

Land Use Regionalization of Rural Settlements in China

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Abstract: This paper compartmentalizes regional land use of rural settlements in China by employing a hierarchical clustering method. The statistic data are sourced from the National Bureau of Statistics of China (NBSC) and the data of land use change from the Ministry of Land and Resources of China (MLRC). The population of rural settlement decreases from the southeast to the northwest of China and the density of rural settlement decreases from the east to the west of China. Land-use scale of rural settlement, the proportion of one-storey houses and the average household area decrease from the north to the south of China. The ratio of area of cultivated land to rural settlement is high in the northeast and southwest of China but low in the southeast of China. The land use regionalization of rural settlement can be divided into four regions, namely: the northern region of China, Qinghai-Tibet, Yunnan-Guizhou, and the middle and eastern region of China. The northern region of China and the middle and eastern region of China can be further divided into nine sub-regions: Xinjiang, Northeast China, Ningxia and Inner Mongolia, North China, the south of the Changjiang (Yantze) River and Sichuan Basin, Jiangsu-Shanghai, South China, the Loess Plateau, and Guangxi. In consideration of the significant regional differences, it is proposed that different policies should be implemented regarding the utilization and management of rural settlements.

Keywords: rural settlement; land use regionalization; hierarchical analysis; China

Citation: Song Wei, Chen Baiming, Zhang Ying, 2013. Land use regionalization of rural settlements in China. *Chinese Geographical Science*, 23(4): 421–434. doi: 10.1007/s11769-013-0592-y

1 Introduction

Geography is the science about the relationship of human beings and the natural environment, of which regional differences are one important feature (Hettner, 1927). Regionalization plays an important role in geography research because it can observe and study things from the view of region (Wu and Guo, 1994). In the 1980s and 1990s, the study of land resources made great progress by combining the basic theories of areal differentiation in geography (especially soil geography), system interaction in ecology (system ecology in particular), optimization allocation in economics (especially productive economics), and has established itself as a relatively independent discipline (Chen, 1993). As

an important research aspect of land science, the regionalization of land use has gradually become one of the hot topics. It is not only the major task and achievement of scientific research in land-use survey, but also an important method for land use study (Wu and Guo, 1994).

Land use regionalization has been employed in land use management for a long time, aiming to mitigate the negative externalities resulted from mixed land use (McMillen and McDonald, 1999). Most of the American cities were regionalized in the 1920s. Therefore, research of land use regionalization outside China has mainly focused on urban areas or the urban fringe. Scholars have been mainly concerned with the regionalization method and regionalization's effects on land use. For example, Mcmillen and Mcdonald (1999) contrasted the land use

Received date: 2012-05-08; accepted date: 2012-08-24

Foundation item: Under the auspices of National Natural Science Foundation of China (No. 41001108)

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of Chicago before and after the regionalization in the 1920s; Zhu (2010) explored how the lack of regionalization affects the land use controls and urban development in Houston. Other scholars have explored various methods of land use regionalization, such as urban land use regionalization based on ecological evaluation (Yong *et al.*, 2010); the application of GIS (Lin, 2000); the application of agent-based models (Magliocca *et al.*, 2012); the method of GIS and cellular automata (Wu and Webster, 1998); and the method of the independent division model (Chambers, 2005).

In China, the studies on land use regionalization can be traced back to the book *Land Utilization in China* compiled by Buck (1937), in which the country is divided into agricultural zones of wheat and rice, and eight other agricultural zones. After the founding of the People's Republic of China (PRC), the first important regionalization about national land use was 'The national regionalization of land use status quo' (Guo, 1989). Since then, the study of land use regionalization in China has made considerable progress. In the 1980s, the Comprehensive Survey Association of the Chinese Academy of Sciences (CAS) put forward the idea of determining nine major potential land resource regionalization, when compiling *The 1 : 1 000 000 Map of the Land Resources in China* (Shi, 1991). Moreover, the Institute of Geographic Sciences and Natural Resources Research (IGSNRR) of the CAS, completed its study of 'The regionalization of proper land use in China' and raised the regionalization plans in 'The general plan of the national land use' in the early 1990s (Huang, 1989). With the development of indexes and methods about land use regionalization, the social, economic and ecological factors are paid much attention in the process of land use regionalization. For example, Chen (2003) proposed an ecological land use regionalization in China and Feng (2001) constructed a new land-use regionalization based on a detailed investigation of China's land use. Currently outside of China, research in land use regionalization concerns urban areas more than rural areas. Whereas in China, land use regionalization is focused on large-scale rational land use regionalization. The use of GIS has become a typical characteristic in the process of modern land use regionalization (Hopkins, 1999; Kammeier, 1999; Lin, 2000; Zhang *et al.*, 2002).

With a huge agricultural population in China, the area of rural construction land has always been a relatively

large proportion compared with urban construction land (Song *et al.*, 2010; 2012). Recently, as a consequence of building new countryside (Long *et al.*, 2010), land consolidation (Lu, 2002; Wu *et al.*, 2005; Dou *et al.*, 2007; Huang *et al.*, 2011), and the adjustment of hollow villages (Liu Y S *et al.*, 2010; Long *et al.*, 2012), the utilization and consolidation of rural settlement have become new research focuses. Because China has a vast territory with diverse nationalities, land use in different rural settlements has significant regional characteristics (Jin, 1989). Thus, a regionalization study of the nationwide rural settlements is urgently required. However, research on rural settlement regionalization has almost always concentrated on land consolidation (Guan *et al.*, 2010; Liu Yu *et al.*, 2010; Zhou *et al.*, 2011), and the regionalization factors have been relatively simple. In addition, there is still a lack of nationwide regionalization case studies. Therefore, this paper constructs the indexes of land use regionalization of rural settlements, and divides the regions of rural settlements at a provincial level. This research will not only contribute to developing geographical theories about human and rural settlement but also help providing technical supports for rational land management and guiding the rational development of rural settlements.

2 Methods and Data Sources

2.1 Indexes of land use regionalization of rural settlement

Land use regionalization aims to divide land use types into groups, considering the similarities and differences of land, the structure and environmental conditions of land, and the location, market and socio-economic conditions (Feng, 2001). The main purpose of regionalization is to discuss the composition and characteristics of land use, especially the structural and functional characteristics, and to understand problems, so as to provide a theoretical basis for sustainable use of the regional land (Chen, 2003; Chen *et al.*, 2007; Yang and Ren, 2010). In this paper, the regionalization of rural settlements is intended to assist regional governments to make corresponding land management policies, such as allotting rural housing land, establishing standards for land use, and controlling hollow villages. As the implementation of these policies is usually carried out in the administrative regions, the indexes in this study are all

discussed within the provincial administrative regions.

