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Analysis of spatial-temporal differentiation and influence factors of construction land expansion of the urban agglomeration in central Yunnan

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Abstract: This paper takes the plateau mountain city: the urban agglomeration in central Yunnan as the research area, 2000-2015 as the research period, and measure and analyze the spatio-temporal differentiation of construction land expansion in the urban agglomeration based on the calculation of kernel density. Use the spatial autocorrelation model to analyze the spatial autocorrelation patterns of construction land on the 1 km ×1 km grid scale, and then use the GIS spatial analysis technique to study the local aggregation area at the $p<0.05$ significance level of the construction land in relation to natural and social driving factors. The result shows that the growth and distribution of urban construction land in this urban agglomeration is affected by natural social factors and land policies, and the area of construction land is growing rapidly. The areas with large distribution density of construction land at four time points are mainly located in flat dam area in the central and eastern part of the urban agglomeration, and mountain in the northern part. The spatial distribution of construction land in this urban agglomeration from 2000 to 2015 is mainly represented by two patterns: high-high aggregation and low-low aggregation. The topographical features dominated by plateau mountains affect the local spatial clustering of the construction land. At 4 time points, the elevation is 1000~3000 m, the slope is between 2°-25° and the sunny slope area is the area with the largest distribution and the most concentrated area of the construction area. The farther away from the water system and the road, the local space gathering area of construction land is decreasing.

1. Introduction

The rapid development of urbanization and industrialization has promoted the expansion and spread of construction land. The expansion of construction land has become a distinctive feature of land use change now and in the future, and it is also an important manifestation of social economic development to a certain stage [1]. Urban development in different periods reflects different forms of spatial expansion of construction land, which makes the expansion pattern of construction land different in the region, and the main reason for this difference is influenced by many factors such as natural geographical conditions, social and economic conditions and policy regulation, especially plateau mountainous areas [2]. In order to understand the development process of mountainous cities, master the spatial and temporal pattern of mountain construction land and its changing laws, it is necessary to systematically analyze the expansion characteristics and driving mechanism of construction land in mountainous cities.

This paper based on land use data and DEM, uses GIS technology to analyze the spatial and temporal differentiation characteristics of construction land expansion of the urban agglomeration in central Yunnan. On this basis, it discusses the spatial autocorrelation characteristics of construction land in research area, and selects elevation, slope, aspect, natural socio-economic factors such as distance from the road, and distance from the water system are analyzed. The influence of these factors on the spatial autocorrelation pattern of construction land in research area is analyzed. In order to understand the spatial and temporal distribution characteristics of construction land expansion in research area, and to reveal the coupling relationship between the spatial autocorrelation pattern of construction land and natural socio-economic factors, it provides important reference adjustment of structural layout and delineation of urban development boundary of urban agglomeration in central Yunnan.

2. Research area and data sources

2.1. Research area
As one of the 19 important national urban agglomerations that are currently developing in China and in the future, the urban agglomeration in central Yunnan is located between 100°43′ - 104°49′ east longitude and 24°58′ - 25°09′ north latitude. It is composed of Kunming, Qujing, Yuxi and Chuxiong Yi Autonomous Prefecture four prefecture-level cities and seven counties (cities) in the northern part of the Hani Yi Autonomous Prefecture in Honghe, with 49 counties and districts in the whole region. The urban agglomeration in central Yunnan is located in the west of Yunnan-Guizhou Plateau; it belongs to the Karst Plateau landform of Lake Basin. It is mainly mountainous and with an intermountain basin landform with a gentle relief. The land area of the whole region is 111421.6995 km^2, accounting for 29.00% of the total land area of Yunnan Province, of which the flat area is 13192.5916 km^2, accounting for only 11.84% of the whole group, and for 3.43% of the total land area of Yunnan Province.
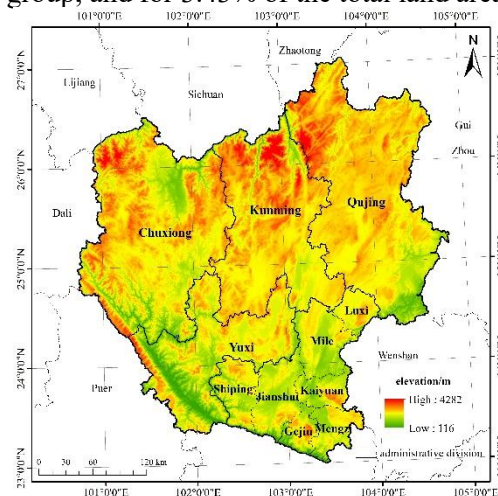

