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## Study of quantitative analysis on rural settlement spatial distribution feature based on the landscape ecology theory and GIS method

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### ABSTRACT

With the rapid development of china's rural urbanization, the demand of construction land has surged, bringing the consequence of a large number of high quality arable land being used for construction land and accelerating the contradiction between supply and demand. How to use limited land resources effectively to realize healthy and harmonious development is a serious issue in front. The spatial distribution characteristics of modern rural settlements embody how to maximize convenient for work, so it is very chaotic. And the core content of this study is to make the distribution of rural settlements become more intensive. In this study, Gangu County is taken as the research area, and the research object is the spatial distribution of rural settlement, and the theory of landscape ecology and GIS method have been adopted to carry on research. Firstly, this study introduces the distribution features of china's rural settlement, and expounds the basic concept of the two methods. Taking rural settlements of Gangu County as an example, residential landscape pattern and spatial distribution features of Gangu County have been studied by using the methods of landscape ecology, and land use landscape index and economic development data and other contents of rural settlement have also been analyzed, the rural settlement optimization model based on GIS method has been introduced, considering the natural environment and social economic characteristics and other factors. Finally, this study comprehensively introduces how to best optimize the different types of rural residential land distribution, practical experience of relevant research has been summarized, providing a good theoretical basis for the optimization of rural settlement in counties of mainland.

### KEYWORDS

Rural settlement; Theory of landscape ecology; GIS method; Spatial distribution feature; Gangu county.



## INTRODUCTION

The rural settlement embodies the relationship between humanity activities and social circumstances, different regions have different life styles, which can be well reflected from the different distributions of the rural settlement. It reflects not just the spatial characteristics, but more of the region's economic, cultural and economic development process of<sup>[1]</sup>, it is also the result of human activities and natural effect under the specific geographical condition and social background<sup>[2]</sup>. The core of man-land relationship is the rural settlement, and through the analysis of its morphology, size and spatial distribution characteristics, the development process of coordinated relationship between human and land can be got. And it will have potential great influence on the development direction and scale of the local area<sup>[3]</sup>. From the comprehensive analysis, we can see that the environment, social economic status, historical and cultural background are the main factors to determine the spatial patterns of rural settlements, and topographic conditions, the natural environment of Gangu county are the decisive factors affecting the spatial distribution of this area. Then distribution regularity of the area has been studied and identified, thus considering in the rapid development of urbanization today, how to make the distribution of rural settlement adapt to the development of urban-rural integration and construction of socialist new countryside.

## THE RESEARCH BACKGROUND AND THEORETICAL BASIS

### Regional background

In recent years, a systematic study has been carried out on the space distribution characteristics of different regions<sup>[4]</sup> including the main valley, desert, oasis, plateau and others. This study takes Gangu County as an example to comprehensively analyze its landscape pattern and the spatial distribution characteristics. Gangu County is an area of a large population, and strong resources and environment contradiction, and the distribution characteristics of rural settlements belong to the random distribution<sup>[5]</sup>. And it provides theoretical basis for Gangu County implementing the feasibility and necessity of ecological migration, and supplies the research foundation for realizing the coordination and sustainable development of the regional ecological environment. The CIS spatial analysis technology has been used to acquire the correlation coefficient matrix of Gugu County distribution. Generally speaking, the traditional correlation analysis method and statistical analysis method are the main methods to study the distribution of rural settlement in this area, and landscape ecology theory and CIS method are combined to study the distribution of rural settlements.

### Landscape ecology theory and CIS method

Rural settlement landscape is a patch formed by humanity patches different in shape, size and the natural combination content, and landscape ecology is just the description of the existing rural settlement distribution. The landscape pattern index reflects simple indicators such as structural component and spatial structure feature<sup>[6]</sup>.