Based on basic theories, as well as the characteristics and purpose of land use regionalization of the rural settlements, this paper mainly selects the indexes from the following aspects (Table 1):

(1) Climatic conditions. These include precipitation and temperature. The precipitation and temperature indexes refer to the average precipitation and temperature over several years in each province separately. Precipitation may have a certain effect on rural housing and land use. For instance, the amount of precipitation determines the roof forms of rural housing. In regions with heavy rainfall, double pitch roofs are adopted in rural housing to facilitate water removal. In contrast, flat roofs are found in the majority of arid regions (Jin, 1989). Temperature also directly or indirectly affect the land use of rural settlement. For example, in Northeast China, which has a relatively low temperature, the sizes of the houses are generally small making them easy to be heated (but the size of the courtyard is relatively big).

(2) Topographic factors. The terrain data, which are indicated by proportion of area of flat ground to administrative region, approximately reflect the topographical features of the province. Moreover, it is obvious that the land use of rural settlements is affected by terrain. In general, there are big differences of land use scales and distribution between rural settlements in mountainous areas and the plains (Liu Peilin *et al.*, 2010).

(3) Scale and density of rural settlement. Three indexes are selected to measure this aspect: land use scales of rural settlement, population of rural settlement, and density of rural settlement. The land-use scale and density of rural settlements show different features in different regions. For example, in the sparsely populated areas, the density of rural settlement will be relatively

small, whereas in the densely populated areas, the density and population of rural settlements may be relatively big.

(4) Form and land-use scale of rural housing. Rural housing land is a major component of rural settlements in China, as it may occupy 70% or even more than 80% of rural settlements (Song *et al.*, 2010; 2012). The form and land-use scale of rural housing is also an important index for the land use regionalization of rural settlements. In this paper, the proportion of one-storey houses and the average household area are selected as the indexes. There is huge difference in the forms of rural housing in different regions in China. For instance, multi-storey houses are the main form in rural settlements in the southeast coast of China, in line with the climate and economic development in these areas, whereas one-storey houses with a courtyard are preferred in Northeast China and North China. Comparatively, multi-storey houses occupy less land than one-storey houses.

(5) Relationship between rural settlement and cultivated land. The formation of rural settlements is closely related to the distribution of cultivated land, and the features of land use and size of rural settlements are closely related to the quality and size of the cultivated land. For example, large-scale rural settlements are usually formed in areas with high-quality cultivated land, which are concentrated and can support a large population. In addition, as it is traditional for Chinese farmers to work from dawn to dusk, the distance between their house and their cultivated land is also an important factor that may restrict the formation and utilization of rural settlements. Here, the ratio of area of cultivated land to rural settlement is selected to measure the relationship between rural settlements and cultivated land.

Table 1 Indexes of land use regionalization of rural settlements

Factor	Index	Connotation
Climatic condition	Precipitation	Average annual precipitation
	Temperature	Average annual temperature
Topographic factor	Proportion of area of flat ground	Proportion of area of flat ground to administrative region
	Land-use scale of rural settlement	Total area of rural settlements /total number of rural settlements
Scale and density of rural settlement	Population of rural settlement	Rural population/number of rural settlements
	Density of rural settlement	Number of rural settlements /(area of rural settlements + area of cultivated land)
Form and land-use scale of rural housing	Proportion of one-storey house	Area of one-storey houses/total area of rural houses
	Average household area	Total area of rural settlements/Number of farm households
Relationship between rural settlement and cultivated land	Ratio of area of cultivated land to rural settlement	Area of cultivated land/area of rural settlements

2.2 Methods for land use regionalization of rural settlements

Clustering analysis can be used to study regional differences by analyzing the level of similarity between multiple factors. It is an important method for the quantitative study of the geographical classification and regionalization (Xu, 2002; Zhao *et al.*, 2010). The main idea of clustering analysis is to cluster categories of objects according to their degree of correlation. Clustering analysis usually includes three types, i.e., hierarchical clustering, dynamic clustering, and fuzzy clustering. Hierarchical clustering is adopted in this paper to study the land use regionalization of rural settlements. Hierarchical clustering seeks to build a hierarchy of clusters through an agglomerative strategy. Agglomerative strategy is a 'bottom up approach' which means that each observation starts in its own cluster, and pairs of clusters are merged, as one moves up the hierarchy. In order to decide which clusters should be combined, an appropriate metric (a measure of distance between pairs of observations) is usually adopted to estimate the dissimilarity between sets of observations. Observations with greater degrees of similarities are grouped into one category. The entire clustering process can be vividly depicted with a tree diagram. As hierarchical clustering does not require a given classification standard or number of categories, it is possible to classify the data objectively (Zhao *et al.*, 2010). SPSS 11 was used in the hierarchical clustering of the land use regionalization of rural settlements. Before performing the clustering analysis, we normalized the original data in order to eliminate the differences between the units of measurement.

2.3 Data sources

The climatic data (average annual precipitation and temperature) are sourced from the statistic yearbooks of 31 provinces, not including Hong Kong, Macao and Taiwan, China for the lack of related data. The data of the area of the national and provincial rural settlements, as well as the data of the area of cultivated land in 2003–2005, are from the Information Center of the Ministry of Land and Resources of China. The relevant economic data are from the *China Statistical Yearbook* (2004–2006) (NBSC, 2005; 2006; 2007). The forms of rural settlement in each province are from the data of the areas of different housing forms in the *China Yearbook of Rural Household Survey* (2004–2006) (DRSES of

NBSC, 2005a; 2006a; 2007a). The number of villages in China and in each province is from the *China Rural Statistical Yearbook* (2004–2006) (DRSES of NBSC, 2005b; 2006b; 2007b). The data of the areas of different types of terrain are from the *The Statistical Table of Terrains (in each province)* in *The Subject Database of Man-Earth System* provided by IGSNRR (2010). All of the regionalization indexes are the mean value of the data for 2003–2005, except for the terrain data of 1991.