Figure 1. Map of geographical location of research area

2.2. Data source and processing
The basic data involved in this paper mainly include land use data (vector and raster) in 2000, 2005, 2009 and 2015. The land use raster data in 2000 and 2005 are from the National Earth System Science Data Sharing Infrastructure, National Science & Technology Infrastructure of China, and the land use data in 2009 and 2015 are from the annual change database of land use status. According to the research needs, the construction land includes urban and rural construction land, traffic and water use land and other construction land. According to the natural and social environmental characteristics of the research area, the elevation, slope, aspect, distance from river system and road are selected as the main factors influencing the formation of the spatial autocorrelation pattern of construction land in the urban agglomeration area. The spatial quantization map of the factor is obtained by SRTM 30 m resolution

DEM data that are converted by ArcGIS 10.2, and the DEM data are provided by the geospatial data cloud platform. The spatial distribution maps of the river system and road distance in the four years were obtained by measuring the distance function of ArcGIS 10.2.

3. Research method

3.1 Construction land expansion characteristic analysis model
In this paper, we first use the kernel density estimation method[3] to measure and analyze the difference in spatial-temporal distribution of construction land expansion in the research area; and then, use the spatial autocorrelation model[4] to analyze the spatial autocorrelation patterns of construction land on the 1 km ×1 km grid scale, and then use the GIS spatial analysis technique to study the local aggregation area at the $p<0.05$ significance level of the construction land in relation to natural and social driving factors.

3.2. GIS spatial analysis
To better analyse the causes of significant cluster of construction land in this urban agglomeration, the spatial values of each factor were graded as follows: (1) According to the topographic characteristics of the urban agglomeration, the elevation was divided into four sections: 116 m - 500 m, 500 m - 1000 m, 1000 m - 3000 m and 3000 m; (2) With reference to the "Technical Regulations for Land Use Status Survey" issued by the China Agricultural Regional Committee, combined with the actual situation of the urban agglomeration in central Yunnan, the slope is divided into five grades: 0° - 2°, 2° - 8°, 8° - 15°, 15° - 25°, and 25° or more; (3) According to the principle of aspect, the aspect is divided into flat (-1° - 122.16°), sunny slope (122.16° - 270.00°) and shady slope (270.00° - 359.99°); (4) Compare and calculate the proportion of construction land to the river system and road in different distances according to the range of the urban agglomeration area, and follow the basic principle of the equal data interval, divide the distance between the river system and road into 0 - 2.0 km, 2.0 - 4.0 km, 4.0 - 6.0 km, 6.0 km - 8.0 km and 8.0 km above. By means of the ArcGIS neighbourhood analysis tool, the spatial local cluster map of construction land in each year and the grading maps of influencing factors in the corresponding years are superimposed, and the cluster area of construction land in each grading zone of each year is calculated to quantitatively analyse the relationship between the spatial cluster area of construction land and the influencing factors.

4. Result and Analysis

4.1. Spatial distribution and change characteristics of construction land density
As shown in Figure.2, from the quantitative calculation of the kernel density of construction land, the maximum values of the kernel density of construction land in 2000, 2005, 2009 and 2015 are 813 blocks·km^{-2}, 1041 blocks·km^{-2}, 732 blocks·km^{-2} and 884 blocks·km^{-2}, respectively, indicating that there are four time points in some areas of the research area, and the number of construction land patches increased significantly in the unit area.

