

Multi-scale analysis on spatial morphology differentiation and formation mechanism of rural residential land: A case study in Shandong Province, China

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ABSTRACT

Using the GIS space “hot spot” detection and kernel density estimation model, the spatial differentiation characteristics of rural residential land in Shandong Province are revealed from the perspective of multi-scale feature units of “point-line-surface”. Then, a geographical detector is used to analyze its factors and mechanisms. Results show that on the domain-wide scale, the rural residential land has obvious characteristics of spatial agglomeration that are sparsely distributed in a ladder from west to east; on the transect scale, the scale and distribution density of rural residential land present a multi-peak distribution, while the plaque shapes are stochastic equilibrium. On the point scale, the rural residential monomer takes on the feature of banded and serrated diversification. The differentiation is the result of scale difference of different influencing factors. Natural geographical conditions are influencing factors of multi-scale stability, especially in macro scale, which plays a comprehensive role in controlling the formation and changes. The characteristics of rural residential land in meso scale are mainly formed under the influence of dynamic equilibrium of economic and social conditions, the periodic change of institutional policy environment has a profound influence on micro-scale rural residential from rigid constraints and timeliness.

1. Introduction

Rural residential land is the direct manifestation of man-land relationship in rural areas, which also has macro-control function on the regional rural development model (Jin, 1988; Wang, Wang, & Li, 2002). The spatial differentiation and revolution of the scale, structure, layout and other forms of rural residential land can reveal the footprint of the man-land relationship in different areas and different stages (Jiang, He, & Qu, 2016; Ma, Li, & Shen, 2012), while the multi-scale differentiation of spatial morphology is the embodiment of the comprehensive effect from macro environment to micro factors. The systematic study of rural residential spatial morphology, especially from the spatial and perspective of multi-scale, is of great importance to grasp the evolution law and formulate differentiated policies, as well as a vital developing aspect and research area of international rural geography (Cai, Lu, & Zhou, 2004; Woods, 2007).

Influenced by such factors as the natural environment, socio-economic development, and cultural customs, the spatial morphology of

rural residential land has obvious regional heterogeneity. Adhering to local conditions and renewal planning are basic principles for analyzing the layout of rural residential land in China (Jiang, Wang, & Yun, 2015), whereas the scientific characterization and multi-scale feature recognition of the spatial morphology of rural residential land are scientific bases for exploring the formation process, evolution laws and regulatory modes (Zhang, Jiang, & Wang, 2015). In the current research, rural residential land is brought into a research framework composed of rural development, rural community planning and construction (Curran, Cain, & Greenhalgh, 2016; Bjarstig and Sandstrom, 2017). Based on the spatial morphology and distribution of rural residential land, it focuses on the flow of population, industry transformation, the constructions of public service facilities and social problems, showing an obvious trend of paradigmatic humanistic society (Sobczyk, 2014; Hedlund and Lundholm, 2015; Pacione, 2013; Cremer, Dominik, & Jean, 2015). Some scholars have paid more attention to material studies of rural residential land, mainly in the spatial structure (Yang, Hao, & Wang, 2011; Min and Yang, 2016), the areal type of rural

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residential land (Ma et al., 2012; Zhang et al., 2015), the revolution of scales under the influence of rapid urbanization (Feng & Yang, 2016), and the “hollowing out” of governance under the drive of new rural construction (Jiang, Ma, & Wang, 2017; Liu, Liu, & Zhai, 2009; Lu & Liu, 2013). These studies show that academia has focused on rural residential land as it becomes gradually mature, which provides abundant theoretical guidance for this research as well.

However, regarding the research methodology, the traditional spatial morphology of rural residential land is qualitatively summarized and described based on singular information, such as the scale and morphology (Yang, Pang, & Song, 2010; Yin & Chen, 1995). Making the best use of GIS spatial analysis, only a few researchers have described its scale, morphology and spatial agglomeration (Jiang, Ma, & Zhou, 2017; Liang, Liu, & Liu, 2017; Zhuang, Jiang, & He, 2015); thus, the development and application of quantitative studies need to be strengthened. In addition, from the perspective of research region and scale, there have been many empirical studies in China, such as along the Yangtze river (Min and Yang, 2016; Long and Li, 2005; Chen & Jin, 2015), Jiangnan region (Chen & Xie, 2016; Li et al., 2014), capital suburb region (Ma, Jiang, & Wang, 2017; Zhang et al., 2015; Zhuang et al., 2015; Zhu, Zhang, & Li, 2014), central region (He et al., 2013; Hai, Li, & Xu, 2013), loess hilly region (Guo, Ma, & Zhang, 2013; Xie, Zhao, & Jiang, 2014), most of which have focused on the spatial division of rural residential land on a large scale; few focus on the mesoscopic or micro scale, especially lack of comparative study on the spatial morphology mechanism characteristics and formation mechanism on different scales. Hence, it is not easy to explore the essential characteristics and regional laws of the multidimensional spatial morphology of rural residential land, and not conducive to analyze the regulation mode and technical specification in different regional environments, leading to the homoplasy of planning and system on different scales. Study on the morphological difference of rural residential land from domain-wide scale, transect scale to point scale can fully reveal the morphological differentiation characteristics, and can also identify the difference and hierarchy of different influencing factors on different scales, which will provide a basis for formulating targeted and multi-scale regulation policies of rural residential land.

