Applied Geography 46 (2014) 158–170

Contents lists available at ScienceDirect

Applied Geography

journal homepage: www.elsevier.com/locate/apgeog

# The effects of China's cultivated land balance program on potential land productivity at a national scale

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*Keywords:*
Land use change
Cultivated land balance
Potential land productivity
China's cultivated land preservation
Urban development

ABSTRACT

Decreases in both quantity and quality of cultivated land in China have drawn close attention recently due to the threat to food security. China has implemented a set of cultivated land balance (CLB) programs since the late 1990s, aiming to maintain the quantity and quality of cultivated land across the country. We assessed the outcomes of CLB policy in terms of both quantity balance and quality balance. In particular, we evaluated the effects of CLB policy on potential land productivity (PLP) of cultivated land. During 1999–2008, a total of 21,011 $km^2$ of cultivated land was lost due to urbanization and economic development while 27,677 $km^2$ of cultivated land was gained by land exploitation, consolidation and rehabilitation. Thus, the quantity balance aimed for by CLB was achieved. In contrast, quality balance was not met due to both the loss of highly productive cultivated land from urban expansion and economic development and a flawed approach to adding newly cultivated land. In particular, China has typically relied on adding cultivated land by exploitation instead of consolidation, which would add higher productivity land. Therefore, the PLP of the added cultivated land has been rather poor. Nevertheless, the average PLP did increase slightly during 1999–2008, but this was despite CLB rather than because of it. The main cause of the PLP increase was actually a grain-for-green policy that induced considerable reduction in cultivation of low productivity cultivated land.



## Introduction

Effects of land use change on potential land productivity (PLP) have drawn close attention recently due to the world wide threat to food security. For example, researchers have assessed the loss in cropland productivity due to deforestation in the Amazon (Weinhold, 1999), analyzed the impacts of land use conversion on food production in China (Yan, Liu, Huang, Tao, & Cao, 2009), evaluated the inherent soil productivity and contributions to China's cereal crop yield increase (Fan et al., 2013), determined how pastoralist needs affect cropping practices in Africa (Washington-Ottombre et al., 2010), and estimated changes in crop productivity under different scenarios of future land use trends in Europe (Ewert, Rounsevell, Reginster, Metzger, & Leemans, 2005). One especially significant spatial conflict that has affected the ability of nations to grow enough food is that between urban development and the need to protect highly productive cultivated land (Foley et al., 2005; Lambin & Meyfroidt, 2011; Tsadila, Evangelou, Tsadilas, Giourga, & Stamatiadis, 2012).

The patterns and rates of land use change such as urbanization are often guided by policies that, if implemented at a national scale, can significantly alter the amounts and proportions of cultivated land at various scales of productivity (Kumar, Merwade, Rao, & Pijanowski, 2013; Moore et al., 2012; Pijanowski & Robinson, 2011; Pijanowski, Tayyebi, Delavar, & Yazdanpanah, 2009; Plourde, Pijanowski, & Pekin 2013; Seto, Guneralp, & Hutyra, 2012; Tayyebi, Pijanowski, & Pekin, 2011). Fearing the negative effects of land use changes on PLP, numerous farmland protection programs have been implemented by nations around the world, with various degrees of success.

Agricultural policies usually have important impacts on both land use and the environment (Morelli, Segoni, Manzo, Ermini, & Catani, 2012; Munroe, Croissant, & York, 2005; Skinner et al., 1997; Tzilivakis et al., 1999). Therefore, it is important to fully assess the effects of any proposed or implemented agricultural policies. In 1985, the Strategic Environmental Assessment (SEA) Program was introduced in the European Community and widely used to assess the effects of development policies on ecosystems (Kumar, Esen, & Yashiro, 2013), measure the sustainability of policy

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0143-6228/$ – see front matter 
http://dx.doi.org/10.1016/j.apgeog.2013.11.009

scenarios (Ren, Zhang, & Wang, 2010), and evaluate the effects of policies on agricultural practices (Tzilivakis et al., 1999). Policy assessments have taken on several forms. Approaches have varied from those applying fuzzy multi-criteria evaluation to assess the effects of food safety policies on land use (e.g., Mazzocchi, Ragona, & Zanoli, 2013), to applying a general equilibrium model to analyze the economic and environmental impacts of European Union bioenergy policy (Dandres, Gaudreault, Tirado-Seco, & Samson, 2012), to those using a Markov model to assess conservation policy effects on land use change (e.g., Benito et al., 2010).

Traditionally, each of these policy assessments has focused on a single aspect of social, economic or ecological consequences. However, due to recent trends as globalization, trade liberalization, market development, and climate change, agricultural policy is now recognized as strongly affecting interactions between the environment, economy and society (Van Ittersum & Brouwer, 2009). Consequently, in recent years, research has shifted to more integrated approaches to assess policy impacts. These integrated approaches are recognized as either analytical or participatory in nature (Therond et al., 2009). The analytical approach is one that embraces models and both scenario and risk assessment, often using geographic information systems and spatial analyses, whereas the participatory approach includes policy exercises using mixed-method approaches combining those that are qualitative and quantitative (e.g., Nassauer & Opdam, 2008; Olson et al., 2008; Washington-Ottombre & Pijanowski, 2013).

