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Rural settlement changes in compound land use areas: Characteristics and reasons of changes in a mixed mining-rural-settlement area in Shanxi Province, China

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ABSTRACT

As a result of rural settlements moving and relocation for coal mining and rural settlements expansion for new village construction, the rural settlements have been dramatically changed in the mixed mining-rural-settlement area of the Pinglu District of Shuozhou City in northern Shanxi Province of China. There are few studies that assess the characteristics and reasons of rural settlement changes in this compound area. This paper used satellite data and secondary data information on social and economic development in a mixed-method case study to analyze the characteristics and reasons of rural settlement changes in Pinglu District of Shuozhou City in northern Shanxi Province of China over the period 1986–2013. Three significant research findings were: (1) There were notable changes in the distribution of the rural settlements, and the total area of rural settlements increased by 1862.28 ha between 1986 and 2013, with the transformation of cultivated land to rural settlements being the most dominant change in land use. (2) The rural settlements increased with buffer radius increased up to 6–8 km which has become the standard boundary for rural settlement distribution. (3) The influential factors that have been identified for rural settlement changes included avoiding impacts due to coal mining, an urgency to build simple houses for the compensation, the relocation of farmers, the construction of new villages and land reclamation of abandoned rural settlements. These findings are useful for resource-based rural settlement management, providing reasonable compensation and relocation options when acquiring land in mining areas both within and beyond the study area in China.

1. Introduction

Rural settlements are located in spaces between cities and consist of small groupings of buildings where residential land use and activities related to agriculture are dominant (Muilu & Rusanen, 2004). Because of the need for economic, political, social and cultural activities, farmers tend to dwell together in the same area (Muilu & Rusanen, 2004; Porta et al., 2013).

As land is limited in extent, using any of it for rural settlement is likely to be at the expense of cultivated land (Cao, Bai, Zhou, & Wang, 2013; Conrad et al., 2015; Long & Li, 2012; Tian, Qiao, & Zhang, 2012), especially in those areas with highly productive soils (Conrad et al., 2015). In China's rural areas, using land for settlements is the second major type of land use, preceded only by using land for cultivation (Liu, Liu, Zhuang, Zhang, & Deng, 2003; Long, Liu, Wu, & Dong, 2009; Tian et al., 2012). In the area of the Loess Plateau in China, due to environmental impacts, rural settlement construction tends to be spontaneous and at the cost of cultivated land in the low and flat areas (Cao et al., 2015; Jiang, Zhang, Qin, Zhang, & Gong, 2006). Accordingly, it is important to curb the expansion of land being consumed by rural settlements to maintain the total cultivated land area in the interests of agricultural sustainability and food security of a growing population (Chen & Ye, 2014; Song & Liu, 2014; Tang, Hao, & Huang, 2016).

Changes in rural settlements reflect the relationship between humans and the land (Jiang et al., 2006; Barbosa-Brandão, Riveira, & Maseda, 2015). Certain influential factors have been identified as reasons driving land use changes in rural settlements. These factors

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include changes in the natural environment (Zhou et al., 2013), continuous rural population growth (Conrad et al., 2015; Song & Liu, 2014), urbanization (Chen, Liu, & Tao, 2013; Li, Long, Liu, & Tu, 2015; Tan & Li, 2013), housing construction (Bański & Wesołowska, 2010; Peng, Shen, Tan, Tan, & Wang, 2013), social transformation (Kiss, 2000; Chen, Liu, & Lu, 2016), and changes in employment opportunities (Cao et al., 2013; Lewis & Mrara, 1986). Meanwhile, the reconstruction of rural settlements in China has become the important new reason driving land use changes in rural settlements (Long & Liu, 2016; Yang, Xu, & Long, 2016).

Rural settlement changes in mining areas often experience three key reasons. Firstly, rural settlements sometimes have to move in order to avoid mining disturbance. In highly disturbed mining areas, rural settlements can rapidly decrease in size as people move away (Cao, Bai, Zhou, & Zhang, 2016a; Li, 2006). Secondly, in contrast, other rural settlements can increase in size as a result of new settlement construction projects as people are attracted to the region to work in the expanding mining sector (Li, 2006). Thirdly, after mining activities cease, abandoned rural settlements can be cleaned up and reused/recycled, especially if they have good access to resources such as agricultural land, water or transport links (Li, Wang, & An, 2009; Tian, Du, & Xu, 2009).

The distribution of rural settlements is, therefore, highly dynamic as areas of land used for human settlement changes. For instance, the distance between rural settlements can increase as people move away from mining areas. In contrast, where the human population is expanding, settlements can aggregate into one larger settlement (Hu & Bai, 2016; Wang, Bian, & Lei, 2006). Such processes can have a negative impact on the availability of cultivated land which can be lost both to mining and urbanization (Andrews-Speed, Yang, Shen, & Cao, 2003; Li, Gu, & Ji, 2014).

