



## The impact of urban expansion on agricultural land use intensity in China



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### ABSTRACT

China's urbanization has resulted in significant changes in both agricultural land and agricultural land use. However, there is limited understanding about the relationship between the two primary changes occurring to China's agricultural land – the urban expansion on agricultural land and agricultural land use intensity. The goal of this paper is to understand this relationship in China using panel econometric methods. Our results show that urban expansion is associated with a decline in agricultural land use intensity. The area of cultivated land per capita, a measurement about land scarcity, is negatively correlated with agricultural land use intensity. We also find that GDP in the industrial sector negatively affects agricultural land use intensity. GDP per capita and agricultural investments both positively contribute to the intensification of agricultural land use. Our results, together with the links between urbanization, agricultural land, and agricultural production imply that agricultural land expansion is highly likely with continued urban expansion and that pressures on the country's natural land resources will remain high in the future.

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### Introduction

During the past several decades, China has experienced rapid urban transformation, represented by significant changes in its demographic composition and large-scale expansion of the urban landscape (Pannell, 2002; Wang et al., 2012). Satellite imagery show that the urban areas of China increased by almost 25% during the 1990s (Liu et al., 2005) and that urban land cover is expanding at rates faster than the growth of urban population (Seto et al., 2011). This has resulted in both the massive loss of cultivated land in the coastal and central provinces and the expansion of cultivated lands into other regions, especially the northern and border provinces of the country (Deng et al., 2006; Lichtenberg and Ding, 2008; Yue et al., 2010). Although the exact figures on the loss in total cultivated land area in China remain controversial, there is some consensus that the newly reclaimed cultivated land is less productive than the converted land (Doos, 2002; Yan et al., 2009). Given the decline of cultivated land, the level of inputs and outputs or frequency of cultivation against constant land (Turner and Doolittle, 1978), or intensity of agricultural land use, is of great

importance for maintaining the food production capacity. However, urban expansion and economic development can lead to a rise in the off-farm opportunities and the resulting labor shortage in the agricultural sector (Wu et al., 2011). Declines in the intensity of agricultural land use and farmland abandonment have been documented for many regions and for different crops (Chen et al., 2009; Li and Wang, 2003; Liu and Li, 2006). This has posed additional challenges for the security of food provision and the preservation of natural ecosystems.

Both the urban expansion on agricultural land and agricultural land use intensity affect agricultural production (Long and Zou, 2010; Jiang et al., 2012). The nature and magnitude of their relationship directly influence agricultural production and food provision and may have further outcomes on the patterns of a nation's agricultural land. An understanding of the relationship between urban expansion and agricultural land use intensity is critical in order to formulate appropriate policies that will balance the pressure between urban growth and agricultural land use and preservation. In addition, a decrease in agricultural land use intensity implies more future farmland expansion at the expense of other ecosystems. Therefore, understanding how urban land expansion affects agricultural land use intensity will facilitate a better examination of the environmental impacts of farmland expansion and the sustainability of the utilization of land resources.

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There is limited understanding about the linkages between the two primary changes that are occurring on China's agricultural lands: the urban expansion on agricultural land and agricultural land use intensity. Urban land expansion suggests both declining agricultural land and a higher level of urban development. It is expected that land scarcity will trigger a more intensive use of agricultural land (Ewert et al., 2006), while urban development increases off-farm employments, which will enhance the opportunity costs of more intensive farming (Phimister and Roberts, 2006; Uchida et al., 2009). Previous studies have investigated the effects of these factors related to urban expansion (Keys and McConnell, 2005; Shriar, 2005). However, to date, no study has systematically examined the influence of urban expansion on agricultural land use intensity. Moreover, the majority of empirical evidence about the changes in the intensity of agricultural land use in China are limited to regional case studies, with considerable variations for different regions and for different periods (Chen et al., 2009; Li and Wang, 2003; Liu and Li, 2006). Most of these studies have sought to explain changes in agricultural land use intensity with an analysis of the shift in the socioeconomic environments, but the analysis is basically descriptive in nature. Therefore, our study also contributes to the understanding about the mechanisms of the changes in China's agricultural land use intensity.

Our study examines the influence of the urban expansion and other socioeconomic factors on agricultural land use intensity at the national scale. The research questions that we ask include: What is the relationship between the urban expansion and agricultural land use intensity and what is the underlying mechanism? What is the impact of land scarcity on agricultural land use intensity? What is the impact of increasing income and other economic opportunities on agricultural land use intensity? What is the effect of agricultural investment on agricultural land use intensity? We aim to derive a better understanding about the links between urban expansion and agricultural land use intensity, and the insights derived are based on correlation coefficients estimated from panel econometric models. Identification of causality among the factors is not within the scope of this study.

