.5. Road Agglomeration Characteristics Of Rural Settlements

By using the software, ArcGIS 10.2, based on road generation buffers, buffer analysis module was superimposed with rural settlements (Table 8). From the area ratio, 52.25% of the rural residential areas in the study area are concentrated in the 1000 m road area, and only 19.57% are concentrated in the road 100 m range. In terms of the proportion, 49.99% of rural settlements are concentrated in the area of 1000 m roads, and only 16.41% are concentrated in the area of 100 m roads. Therefore, regardless of the area or quantity, road agglomeration characteristics of rural settlements in the study area are more significant, but there are still 25% of rural settlements distributed in areas other than 2000 m from the road.

Table 8. Distribution of the rural settlements to road in the study area.

Distance (m)	Area (hm^2)	Area Ratio (%)	Quantity	Proportion of Quantities (%)
0–100	1599.70	19.57	7850	16.41
100–200	369.60	4.52	2294	4.79
200–300	315.61	3.86	1983	4.14
300–400	321.14	3.93	1911	3.99
400–500	322.60	3.95	1886	3.94
500–600	309.36	3.78	1849	3.86
600–700	259.13	3.17	1675	3.50
700–800	266.54	3.26	1613	3.37
800–900	257.25	3.15	1462	3.06
900–1000	250.66	3.07	1396	2.92
1000–1100	227.10	2.78	1352	2.83
1100–1200	229.89	2.81	1441	3.01
1200–1300	204.68	2.50	1293	2.70
1300–1400	199.81	2.44	1175	2.46
1400–1500	198.46	2.43	1210	2.53
1500–2000	795.97	9.74	4861	10.16
2000–3000	1061.54	12.98	6481	13.55
3000–4000	558.06	6.83	3342	6.99
> 4000	428.32	5.24	2770	5.79

Combining (Table 7) with (Table 8), the rural settlements in the study area show the following rules along the water source and the road: (1) Small peaks appear simultaneously in the buffer zones of 0~100 m, 1500~2000 m, 2000~3000 m, and (2) those small peaks are very similar. (3) In the same agglomeration area, the agglomeration characteristics of roads are slightly more significant than water sources.

5.6. Characteristics of Cultivated Land Agglomeration in Rural Settlements

By using the software, ArcGIS 10.2, based on the cultivated land generation buffer, buffer analysis module was superimposed with rural settlements (Table 9). From the area ratio, 99.55% of the rural settlements in the study area gather in 100 m of cultivated land. In terms of quantity, 99.48% of the rural settlements in the study area are concentrated in the area of 100 m of cultivated land. Therefore, regardless of the area or quantity, the characteristics of rural settlements in the study area are very significant.

Table 9. Distribution of the rural settlements to cultivated land in the study area.

Distance (m)	Area (hm^2)	Area Ratio (%)	Quantity	Proportion of Quantity (%)
0–100	8139.05	99.55	47,597	99.48
100–200	20.28	0.25	171	0.36
200–300	10.53	0.13	49	0.10
300–400	3.40	0.04	20	0.04
400–500	1.88	0.02	5	0.01
500–600	0.19	0.00	1	0.00
600–700	0.00	0.00	0	0.00
700–800	0.00	0.00	0	0.00
800–900	0.11	0.00	1	0.00

5.7. Urban Agglomeration Characteristics of Rural Settlements

By using the software, ArcGIS 10.2, based on town-generated buffers, buffer analysis module was used to superimpose statistics with rural settlements (Table 10). Regardless of the area or the proportion, there is a distribution in the buffer radius of 0~4000 m, and there is no obvious peak. Even in the distance of 4000 m from the town, there are still nearly 50% of rural settlements in the study area. It shows that the urban agglomeration of rural areas in the study area is not significant.

Table 10. Distribution of the rural settlements to urban in the study area.