From the spatial distribution of the kernel density of construction land, the following conclusions can be drawn: (1) The spatial distribution of the kernel density of construction land shows a similar pattern of "two in two" at four time points, showing a high spatial distribution in the central and eastern regions, while a low spatial distribution in the northwest and southwest regions. (2) The spatial distribution pattern of the kernel density of construction land from 2000 to 2015 showed the trend of multi-nuclear diffusion and fragmentation. Compared with the 2000 and 2005, the nuclear positions in 2009 and 2015 have spread over a large area in the original spatial distribution pattern, and the diffusion area is mostly located in the gentle slope area and many subnuclei are derived around the main nucleus, the degree of fragmentation is high but the overall distribution is continuous.
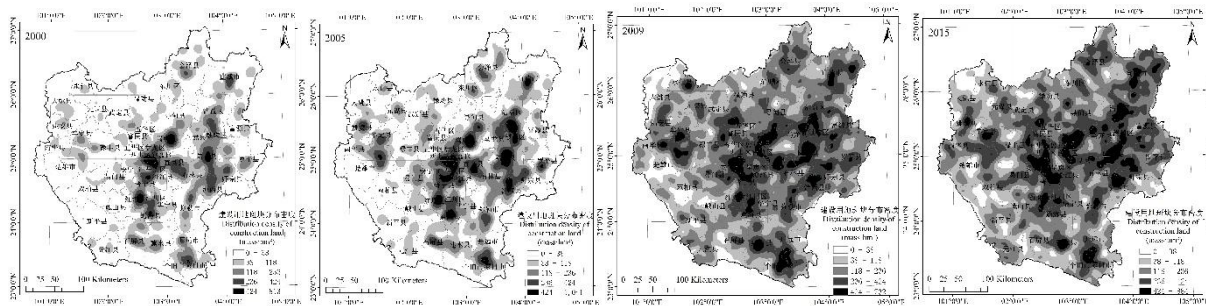
Figure 2 Spatial distribution of kernel density of construction land in research area in 2000-2015

4.2. Spatial autocorrelation analysis of construction land

4.2.1. Global spatial autocorrelation

Since spatial autocorrelation analysis has certain requirements on the number of samples, this paper takes the proportion of construction land in the 1 km×1 km grid scale as the observed variable, based on the K-nearest proximity weight, and calculates 2000, 2005, 2009 and in 2015, the overall Moran's I of construction land was calculated and its significance is tested. It is known from Table 1 that the Moran's I index of construction land proportion in the research area is positive from 2000 to 2015, that is, the overall appearance of spatial aggregation characteristics shows a high degree of global spatial positive autocorrelation. The spatial autocorrelation of construction land at four time points is generally enhanced.

Table 1 Significance test for global Moran's I of construction land at 1 km grid scale (in 2000-2015)

Year	Moran's I	Zscore	p
2000	0.8504	35.5099	＜0.001
2005	0.8616	47.4911	＜0.001
2009	0.8959	73.6271	＜0.001
2015	0.8709	74.9393	＜0.001

Note: Zscore is a test statistic, p represents probability; Zscore is associated with p, when Zscore > 1.96 or Zscore < 1.96, p< 0.05, that is, confidence > 95%.

