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Rural spatial restructuring in ecologically fragile mountainous areas of southern China: A case study of Changgang Town, Jiangxi Province

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ABSTRACT

Against the dynamic background of Chinese rural transformation development, this study takes the countryside as a regional system, and closely examines rural spatial restructuring in an ecologically fragile mountainous area of southern China at a village-township level. It puts forward a set of methods for rural spatial restructuring based on landscape security pattern construction as well as a model of rural residential land expansion using an ant colony optimization algorithm and scenario simulation. These methods are applied to the case area of Changgang Town, Jiangxi Province. The case study results indicate that the land use security pattern of the study area under the ideal security scenario is the best scenario of three examined, with the least extent of residential land and the minimum loss of key ecological land. Moreover, this scenario can fully satisfy the land demands of ecological security, agricultural production and regional socioeconomic development. These results indicate that the method we proposed can provide technical support for rural spatial restructuring in the ecologically fragile mountainous areas of southern China. Simulation results and spatial zoning control strategies for the case area can provide decision-making references for local spatial planning and control practices. In contemporary China, it is necessary to recognize and better explore the multiple functions of the countryside. The government's scientific planning and appropriate control of self-renewal processes of rural space can make more economical use of land, and can guarantee the provision of public goods such as ecological welfare and food security.

1. Introduction

With rapid industrialization and urbanization, human interactions with the environment have dramatically changed in rural China. The persistent expansion of construction land has displaced and fragmented highly productive farmlands, thus threatening national food security (Li, 2009; Long et al., 2009). Furthermore, development has built over or bisected large areas of ecologically sensitive land, with complex consequences, such as environmental destruction, soil erosion and biodiversity reduction, due to the disorderly expansion of built land and farmland exploitation driven by the land-use policy of cultivated land requisition-compensation balance. The rural environment is deteriorating, and its ecological regulation and protection functions are weakening, thus threatening national ecological security (Long, 2014; Xu and Zhang, 2015). The Thirteenth Five-Year Plan for National Economic and Social Development of the People's Republic of China issued on March 2016 put forward some important development strategies 'to scientifically plan the spatial pattern of construction of villages and small towns, farmland protection, villages distribution and ecological conservation', 'to strengthen economical land use' and 'to strictly control the area of rural construction land'. Hence, it is obvious that the Chinese government advocates the ecology-orientated and economical land use-orientated rural spatial restructuring. In order to effectively advance the pace of new rural construction and realize Chinese rural transformation development, it is necessary to promote rural spatial restructuring that aims at establishing intensive and effective production spaces, modest yet functional living spaces as well as beautiful ecological spaces (Long, 2014).

Theoretically, the demand for rural built land will decrease with the promotion of urbanization. However, demand for rural residential land has grown in synchrony with urban land use in China. Chinese per capita rural built land increased by 18.28% from 1996

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to 2007 (Long, 2012). The reasons for this phenomenon are as follows: first, with rapid industrialization and urbanization, the comparative benefit of agriculture is declining, and the opportunity cost of working in agriculture is rising. More and more young rural laborers have emigrated to urban areas for off-farm work, and farmers' house-building capacity grows with their increasing income. Meanwhile, the principal residences and identity attributes of the migrant rural laborers remain attached to rural areas due to the long-standing urban-rural dual structure, causing farmers' housing demand to increase (Long, 2014). Because the dual structure splits rural families and prevents rural workers from settling in cities, rural workers' wage income from off-farm employment thus mainly returns to the countryside, which boosts the residential construction boom in rural areas, resulting in continued conversion of rural land to residential use (Li et al., 2010; Yang et al., 2015a). In 2007, Chinese rural residential land per capita area rose to 228 m^2, a figure much higher than the standard upper limit for urban and rural built land of 150 m^2 per capita (Long, 2012). This condition is obviously not conducive to the national strategic objective of economical and intensive use of construction land.

There are two different understandings for the concept of rural spatial restructuring in existing literature. One refers the physical evolution of the rural space driven by the social and economic changes, that is, the self-renewal process of rural space. While the other refers optimization and adjustment of the present rural space by means of planning, generally government oriented (Li et al., 2015b). Two kinds of extreme phenomena exist in contemporary Chinese rural spatial restructuring. In some developed regions, the rural spatial restructuring has been excessively intervened by the government-oriented administrative planning which generally ignores the unique rural landscape, ecological service and other multiple functions of the countryside, imitates the urban mode to construct rural space, resulting in loss of unique rural characteristics (Ding, 2013; Li et al., 2015b). In contrast, tremendous land use problems such as rural hollowing and disordered expansion of rural residential land have occurred in the vast less-developed mountainous regions due to lack of scientific planning and effective policy guidance (Li, 2009; Liu et al., 2014).