3 Results and Discussion

3.1 Regional differences of major regionalization indexes

3.1.1 Regional differences of scale and density of rural settlement

The difference between the north and south of China in land-use scale of rural settlement is very big on a national scale (Fig. 1). The land-use scale is relatively large in Heilongjiang, Jilin, Liaoning, Xinjiang and Inner Mongolia of the northern China, as well as in Guangdong, Guangxi, Yunnan and Hainan of the southern China. By contrast, the land-use scale is small in the other provinces, especially in Tibet, because the Tibetan nomadic lifestyle makes it hard to form large-scale fixed settlements. The land-use scale of rural settlement is generally large in the north of China, especially in Northeast China. This may be attributed to the vast land in the locality, which makes it possible for each household to have spacious rural housing.

The regional distribution of the population in rural settlements is different from the distribution of the land-use scale. There are not only north-south differences, but also obvious east-west differences, generally showing a decreasing trend from the southeast to the northwest of China (Fig. 2). In particular, the population can reach more than 2000 in rural settlement in Guangdong, Guangxi, Jiangsu, and other provinces in the southeast coast of China. However, the average population is only 370 in each rural settlement in Tibet, and 850 in Qinghai. The formation of this distribution may be mainly ascribed to the overall geographical settings and level of economic development. The population of rural settlement is relatively big in the eastern and southeastern coast areas of China, as plains and hills are the main forms of terrain. Moreover, as the climate is mild with abundant rainfall, it is suitable for economic develop-

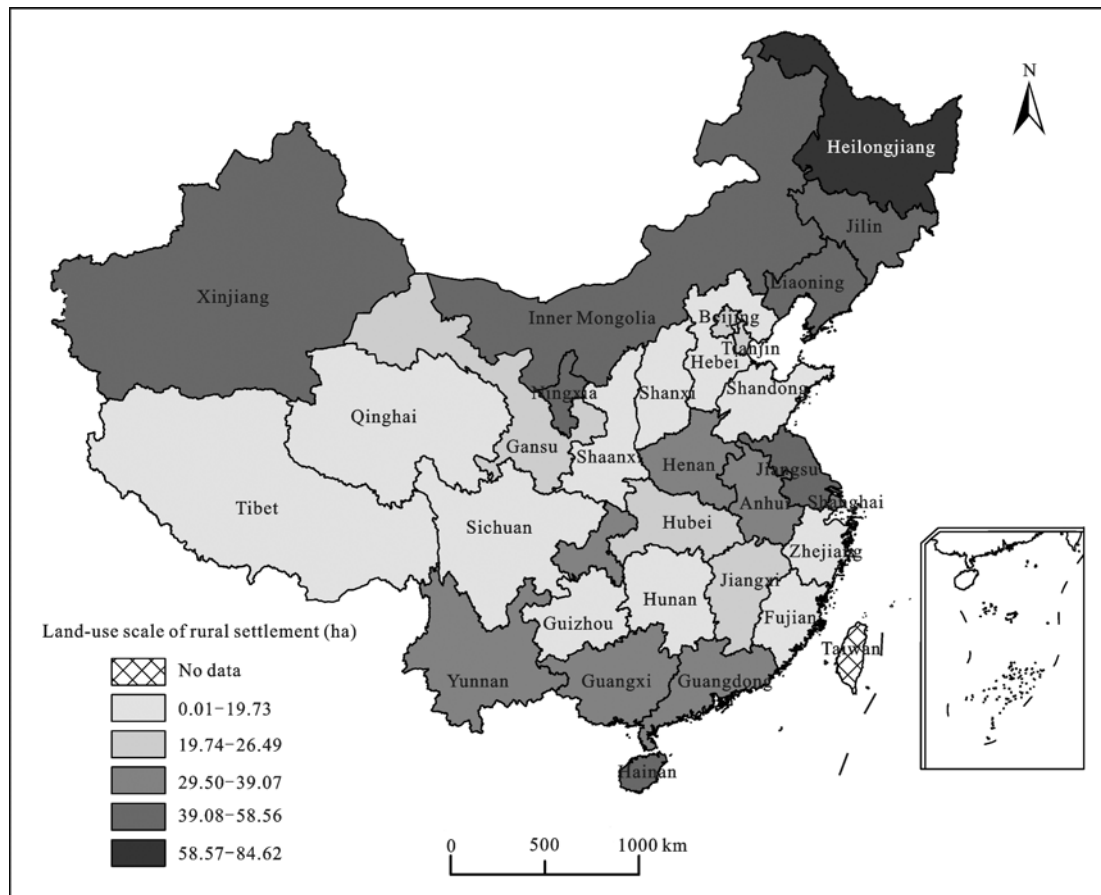


Fig. 1 Land-use scale of rural settlement in different provinces of China

ment and the aggregation of the population.

Density of the rural settlements in different provinces shows a gradual decrease from the east to the west of China (Fig. 3). The density of rural settlement in the east of China, especially in Shandong, Tianjin, and Hebei, is relatively high, whereas the density in the most western regions of China, such as in Qinghai, Tibet, and Xinjiang, is low. Additionally, although Heilongjiang has a relatively large land-use scale of rural settlement, its density of rural settlement is still lower than in North China. The low density of rural settlement in Northeast China may be mainly attributed to the following aspects (Jin, 1989):

- (1) The population in Northeast China is relatively small despite the vast area of land, which restricts the density of rural settlement.
- (2) As there are more cities in Northeast China, the population in the rural settlements is relatively smaller than in the cities.
- (3) As the cultivated land in Northeast China is in large quantities, the per capita area of cultivated land

and the degree of agricultural mechanization is large. Moreover, as vast areas of cultivated land are usually concentrated together, the number of rural settlements may be smaller.

3.1.2 Regional differences in form and land-use scale of rural housing

In terms of the proportion of rural one-storey houses, there is an obvious north-south difference, showing a decreasing trend from the northwest to the southeast of China (Fig. 4). The regional distribution of the form of rural settlements is closely related to the natural conditions, customs, and levels of economic development. In general, in the more developed regions, farmers have higher income and they are more willing to change the form of their housing. Hence, the proportion of rural buildings will be higher. In many areas of the southern China, with plenty of precipitation and damp ground, the local farmers prefer living in buildings. Therefore, the proportion of rural buildings is relatively very high. The regional distribution of average household area is approximately the same as that of rural one-storey houses.