Since the reform and opening up, Shandong province has experienced rapid industrialization and urbanization, and gradually formed a pattern with a stable primary production, a dominate second production, and accelerated development of tertiary industry. In 2016, the ratio of output value of three industries in Shandong was 7.3: 45.4: 47.3, close to that of national for the same period (8.4: 44.4: 47.2). In addition, the regional differences of economic development in Shandong Province are significant, including economically developed area in Jiaodong Peninsula, moderated developed area in central Shandong, and economically underdeveloped area in western Shandong, similar to the pattern of economic development in China. Therefore, in a sense, Shandong Province can be seen as a microcosm of China's economic and social development pattern (Qu, Jiang, & Zhao, 2017).

Under the condition of stable economic development and regional differences, Shandong Province is extremely representative because of active changes and diversified spatial morphology of rural residential land. Thus, using exploratory spatial data (ESDA) technology and basic theories of geographical spatial studies, from the perspective of the multi-scale of “point-line-surface”, this paper quantitatively deconstructs the differential characteristics of multidimensional spatial morphology of rural residential land in Shandong Province, and thoroughly analyzes its formation mechanism, which will provide a scientific basis for the regional classification and optimal regulation of regional rural residential land.

2. Methods

Rural residential land has large patches and small patches in space,

showing the characteristic of scale; while the permutation and combination among different patches in some kind of order makes rural residential land have different morphological characteristics, presented as the complexity of patch boundaries and its agglomeration or discreteness (Zhang et al., 2015).

Since the development and application of landscape pattern software (FRAGSTATS), there have been many indicators to measure the patch boundary and spatial distribution of rural residential land. Due to the high degree of correlation among these indicators, many indicators do not meet the requirements of mutually independent statistical properties (Qi, Qu, & Liu, 2009; Riitters, 1995). Ideally, a group of independent but not redundant morphological measure index system should be used. Therefore, based on the data obtained from remote-sensing image interpretation of rural residential land patches, this passage uses principle components to screen a presentative morphological measure index system. Furthermore, in order to disclose the internal mechanism and spatial differentiation of its spatial morphology in depth, this paper considers the differences of natural environment and social economic development among eastern, western, central, coastal and inland Shandong, and investigates the characteristics of the spatial morphology from the perspective of “point-line-surface” multi-scale feature unit.

The “surface” unit, namely the domain-wide area of Shandong Province: the research mainly uses “hot spots” detection in GIS space and the nuclear density estimation algorithm to reveal the regional differentiation of the spatial morphology of rural residential land in Shandong Province. Based on the analysis of the belt transect method and Geostatistics trend method (Egenhofer M J, 1998), together with the standard of the International Geosphere-Biosphere Programme (IGBP) (Long, 2012), the “line” unit refers to 5 typical transects, located respectively in eastern, central, western, southern and northern Shandong (as shown in Fig. 1, Table 1). The research projects spatial morphology indexes of rural residential land on the orthogonal plane of the East-West and North-West directions, so the spatial morphology characteristics in different directions can be depicted by the optimal fitting curve made with projection points. The “point” units are based on the analysis of the domain-wide area and transect: to analyze the spatial differentiation characteristics from the microcosmic perspective of patches, using type divisions of spatial morphology of rural residential land, we select several sample points in each type of region. Finally, with the aid of geographical detectors, this paper discusses the influencing factors and formation mechanisms of the spatial morphology differentiation of rural residential land in detail.

2.1. Data acquisition and processing

To extract patches of rural residential land in Shandong Province,

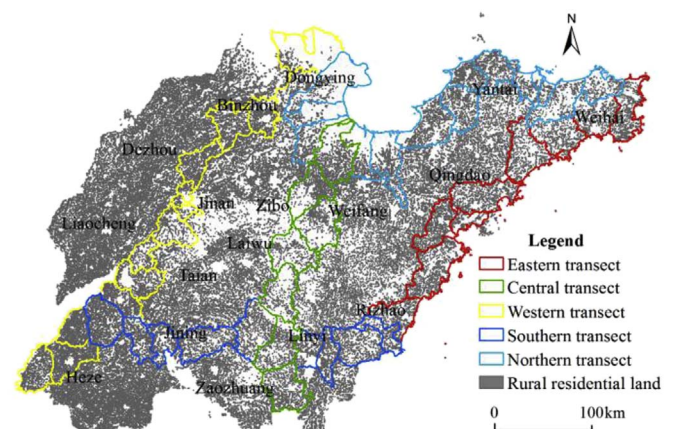


Fig. 1. Distribution of rural residential land and transects in Shandong Province.

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