The GIS method also known as geographic information system, it has strong spatial information analysis function which is one of the features that distinguish it from computer mapping system. The user can obtain a new experience and knowledge through the observation and analysis of the original data, and it has become the basis for decision making of spatial analysis. Spatial pattern characteristics can be better determined by using Patch Analyst of calculation module in landscape ecological parameters of GIS method. Through the basic characteristics and high correlation landscape index of study object, parameter indexes such as the main type area, the patch number, density, mean size and perimeter area ratio have been selected. The plate area of rural settlement is reflected by type area, and distribution condition is reflected by patch density, and the bigger density value means the larger spatial distribution. Spatial information analysis is the core content of GIS method, and it has extremely rich connotation, and can be used in the application of geographic data.

## SPATIAL DISTRIBUTION AND LANDSCAPE FEATURES OF RURAL SETTLEMENT IN GANGU COUNTY

### The natural condition and current situation of gangu county

Landscape ecology of rural settlement different greatly in size, shape and configuration, the characteristics of landscape structure and spatial configuration relationship can be well reflected through the analysis and operation of the relevant index<sup>[7]</sup>. This study uses the calculation method of landscape ecology and GIS technology to carry out well quantitative analysis of rural settlement patch characteristics in Gangu County, the specific data is shown in TABLE 1:

As can be seen from TABLE 1, the total area of rural settlement in this region is that of Gangu county\* hm2, there are great differences in the spatial distribution density, size and shape features between the villages, and mainly because of different patterns in river valley, the hill and mountain. Among which the area of Xinxing town is the biggest of all, and has the largest number of settlements, while the residential area of Wu Jiahe town is the smallest. The main reason is that these towns are located in flat areas of the rivers. The attribute data and related attribute data (height and slope) of rural settlement have been fully stacked to calculate the spatial distribution feature of each rural settlement by using overlay functional module in GIS. Through the determination of the distance function of GIS, the distances of rural settlements to the orchard, farmland and canals have been obtained, and rural residential average raster value can be got through statistics, meanwhile the average distance of rural settlements to the orchard, farmland and canals can be also acquired by calculating<sup>[8]</sup>. Then the

statistics distribution data are classified according to certain criteria. The TABLE 2 shows the levels of various environmental factors effect on agricultural life and social economy.

**TABLE 1 : Distribution pattern index of rural settlements in gangu county**

District	CA/hm <sup>2</sup>	NP	MPS/hm <sup>2</sup>	PSCOV	PSSD/hm <sup>2</sup>	MSI	MPAR	MPFD
Lixin	390.43	199	1.962	1.575	3.091	1.758	0.066	1.390
Dashi	614.42	168	3.657	1.356	4.958	1.776	0.050	1.371
Xiping	486.76	290	1.678	1.412	2.370	1.673	0.063	1.383
Xinxing	1366.82	179	7.636	1.497	11.430	1.779	0.050	1.361
Liufeng	488.77	106	4.611	1.310	6.042	1.787	0.052	1.368
Panan	739.67	173	4.276	1.480	6.330	1.831	0.057	1.379
Gupo	117.50	74	1.588	1.116	1.773	2.050	0.080	1.423
Jinshan	899.10	278	3.234	1.306	4.224	1.870	0.056	1.384
Dazhuang	515.90	272	1.897	1.349	2.559	1.721	0.063	1.385
Anyuan	826.52	239	3.458	1.213	4.196	1.685	0.047	1.360
Baliwan	790.26	297	2.661	1.348	3.587	1.734	0.054	1.374
Daxiangshan	388.85	40	9.721	1.186	11.526	1.819	0.038	1.348
Wujahe	224.01	107	2.094	1.121	2.346	1.832	0.063	1.393
Baijiahe	347.08	95	3.653	1.230	4.493	1.977	0.058	1.391
Xiejiawan	478.93	127	3.771	1.090	4.111	1.841	0.053	1.378
Whole county	8675.00	2644	3.291	1.613	5.308	1.781	0.057	1.379

**TABLE 2 : The classification standards of various environmental factors**

Level	Elevation/m	Slope/ (°)	Slope direction	Distance from irrigated land /m	Distance from the orchard /m	Distance from the trench /m
1	1224-1400	0-5°	flat	0-500	0-500	0-500
2	1400-1600	6-10°	north	501-1000	501-1000	501-1000
3	1600-1800	11-15°	northeast	1001-1500	1001-1500	1001-1500
4	1800-2000	16-20°	east	1501-2000	1501-2000	1501-2000
5	2000-2200	21-25°	southeast	2001-2500	2001-2500	2001-2500
6	2200-2708	>25°	south	>2500	>2500	>2500
7			southwest			
8			west			
9			northwest			