4.2.2. Local spatial autocorrelation

Further determine the specific location of local spatial cluster or the abnormality of construction land of the research area. It can be seen from Figure 3 that the construction land in the research area 2000-2015 shows three types of high-high aggregation, low-low aggregation and low-high anomaly in the spatial layout, and the distribution range of aggregation or anomaly area is expanding year by year situation. The high-high aggregation area of construction land area increases from 92.5604 km^2 in 2000 to 892.4825 km^2 in 2015. It is mainly distributed in the middle of the urban agglomeration, these areas are relatively flat and the construction land is large and distributed; the spatial distribution of the low-low aggregation areas still shows a state of aggregate distribution. The area of this type of area changes from 251.0473 km^2 in 2000 to 511.9183 km^2 in 2015, mainly distributed in the northwest, west and southwest. These areas are relatively high in terrain, limited in land development, and the construction land is concentrated in small areas and scattered. The low-high anomaly area is small, and the area has changed from 2.000 km^2 in 2000 to 8.3820 km^2 in 2015, with a small increase in area.
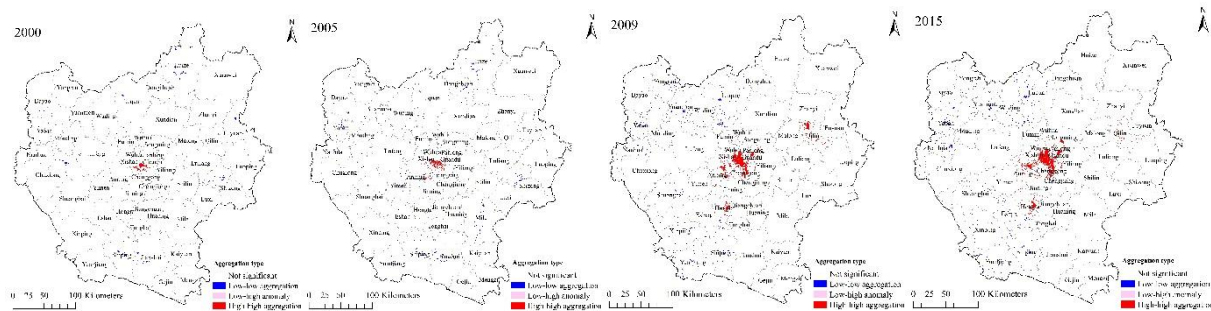
Figure 3 LISA map of construction land of the research area in 2000-2015

4.3. Influence factor

Because the spatial distribution of construction land in research area is the high-high aggregation or low-low aggregation, the abnormal area is less active, therefore this study only analyses the relationship between construction land aggregation area and various factors.

4.3.1. Elevation

It can be seen from Figure 4 that at four time points, the high-high aggregation area of the construction land is mainly distributed in the area with an elevation of 500 ~ 3000 m, of which the area with the elevation of 1000~3000 m is the most distributed, and the area is 92.5604 km^2 in 2000, 95.6378 km^2 in 2005, 454.1097 km^2 in 2009 and 892.4825 km^2 in 2015; there are few or no high-high aggregation areas in other elevation grading zones. It shows that the distribution of construction land in the research area is mainly concentrated in the middle and high elevation areas.

The low-low aggregation areas of construction land are still mainly distributed in the elevations of 1000~3000 m (Figure 4), and the area is increasing year by year, from 247.0473 km^2 in 2000 to 487.0319 km^2 in 2015; the elevation is between the low-low aggregation area of construction land in the elevation of 500~1000 m and 116-500 m is less distributed, and it tends to increase first or then decrease or decrease; the construction land is within the altitude of 3000 m or higher there is few distribution.
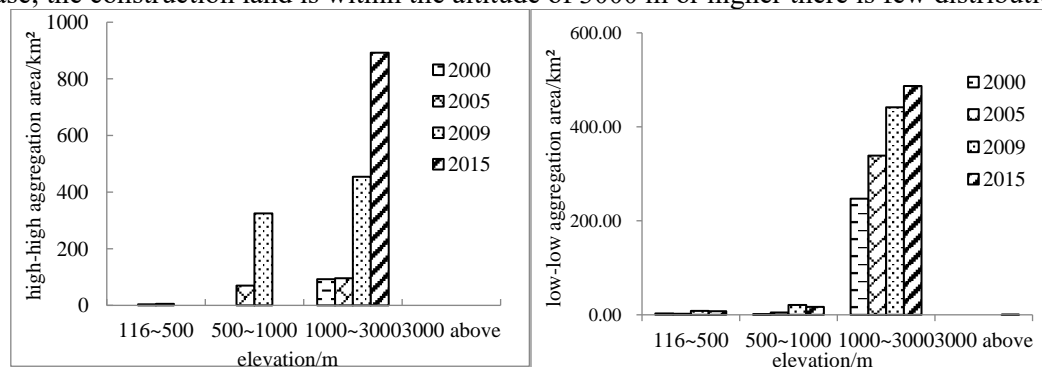