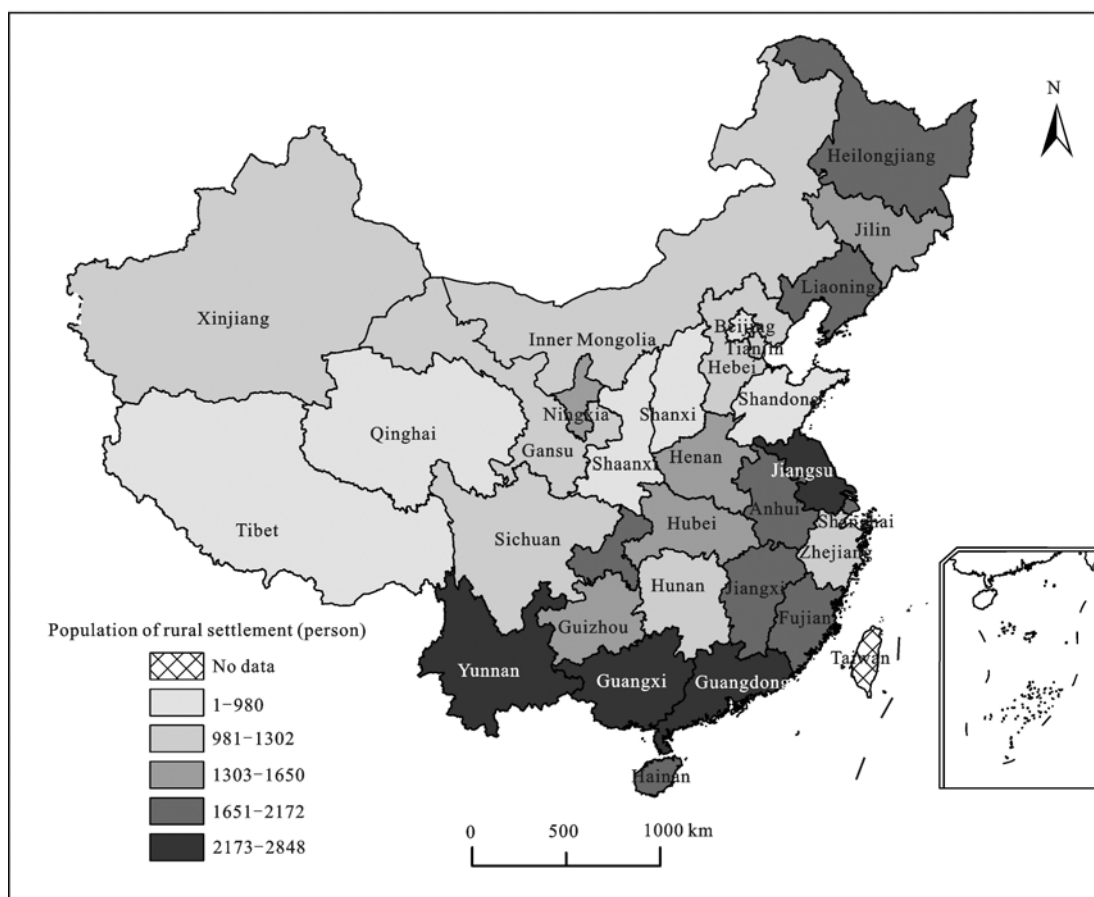


Fig. 2 Population of rural settlement in different provinces of China

In general, the average household area is big in regions full of one-storey houses but small in regions full of buildings.

3.1.3 Regional differences about ratio of area of cultivated land to rural settlement

The distribution of the ratio of the area for cultivated land to rural settlement is different from all the other indexes. To be exact, it is high in the northeastern and southwestern China, and low in other regions (Fig. 5). The high ratio may be closely related to the level of productivity and amount of regional cultivated land. Though the black soil in Northeast China is fertile, it can only yield one harvest per year due to the climate. Thus, more cultivated land is needed to support the population than in the southeast coastal regions of China. The ratio of area of cultivated land to rural settlement is relatively high here with large plots of cultivated land. Similarly, the ratio is also very high in Inner Mongolia, due to the poor quality of cultivated land and the cropping system (one harvest a year). It is the same situation in Tibet, Xinjiang, Yunnan and Guizhou.

3.2 Land use regionalization of rural settlement

3.2.1 Regions

With a clustering analysis of the standardized regionalization indexes of rural settlements, we can get a clustering figure of the land use regionalization of rural settlements in different provinces in China (Fig. 6). With the method of hierarchical clustering, the land use of rural settlements can be regionalized into two classes. To be more specific, regions are initially regionalized with the first hierarchical clustering analysis, and then sub-regions were divided within regions by the second hierarchical clustering. There are four regions: the northern region of China (Inner Mongolia, Xinjiang, Jilin, Liaoning and Heilongjiang), Qinghai-Tibet region (Qinghai and Tibet), Yunnan-Guizhou region (Yunnan and Guizhou), and the middle and eastern region of China (other provinces).

3.2.2 Sub-regions

Sub-regions are derived after the division of regions by hierarchical clustering. The division of sub-regions is focused on the middle and eastern region of China.

