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Spatial-temporal evolution and classification of marginalization of cultivated land in the process of urbanization

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ABSTRACT

Marginalization of cultivated land, resulting from rapid urbanization, exists as an important form of land use change, and represents a new research direction in land-use and land-cover change (LUCC). This article proposes a classification of such marginalization on the basis of elasticity of input and income, categorizing marginalization of cultivated land as either policy-induced (PIM), nature-induced (NIM) or economy-induced (EIM) marginalization. These classifications are further explored as either positive or negative marginalization, depending on whether the land is transformed from or into cultivated land. This innovative framework is applied to analyses of marginalization in Lianjiang County, located in southeastern coastal China. This research analyzes characteristics of spatial-temporal evolution of categories of marginalization of cultivated land using 3D kernel density methods. Significant findings point to spatial-temporal processes and driving forces of marginalization, including: (1) Concentrations of positive (P-PIM) and negative (N-PIM) policy-induced marginalization both occur and agglomerate in separate spaces, with the former mainly in the southeastern portion of the county and the latter in the northwest. (2) By contrast, patterns of positive (P-NIM) and negative (N-NIM) nature-induced marginalization complement each other in space - N-NIM tends to be more discrete in areas with P-NIM aggregations, and vice versa. (3) Finally, areas with aggregations of positive (P-EIM) and negative (N-EIM) economy-induced marginalization overlap. The research suggests that relevant land use policies should be formulated in response to these characteristics of cultivated land marginalization so as to address marginalization of cultivated land, especially as associated with rapid urbanization.

1. Introduction

Cultivated land exists as a non-renewable natural resource, limited in quantity and relatively stable in quality (Deng, Huang, Rozelle, & Uchida, 2006), with protection and utilization of such land highly correlated with both industrialization and urbanization (Xu et al., 2015). Extensive separation of agricultural producers and their land commenced in England with the enclosure movement of the 16th and 17th centuries (Neeson, 1994), with of marginalization of cultivated lands following. The end of the second industrial revolution in the 19th century marked a gradual weakening of the importance of agricultural production to national economic growth, with its formerly dominant position replaced by industry and commerce. As part of this shift, large amounts of cultivated land were withdrawn from grain production and permanently converted to industrial and commercial uses (Wu, Zhang, Skitmore, Song, & Hui, 2014). Contemporary patterns of rapid urbanization and population growth, in tandem with widespread destruction of cultivated land and declines in the rural labor force, elevate problems of marginalization of cultivated land in developing countries among academics worldwide.

As a developing country with a large population and cultivated land under threat from rapid urbanization, China faces a number of challenges to its food security. Aside from urbanization, other factors, including Chinese farmers' unwillingness to participate in food production, seasonal and permanent abandonment of cultivated land (Li, Huang, Kwan, Bao, & Jefferson, 2015), and acceleration of non-agriculturalization of cultivated land pose serious threats to

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national food security. Further, these shifts undermine ecological balances, strongly impact upon China's agricultural sustainable development, and even shrink the foundation for social stability (Zhang et al., 2009). In 2014, China's per capita arable area was only about one third of the world average. Globally, China's cultivated land accounts for 8.69% of the total area of cultivated land, while needing to feed 18.86% of the world's population (Grădinaru et al., 2015; Lyle, Bryan, & Ostendorf, 2015). Forecasts indicate that China's population will peak in 2030 (Wu, Luo, Zhang, & Skitmore, 2016), however its cultivated land continues to decrease. As such, addressing the marginalization of cultivated land is central to resolving problems of food security and agricultural productivity, as well as ensuring futures for farmers within society.

Previous research on the marginalization of cultivated land often does not approach the problem at a theoretical level, with studies relying on varying methodology and occurring in relatively scattered locations (Brouwer, Rheenen, & Dhillion, 2008; Kang et al., 2013). Further, there are deficiencies in definitions of marginalization, and acknowledged opportunities for improvement and innovation in research method and outcomes in this area (Milbrandt, Heimiller, Perry, & Field, 2014; Zhang et al., 2012). This research endeavours to remedy two problems: the first being a lack of a scientific and systematic classification standard for types of marginalization of cultivated land, grounded in an appropriate theoretical basis; and a deficit of quantitative research and spatial-temporal analyses of the marginalization of cultivated land.