Figure 4 Relationship between significant aggregation areas of construction land and elevation

4.3.2. Slope

As shown in Figure 5, at the four time points, the construction land aggregation area is distributed at each grade level, and the area with the increase of the slope increases first and then decreases, and the area distribution of the high-high aggregation area in each year, and mainly concentrated in the area of slope≤25 °. The distribution area of high-high aggregation area of construction land with different slope grades is the largest with slopes of 2°-8° and 8°-15°, followed by high-high aggregation with slopes between 15°-25°. Especially the area growth after 2009, the area is the most prominent. The slope is 25° and above, the area of the high-high aggregation area is increasing. It is considered that the reason for its annual increase is for other construction such as traffic water use land development. Therefore, the

high-high aggregation area of the construction land is mainly distributed in the relatively flat terrain.

The area distribution of low-low aggregation area of construction land is similar to that of high-high aggregation area, and it is still mainly concentrated in the area of slope≤25°. The difference is that the area distribution of low-low aggregation area at slope of 25° and above is obviously higher than that. The high-high aggregation area increased from 19.1551 km^2 in 2000 to 103.3450 km^2 in 2015.
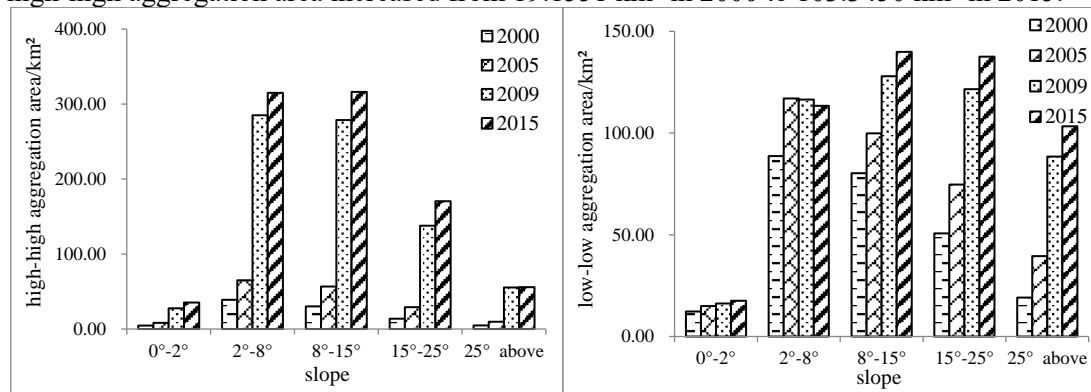

Figure 5 Relationship between significant aggregation areas of construction land and slope

4.3.3. Aspect

It can be seen from Figure 6 that the high-high aggregation area and low-low aggregation area of construction land in the research area from 2000 to 2015 are mainly concentrated in sunny slope and shady slope, and the area of the aggregation area is increasing year by year, which is distributed in the sunny slope. The area of high-high aggregation increased from 49.9746 km^2 in 2000 to 513.6807 km^2 in 2015, while the area of high-high aggregation area distributed to the shady slope increased from 41.2544 km^2 in 2000 to 373.0491 km^2 in 2015; The area of the low-low aggregation area of sunny slope increased from 140.1896 km^2 in 2000 to 287.8911 km^2 in 2015, while the area of low-low aggregation area distributed to the shady slope increased from 108.3383 km^2 in 2000 to 222.1972 km^2 in 2015. There is very little distribution the aggregation area of construction land in the flat slope area. From the distribution of aggregation areas of construction land in each year, the site selection of construction land, especially for urban residents, tends to be sunny slope.
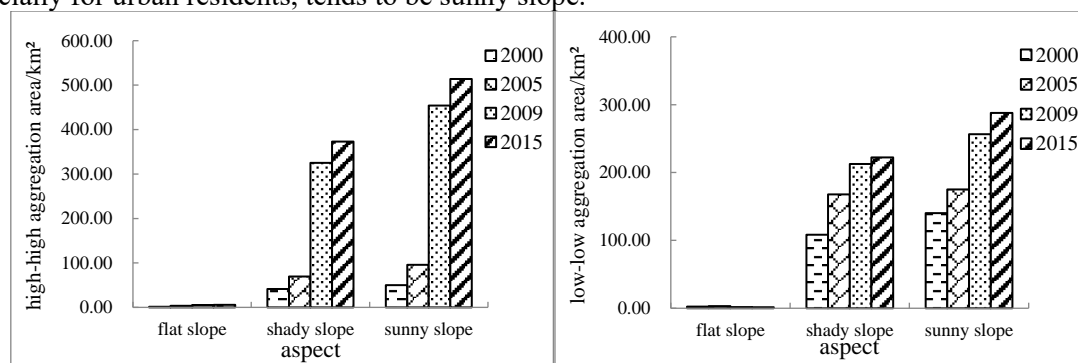