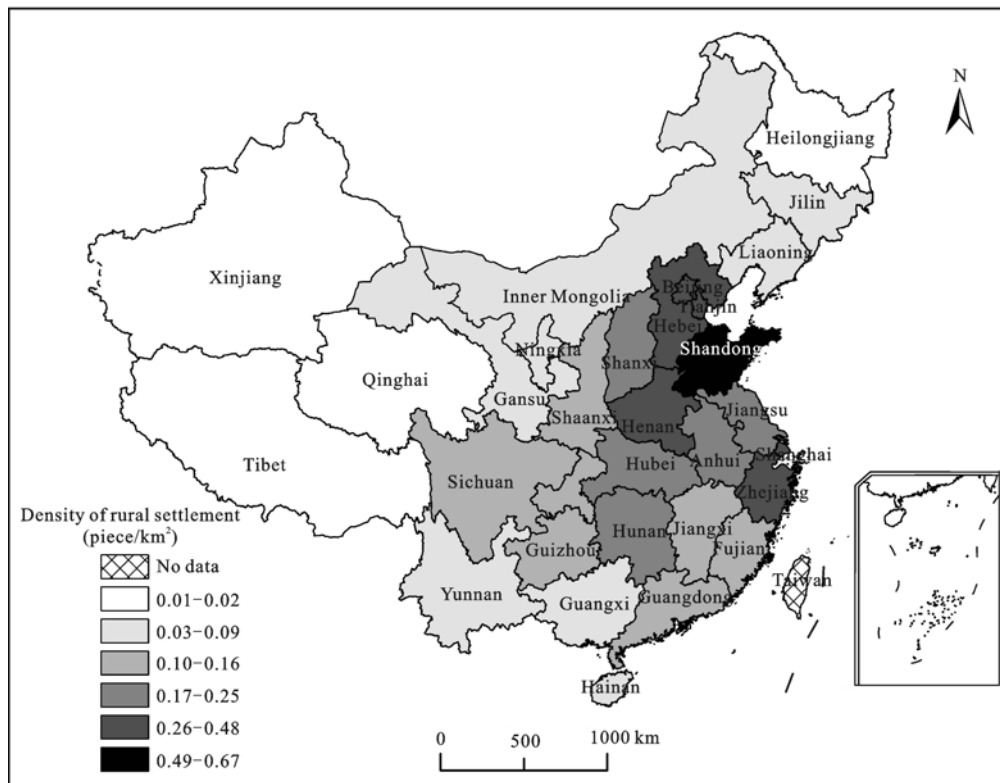


Fig. 3 Density of rural settlement in different provinces of China

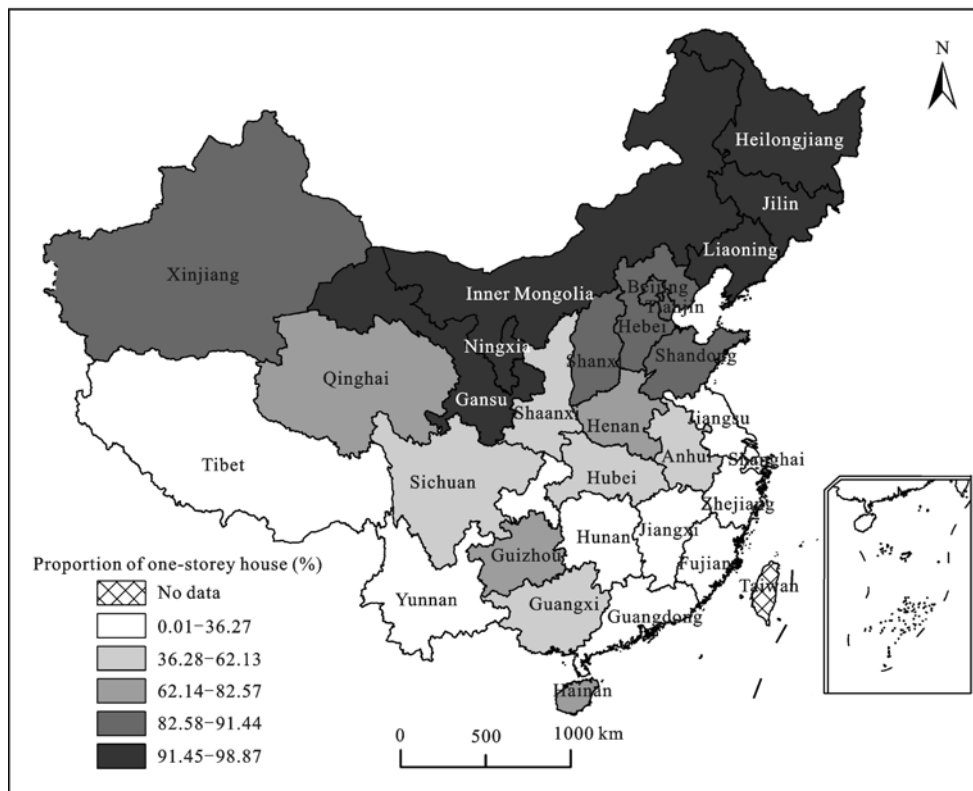


Fig. 4 Proportion of one-storey house in different provinces of China

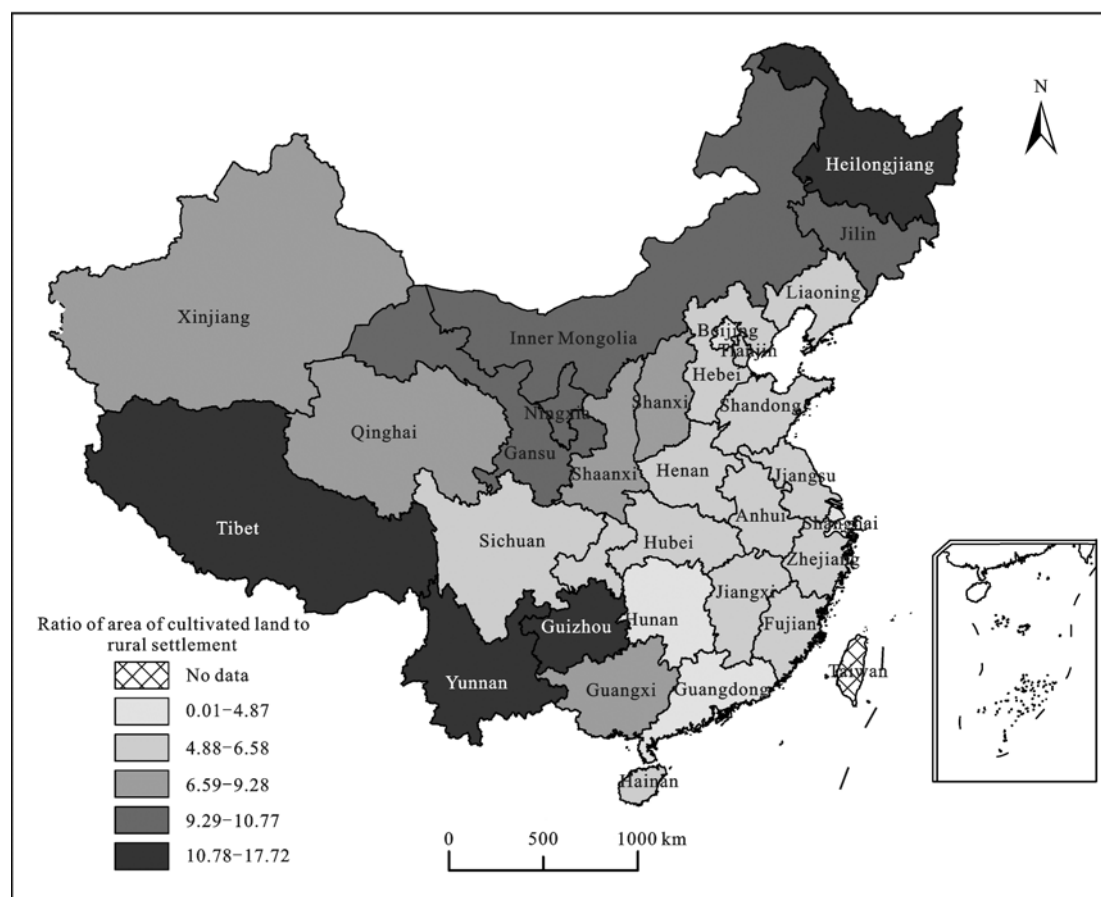


Fig. 5 Ratio of area of cultivated land to rural settlement in different provinces of China