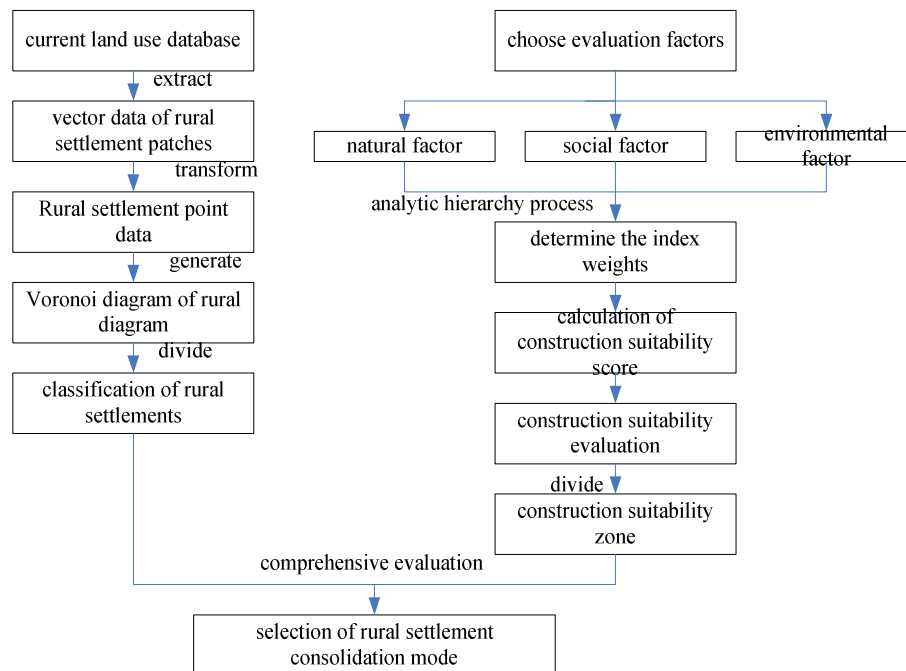
**TABLE 3 : Distribution relationship between the elevation and rural settlements**

Slope direction/level	CA/hm <sup>2</sup>	NP	PD/hm <sup>2</sup>	MPS/hm <sup>2</sup>	MSI	MPFD	MPAR
1	7.61	11	145.35	0.688	1.407	1.552	0.034
2	761.77	292	38.34	2.608	1.598	1.525	0.049
3	988.28	343	34.71	2.881	1.571	1.493	0.032
4	1289.45	373	28.89	3.461	1.601	1.372	0.149
5	1373.64	375	27.36	3.656	1.592	1.577	0.032
6	1435.37	325	22.61	4.422	1.620	1.486	0.067
7	1236.44	331	26.77	3.735	1.623	1.079	0.041
8	881.66	292	33.10	3.021	1.616	1.386	0.032
9	701.20	302	43.07	2.322	1.587	1.592	0.096

Natural environment has the greatest influence on the formation and development of the rural settlements, and of which the main factors are topography and geomorphology. The distribution features of the rural settlement shows the spatial distribution characteristic of local land production capacity, and the landform and terrain has great influence on the production ability of land<sup>[9]</sup>. However, although landform has provided a space for the existence and development of residential areas, at the same time it has limited the extension ability of the residential areas. This study mainly explores the factors including height, gradient and slope direction influencing on the distribution and change of rural settlement, because the slope, elevation and other related factors directly concerns the distribution pattern of local residential areas. The TABLE 3 shows the coefficient of elevation in the rural settlement distribution:

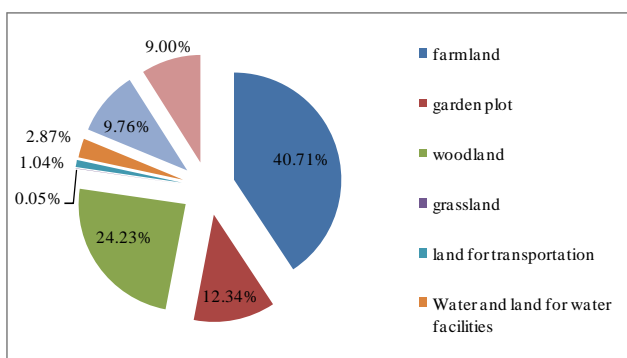
### The principle of rural settlement space distribution optimization

The space division characteristics of the Voronoi diagram in GIS method has been used to determine the influence of villages and towns within a certain area, eventually forming reasonable distribution state of rural settlement in this region. And on the basis of that, the development potential in this region has been analyzed, determining the consolidation mode of rural residential areas in different regions. The specific technical route is shown in Figure 1:



**Figure 1 : The research technical route diagram**

Rural settlement landscape is the carrier of ecological, economic and social functions, through which the ecological, social and economic conditions of different rural residential areas can be clearly reflected. If you want to optimize the spatial distribution of the rural residential areas, various factors shall be combined with to consider comprehensively, only in this way can achieve the best goal<sup>[10]</sup>. And then a comprehensive analysis has been carried out about the influence of rural settlement landscape pattern on the ecological and social functions, so as to determine the patterns of rural settlement in future. However, although Traditional rural settlement is mixed and disorderly, the local customs can be fully reflected. And the construction of rural settlement also integrated with the local environment including landform, preparation and water and soil, forming a unified whole. And traditional rural residence also has architectural creation value, which is the characteristic point of China's rural dwellings, so when optimizing the spatial distribution of the rural settlement. Attention shall be put on how to protect the local customs and architectural style. Figure 2 is the structure map of local land utilization:



**Figure 2 : The local land utilization**

The optimization of rural residential areas shall comprehensively consider the local space location and size to obtain the maximization economic, environmental and social benefits, and the distribution pattern and optimization goal of development of rural settlement are mainly as follows:

(1) It must be benefit for production and living conditions, the layout optimization of rural settlement shall be carried out within the range of natural environment and social economic development, and it shall be maximize convenient for agricultural production and land resources utilization, also create the best living environment for residents, ensuring the order smoothly;

(2) Set a reasonable settlement and the principle is to keep centralization and compact. From the macro view, the spatial distribution of rural settlements is reflected by rational layout of central village and grassroots village, and the rationality is just centralization and compact. And this layout is very effective for the improvement of the public facilities and the decrease of project cost. Therefore the idle village and land can be transformed and merged, increase the comprehensive utilization rate and volume rate of land effectively.

(3) The space layout is rational in economic, and only a comprehensive optimization layout can produce better economic benefits, and ensure the rationality of the layout. What’s more, the scale of construction land can be well reduced to save land, and it can be also effective for transportation convenient and cost reduction.

Generally speaking, the contents such as patch size, shape and distribution condition are the basic factors to ensure the rationality of spatial distribution, a set of perfect evaluation system shall be established to evaluate these factors reasonable rationally and comprehensively. The TABLE 4 shows the influence of various indexes.