Figure 6 Relationship between significant aggregation areas of construction land and aspect

4.3.4. Distance from the river system

As shown in Figure 7, at the four time points, the area of the high-high aggregation area of the research area is decreasing from the river system. The high-high aggregation areas of construction land in each year are concentrated in the range of 4.0 km from the river system, and the area of high-high aggregation area in the range of 2.0-4.0 km from the river system increased from 40.5233 km^2 in 2000 to 400.1187 km^2 in 2015. The area within 2.0 km of the river system increased from 26.13118 km^2 in 2000 to 461.4207 km^2 in 2015. More than 4.0 km from the river system, the area of high-high aggregation area

of construction land in each year is relatively small. This shows that the closer to the river system, the area of high-high aggregation area of construction land increases rapidly.

The distribution pattern of low-low aggregation area of construction land in the research area from 2000 to 2015 is the same as that of high-high aggregation area. The farther away from the river system, the low-low aggregation area shows a decreasing area.
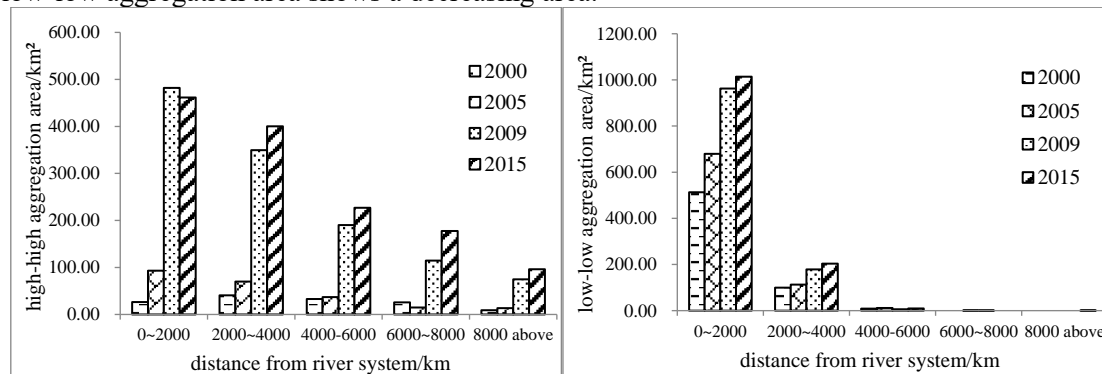

Figure 7 Relationship between significant aggregation areas of construction land and river system

4.3.5 Distance from the road
As shown in Figure 8, the distribution of high-high aggregation areas of construction land in the research area from 2000 to 2015 is mainly reflected as the distance of the road increases. The high-high aggregation area of construction land is concentrated in the range of 4.0 km from the road, and the area of high-high aggregation area within 2.0 km from the road is the most distributed; within the range of 2.0~4.0 km from the road, the area of high-high aggregation area of construction land in each year is relatively small, all below 250 km^2. Within the range of 4.0~6.0 km from the road, the area of high-high aggregation area of construction land in each year is below 90 km^2; more than 6.0 km away from the road, only a few high-high aggregation areas of construction land are distributed in 2015, with an area of 15.4576. km^2, in the remaining years, there is no high-high aggregation area for construction land. This shows that the closer to the road, the faster the area of high-high aggregation area of construction land increases.