### Theories of agricultural land use intensity

The literature on agricultural land intensification provides explanations about the pathways through which these factors related to urban expansion affect the intensity of agricultural land use, and about other major factors contributing to intensification of land use. However, no study has empirically studied the links between urban expansion and agricultural land use intensity. Urban expansion on agricultural land is associated with changes in the level of land scarcity and off-farm opportunities.

The classical land intensification theory is based on a unidirectional process of intensification of land use in response to locally driven increased demands for land-based products and services (Boserup, 1965). The underlying assumption here is that land use intensity is based on a finite amount of land. Boserup's theory and others (Chayanov, 1966; Darity, 1980; Robinson and Schutjer, 1984) describe the long-term process of land use intensification as driven by population pressure and land scarcity, which endogenously induces technological and institutional innovations to raise agricultural output from the given land. The validity of the theory is confirmed by a large amount of evidence from the broad agrarian change history. Under the pressure of population growth, a shift from extensive to relative intensive systems of land use has been witnessed in almost every part of the world (Boserup, 1965). This explanation of land use transitions emphasizes the relationship between demand and land resources. Based on this explanation, it is anticipated that both increased demand caused by population

growth and land scarcity caused by declining agricultural land are likely to trigger intensification of land use. Later scholars extended the theory, arguing that other demand factors such as consumer diets and affluence may also influence the intensity of agricultural land use (Ewert et al., 2006; Keys and McConnell, 2005).

Market-based explanations of agricultural land use intensification differ from Boserup's theory and account for market demands and off-farm employment (Lambin et al., 2000). Angelsen (1999) builds conceptual models that explore open economy situations, in which farmers make decisions about agricultural production by responding to market demands and exogenously given commodity prices. Angelsen finds that better off-farm employment opportunities which results in higher real wage will lead to longer fallow periods and less labor inputs. Despite an emphasis on the market influence, Angelsen recognizes that neglecting demand factors when analyzing agricultural land use intensity is less realistic for the macro studies of a region or country. In fact, a generally accepted view is that with a higher degree of the openness of economy, the intensity of agricultural land use will be less related to population and demand, but more dependent on production factors including costs of land, off-farm employment, and market access, and is closely related to environmental conditions (Keys and McConnell, 2005; Phimister and Roberts, 2006; Shriar, 2005).

In the case of China, the market of agricultural product is still heavily controlled by the government and state-owned companies and provincial governors are required to take responsibility for local grain self-sufficiency (Yang, 1999). Given the limited market openness of agricultural product, both demand and production factors determine agricultural land use intensity. Additionally, policy intervention seems to play an important role on the change of agricultural land use and production in China. Most notably, the Chinese government has consistently increased the amount of investment allocated to agriculture in order to improve agricultural productivity (Deng et al., 2008). The importance of subsidy intervention on agricultural land use intensification has been highlighted in a number of studies concerning the processes of regional and global land-use changes (Ewert et al., 2006; Keys and McConnell, 2005).

### Data

Agricultural land use intensity is commonly measured in three ways: (1) cropping frequency for a constant unit of land and time period, (2) agricultural outputs per unit land per unit time, or (3) inputs of capital, labor and skills that contribute to agricultural production (Brookfield, 1972; Turner and Doolittle, 1978). We use cropping frequency as a measure of agricultural land use intensity, a direct measurement about how frequently land is cultivated. Cropping frequency has been used as a measurement of land use intensity in both theoretical literature (Boserup, 1965) and empirical studies (Li and Wang, 2003; Liu and Li, 2006). There are a couple of reasons why we use cropping frequency. First, this study focuses on understanding changes in the management of agricultural land rather than yield increase. Agricultural economists have extensively studied yield increase, the outcome of agricultural land use intensification, in relation to management practices and conditions using production functions (Huang and Rozelle, 1995; Yao and Liu, 2008). However, few studies have revealed the factors and mechanism that lead to changes in land use management (Lambin et al., 2000). Second, measures in value of production (e.g. total value of output and total production cost) at the county level are either not available or inconsistent (Fan and Zhang, 2002). Third, because of the geographic and cultural diversity in China, there are considerable variations in crop structure across regions. For example, with the same grain output, the composition of output among

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