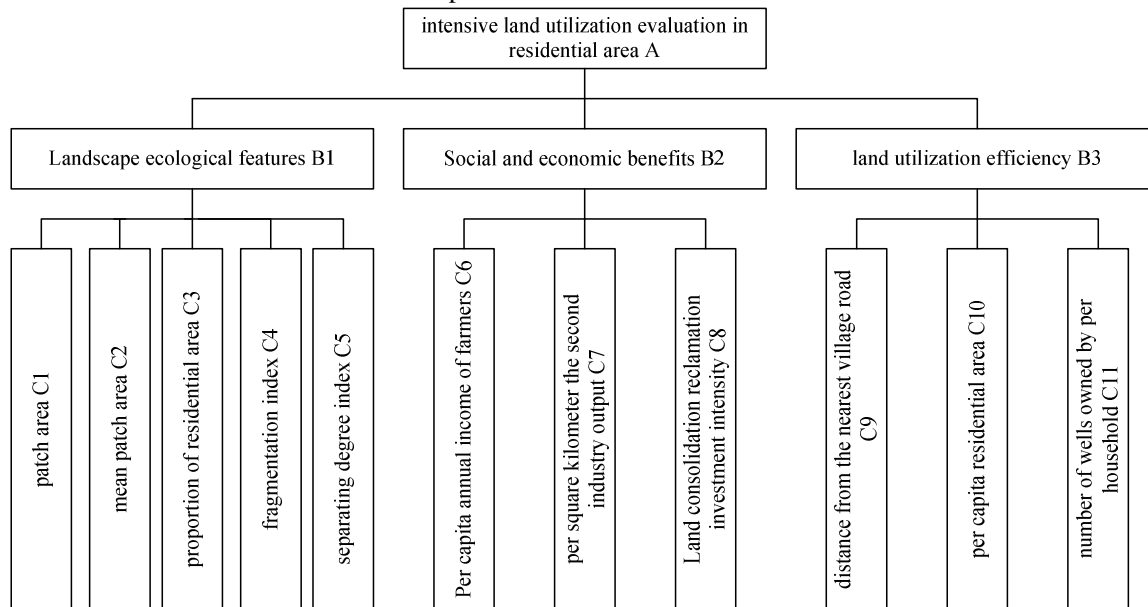
**TABLE 4 : Factors and indexes of influencing the spatial distribution of rural settlements**

Factors	Select the index	Meaning of each index
patch size	area of the largest patch	The proportion of each township roads and rural road area and the total land area, reflecting the unobstructed degree between patches
	area of the average patch	
	patch area of rural settlement	
patch shape	surface edge ratio	The ratio of each villages and towns rural residential land of the total land area, reflecting land use situation
	nearly square ratio	
distribution condition of the patch	fragmentation index	The proportion of each villages and towns rural residential land use area and agricultural population, reflecting rural residential land use situation.
	separating degree index	
corridor unobstructed degree	proportion of highway and rural roads	Reflect the living standards of rural residents and the ability to change the living environment
	proportion of rural settlement land	
land use conditions of rural settlement	per capita rural settlement area	The ratio of GDP and land area of each villages and towns, reflecting the economic development situation
	Per capita disposable income of farmers	
Economic development situation	land economic density	

The rural settlement optimization engineering is very complicated system engineering. And it not only needs to make full use of engineering technology, but also the adjustment of the land property rights, and controls the overall layout, achieving the improvement of agricultural production and living conditions. However, it is limited by the local natural environment and economic development. Only fully understand the basic situation of the local can achieve the goal of natural, social optimization. Meanwhile, a corresponding evaluation index system is needed, and Figure 3 shows the evaluation index system hierarchical chart of land utilization rate:

Optimization model schemes for Gangu County are mainly as follows:

(1) Centralized spatial distribution pattern, through the map of this region, the current situation of the rural settlement are mainly the following two distributions: decentralized distribution along the valley and the field distribution along the field. The basic units of this kind of rural settlement are existing administrative villages and grass-roots village, in theory, the region which has larger patch area is taken as centralized location, rural settlement within the farming radius as the gathering center, and the farming radius size should be adjusted according to the actual situation in order to form a big scattered, small centralized distribution mode. The basic principle of concentration is traffic inconvenience centered to patch place where traffic is convenient; small population density concentrate in patches where the population density is large; and likewise economic backwardness to the advanced patches.



**Figure 3 : The evaluation index system hierarchical chart of land utilization in residential area**

(2) Distribution patterns along the main traffic line, in fact, this is the basic choice of people to traffic, although this mode can also lead to scattered settlement, in violation of the concentration principle of village planning, but as a whole it is very complete and regular, having very high social existence and ecological value. It helps the valley plain form large areas of farmland patches, benefiting for the later mechanized farming. What's more, with the improvement of the traffic facilities, it will form better central tendency. Taking the corridor within the Gangu County as an example, the existing rural settlements distributes around the corridor, and meanwhile control the development towards the outside, the original scattered settlements has been gradually formed a larger patch, and former patch is transformed into farmland or woodland.