Distance (m)	Area (hm^2)	Area Ratio (%)	Quantity	Proportion of Quantity (%)
0–100	290.74	3.56	811	1.70
100–200	95.89	1.17	463	0.97
200–300	101.19	1.24	484	1.01
300–400	88.37	1.08	399	0.83
400–500	69.81	0.85	435	0.91
500–600	83.06	1.02	474	0.99
600–700	85.01	1.04	452	0.94
700–800	77.64	0.95	479	1.00
800–900	94.24	1.15	505	1.06
900–1000	78.16	0.96	554	1.16
1000–1100	97.33	1.19	592	1.24
1100–1200	97.88	1.20	566	1.18
1200–1300	84.85	1.04	535	1.12
1300–1400	95.30	1.17	551	1.15
1400–1500	92.15	1.13	536	1.12
1500–2000	505.66	6.19	3083	6.44
2000–3000	1155.62	14.14	6923	14.47
3000–4000	999.45	12.23	6054	12.65
> 4000	3983.06	48.72	23,948	50.05

5.8. Differences in Agglomeration Characteristics of Rural Settlements

According to Tables 1–10 by comparing the agglomeration characteristics of different factors affecting the spatial distribution of rural settlements in the study area, we found: 1) The topography

(elevation, slope), roads, water sources and cultivated land of the study area have agglomeration effect on the distribution of rural settlements, while towns and slopes do not. The effect on agglomeration is not significant; 2) The distribution of cultivated land to rural settlements is very significant; 3) The agglomeration presents cultivated land > elevation > road ≥ water source > slope > field town > slope direction.

6. Discussion and Conclusions

6.1. Discussion

On the basis of the land use database, the techniques and methods of exploratory spatial data analysis such as spatial buffering and kernel density analysis are used to analyze the spatial agglomeration characteristics and environmental factors of rural settlements in the study area. In poor mountainous areas, convenient farming is the primary condition for production and life. Elevation and slope affect the distribution of agricultural resources such as light, temperature and water, thus affecting farming and the distribution of rural settlements. Rural settlements are highly correlated with cultivated land. Rural settlements are scattered and gathered together with cultivated land, and 99.48% of rural settlements are concentrated within the 100 m area of cultivated land. The distribution of cultivated land dominates the concentration of rural settlements. In the poverty-stricken mountainous areas, cultivated land is the most valuable resource, and rural settlements do not occupy and occupy less high-quality cultivated land with less slope. There are very few rural settlements in the 0–2° slope, and 77.59% of rural settlements are concentrated in the 6–25° slope area, which fully reflects that the high-quality cultivated land with smaller slope is preferentially used for agricultural production rather than rural settlement development.

The economic and social factors such as cities and towns are not significant for the accumulation of rural settlements. From the area or quantity ratio, there are distributions within the range of 0~4000 m from the town; even beyond 4000 m from the town, there are nearly 50% of rural settlements, indicating that the urban agglomeration effect on rural settlements is not significant.

These findings highlight the central role of agriculture in supporting the traditional communities in the mountainous areas. The economic weakness will be enlarged with the accelerated urbanization and declining role of agriculture, which implies an urgent need to reconstruct the rural settlement pattern and industrial transformation. However, given the natural and economic conditions, it should be emphasized that the livelihoods' transformation, improvement of living conditions and ecological protection should be integrated into the planning of settlement reconstruction and rural revitalization.

6.2. Conclusions

In this paper, we employed spatial buffer and kernel density to analyze the spatial agglomeration characteristics of rural settlement in Pengshui County. We found that there is a high spatial correlation between rural settlements and cultivated land in poverty-stricken mountainous areas. The rural settlements are not more than 100 m away from cultivated land. It is highly anastomosed to the view that "the rural residential areas in mountainous areas of China are scattered by cultivated land, and concentrated living is not conducive to nearby planting", proposed by Jin Qiming [32]. Although the spatial distribution of cultivated land is the result of the combined effects of nature, economy and society, natural factors dominate. The spatial pattern of rural settlements in poverty-stricken mountainous areas under the guidance of agricultural farming is controlled by the quantity and quality distribution of cultivated land. The quantity and quality distribution of cultivated land are mainly controlled by natural factors. In other words, in poor mountainous areas, the spatial agglomeration of rural settlements is largely a natural process. When the economic and social pillars of poor mountainous areas are transformed from agricultural farming to industrialization or going out to work, the close relationship between rural settlements and cultivated land will undergo fundamental changes. Due to the change of rural settlements, arable land in mountainous areas is often abandoned [37–39]. In the

process of rural revitalization, the adjustment and optimization of rural settlement space and the abandonment of cultivated land and the protection of cultivated land should be considered. The next step we will study is the coupling relationship between rural settlements and cultivated land in poor mountainous areas, and the possibility of predicting decoupling.

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