Qinghai-Tibet region and Yunnan-Guizhou region are not regionalized further. The middle and eastern region of China is further divided into six sub-regions (Fig. 7): North China (Anhui, Henan, Tianjin, Shandong, Hebei and Beijing), the south of the Changjiang River and Sichuan basin (Hubei, Sichuan, Chongqing, Jiangxi, Hunan, Fujian and Zhejiang), Jiangsu-Shanghai (Jiangsu and Shanghai), South China (Guangdong and Hainan), the Loess Plateau (Shanxi, Shaanxi and Gansu), and Guangxi. The northern region of China is divided into Northeast China (Heilongjiang, Jilin and Liaoning), Ningxia and Inner Mongolia, and Xinjiang. Though the results of the clustering analysis in the Ningxia and Inner Mongolia, and Xinjiang are similar, they are divided up in consideration of the continuity of geographical distribution.

3.2.3 Results of regionalization

Eventually four regions and nine sub-regions are regionalized after the clustering analyses. As can be seen from Fig. 8, the natural and geographical conditions have

an obvious impact on the division of regions. Apart from the middle and eastern region of China, the other three regions are mostly located on plateaus, like the Qinghai-Tibetan Plateau, the Yunnan-Guizhou Plateau and the Inner Mongolian Plateau. In addition, the temperature in Jilin, Heilongjiang and Liaoning of Northeast China is significantly lower than that of the middle and eastern region of China. Apart from the three northeastern provinces, it is obvious that Xinjiang, Tibet, Qinghai and Inner Mongolia have less precipitation than other regions. It is clear that natural and geographical factors, such as terrain, precipitation, and temperature, or the regional differences caused by these factors, are the dominating factors for the regionalization of the regions.

The regionalization of the sub-regions is carried out within the regions, where the natural and geographical conditions are relative consistent. The division of sub-regions is not only influenced by factors of physical geography conditions but also affected by forms in rural housing, customs and level of economic development

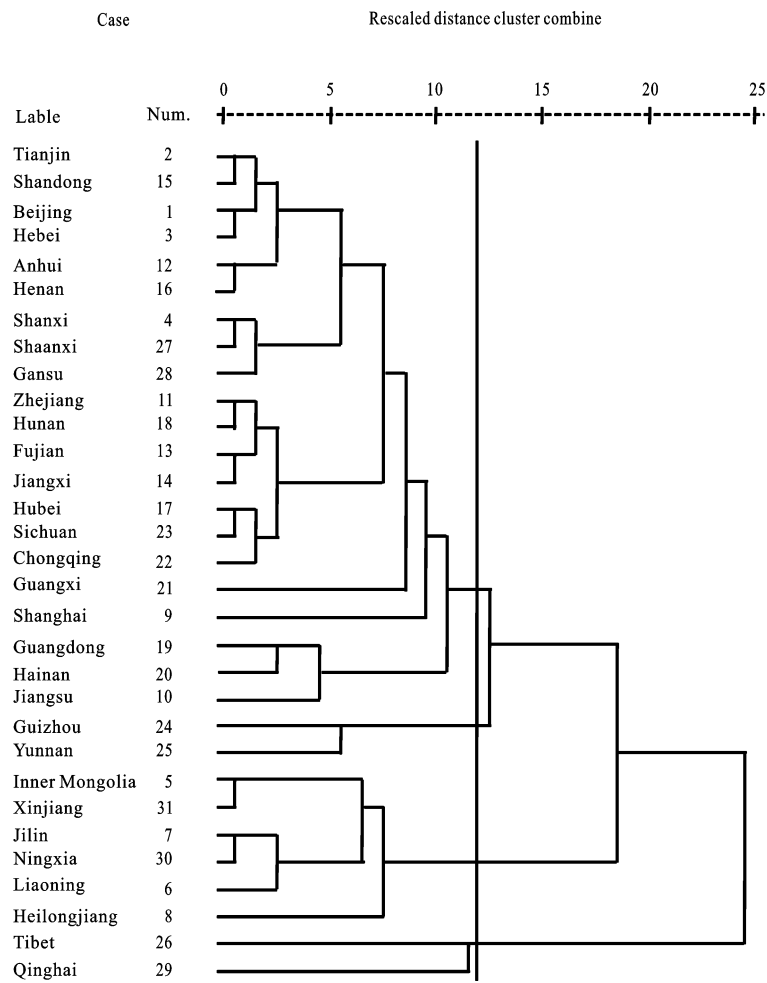


Fig. 6 Clustering tree of land use regions of rural settlement in China

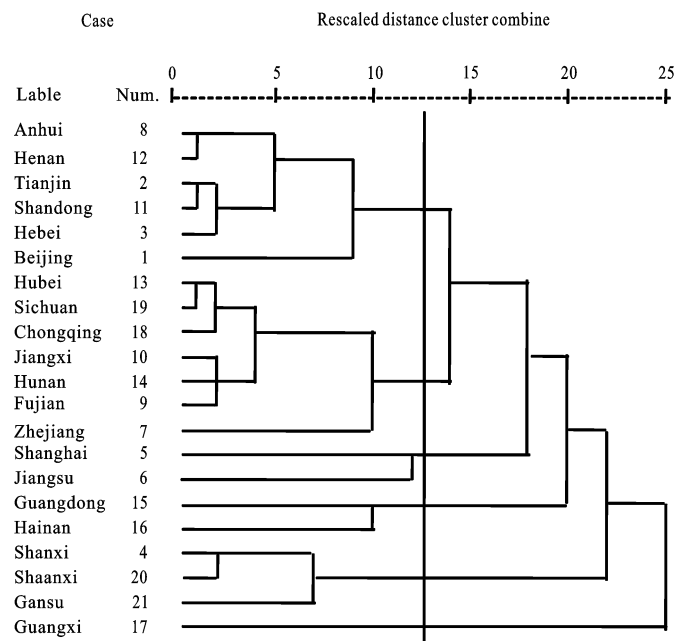


Fig. 7 Clustering tree of land use sub-regions of rural settlements in middle and eastern region of China