(3) The central town and city center optimization mode, because they both have the advantage of better location, through them a good linkage effect can be formed and also the forming scale town can increase the ability of economic development. In addition, in order to avoid the problems such as disorderly spread and distribution confounding, all the contents shall be into the unified planning, forming rational planning of land resource allocation.

## CONCLUSION

China's accelerating urbanization and new rural construction, requiring the spatial distribution of the rural settlement more optimization and conforming to the road of sustainable development. And the process of optimization also needs to give full consideration to the land utilization rate. The combination of the theory of landscape ecology and GIS method will reveal the factors affecting the spatial distribution of the rural settlement, and it is an extremely effective method to explore the formation of space distribution of rural settlements. Through the spatial distribution study of rural settlements in Gangu County, it can be concluded that the distribution of the local rural settlement density, size and shape has a very large gap; Factors such as slope, elevation, slope direction, agricultural land are the main factors influencing the distribution of rural

settlements. The analysis shows that the overall tendency of the local rural settlement appears as mild concentration distribution characteristics, through these studies it can provide better theoretical basis for the rational distribution of local settlement. The land resources used by local rural settlement are very limited, so the damage and infestation to the natural ecological environment shall be reduced. Scientific methods featuring step-by-step and sub-regional, weight different shall be adopted to rationally distributed of settlement in each area, improving the reclamation and accelerate the construction of key village project, to maximize the improvement of rural living environment.

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### REFERENCES

- [1] Pan Jinghu, Jin Xuetao, Han Wenchao; Landscape patterns and spatial distribution characteristics of rural residential areas in Gangu County[J], Journal of Northwest University (Natural Science Edition), **41(1)**, 127-133 (2011).
- [2] Yu Miao, Bian Zhenxing, Li Jiandong; Analysis of landscape pattern and spatial distribution feature in huanren county by remote sensing and geographic information system, Journal of Southwest China Normal University: natural Science Edition, **34(4)**, 106-114 (2009).
- [3] Zhu Yuqing, Shen Zhongwei, Zhang Jinzong; Study on the spatial distribution features of residential areas of liaocheng, Journal of Ningxia University: Natural Science Edition, **30(1)**, 91-93 (2009).
- [4] Chen Zhenjie, Li Manchun, Liu Yongxue; A GIS based research on spatial distribution of rural settlement in tonglu county, Resources and Environment in the Yangtze Basin, **17(2)**, 180-184 (2008).
- [5] Li Jun, Li Xiaojian; Study on the effect factors and distribution changes of rural residential under the multiple regional environment --a case study of gongyi city in henan province [J], Resources Science, **31(7)**, 1195-1204 (2009).
- [6] Zhang Xiaojun, Li Xueyan, Yin Weihong; GIS spatial analyst: research on western poor and eco-environment frangible area --a case study of longxi county in gansu province [J], Journal of Arid Land Resources and Environment, **20(2)**, 37-43 (2006).
- [7] Yan Qingwu, Bian Zhengfu, Wangzhen; A spatial analysis on patterns of settlements distribution in Xuzhou[J], Science of Surveying and Mapping, **34(5)**, 160-163 (2009).
- [8] Liu Xiantao, Zheng Xinqi, Li Daobing; Voronoi diagram-based research on spatial distribution characteristics of rural settlements and its affecting factors [J], Journal of Ecology and Rural Environment, **25(2)**, 30-33 (2009).
- [9] Jiang Guanghui, Zhang Fengrong, QinJing; Relationship between distribution changes of rural residential land and environment in mountainous areas of Beijing [J], Transactions of the Chinese Society of Agricultural Engineering, **22(11)**, 85-92 (2006).
- [10] Pan Jinghu, Yang Wangming, Zhao Ruifeng; Spatial statistic and analysis of patterns of rural settlements distribution in loess hilly-gully region--a case study of gangu county[J], Northwest Population Journal, **31(5)**, 77-81, 87 (2010).