Towards these ends, the research classifies marginalization of cultivated land relying upon the elastic theory of income-input to differentiate policy-induced (PIM), nature-induced (NIM) and economy-induced (EIM) marginalization. Application of this schema to a land-use and land-cover dataset from Lianjiang County, China, allows for exploration of the internal logical relationships of the different types of cultivated land marginalization, identification of the manifest forms of marginalization, and specific reference to various marginal lands using 3D kernel density analysis. Relying upon review of such spatial-temporal evolution of cultivated land marginalization, the paper provides theoretically grounded policy recommendations for improvement of the sustainable utilization of cultivated land, towards guaranteeing national food security and maintaining social stability in the face of rapid urbanization.

2. Theoretical framework and methodology

2.1. Theoretical exploration of research on marginalization of cultivated land

2.1.1. Definition and classification of marginalization of cultivated land

Marginalization of cultivated land exists as the processes and patterns of continuously decreasing net income associated with cultivated land utilization. As marginalization occurs, gains associated with production gradually decline so as to be insufficient to cover costs (Liu & Li, 2006), which can also be expressed as food economic production capacity of less than or equal to 0 (Bao, 2014).

The extent of responsiveness of income with change in the price is not always the same. The income for a grain product can be elastic or inelastic, depending on the rate of change in the income with respect to change in input of a grain product. This research has classified the marginalization of cultivated land into perfectly inelastic, lack of elastic and elastic based on the elastic theory of input and income. As there has a battery of factors (e.g., political competition among local governments, central government controls, local endowments) that can affect the elasticity, the types of elastic and lack of elasticity are in the form of curves, rather than straight line.

(1) An income-input elasticity of zero ($e = 0$) represents perfectly inelastic (Fig. 1), wherein variable inputs do not result in changes in income (Sun, Hupman, Ritchey, & Abbas, 2016). Under such conditions, proceeds from food production will remain unchanged or may reduce to nil even if there is an increase in various production factors considered as an increase in investment (Sabatelli, 2016). In other words, input of grain production factors will not affect the income of grain production in this land parcel or the food production income there will be zero. As a consequence of urban expansion policies, vast acreages of cultivated land are turned to construction land and are removed from grain crop production, which means the inelasticity of income-input. When $e = 0$, marginalization of cultivated land is described as policy-induced marginalization (PIM).

(2) Where the absolute value of income-input elasticity is less than one ($|e| < 1$), income is described as lack of elasticity. As Fig. 2 illustrates, increases in incremental input are not met by increases in incremental income of similar magnitude. Although inputs of production factors have been increased, they still have limited contribution to the production of cultivated land. For instance, economic production capacity of cultivated land will always be limited by gradient, soil conditions and water sources. Consequently, the income-input of this land is inelastic; resulting in either further abandonment of the land or its return to forestry. Either way it is no longer farmed for food production. Marginalization of cultivated land is referred to as nature-induced marginalization (NIM) if $|e| < 1$.

(3) When the absolute value of income-input elasticity exceeds one ($|e| > 1$), variable inputs result in amplified changes in income, and income is said to be elastic (Sun et al., 2016). For example, a 1% shift in inputs results in changes of income in excess of 1% (Sabatelli, 2016). As seen in Fig. 3, a small increase in input s from c_2 to c_1 results in a relatively large increase in income from R_2 to R_1. Increasing inputs of production factors can make tremendous contribution to economic production of cultivated land. For instance, with only a small investment, high quality cultivated land produces considerable grain yield. However, when high quality cultivated land is used to grow other food and non-food crops (e.g., vegetables, fruits, flowers, plants, medicinal materials), the net economic income may far surpass that associated with food. This economic advantage may drive some cultivated land to be converted to other farmland types, removing it from food production. Under conditions where $|e| > 1$, marginalization of cultivated land can be said to be economy-induced marginalization (EIM).

2.1.2. Internal logic relations and spatial manifestation forms of marginalization of cultivated land

Each form of marginalization can be further classified as either positive or negative, with positive marginalization removing

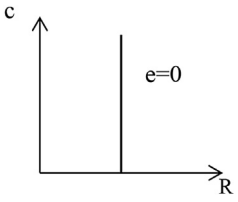

Fig. 1. Perfectly inelastic.