Nowhere is the need for agricultural protection policies greater than in China. The large Chinese population needs to feed itself (Ash & Edmonds, 1998; Brown, 1995; Lichtenberg & Ding, 2008; Smil, 1999), and the shortage of cultivated land in China (He et al., 2013; Huang, Zhu, & Deng, 2007) presents many challenges to achieving this goal. Increasing food production in China can be reached in various ways (Deng, Huang, Rozelle, & Uchida, 2006; Fan et al., 2013; Ho, 2001; Smil, 1999; Yang & Li, 2000). These solutions include: (1) increasing yields through proper management of agricultural inputs such as nutrients and water (Fan et al., 2012; Lin, 1987); (2) increasing production through expansion of cultivated land (Angelsen, 1999; Tilman et al., 2001); and (3) ensuring, through cultivated land protection policies, that highly productive cultivated lands are protected and used to grow crops (Heilig, 1997; Lichtenberg & Ding, 2008; Lin & Ho, 2003; Liu, Liu, Zhuang, Zhang, & Deng, 2003). It is well documented that China has improved crop yields per unit of cultivated land area by increasing fertilizer application and the use of hybrid seed varieties (Fan, Stewart, Yong, Luo, & Zhou, 2005; Huang & Rozelle, 1995; Wang, Halbrendt, & Johnson, 1996). This has been especially true for rice, because, since 1978 the introduction of the Household Contract Responsibility System has held farmers accountable for farm profits or losses. However, the conservation of cultivated land in China has remained a challenge (Deng, Huang, Rozelle, & Uchida, 2006; Yang & Li, 2000), as the amount of cultivated land has decreased over the last two decades.

In particular, explosive urban growth in China has presented many challenges to protecting cultivated land. Over the past 30 years, as China's annual GDP (gross domestic product) has averaged more than 8%, this extensive economic growth has led to ever-increasing urbanization and loss of cultivated land with high PLP (Ho & Lin, 2004; Yang & Li, 2000). This has been especially true in the southeast coastal areas of China where development rates are the nation's greatest (Liu et al., 2003; Verburg, Veldkamp, & Fresco, 1999). The new expansion of urban land use, broadly known in China as "construction occupation", has converted highly productive cultivated land at the urban–rural fringe to non-agricultural uses at enormous rates (Tan, Li, & Lu, 2005).

In order to mitigate the pressure of cultivated land loss and ensure food security in China, the government has implemented, since the late 1990s, the Cultivated Land Balance (CLB) land use policy to maintain the quantity and quality of cultivated land across the country. During the same period that the CLB policy has been in effect, China has also had in place two other major policy programs aimed at influencing the use of cultivated lands: one referred to as grain-for-green and another called agricultural restructuring.

The grain-for-green policy is the largest land retirement/afforestation program in China. It was initiated primarily to mitigate the land degradation (soil erosion) from misguided land use and to improve ecological conditions, by returning steeply sloping cultivated land to forests or grassland. The program was begun in the Loess Plateau in 1999 and expanded to cover all of China as a national program in 2000. The primary aim of agricultural restructuring (which began in 1999) is to change from only planting grains to growing cash crops such as fruits and vegetables according to the particular advantages of the given region. Changing from grains to cash crops can have significant restructuring effects, as land for some types of crops needs to be reconditioned. Additionally, restructuring can result in reclassification of affected sites, such that they lose or gain designation as cultivated land. For example, if agricultural fields are replaced with orchards or fishponds under an agricultural restructuring plan, the land will no longer be counted as cultivated. This policy can therefore lead to both losses and additions to cultivated land.

In light of these complicated land use policies and drastic, ongoing urban and economic development, an assessment is needed of the effects of the CLB policy on the PLP of the cultivated land in China. However, there is a lack of published studies addressing this topic.

Here, we attempt to assess the consequences of CLB policy for the PLP of China in order to provide some guidance for agricultural management and stable agricultural development. Specifically, the purposes of this paper are to: (1) assess the land use conversion patterns of cultivated land in China between 1999 and 2008; (2) examine changes in PLP of cultivated land associated with each type of land use changes occurring during this 9-year period; and (3) present an evaluation of the effects of CLB policy on PLP, using the new Agricultural Land Classification (ALC) data from the Ministry of Land Resources of China (MLRC).

## Cultivated land balance policy

In 1996, given the magnitude of the cultivated land loss in China, the National Bureau of Land Management (the predecessor of the MLRC) adopted the CLB policy of maintaining the existing amount of cultivated land nationally (Liu, Liu, Jiao, & Zhang, 2004; MLRC, 1997). This policy has been viewed as a crucial attempt by the Chinese government to preserve cultivated land (Ash & Edmonds, 1998; Lichtenberg & Ding, 2008). CLB directs that within a given period and administrative unit, any area taken out of cultivation must be offset by putting at least an equal additional area into cultivation. Thus, when CLB was first proposed, it focused on the quantity balance of total cultivated land in general. However, this approach was soon found to be impractical due to various sources of cultivated land loss, especially from such other policies as grain-for-green and agricultural restructuring. Therefore, CLB implementation came to focus particularly on the balance between cultivated land losses by construction occupation and cultivated land supplement. According to this approach, if a plot of cultivated land was replaced by construction, the land developer should create another plot of cultivated land of the same area.

CLB was formally codified in the amended 'Land Management Ordinance' of 1998. In this ordinance, provincial governments were