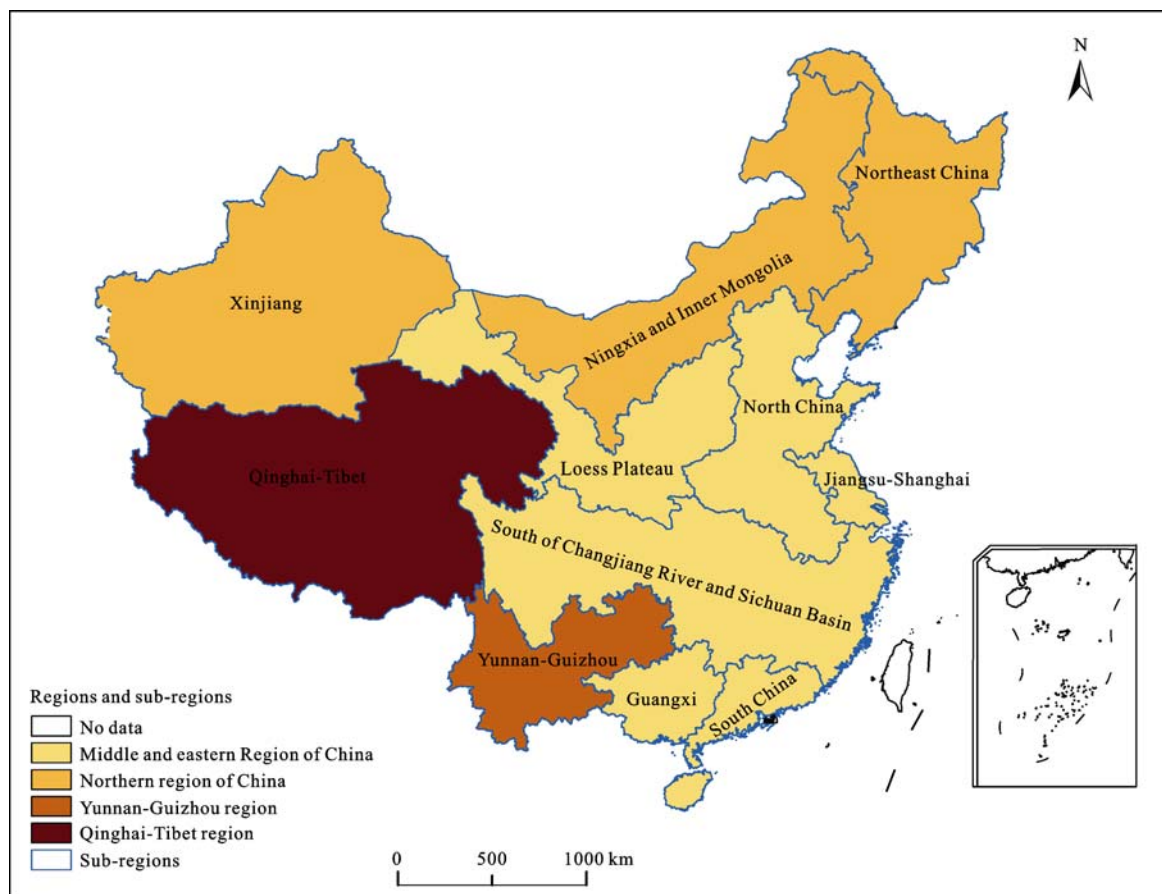


Fig. 8 Land use regions and sub-regions of rural settlement of China

(Fig. 8). For example, the division of sub-regions of the Loess Plateau and the south of the Changjiang River and Sichuan Basin is deeply influenced by geographical conditions but the division of sub-region of Jiangsu-Shanghai is mainly decided by the economic development.

3.3 Main features of land use regionalization in different rural settlements

The rural settlements in Qinghai-Tibet region mainly show the features of small land use scale, small population, low densities, and high proportion of area of cultivated land to rural settlement (Table 2). Located at a high altitude, Qinghai-Tibet region has poor natural conditions. Therefore, this area is not suitable for large-scale settlements and thus, the population and density of the rural settlements is very small. At the same time, due to the poor quality of cultivated land and the need of grazing, the ratio of area of cultivated land to rural settlement is very high. The main features of rural settlements in Yunnan-Guizhou region are: small land-use

scale, big population, and high ratio of area of cultivated land to rural settlement. The reasons are listed as follows. Although the scale of rural settlement is relatively small in Yunnan-Guizhou region, the population is dense because of the abundant precipitation and warm climate. Due to the restricting terrain conditions, there is not much land suitable for the construction of rural settlements. As a result, a relatively large population is distributed in relatively small rural settlements, and the average household area of the rural settlements is small in this region.

The main features of the land use of rural settlements in Xinjiang are: a big land-use scale of rural settlements, large average household area, and relatively low population of rural settlement. It is different from Qinghai-Tibet region and Yunnan-Guizhou region. With the large land-use scale of rural settlements in Xinjiang (as the main form is one-story houses), the density is low. This may be attributed to the local customs in Xinjiang, which have promoted the large areas of rural settlements. For example, in 'Ayiwang' (a special housing form in

Xinjiang), the common residential floor area is of several hundred square meters, which is one characteristic of the local ethnic minorities. Furthermore, the density of rural settlement is very low because of the vast area of land. Although the rural settlement in Ningxia and Inner Mongolia is similar to that of Xinjiang, it is further divided in sub-regions as a result of the discontinuity of geographical distribution. The land-use scale and population of rural settlement in Northeast China is slightly less than that in Xinjiang^①. However, due to the form of rural courtyards (front and rear courtyards), the average household area is large in Northeast China. In addition, the ratio of area of cultivated land to rural settlement in Northeast China is also significantly lower than that of Xinjiang and Ningxia and Inner Mongolia.