Although the loss of agricultural land is a result of an expanding mining sector, it is equally important to understand how those living near mines are affected by mining activities. Besides that, greater attention should also be paid to the present land management policies that have impacts on rural settlement changes. Hence, this paper addressed these research gaps through the analysis of rural settlement changes and their reasons in the Pinglu District of Shuozhou City in the northern Shanxi Province of China. A mixed-method case study approach was employed in this study to identify how rural settlements have changed and what has affected these changes in the Pinglu District over the time period 1986–2013. The research findings from this study not only identify ways forward to guide rural settlement management in the studied area, but also offer references and suggestions in rural settlement management, and provide reasonable compensation and relocation options when acquiring land in mining areas both within and beyond the study area in China.

2. Study area

The study area is located in the Pinglu District of Shuozhou City in the northern Shanxi Province of China. It is a mixed mining-rural-settlement area, which is a community of resource, economy and society which exists material circulation and energy flow in the process and development, which refers to mineral resources exploitation, processing and service with agricultural production and biological resources utilization as the primary industries (Cao & Bai, 2015). The Pinglu District encompasses Jingping Town, Xiangyangbao Township, Baitang Township, Yuling Township, Taocun Township and Xiamiangao Township. Key industries in this study area include mineral resource exploitation, processing and service industries, and agricultural production and biological resource utilization (Cao & Bai, 2015). There are three surface mines and three underground mines that are part of Pingshuo China Coal Corporation as well as some other local underground mines (Cao et al., 2016a) (Fig. 1). The mines account for 70% of the entire study area (517 km^2) and produced 120 million tons of coal in 2013. The rural population was 78 thousand in 2013, which was more than triple the 1986 level (PLSB, 1987; PLSB, 2015). Located in the semi-arid, warm, temperate, continental monsoon climate zone, the study area has an annual average temperature of 4.8–7.8 °C, annual rainfall of 428.2–449.0 mm, and a terrain altitude of 1300–1400 m. In 2013, the area consisted of 42 thousand ha of farmland, 37 thousand ha of construction land and 6 thousand ha of destruction land, thus accounting for approximately 81%, 8% and 12% of the total area, respectively (Cao et al., 2016a). From 1986 to 2013, the damaged farmland was up to 17 thousand ha in the surface coal mining area, including 10 thousand ha damaged cultivated land (Cao & Bai, 2015). Due to the mining of coal resources, the resource-dependent urban area is growing around the core area, and the relocation of coal villages has injected new vitality into the construction of new rural settlements. According to the distribution traits of land use types, administrative boundary and mining boundary, Cao and Bai (2015) divided the study area into an underground mining and agriculture zone, an agricultural production zone, a rapid urbanization zone, an ecological reconstruction zone, an opencast mining zone and an opencast mining transition zone (Fig. 2).

3. Research data and methods

3.1. Remote sensing data sources and processing methods

Remote sensing (RS) in combination with geographical information systems (GIS) is a reliable method for the urban mapping and monitoring of large areas (Taubenböck et al., 2012), and it has also been recognized as a powerful and effective tool for detecting spatio-temporal dynamics of land use and land cover change (Gao, Liu, & Chen, 2006; Huang, Cai, & Peng, 2007; Nagendra, Munroe, & Southworth, 2004). We used six remote-sensed images from 1986, 1996, 2000, 2004, 2009 and 2013. The SPOT images were obtained from the Shibao Satellite Imagery Corporation in Beijing. The TM images were drawn from the US Landsat resource sharing platform. TM images and SPOT images were used to map rural settlement changes at approximately 4-year intervals except 1986–1996. These images were chosen to represent, as closely as possible, recent developments in China's coal industry: formation of coal industry (1986–1996); development of coal industry (1996–2000); growth of coal industry (2000–2004); maturity of coal industry (2004–2009); and prosperity of coal industry (2009–2013) (Cao, Bai, Zhou, & Zhang, 2016b). The statuses of the mine in the study area are shown in Table 1.

With reference to the geographic map (scale 1:10,000) of the mine area, the six images were corrected using the ENVI 5.0 Software. During the high-precision rectification process, 12 ground control points were evenly selected, and the quadratic polynomial and neighbouring re-sampling methods were used (Fan, Wang, & Zhang, 2012; Zeng et al., 2012). Rectified data were then presented using UTM projection with the WGS-84 ellipsoid as reference (Cao et al., 2015).

Based on the standards of land use classification in China (SAC 2007) and the land use type characteristics of opencast mine areas (Cao et al., 2016a), land use types were classified into cultivated land, woodland, grassland, urban land, rural settlement, opencast area, stripped area, dump site, industrial site and transportation land (Cao, Bai, Zhou, & Ai, 2015; Cao et al., 2016a). The textural features of each land use type as presented in the images were used to establish the interpretation signs (Yu, 2014). ENVI 5.0 Software was used to classify land use types under appropriate