The distribution pattern of low-low aggregation area of construction land in the research area from 2000 to 2015 is the same as that of high-high aggregation area. It is easy to as the road distance increases, its area continues to decrease.
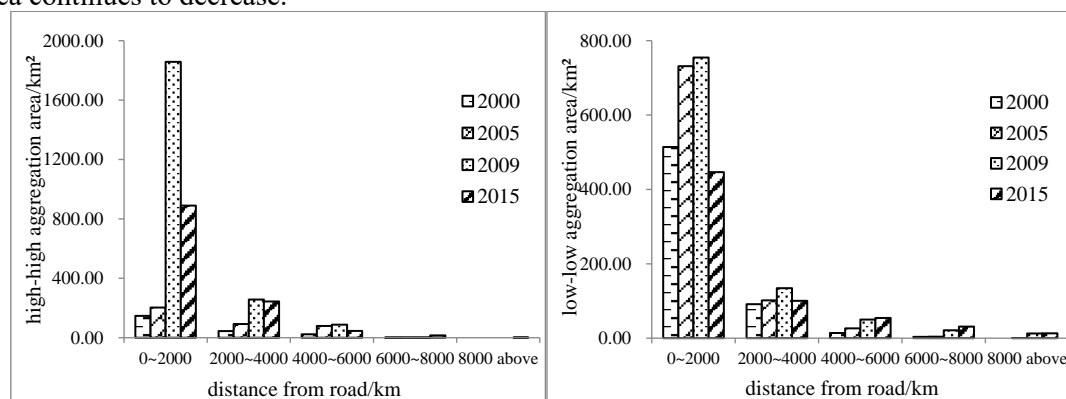

Figure 8 Relationship between significant aggregation areas of construction land and road

5. Conclusions and discussion
(1) the spatial distribution of construction land in the research area is obviously affected by the terrain conditions. The distribution density of construction land is mainly concentrated in the plain dam area in

the east and the mountainous area in the north of the research area, while the distribution density of construction land in the northwest and southwest mountainous areas is significantly lower than other areas. The spatial distribution pattern of kernel density of construction land in each year shows the trend of multi-core diffusion and fragmentation.

(2) the spatial distribution of construction land in the research area shows a high degree of global spatial positive autocorrelation. The spatial aggregation of construction land with high proportion of land use shows obvious agglomeration state. From the local Lisa spatial aggregation map, the spatial structure of construction land in the research area in 2000-2015 only shows three types: high-high aggregation, low-low aggregation and low high anomaly, and the overall difference of regional spatial pattern is small.

(3) the local spatial distribution of construction land in the aggregation area is affected by the terrain characteristics dominated by the plateau mountainous area. At the four time points, the local spatial aggregation areas of construction land are mainly concentrated in the areas with an elevation of 1000-3000 m, a gradient of 2 ° - 25 ° and sunny and shady slopes. Although the local aggregation areas are distributed at all slope levels, the area increases first and then decreases with the increase of slope. According to the proportion of the local aggregation areas of construction land in sunny slope and shady slope in each year, the site selection of construction land, especially the urban residential land, is more inclined to sunny slope.

(4) on the four time points, the farther away from the river system and road, the smaller the local spatial aggregation area of construction land is. In each year, the area of high-high and low-low aggregation area of construction land is mainly distributed within 4.0 km away from river system and road, and more than 4.0 km away from river system and road. The area distribution of local spatial aggregation area of construction land in each year is reduced. Therefore, the closer to the river system and road, the higher the area of high-high and low-low aggregation area of construction land increases rapidly.

Acknowledgments

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