Although the land use of rural settlements in North China is similar with other northern regions of China, the differences are also apparent. The density of the rural settlements in North China is as high as 0.41 piece/km², which is significantly different from that of the sparsely populated rural settlements in other regions of the northern China. In addition, due to the intense man-environment relationship, the ratio of area of cultivated land to rural settlement is far lower than that in other regions of the northern China. In terms of the form of rural housing, 'quadrangle courtyard' is the outstanding feature of the rural settlements in North China. This is different from the front and rear courtyards in

Northeast China, the yurts in Inner Mongolia, and 'Ayiwang' in Xinjiang. Although one-story houses are still the main form, buildings have become more and more popular in North China following the economic development in recent years. Thus, the proportion of one-story houses is lower than that of the northern region of China as a whole. The land-use scale of rural settlement, population, and proportion of one-story houses on the Loess Plateau are similar to those of North China. However, as the rural settlements are relatively scattered, the density is far lower than that of North China. As to the features of the rural settlements, cave dwellings on the Loess Plateau are quite different from other northern regions of China. In addition, a lot of marginal land is reclaimed to obtain more food, due to the poor quality of cultivated land. Hence, the ratio of area of cultivated land to rural settlement is higher than that of North China.

Multi-storey houses are the main housing form of rural settlements in the south of the Changjiang River and Sichuan Basin. Because of the restriction of the hilly terrain, the cultivated land is scattered. Therefore, a number of small-scale rural settlements are formed for the sake of convenience. However, as the density of rural settlement is high and it is densely populated, the ratio of area of cultivated land to rural settlement is relatively low. The rural settlements in the south of the Changjiang River and Sichuan Basin are also unique.

Table 2 Features of land use in different rural settlements

	LSRS (hm ²)	PRS (person)	DRS (piece/km ²)	POSH (%)	AHA (m ²)	RACLRs
Qinghai-Tibet	9.68	611.87	0.01	43.24	699.57	12.77
Yunnan-Guizhou	24.29	2133.55	0.09	50.08	457.90	13.97
Xinjiang	65.42	1838.09	0.06	97.58	1321.98	10.52
Northeast China	52.11	1066.74	0.01	88.99	2169.58	8.49
Ningxia and Inner Mongolia	50.19	1370.14	0.05	96.97	1577.89	10.16
North China	24.39	1248.00	0.41	81.21	685.49	5.37
South of Changjiang River and Sichuan Basin	21.19	1547.86	0.19	30.46	504.02	5.82
Jiangsu-Shanghai	39.74	2302.65	0.34	24.28	551.53	5.02
South China	37.68	2412.96	0.12	54.19	760.13	5.36
Loess Plateau	20.39	1004.66	0.13	81.46	821.73	9.04
Guangxi	31.87	2833.67	0.08	49.01	477.86	9.28

Notes: LSRS is land-use scale of rural settlement; PRS is population of rural settlement; DRS is density of rural settlement; POSH is proportion of one-storey houses; AHA is average household area; RACLRs is ratio of area of cultivated land to rural settlement

^① The slightly smaller population in Northeast China may be due to the smaller land-use scale of rural settlements than that in Xinjiang. In this paper, the land-use scale of rural settlements is discussed within the administrative villages rather than in the natural villages.

There are the Huizhou's folk domicile, west Hunan's earth buildings, and south Anhui's residential houses, *etc.* The land use of rural settlements in South China is similar to that in the south of the Changjiang River and Sichuan Basin, except that land-use scale and the population is relatively big in South China. The situation in Jiangsu-Shanghai is also similar to that in the south of the Changjiang River and Sichuan Basin. However, as it is more developed, the population of rural settlement is much higher in Jiangsu-Shanghai. Moreover, the land-use scale, population, and density of rural settlement are also very large in Jiangsu-Shanghai. Most of the land use of rural settlements in Guangxi is similar to that in South China, except that the density of rural settlement is slightly lower than South China and the ratio of area of cultivated land to rural settlement is much higher than South China.

4 Conclusions

In line with the regional differences of natural and geographical conditions, the land use regionalization of rural settlements can be divided into four regions: the northern region of China, the Tibetan, Yunnan-Guizhou, and the middle and eastern region of China. The northern region of China and the middle and eastern region of China can be further divided into nine sub-regions: Xinjiang, Northeast China, Ningxia and Inner Mongolia, North China, the south of the Changjiang River and Sichuan Basin, Jiangsu-Shanghai, South China, the Loess Plateau and Guangxi. Together with the Qinghai-Tibet and Yunnan-Guizhou region, the national land use regionalization of rural settlements is divided into 11 regions and sub-regions. There are significant regional differences in the land use of rural settlements in different regions and sub-regions. The land-use scale and average household area is large in the northern region of China. With one-storey houses as the main form, the density is low and the ratio of area of cultivated land to rural settlement is high. In the Qinghai-Tibet region, the land-use scale, density, and population of rural settlement is small, while the ratio of area of cultivated land to rural settlement is high. In the Yunnan-Guizhou, the land-use scale of rural settlements is small while the population is large. Thus, the average household area is relatively small and the land use is intensive. In the middle and eastern region of China, the land-use scale

of rural settlements is moderate. However, as it is densely populated, the density of rural settlement is high. Moreover, as the ratio of area of cultivated land to rural settlement is relatively small, the man-environment relationship is relatively intense. Together with the unique characteristics of rural settlements, regional natural and geographical conditions, ethnic customs, and life styles have combined effects on the use of rural settlements.

The regionalization of rural settlements can not only reflect the similarities of different regions but also present the differences. Thus, with respect to the construction, utilization and management of rural settlements, different policies should be made according to regional differences. Firstly, an area standard of rural settlement should be established according to the land use regionalization of the rural settlement. Nowadays, each province has enacted an area standard of rural settlement. These standards were so confused that even provinces with similar natural, economic, and social conditions have greatly different standards, such as Heilongjiang, Jilin and Liaoning. Hence, the standard of rural settlement should be enacted according to the land use regionalization. Secondly, land use regionalization can be adopted in land consolidation planning. Land consolidation of rural settlement is becoming more and more important in China. The government arranges many projects of rural settlement consolidation every year, but rural settlements in different regions have different land use features. Therefore, the land consolidation pattern and investment standards should be enacted according to different land use regionalization. Lastly, the development of rural settlements can be guided according to different land use regionalization. The development of rural settlements has different developing stages. Rural settlements in different land use regionalization are similar in the developing stage. Therefore, the policies and suggestions to guide the development of rural settlements can be enacted according to the land use regionalization of rural settlement.

This paper divided the land use regionalization of rural settlements based on provincial units; the results obtained are approximate. The ideal result is to compartmentalize the land use regionalization of rural settlements in China at county level. However, the most important problem in accomplishing this work is lack of data at county level, such as the data of housing forms of rural settlements and land-use scale of rural settle-

ments. Therefore, this paper finalized the division of land use regionalization of rural settlements at a provincial level.

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