Existing studies in China have shown great concern at the spatial demand of rural population and socioeconomic development, and have focused mainly on spatial optimization and restructuring of the rural settlements. Du et al.(2015) adopt the gravity model to optimize the rural living space via quantitatively analyzing the mutual attraction of rural settlements, and identifying the core nodes and spatial radiation range of rural settlements. Wang et al. (2014) establish a rural residential restructuring symbiotic system based on the symbiotic theory, design productivity-oriented, service-oriented and living-oriented kinds of functional settlement groups, and form the layout of 'one axis and three groups' at the village scale. Xie et al. (2014) combine the weighted Voronoi diagram with the rural 'residential field potential' to increase the spatial utility of the relocated villagers. For the purpose of more economical land use and easier infrastructure allocation, Sun et al. (2009) explore the methods of village hierarchical system construction and promote different rural spatial restructuring modes. Based on an improved gravity model and the weighted Voronoi diagram, Kong et al. (2014) analyze the spatial interaction mechanism of growing points, including the town, the center village and the grassroots village, and the axis of roads on the layout of rural settlements, and then construct the optimization system of rural residential area. Actually, the countryside is not only a living place, but also can provide several other functions, including agricultural production, aesthetic and environmental landscapes as well as ecological services. During the course of urban and rural transformation development, the function of rural settlements has gradually shifted from a single 'living function' to a multifunction of 'production, living and ecology' (Liu et al., 2009). However, though the aforementioned studies provide useful information on the optimization and restructuring of rural living space, they pay insufficient attention to rural production and ecological functions.

A few studies explore some issues about the rural spatial restructuring, taking the countryside as a regional system but from the theoretical and regional macro perspectives. Based on the theory of Transit-oriented Development, He et al.(2014) promote a rural road-oriented spatial optimization model, but the regional characteristics are not taken into consideration. Chen and Xie (2016) discuss the basic idea of rural spatial restructuring in the mountainous area of South Jiangxi Province from a regional macro perspective and conclude that the rural spatial restructuring should undergo element reconstruction, structure reorganization and function remodeling in three stages. From the major function-oriented zoning perspective, Li et al. (2015a), taking townships of Wuhu city as the basic evaluation unit, establish the two dimensional matrix of 'natural ecological constraints versus industrial development support' to determine the development type of every basic unit, but do not select typical villages or townships to do further spatial restructuring at a micro level.

The literature analysis makes clear that the research on rural spatial restructuring based on the dynamic background of China's rural development, which focuses on optimization of rural production, living and ecological spaces at the village-township level, has been poorly investigated (Yang et al., 2015b). In China's vast rural areas, especially in mountainous areas, rural residential land is present in small, scattered patches (Zhou et al., 2003; Tian et al., 2012; Fan et al., 2015; Chen and Xie, 2016). It is imperative to carry out land use pattern optimization at a village or township scale because studies based on small-scale maps tend to ignore small and scattered settlements, which are often dissolved into surrounding features of other types. Such studies are thus unable to realize the optimization of rural production, living and ecological spaces. In addition, there are extreme regional discrepancies in both socio-economic development as well as geographical and biophysical conditions in China due to the vastness of the country. Rural land-use conflicts are different in different types of regions. The main conflict in plains regions is the conversion of much high-quality arable land to construction land (Yang et al., 2015a; Cai and Pu, 2014), while the conversion and fragmentation of ecological spaces by development and construction activities are the main problems for ecologically fragile mountainous areas (Gao et al., 2011; Zheng et al., 2010). Therefore, it is necessary to explore different restructuring paths according to local conditions.

Against this background, this study selects a typical case area to optimize and restructure the rural space in the ecologically fragile mountainous area of southern China at the village-township level, aiming to provide technical support and decision-making references for this type of rural spatial restructuring. This paper is organized into five sections. Following this introduction, the geographical and biophysical conditions as well as the socioeconomic development status of the case study area, its main land-use conflicts and its spatial restructuring demands will be analyzed, and the data sources will be explained. The third section introduces the procedure and the step-by-step methods of rural spatial restructuring adopted in the ecologically fragile mountainous area. The fourth section presents the results of the constructed ecological security pattern and the land use patterns under different scenarios in the study area, evaluates the effect of land use patterns under different scenarios combining the areas of different types of land use, the key ecological land loss and the